

# **A Systematic Literature Review on Visibility in Sustainable Supply Chain Ecosystems**

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## **Abstract**

Sustainable supply chain allows integration of environmentally sound choices into supply chain management, shifting focus towards environmental, social and economic impacts across products and services lifecycle. Pressures arising from mounting environmental costs, consumer demand for eco-friendly products and services, and profitability amongst others are driving shift towards a sustainable supply chain. Growing evidence suggests that to effectively respond to these pressures, a key requirement is visibility i.e. the extent to which actors within a supply chain has access to, or share, information which they consider as key or useful to their operations, improves decision making, and is of mutual benefit. This paper contains a systematic literature review on visibility-enabled sustainable supply chain ecosystems. A total of 44 accepted refereed papers between 2007 and first quarter of 2017 have been selected and reviewed. The selected papers are then analyzed based on their content and the appropriate developed categories. The results show that visibility impacts significantly on sustainable supply chains and salient themes are emerging in the subject area.

## **Keywords**

Sustainability, Supply Chains, Visibility, Systematic Literature Review.

## **1. Introduction**

In the last few years, the evolution of the economic, technological, and environmental landscape in the context of the global industry has for supply chain process led to many significant changes. Global supply chains are having to adapt towards fulfilling a growing role that demands increased interconnectedness amongst participants, including suppliers and manufacturers. The increasing interconnectedness with attributable dependencies amongst supply chain participants results from advances, for example, in outsourcing, globalization, and innovations. A consequence of these relationships is the growing complexity of supply chains (Gunasekaran and Ngai, 2004). Supply chains are embracing sustainability with a premise that as the complexity of supply chain networks increases, so is a need for supply chains to take full responsibilities of their business operations and clearly demonstrate their environmental and ethical behavior (Grzybowska, Golinska and Romano, 2012).

Whilst the focus in traditional supply chains has been solely on cost considerations (Goetschalcks and Fleischmann, 2008), sustainable supply chains on the contrary are developing strategies and initiatives that simultaneously

addresses economic, environmental, and social aspects of the business. The sustainability paradigm for supply chain is largely in response to increasing pressures and incentives from legal constraints, customer preferences, competitive pressures, and stakeholder requirements (Seuring and Müller, 2008).

It has been recognized that to attain its sustainable aims, supply chain networks must develop and maintain close relationships with all stakeholders (Meixell and Luoma, 2015) develop ability to manage materials and information flows (Khann, Hussain and Saber, 2016), and manage complex relations with partners (Caridi *et al.*, 2010a). Thus, the trend in modern supply chain network is to initiate the concept of visibility amongst the stakeholders in the supply chain. The belief that visibility amongst stakeholders in the supply chain could act as a critical enabler for reducing supply chain uncertainty and offer an opportunity to improve the overall performance of the system is becoming more attractive to business organizations (Butner, 2010). This is because every business wants to reduce waste, disruptions, minimize risk, meet customer flexible demands, reduce total cost and improve business responsiveness (Yu and Goh, 2014). Without such visibility, stakeholders within the supply chain would have limited access to information about the various activities in their network (Olorunniwo *et al.*, 2014). Visibility is therefore proposed to be a prerequisite for efficient and effective sustainable supply chain management (Almeida, Vilas-boas and Ferreira, 2015).

Due to its importance, visibility is an extensively researched concept in the literature of supply chains. Also, increasingly researched is sustainability in supply chains. This paper presents a systematic literature review on visibility in supply chains. The objective of this study is to review relevant papers in the overlapping areas of visibility, sustainability, and supply chains. Based on a content analysis of the papers reviewed, the impact areas of visibility in sustainable supply chains will be discussed and the emerging themes highlighted. The rest of the paper is structured into four sections. Section 2 contains a background to visibility in sustainable supply chain ecosystems. The research methodology is presented in Section 3. Section 4 contains the results and its discussion. The paper ends in Section 5 with conclusions and areas of future work.

## **2. Sustainable Supply Chain Ecosystems and Visibility**

In the literature, sustainable supply chains is defined as supply chains that do well consistently on financial, environmental and social dimensions (Pagell and Wu, 2009). As expected, these three dimensions are those identified with sustainable development. Management of the chains entail the management of the materials and information flows and sharing of the pertinent information amongst the companies in the ecosystem. A supply chain ecosystem is a composition of networks of supply chains and the materials and information flows through the supply chains. These linkages that exerts the influences can be internal or external to the chains and can come through companies, countries and their governments, influencing resources and their providers. it also comprises of companies, countries and their governments, technical and non-technical logistics infrastructure and management, amongst others.

Supply chain visibility has been defined in a variety of ways including from a broad perspective as “traceability and transparency of supply chain process” (Tse and Tan, 2012). The goal of supply chain visibility is to: reduce business and supply chain risk, improve lead times and performance and identify shortage and quality problems along the supply chain. Integration of information across a supply chain (Campos *et al.*, 2017) requires partners to develop capabilities to (1) share information (Ren *et al.*, 2010), (2) optimize the staging and flow of materials by leveraging the visibility of resources (Lee and Rim, 2016), and (3) streamline financial operations such as billing and payments that are interdependent (Rai, Patnayakuni and Seth, 2006). Level of visibility depends on the context and may vary across sectors. For example, it has been reported that fast-moving industries such as the retail and fashion sectors often lack supply chain visibility beyond second-tier suppliers (Opara *et al.*, 2003; Roth *et al.*, 2008). Knowledge about indirect supplies and the scope for independent verification of information also play a key role in determining the level of supply chain visibility. From the perspective of sustainable supply chains, the context dependency of visibility levels can be more pronounced. It has been suggested that the implementation and management of sustainable supply chains are context-specific challenges making difficult to come up with theoretical, managerial and policy generalisations (Silvestre, 2016). All these poses significant challenges for sustainable supply chain visibility.

The challenges of sustainable supply chain visibility can be alleviated through the increasing trend towards global industry which is leading the way to many significant changes in supply chains. In the emerging global industry,

intelligent and smarter chains in ecosystems will be increasingly interconnected, instrumented, and intelligent (Butner, 2010). Whilst there are significant benefits associated with sustainable supply chain ecosystems there is also the issue of growing complexity of supply chains (Gunasekaran, Hong and Fujimoto, 2014) and ramifications for increased visibility that crosses boundaries and consequences of information silos.

### 3. Methodology

This section contains a description of the research methodology adopted in this work and explanation of how data was obtained. This study adopted a systematic literature review approach to examine sustainable supply chain visibility. A systematic literature review is an explicit, comprehensive, and reproducible method used to identify, appraise, and synthesize all available research relevant to a research question, topic area, or phenomenon of interest (Durach, Wieland and Machuca, 2015). To identify papers relevant to this study, the systematic literature review methodologies of (Kilubi and Haasis, 2015) and (Crossan and Apaydin, 2010) were adopted. The methodology used in this paper is summarized in Figure 1.

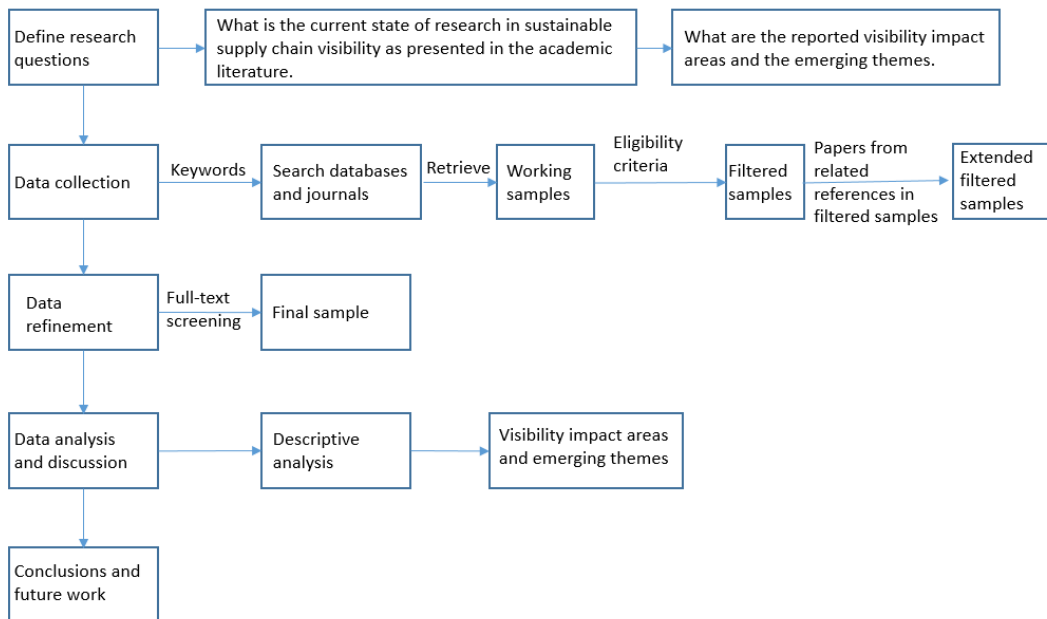


Figure 1. Research Methodology

In the first step, the research questions were established. These were two-fold: a) what is the current state of research in sustainable supply chain as presented in the academic literature and b) what are the reported visibility impact areas and the emerging themes. Before conducting the search of the literature, the following inclusion/exclusion criteria were defined: a) the search is limited to papers that appeared in peer-reviewed journals, b) only papers written in English language were considered, and c) papers whose full-text is not assessable was excluded. The next step involves data collection. The following keywords were defined: information sharing, visibility, RFID, transparency, green, reversible, closed loop, sustainable supply chains and then used to search scholarly databases and major online journal search engines, namely science direct, Scopus, Taylor & Francis group, EBSCO, springer link, Emerald insights and Wiley.

The results of the searches constituted a working sample for 145 papers for which one or more of the keywords is found in their titles, abstract and/or list of keywords. After applying the eligibility criteria, excluding irrelevant papers based on the pre-specified inclusion/exclusion criteria defined above, a set of 82 filtered samples were obtained. Next, all references of the filtered sampled papers were checked and 5 were found to be relevant and added to the filtered sample thus resulting in a set of 87 papers. Finally, in the data refinement stage, articles were completely read to assess their relevance, and 44 papers remained in the final sample. The content of each paper in

the final sample was then analyzed and the findings discussed, leading to drawing of conclusions and suggestion of future work.

#### 4. Analysis and Discussion

The analysis is in two parts. First, presented in Section 4.1 is the descriptive analysis of the final sample. This is followed in Section 4.2 by an analysis of the visibility impact areas identified in the papers reviewed. Also contained in Section 4.2 is the emerging themes observed. The review covers the period between 2000 and the first quarter of 2017.

##### 4.1 Descriptive Analysis

Figure 2 shows the distribution of papers in the final sample per year across the period study. An analysis of the years in which the 44 papers were published shows, as illustrated in Figure 1, that no paper was found for 2000 to 2006 inclusive, and three was found in 2007, none was found in 2008. Majority of the papers falls between 2009 and 2017, accounting for approximately 93% of the final sample. The paper with significant elements of sustainability and visibility in supply chains were found post-2015. Furthermore, there is the indication of a growing interest in the subject and this appears to align with the advancements in information technology.

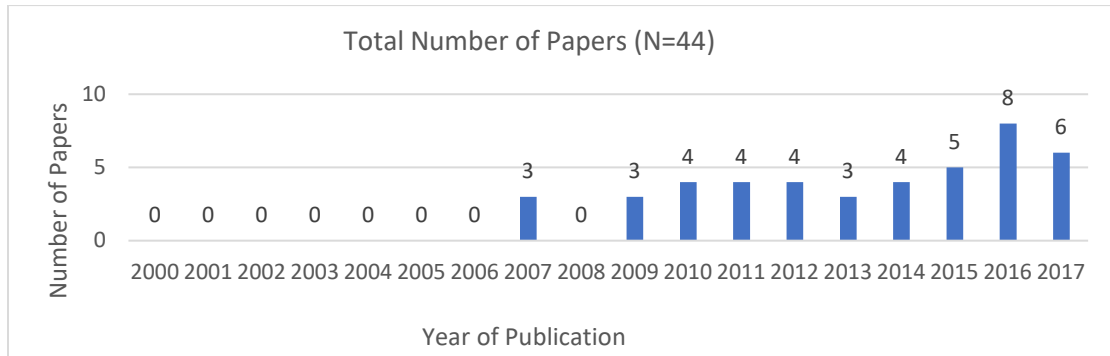


Figure 2. Distribution of publication per year across the period studied

The papers in the final sample are mainly distributed across 31 publication sources, 26 journals and 5 conference papers. As shown in Figure 3, most i.e. 6 of the papers were found in the international journal of production economics (IJPE); the top four leading journals that featured in the final sample are International journal of production economics (IJPE), Journal of cleaner production (JCP), international journal of physical distribution and logistics production (JPDL) and International journal of operations and production (IJOP). Followed closely by computer in industry (CI) and Journal of operation management (JOM) with 2 respectively and other sources came up with 1 paper each in the final sample, representing 52% of the sample size.

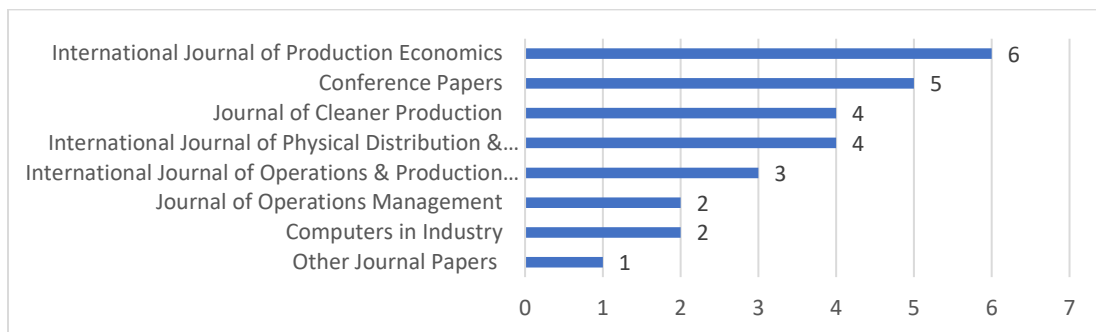


Figure 3 Distribution of reviewed papers by journals (n=44)

The papers reviewed adopted a variety of methodologies. Using the framework suggested by Winter and Knemeyer (2013), the papers was grouped into seven categories: (1) case study; (2) simulation/modelling; (3) literature review; (4) surveys/questionnaires; (5) theoretical and conceptual paper; (6) multiple methods; (7) secondary database to analyze the methodologies they used. The seven categories are shown in Figure 4. Case study, theoretical/conceptual papers, multiple methods and simulation/modelling are the four most common methods. The paper with significant elements of sustainability and visibility in supply chains used a lot more of case study and simulation methodologies.

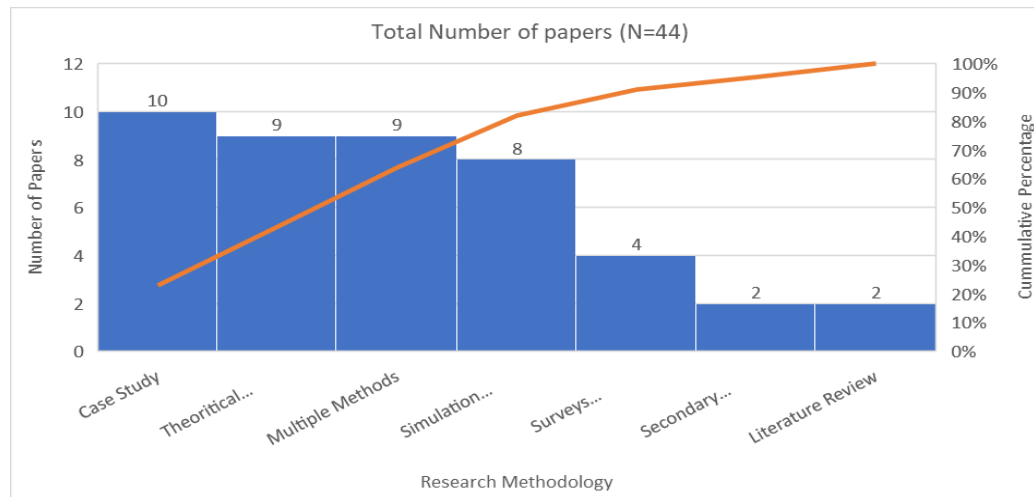


Figure 4. Research Methodologies applied

## 4.2 Visibility Impact Areas and Emerging Themes

There is evidence from the papers reviewed that visibility impacts on several areas of sustainable supply chain ecosystems. The areas of impact covers technical Lee et al. (2014), non-technical Klueber and O'Keefe (2013) and managerial Klievink *et al.*, (2012), aspects of the ecosystems. The impacts areas are increasingly apparent with growing interests in sustainability and advances in technology. Some of the papers reviewed (Barratt & Oke 2007; Meixell & Luoma 2015) indicates that sustainable supply chains can benefit from quality shared information which can impact on decisions and overall performance. This helps supply chains move towards a balanced system that enables integrated quality decision making process by sourcing and analyzing information with regards to all the three aspects of sustainability i.e. environmental, social and economic.

Also evident is the impact of visibility on waste Kaipia, Dukovska-Popovska and Loikkanen, (2013) and opportunities for companies to for example continuously improve their operations with advance notice of returns Nakabi, Beidouri and Othmane, (2012) with prior knowledge of product reuse and recycling (Wong, 2013). Linked to quality information sharing is improvements in communication throughout the ecosystem which helps reduce costs and wastes, amongst others (Dües, Tan and Lim, 2013). Improving supplier partnership, customer relationship and enhanced stakeholder's management are other important areas visibility has been seen to impact upon (Bartlett, Julien and Baines, 2007). Companies responds to stakeholders' pressure by evolving their capabilities to gain legitimacy and performance improvement (Parent and Deephouse, 2007; Gualandris *et al.*, 2015; Felipe-Lucia *et al.*, 2015), integrating training will help companies in their adoption of particular environmental practices (Petrini and Pozzebon, 2010). Achieving high level visibility requires companies to, amongst others, overcome obstacles to process integration along the supply chain and this requires appropriate training and preparedness; motivated and capable trading partners; and adequately aligned organisational cultures (Katunzi, 2011). Four emerging themes are identified and discussed as follows.

### A. Realization of quality information in Supply Chain Ecosystems

The quality of information is a complex concept Li and Lin, (2006) and is subject to on-going research According to USPTO, (2014) quality of information, in comprehensive terms, consists of *objectivity, utility and integrity*.

Objectivity involves two elements namely presentation and substance. The presentation element focuses on ensuring accurate, clear, complete and unbiased presentation of information, while the substance focuses on ensuring accurate, reliable and unbiased information. Utility refers to the usefulness of the information while integrity focuses on the security of the information (Marinagi, Trivellas and Reklitis, 2015). The exchange of quality information between the focal company and its partners in a supply chain network is a vital component in obtaining optimal performance of the system. (Caridi *et al.*, 2010a). Access to the quality information enable firms to minimize uncertainties and improve the way they respond to changes in market conditions (Li and Lin, 2006). Quality information enables managers to make operational, tactical and strategic decisions. The overall importance of information quality cannot be overemphasized. In summary, several studies have proposed that increase in the quality of information might lead to an overall increase in the performance of a supply chain (Barratt and Oke, 2007), (Yu and Goh, 2014), (Klueber and O'Keefe, 2013), (Caridi *et al.*, 2010b). There is a fundamental need for information sharing to gain visibility if supply chains and the firms within them are to improve their performance. Also of significance is the model of information sharing adopted by supply chains and the conditions attached to it e.g. unilateral sharing of information versus partial information sharing (Hosoda, Disney and Gavirneni, 2015). Whilst this information sharing premise is widely accepted, it has also been suggested (Barratt and Oke, 2007) that arguably, to meet the requirements for elevated visibility levels, attention should be directed towards the quality and the extent to which the shared information is perceived as meaningful and useful. Visibility is much more than just sharing information amongst stakeholders within the supply chain, rather it's the characteristics of the information shared which must be relevant and meaningful; which needs to be holistically viewed through a combination of economic, social and environmental perspectives. It is increasingly clear that the right level and quality of information shared is paramount. Martínez-Sala *et al.*, (2009) showed that more information by itself may not help, the information recipient should consider the impact of using such information on the transparency of orders placed and respond by perhaps considering information he provides in return.

#### *B. Advances in technology, tools, and the critical role of industry 4.0*

Advances in technology has always been the main differentiator with regards to the capability of firms having a competitive advantage over other supply chains (Jeffers, 2010; Xu and Quaddus, 2013). More so with the advent of Industry 4.0. Industry 4.0, known as the fourth industrial revolution, is characterized by cyber-physical systems that facilitates automation, smart data capture and exchanges, and knowledge integration. Supported in the industry 4.0 paradigm are internet of things (IoT) and cloud-based systems, both of benefit to the industry including sustainable supply chains (Xu, He and Li, 2014). The revolution brings about advances in technologies such as Radio Frequency Identification (RFID), also found useful in sustainable supply chains ((Karvonen *et al.*, 2015). According to Acharyulu (2007) the greatest benefit derivable from RFID supply chains is visibility across the entire chain. RFID and IoT implementations offers several advantages to sustainable supply chains including real-time tracking, visibility of inventory data, speeds up information flows and order fulfilment, efficient management of post-sale services, leaner systems, management of returnable containers, customer experience and supply chain responsiveness (Ngai, 2010; Bougdira, Ahaitouf and Akharraz, 2016; Thoro, Melski and Schumann, 2009). In addition, can help to significantly reduce uncertainty and complexity of product reuse and recycling processes (Kumar and Rahman, 2014), and can also help in building trust towards credible approaches to sustainability in supply chains (Almeida, Vilas-boas and Ferreira, 2015). RFID and associated technologies can also facilitate the reporting of threats and managing risk.

In the emerging digitization era, visibility in sustainable supply chains is being boosted by use of smart systems that allows for energy consumption visibility and optimization, an example is reported by Perspective *et al.* (2014) in the context of material handling technologies. Quality of information sharing will improve with the emerging technologies and there are emerging evidence to support this premise. The EPC Global Network offers different types of information Watson, Wysocki and Bucklin (2015) with increasing opportunities for sustainable supply chains to better manage information sharing for elevated visibility. Big data analytics is also reported to play a role. Quality information about patterns of consumption can help improve visibility in reverse supply chains and 'use-visibility' research is at early stage of development.

The product lifecycle is a necessary source of information which can make a supply chain sustainable (Bougdira, Ahaitouf and Akharraz, 2016). Using RFID's to collect useful information in a product's lifecycle and making available the relevant information on an IoT platform have reported benefits. For example, manufacturers have increased opportunities for effective post sale services and management of their reuse and recycling processes

especially when the products are tracked real time and using IOT-based functionalities. RFID technology in closed-loop supply chain will help improve the efficiency of ordering and the operation of a just-in-time remanufacturing system (Tsao, 2014). Empirical evidence indicates that sharing information on returns rate is beneficial regarding effective risk responses and the integration of sustainable practices (Parry *et al.*, 2016). Accruing substantial benefits from these technologies is premised on ensuring visibility on the entire remanufacturing cycle Karvonen *et al* (2015) to recognize risk as a systemic issue through the aid of RFID which can report threats ranging from fluctuation in temperature, tampering, theft, accidents and natural disasters. This capitalizes on real-time connectivity across the supply chain to respond in a rapid, intelligent and coordinated way (Butner, 2010). In addition, for turbulent market environments an adoption of adaptive intelligent ad-hoc collaborative order policies would help Increasing level of information visibility of reverse logistics processes in closed loop supply chains and can be achieved by building on known order policies such as those of Tang and Naim, 2004 and Wang and Disney, 2016).

Adopting these technologies, invariably requires investments and design of the supply chain to optimally leverage the use of the technologies for increased level of visibility. In adopting these new technologies, finding out where they fit in the organization and how best to integrate them with existing supply chain applications is paramount (Acharyulu, 2007). Tsao, Linh and Lu, (2016) illustrates the use of continuous approximation techniques to model a closed-loop supply chain network for the remanufacturing of products under RFID technology. The use of continuous functions help reduces the complexity of the problems and decrease the amount of data required to optimize the design of such networks. Visibility leveraged by advances in technology has been reported to be a vital step in building trust which leads to sustainability (Rai, Patnayakuni and Seth, 2006).

### *C. Reference Models, Architectures and Frameworks*

Global standards is emerging as an integral part of visibility enablers in sustainable supply chains (Grzybowska, 2012). Supply chains needs an agreed unified format of information exchange, interoperability, ontology building, and reference models. According to the European commission, “*Standards and other standardization publications are voluntary guidelines providing technical specifications for products, services and processes*”(Commission, 2015). There exists a variety of supply chain standards,(Fabbe-costes and Roussat (2011) highlighted the standards and observed the need for more work in this area. Borsato, (2014) noted that industry demands solutions for interoperability that can support quality information sharing particularly between heterogeneous systems and suggested ontology building as a way of overcoming the issues raised. Whilst several reference frameworks have been established for green enterprise process modelling, the Supply Chain Operations Reference (SCOR) model is seen as de facto standard employed in supply chain domain (Ntabe, Munson and Santa-eulalia, 2014). In a review of the Supply Chain Operators Reference (SCOR) model with emphasis on environmental issues, Ntabe, Munson and Santa-eulalia, (2014) noted that there is a positive trend in research papers on green SCOR relating to environment and return process. They observed that the SCOR model offers a practical decision support platform for environmental assessment and competing choices along the supply chain.

### *D. Creating Integral Value for stakeholders*

According to (Schenkel *et al.*, 2015) firms do create value by integrating visibility within their respective sustainable supply chains. Visibility requires stakeholders to develop certain capabilities, enabling the stakeholders to hold the firms responsible and accountable for sustainability conditions in their supply chains (Dingwerth and Eichinger, 2010). Maintaining close contact with one’s customers, as well as one’s competitors, and ensuring that knowledge and insights so acquired are internalized quickly to guide operations within can effectively transform the firm’s operations into a strategic weapon with the potential to enhance firm performance. Value for customers may result from a detailed information sharing on the customer’s order patterns, usage rate and its product return which would provide valuable information on the product lifecycle and design (Mafakheri and Nasiri, 2013). However, further research is needed that synthesis these values as it affects the Triple Bottom Line approach (TBL) (Gualandris *et al.*, 2015). In managing the interest of stakeholders in a sustainable supply chain, there is a need to consider the level of influence various stakeholders would have because stakeholder may not show similar interest in three bottom line approach.

In recent times, there has been a paradigm shift towards transparency between firms and stakeholders within their supply chain (Dhawan *et al.*, 2010). These firms are creating meaningful and relevant experiences and engaging with

partners, non-governmental organizations, co-operate bodies and consumers through every point in the process. This results in increased stakeholder's participation through co-creation and co-ownership. This shift requires a balance between economic, environmental and social objectives of their supply chain. Firms with the right response on how to address these issues can turn challenges into opportunities that would help improve the relationship with the various stakeholders thereby enhancing the reputation of their supply chain (Corporate Citizenship, 2013). Further to the emerging theme on technological advances, combining real-time sensor data with environmental data can provide intelligence of higher order to all stakeholders in the ecosystem. This improves the social awareness of the stakeholders which enables the stakeholders in their decision-making process. This moves the supply chain process from a reactive mode to a proactive one as a result of quality information sharing. To identify, assess and manage these risk, firms must understand stakeholders' different perspective, expectations, and values (Wu, Chuang and Hsu, 2014). Hence an attentive and cooperative stance must be given towards improving the visibility of the supply chain (Wong, 2013).

Transparency includes not only reporting to stakeholders, but actively engaging stakeholders and using their input to both secure buy-in and improve supply chain processes (Carter and Rogers, 2008). Transparency offers a way of transferring powers to stakeholders allowing for increased accountability (Dingwerth and Eichinger (2010) and one should be mindful of a blame culture (Egels-Zandén, Hulthén and Wulff, 2015). A challenge is in ensuring that interventions are not limiting or negating any of the overall net benefits (Godar et. al. 2016). The integration of stakeholders in supply chain is a key driver towards the implementations of certain standards and codes of conducts. According to (Asif *et al.*, 2013) stakeholder management is crucial for driving and improving firm's performance. The ability of a manager to respond to various stakeholder demands (Internal and external) while maintaining close relationship creates value and is shared among the stakeholders (Schenkel *et al.*, 2015). Value chain theory suggest that firms create value in a chain which is of strategic importance between the firm and the customers. This theory mostly focus on value creation for the customer as a major source of competitive advantage (Gummerus, 2013).

## **5. Conclusions and Future Work**

A systematic literature on sustainable supply chain visibility was conducted and four main themes were highlighted. Theoretical, case study and modelling were found to be the main research methodologies applied in this subject area. Whilst visibility is widely acknowledges to be central to supply chain performance, studies in on supply chain visibility and sustainability are recent and growing. Sustainable supply chain ecosystems are significant benefits with attendant yet unresolved issue of growing complexity of supply chains and this has ramifications for increased sustainable supply chain visibility. Emerging are increasing efforts at realization of quality information and its sharing across the supply chain, leveraging of advances in technology particularly relating to IoT, developing global standards and reference models, and consolidating on integral values for stakeholder. The present literature review has its limitations particularly relating to the search pattern applied as it is possible that some papers related to the research focus but with different keywords were excluded. Future work could look at extending the scope of this paper and seek to provide further understanding of the interactions between the themes identified and their relationship to overall performance of sustainable supply chains.

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