Barriers and opportunities in green supply chain management:

Cause and effect analysis

By

Maria Ahmed

(NUST2015MSCE&M0700000117832)

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science

In

Construction Engineering and Management

Department of Construction Engineering and Management

National Institute of Transportation – NIT

School of Civil & Environmental Engineering (SCEE)

National University of Sciences and Technology

Islamabad, Pakistan

(2018)

This is to certify that the

thesis titled

Barriers and opportunities in green supply chain management: Cause and effect analysis

Submitted by

Maria Ahmed

(NUST2015MSCE&M0700000117832)

has been accepted towards the partial fulfillment

of the requirements for the degree of

Masters of Science in Construction Engineering and Management

_____

Dr. Muhammad Jamaluddin Thaheem

Supervisor,

Department of Construction Engineering and Management,

NIT, National University of Sciences and Technology (NUST), Islamabad

THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS thesis written by Mr./Mrs. **MARIA AHMED (Registration No. 00000117832)**, of **NIT (SCEE)** has been vetted by undersigned, found complete in all respects as per NUST Statutes / Regulations, is free of plagiarism, errors, and mistakes and is accepted as partial fulfillment for award of MS/MPhil degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the said thesis.

Signature: _____

Name of Supervisor: Dr. Muhammad Jamaluddin Thaheem

Date: _____

Signature (HOD): _____

Date: _____

Signature (Dean/Principal): _____

Date: _____

This thesis is dedicated to my mother for making me be who I am, my father for supporting me all the way and those who made it possible for me.

ACKNOWLEDGEMENTS

All praise is only for the Almighty who taught us to read, write, speak, listen and see. I am thankful to the Magnificent Allah who is the one who always helped me through the hard times in my life and I pray to Allah for blessing till the last breath. I am in debt of gratitude to my research supervisor Dr. Muhammad Jamaluddin Thaheem for his guidance and encouragement to complete this research work. His motivation, appreciation and time made this research possible. I am also grateful to my committee members Dr. Hamza Farooq Gabriel, Dr. Sohail Anwar Malik and also Dr. Khurram Iqbal for their sincere guidance to complete this research work.

I am very grateful to all the respondents for their valuable contribution to this research and also to my friends Shamraiza and Absar and batchmates of MS CE&M 07 for being the best community around. I am obliged for their contributions in this research. Last but not the least; I would like to pay earnest gratitude to my family, my parents and my siblings, for their unconditional support, encouragement, prayers and patience.

Abstract

Today, the environmental issues are becoming serious challenges for organizations due to an ever-mounting shortage of resources, increased awareness among costumers, legislative reasons and impact on environment contributed by supply chain activities. Therefore, environmental management is gaining emergent importance among researchers and organizations in the form of green supply chain management (GSCM). The scope of GSCM involves various proactive approaches such as reduce, reuse, rework, recycle and reverse logistics hence resulting in positive environmental and financial benefits. Due to its various potential benefits, most of the developed countries are already adopting these practices but developing countries still need further attention and motivation. It is most particularly in the construction sector. Thus, the basis of this research is to find out the critical barriers and opportunities in GSCM of construction industry in developing countries. It also envisages to propose the strategies to avoid the critical barriers and exploit the opportunities for a better environmental performance of construction industry. For this purpose, a causal loop framework is developed showing how various barriers and opportunities are connected with each other. The research is carried out in different phases: identification of critical barriers and opportunities through literature using content analysis, questionnaire survey to determine the current industry trends regarding these barrier and opportunity and finally the development of a causal loop framework by using the top most barriers and opportunities showing their interconnectedness. This research is expected to help in adoption of GSCM practices by presenting a clear picture of possible benefits that can be exploited by removing the critical barriers in construction sector of developing countries.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Construction environmental footprint and role of supply chain

Globally, construction sector is considered as one of the largest fragmented industries which is experiencing an unparalleled growth. It is considered among a highest contributors in terms of output and employment in both developing and developed countries (Durdyev et al., 2012). The annual global construction output estimated in 1998 was over $3000 billion out of which 77% contribution was made by high income countries like North America, Japan and West Europe and 23% by middle or low income countries and this contribution is vice versa in terms of employment (Durdyev et al., 2012; Khan, 2008). However, this estimated output was close to $4.5 trillion in 2004 (Khan, 2008). As a result of a survey carried out in European countries, it was estimated that around 44.6 million workers are directly or indirectly attached to this sector (Khattak et al., 2013). The role of construction industry is vital in boosting the economy and providing employment in developing countries as well. For example, in Jordan, construction industry represents 5% of total GDP (Al-Werikat, 2015), 11.5% in UAE as of 2010 statistics (Balasubramanian, 2012) and 19.2% in Ghana (Ametepey et al., 2014). Similarly, it has contributed around 6-9% of India's total GDP within a period of five years and has provided employment to 31.46 million people (Doloi et al., 2012). Also, approximately 30-35% population in Pakistan is directly or indirectly associated with this industry (Farooqui et al., 2008).

In spite of its major contribution to employment, construction industry is considered as the most hazardous industries, and its impact lasts on the present and future generations for decades (Ametepey et al., 2014). This industry has been accused of causing serious issues related to environment ranging from extreme energy and resources consumption to the pollution of surrounding environment and global warming (Ding, 2008). It is considered as the largest contributor responsible for global consumption of 33% of resources, 40% of energy and 25% of the world's total water, generating, in result, 30-40% of carbon and 40% of material waste (Balasubramanian, 2012; Wahga et al., 2015).

In construction, choice and selection of appropriate material plays a major role (Ametepey et al., 2014). Megaprojects involve large volumes of material resources which demand a

systematic process of selection, extraction, manufacturing, assembling and delivering of these materials (Bhool et al., 2013). The sequential and organized form of these processes is called supply chain (Ofori, 2000) whereas supply chain management (SCM) involves active and strategic management of the flow of all the tasks, activities , processes and information within various organizational networks to deliver a quality product to the costumer (Akintoye et al., 2000). By effectively using SCM practices some firms in UK especially Balfour Beatty reduced its supplier base by 75%, developed better relations with suppliers, solved problems by training programs and established new systems to rate performance of suppliers on basis of their speed, price and quality of work (Ofori, 2000).

In construction supply chain, a large amount of non-renewable resources is used for material manufacturing and disposal. Steel, a commonly used construction material uses coal during its manufacturing as well as recycling process that accumulates vast amount of pollutants in the environment (Ho et al., 2009). Blengini (2009) stated that in Italy the manufacturing of construction materials including cement, bricks, glass, ceramics, etc. and the buildings use phase results in 41% of greenhouse emissions. So, it is evident that the associated processes of material manufacturing and their construction activities can accumulate significant amount of pollutants in the environment (Ametepey et al., 2014). As every link in the supply chain contributes to this environmental degradation (Ho et al., 2009), it stimulates the development of strategies for environmental management of supply chains (SCs).

1.2 Green Supply Chain Management and its importance

To respond to this threat, an environmental innovation known as Green Supply Chain Management (GSCM) has been introduced which integrates the environmental concern into SCM (Ojo et al., 2013). GSCM is the incorporation of ecological thinking into various phases of a product's lifetime i.e. starting from extracting material in its raw form till its designing, manufacturing and then distribution phases. Also it extends to the usage of the product by customers and its removal after its useful lifetime (Walker et al., 2008). Materials are obtained from nature thus they need to be ecofriendly (Ojo et al., 2013) but the worldwide rapid industrialization is growing at such a fast pace that it is causing some serious irreversible damages to the environment such as depletion of ozone layer and icebergs (Demeter et al., 2007). These effects are compelling the manufacturers to produce environmental friendly products (Lakshmimeera et al., 2013).

Another main reason for this emerging importance towards GSCM is due to deterioration of the surroundings like extinction of raw material sources, more waste locations and increased toxic level but it is not only about environment but also about higher profit and good business knowledge (Srivastava, 2007).

In such a situation GSCM practices such as reduce, reuse, rework, recycle and reverse logistics etc. (Srivastava, 2007) can help in developing products that are environment friendly and can reduce the emissions of carbon (Walker et al., 2008). A case study done by Blengini (2009) showed that recycling could reduce the emissions by 18%. These practices can also help in reducing packaging material and waste generation (Ho et al., 2009) and in some cases, improving environmental supply that can help in reduction of costs and improvement in organizational performances (Testa et al., 2010). It can also help in achieving objectives and profit goals while introducing minimal amount of risks and impacts to environment (Azevedo et al., 2011).

Initially, the manufacturing industry started focusing on the concept of greening their SCs to pay attention to environment related problems. Much work has been done on GSCM practices. However, their focus is still limited to identifying the barriers that are hindering the implementation of GSCM (Govindan et al., 2014). Recently, construction enterprises have also started considering GSCM for the purpose of acquiring a competitive advantage over other enterprises (Chun et al., 2015).

1.3 Previous work

In last few years, construction sector has seen active research in SCM in the field of operation management by developing computer-based programs to experiment with the recent SCM concepts (Papadopoulos et al., 2016). Whereas GSCM research is mostly focuses on its features like green purchasing, management of internal environmental operations, or green logistics (Lakshmimeera et al., 2013). Many authors propose that research on GSC should now move more towards experimental and theoretical approaches instead of just subjective approach (Govindan et al., 2014; Zsidisin et al., 2001). Extensive study on GSCM has been done for developed countries but for emerging or developing countries there is only a little work done (Mitra et al., 2014) particularly in Asian Areas (Seman et al., 2012) Countries which contributes the most towards research in the field of GSCM includes Taiwan, China, USA and UK (Malviya et al., 2015). Recently growing interest has been

observed in inspecting special challenges that hinder organizations from taking up GSCM (Govindan et al., 2014).

While talking about the construction sector at present no studies published so far have been able to provide a comprehensive and systematic green investigation covering various stages of supply chains and to address relevant issues, therefore a holistic GSCM oriented study on construction can provide various conditions necessary for greening the sector (Balasubramanian et al., 2017). Some of the literature is available for the manufacturing firms, similar scheme can be used in construction sector to get the desired results (Ojo et al., 2013).

1.4 Barriers and opportunities in green supply chain – problem statement

For the successful implementation of GSCM practices first and the foremost thing is to find out the barriers and opportunities in GSCM because barriers limit the ability of firms to implement green practices (Balasubramanian et al., 2017) which can hinder a company's success. Whereas opportunities are those which can be exploited during the implementation of these practices that is by concentrating more on greening the procedures and products firms can increase their profits, efficiency, productivity and also the quality of their products (Chiou et al., 2011)

So, the main purpose of this research is to find out the barriers and opportunities in GSCM as well as their significance and to propose the strategies to avoid these barriers and to use these opportunities for the prosperity of construction industry. Because a powerful way of gaining success and differentiating a company from its competitors is GSCM approach (Wittstruck et al., 2012).

1.5 Objectives of study

- To identify the barriers and opportunities in implementation of green supply chain management practices in construction industry.
- To assess the significance and interconnectedness of identified factors.
- To propose strategies to avoid significant barriers and exploit opportunities

Chapter 2

Literature Review

2.1 Supply Chain Management (SCM)

Construction is one of the most competitive and complex industry with various problems like differentiation in design and construction, lack of communication and poor coordination among various disciplines (Albaloushi et al., 2008). And to manage this industry effectively a promising approach is SCM (Papadopoulos et al., 2016). A firm's SC system consists of vendors or suppliers, company's internal tasks, distributors, and customers that are the end users (Hervani et al., 2005). Construction SC has four major participants which are client, consultant, and general and sub-contractors. Main loop of the construction supply chain is between client and general contractor (Khattak et al., 2013). Supply chain management can be defined as coordinating and managing the complex network of various activities to deliver the completed product to the costumer or end user (Ninlawan et al., 2010). SCM is considered as one of the main strategies to enhance the revenues, to save costs and to improve the processes in today's world (Tommelein et al., 2003). SCM technique was first used by manufacturing industry with (JIT) Just in Time system in 1990's and first implemented by Toyota (Raju et al., 2016). Major difference between construction and manufacturing SCs stated by Papadopoulos et al. (2016) is that construction product is mostly for a single client and product is different for every construction project along with the equipment, place and production method. Construction is a project based discontinuous nature industry and there is lack of research on these type of industries (Segerstedt et al., 2010).

An important matter in SCM is management of environment related issues (Azevedo et al., 2011). This is because the increased economic growth increases energy and material consumption which leads to various environmental issues like depletion of resources. So only economic feasibility cannot help to sustain an organization in the long run, environmental and social aspects also play an important part (Mitra, 2014). Also great revenue can be generated in the future because of the natural opportunities provided by the environment (Markley et al., 2007).

2.2 Green Supply Chain Management (GSCM)

Most of the construction firms are now emphasizing to increase environmental friendly products to enhance environmental value and financial growth, reduce poverty while improving working conditions, health, safety, and sustainability (Lakshmimeera et al., 2013).. In this context GSCM can be used as an emergent organizational philosophy that can reduce the environmental risks (Diabat et al., 2011). It can be used as one of the finest strategies that can meet the challenge of carbon reduction and also to improve the ecological performance of the firm (Balasubramanian, 2012). It has been widely studied since 1990's, the discussion on sustainability is SC gained momentum since early 2000s (Mitra, 2014). Now for the organizations to increase their environmental awareness is becoming increasingly possible because large number of international costumers now require their suppliers to deliver danger and poison free materials (Chiou et al., 2011).

Initially some of the best practices for SC were Just in Time (JIT) or lean manufacturing and their main focus was to improve the efficiency of operations and minimization of waste, but for economic purposes not environmental (Ojo et al., 2013). Mitra et al. (2014) stated that sustainability practices in SCs are the natural extension of JIT and lean manufacturing. Some worldwide enterprises are already considering GSCM for adoption or have already adopted it. And the reasons could be environmental rules and legislations, improved image, innovation in work or may be for cost reduction (Chun et al., 2015). GSCM can also decrease the environmental influence of various industrial activities without compromising on cost, quality, performance or energy consumption efficiency. However these areas are of challenge for the practitioners, academicians and researchers (Srivastava, 2007).

2.2.1 Definition

Table 2.1. for definitions of GSCM from literature is given below. The definition of GSCM has evolved from a mere green design (Handfield et al., 1997) to a full-blown integration of environmental thinking into SC (Dubey et al., 2017). Various features of GSCM have been developed and reported in the literature overtime. These features have been synthesized in Table 2 along with various publications which demonstrate the level of subscription by these authors to GSCM features in the definitions they have developed. It is interesting to see that from a total of 14 features, no definition subscribes to all of them. The maximum subscribed features (7) are in definitions provided by Handfield et al. (1997) and Sarkis et al. (2006). Moreover, a good number of definitions are unidimensional (Albino et al., 2009; H'Mida et

al., 2007; Hung Lau, 2011; Lakhal et al., 2007), bidimensional (Bhool et al., 2013; Lee et al., 2008; Sarkis et al., 2011; Sheu et al., 2005) and tridimensional (Büyüközkan et al., 2012; Zhu et al., 2005). As can be seen from Figure 1, there is necessarily no temporal evolution in the number of dimensions covered by subsequent definitions which points that the publications devoted to GSCM have remained overly focused in their explanation and application.

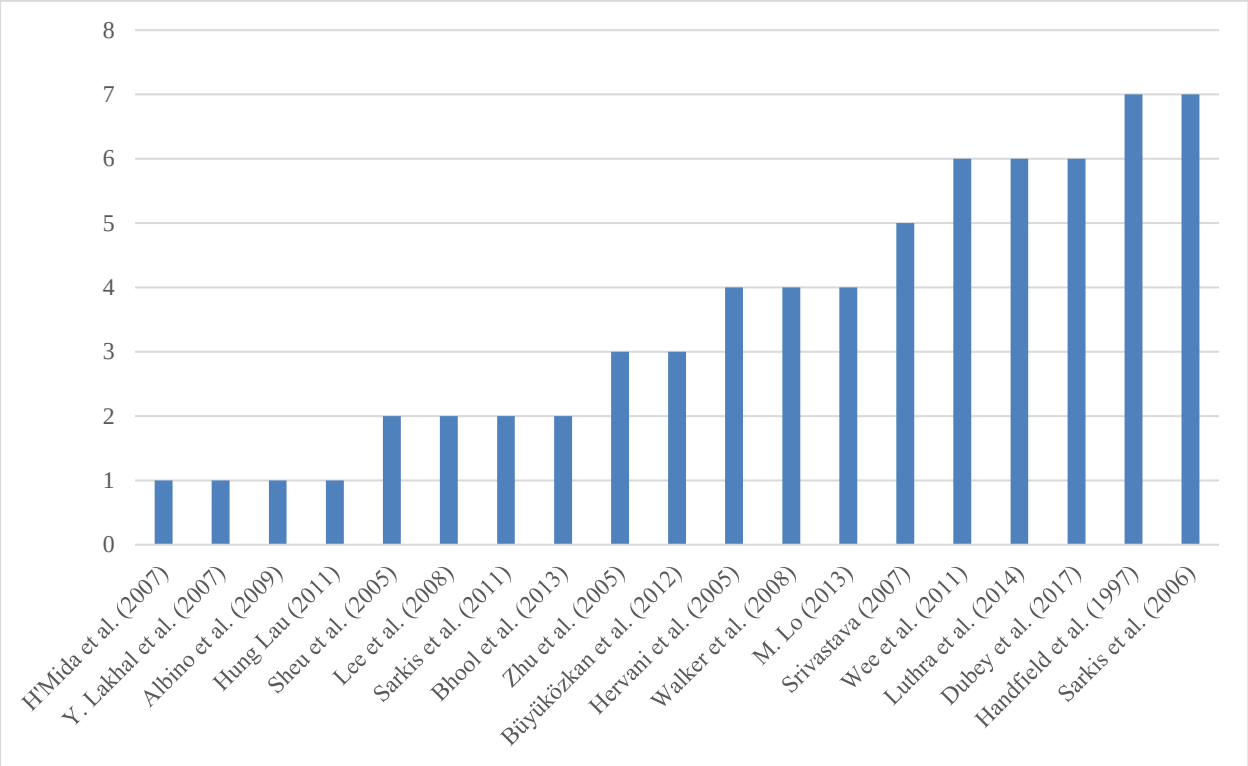

Figure 2.1: Dimensional evolution of definition of GSCM

Moreover, the dimensions of green manufacturing (10), green distribution (8) and reverse logistics (8) have been frequently discussed in the literature. Green manufacturing involve techniques that use minimum amount of energy and resources to make products that can be recycled and reused resulting in reduced consumption of virgin resources (Srivastava, 2007). Also, it involves using materials that are efficient and less toxic. An industrial case study carried by Deif (2011) showed that the successful implementation of green manufacturing activities can save up to $ 46,740 along with positive impact on time, material consumption and environment. While green distribution includes strategies like green packaging and logistics/transportation. Better packaging with arranged loading patterns helps utilize the space properly with reduced material usage and handling (Ninlawan et al., 2010)

Table 2.1: Definition of GSCM

Reference	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	Total dimensions
Handfield et al. (1997)		✓			✓	✓	✓	✓	✓						7
Zhu et al. (2005)											✓	✓	✓		3
Hervani et al. (2005)				✓	✓				✓	✓					4
Sheu et al. (2005)					✓					✓					2
Sarkis et al. (2006)				✓	✓	✓	✓	✓	✓	✓					7
Srivastava (2007)		✓	✓		✓				✓	✓					5
H'Mida et al. (2007)													✓		1
Lakhal et al. (2007)														✓	1
Lee et al. (2008)	✓												✓		2
Walker et al. (2008)		✓			✓				✓	✓					4
Albino et al. (2009)	✓														1
Wee et al. (2011)	✓	✓	✓		✓				✓	✓					6
Hung Lau (2011)	✓														1
Sarkis et al. (2011)	✓									✓					2
Büyüközkan et al. (2012)											✓	✓	✓		3
Bhool et al. (2013)											✓		✓		2
Lo (2013)		✓		✓	✓			✓							4
Luthra et al. (2014)		✓	✓	✓	✓			✓	✓						6
Dubey et al. (2017)	✓			✓	✓			✓	✓	✓					6
Total mentions	6	6	3	6	10	2	2	5	8	8	3	2	5	1	

D1: Integrate environmental thinking in SC; D2: Green design; D3: Sourcing and selection; D4: Green procurement; D5: Green manufacturing; D6: Assembly; D7: Green packaging; D8: Logistics; D9: Green distribution; D10: Reverse logistics; D11: New archetype to achieve profits and objectives; D12: Lowers environmental risks; D13: Improved ecological performance; D14: Zero emission, waste, waste of resources, toxics and waste in product's life

Whereas green logistics comprises use of fuel efficient transportation such as railway and waterways to lower the emission levels and transfer the products together, rather than in shifts directly to end user (Rao, 2002; Rao et al., 2005) because during construction of a project about 6-8% of carbon is emitted during the material transportation (Balasubramanian et al., 2017). End of life management or reverse logistics is retuning the product at the end of its useful life from the end user to supplier who can then recycle, remanufacture or repair the material (Wooi et al., 2010). This process can significantly reduce the emissions; for example recycling of steel and aluminum saves half of their energy and reduces emissions (Yan et al., 2010).

2.2.2 Evolution of research in GSCM

In the last few years, there have been number of articles and reviews on GSCM. Detailed study on many categories of GSCM has been done such as remanufacturing but further depth is required in the areas such as impact of remanufacturing on SC, commitment of firms to GSCM, how quality of service effects customers behavior etc. (Srivastava, 2007). In future as suggested by Zhu et al. (2005) much attention must be given to the involvement with the customer in green design, packaging and transportation. Despite of various studies on GSCM, there is lack of understanding between theoretical and operational approaches of GSCM (Malviya et al., 2015).

Environmental consciousness started in USA in 1960s and spread world widely (Sarkis et al., 2011). Rao (2002) claimed that green practices in SCs had started in South East Asian countries such as Philippines, Malaysia, Thailand, Indonesia and Singapore. But still there is limited research on GSCM in emerging countries most particularly in Asian sectors (Seman et al., 2012). Although late but countries like China and India are now incorporating environmental practices into their strategies (Dubey et al., 2017).

Wu et al. (2011) noted that many firms from developed countries do not want to source materials even if it would be cheaper, from countries like China and India where there are no such ecological norms. Literature has shown that larger firms are more attracted towards GSCM practices as compared to the smaller ones due to more access to the resources and this proactive implementation helps them gain competitive and economic advantages (Mitra, 2014; Wu et al., 2011).

Some work on barriers and opportunities in various countries is represented in the following Table 2.2.

Table 2.2: Geographical distribution of barriers and opportunities in GSCM

Country	Studies	
	Construction sector	**Manufacturing sector**
China	Shi et al. (2013)	Sarkis et al. (2006)
Canada		Testa et al. (2010) Cote et al. (2008)
France		Testa et al. (2010)
Germany	Harms et al. (2013), Wittstruck et al. (2012)	Testa et al. (2010)
Hungary		Testa et al. (2010)
India	Raju et al. (2016) Arif et al. (2009)	Luthra et al. (2011), Mathiyazhagan et al. (2013), Govindan et al. (2014), Ravi et al. (2005), Mudgal et al. (2010), Bhatele et al. (2016), Dashore et al. (2008), Sarkis et al. (2006)
Japan		Testa et al. (2010), Zhu et al. (2010)
Malaysia		Wooi et al. (2010), AlKhidir et al. (2009)
Norway		Testa et al. (2010)
Nigeria		Ojo et al. (2014)
Singapore	Hwang et al. (2012)	
Taiwan		Chiou et al. (2011)
UK	Walker et al. (2008), Sourani (2011)	Revell et al. (2003)
UAE	Balasubramanian (2012) Balasubramanian et al. (2017)	
USA	Ho et al. (2009)	Testa et al. (2010), Beamon (1999), Markley et al. (2007), Ho et al. (2009)

2.3 GSCM v/s conventional SCM

Conventional SCs and green SCs are different in several ways. The main difference is tracking down all the 3 dimensions of sustainability i.e. environmental dimension, social dimension and economic dimension. GSCM organizations deals with all 3 sustainability dimensions while the focus of conventional SCM is the economic dimension from TBL approach. Conventional SCM does consider the ecological standards but its optimization scope is sometimes limited e.g. conventional chains just consider the toxicological effects on human without taking into account the environmental impact (Ho et al., 2009; Luthra et al., 2011; Stefan Schaltegger et al., 2014b).

Focus of conventional SCM is on the end product regardless of how harmful its impact can be for the environment. While GSC is an integrated and ecologically-optimized approach that considers the toxicological effects on human beings while taking into account the adverse environmental impacts. Tabular presentation of differences is shown in Table 2.3.

Table 2.3: Difference between GSCM and conventional SCM

Characteristics	GSCM	Conventional SCM	References
Objectives and values	Environmental and economical	Economical	Beamon (1999) Ho et al. (2009) Luthra et al. (2011) Walker et al. (2008)
Environmental impact	Integrated approach Low environmental impact	High environmental impact	
Selection of supplier's criteria	Ecological aspects Based upon long term relations	Based upon short term relationship and prices	Ho et al. (2009) Luthra et al. (2011) Walker et al. (2008)
Cost pressure	High	High	
Flexibility	Low	High	
Speed	Low	Low	
Prices	High	Low	Ho et al. (2009)
Risk	High	Low	Stefan Schaltegger et al. (2014a)
Use of Standards and Certification	Yes	Yes	
Life cycle assessment	Yes	No	
Stakeholder management	Yes	No	
Focus on TBL elements	Focuses on all the 3 dimensions	Strong focus on economic dimension	

2.4 Barriers in GSCM in construction industry

The diffusion of GSCM practices in developing or emerging countries is lower than that in developed countries (Mitra, 2014). Lack of effective framework for evaluation and modeling of barriers can result in lack of green initiatives in construction industry. Therefore we need to know about the critical barriers, relationship among them, development of framework to show their interdependence and their classification based upon their importance and criticality (Balasubramanian, 2012).

2.4.1 Factors

There are two types of factors involved

2.4.1.1 External factors

The factors that are not manageable by the project team are termed as external factors. These factors cause problems in the supply chain and adversely affect project performance parameters that can be cost, quality and time.

2.4.1.2 Internal factors

Internal factors are those which can be controlled and developed by project team over a period such as trust, risk management and joint working etc. But factors beyond the control of project team are termed as external factors and have huge impact on the internal factors, suppliers, and overall project performance parameters. (Khattak et al., 2013)

Some of the major barriers extracted from the literature are described in Table 2.4. These barriers are ranked according to their literature score obtained through content analysis where the impact of each barrier (High, Medium and Low) is assessed through detailed literature review. A quantitative number is assigned to each impact (High=5, Medium=3 and Low=1) and the highest frequency impact is selected for each barrier. Literature score is then calculated using the formula given in Equation 1 where 5 is the highest impact score and frequency is the number of times a factor is mentioned in all reviewed papers.

$$Literature\ Score = Impact\ Score\ x\ \left(\frac{Frequency}{Total\ No.of\ Papers\ x\ 5}\right) \qquad Equation\ 1$$

Next step is to turn this literature score into normalized score by dividing individual literature score of each barrier with the sum of literature score. Normalized score is then arranged in descending order and cumulative score is calculated. This technique is used to eliminate less significant factors (Ullah et al., 2017) but current study did not eliminate any of the identified barriers and opportunities to collect industry score for all of them. Such an exhaustive approach is adopted to ensure holistic coverage of topic under consideration.

Insufficient policies, incentives, regulations or commitment by leaders or top management has been ranked as the most significant barrier hindering the implementation of GSCM. It has been established in the literature that top management's commitment is essential for successful implementation of strategic approaches like GSCM (Ojo et al., 2014). It is necessary to understand the value of GSCM, and the necessary efforts and support required for its successful deployment (Raju et al., 2016). These efforts can be in the form of appropriate policies, knowledge, training and providing incentives to help initiate GSCM practices. Further, lack of awareness or knowledge is the second most significant barrier which can prevent organizations from taking right decision regarding the selection of appropriate material or product in view of the economic and environmental impacts, and the process through which it will be obtained and recycled after usage (Sourani, 2011). The barrier lacking integration in industry, despite of frequent occurrence but low impact, comes out to be least significant. Similarly, lacking in energy & waste management of an organization becomes least significant due to lower frequency and lower impact.

Table 2.4: Barriers in GSCM

#	Code	Factor	Literature Score	Normalized Score	Cumulative Score	Selected references
1	B1	Insufficient policies, incentives, regulations or commitment by leaders or top management	0.636	0.079	0.079	Ojo et al. (2014), Sourani (2011), Raju et al. (2016), Bhatele et al. (2016), Govindan et al. (2014)
2	B2	Lack of awareness or knowledge	0.590	0.073	0.153	Balasubramanian et al. (2017), Balasubramanian (2012), Revell et al. (2003), Luthra et al. (2014), Bhatele et al. (2016)
3	B3	Lack of funds or resources	0.545	0.068	0.221	Balasubramanian (2012), Walker et al. (2008), Ravi et al. (2005), Luthra et al. (2011), Mudgal et al. (2010), Arif et al. (2009)
4	B4	General perspective that sustainability leads to greater costs / financial implications	0.545	0.068	0.289	Bhatele et al. (2016),, Balasubramanian et al. (2017), Liu et al. (2012), Revell et al. (2003), Raju et al. (2016)
5	B5	Lack of legal enforcement by the government for GSCM or government support	0.545	0.068	0.357	Balasubramanian (2012), Lin et al. (2008), Arif et al. (2009), Ofori (2000), Revell et al. (2003)
6	B6	Lack of IT support system or technology infrastructure	0.454	0.056	0.414	Balasubramanian (2012), Raju et al. (2016), Govindan et al. (2014), Luthra et al. (2011),

						Arif et al. (2009)
7	B7	Lack of information distribution or understanding among construction organizations and suppliers or stakeholders i.e. stakeholders' engagement and collaboration	0.409	0.051	0.465	Balasubramanian et al. (2017), Mudgal et al. (2010), Liu et al. (2012), Morledge et al. (2009)
8	B8	Problem in maintaining environmental suppliers or shortage of green suppliers	0.409	0.051	0.516	Govindan et al. (2014), Luthra et al. (2014), Shi et al. (2013), Mudgal et al. (2010), Balasubramanian (2012)
9	B9	Lack of public awareness / interest	0.363	0.045	0.561	Ojo et al. (2014), Balasubramanian (2012), Govindan et al. (2014), Mudgal et al. (2010), Arif et al. (2009)
10	B10	Lack of technical expertise i.e. green professionals	0.318	0.039	0.601	Mathiyazhagan et al. (2013), Govindan et al. (2014), Balasubramanian et al. (2017), Luthra et al. (2014), Revell et al. (2003)
11	B11	Transport and logistics issues or lack of knowledge	0.318	0.039	0.641	Raju et al. (2016), Govindan et al. (2014), Mathiyazhagan et al. (2013), Luthra et al. (2014), Beamon (1999)
12	B12	Lack of organizational support	0.272	0.034	0.675	Raju et al. (2016), Balasubramanian (2012), Mathiyazhagan et al. (2013), Mudgal et al. (2010), Ravi et al. (2005)
13	B13	Competitive nature of market &	0.272	0.034	0.709	Bhatele et al. (2016), Balasubramanian (2012),

		uncertainty				Raju et al. (2016), Govindan et al. (2014), Mudgal et al. (2010)
14	B14	Resistant towards change	0.218	0.027	0.736	Sourani (2011), Ravi et al. (2005), Sarkis et al. (2006), Luthra et al. (2011), Mudgal et al. (2010)
15	B15	Insufficient training and guidance	0.190	0.023	0.760	Govindan et al. (2014), Mathiyazhagan et al. (2013), Luthra et al. (2014), Ravi et al. (2005), Sarkis et al. (2006)
16	B16	Non-involvement or less time to address issues related to sustainability	0.181	0.022	0.783	Sourani (2011), Govindan et al. (2014), Revell et al. (2003)
17	B17	Difficulty in reusing / recycling the product	0.181	0.022	0.805	Mathiyazhagan et al. (2013), Govindan et al. (2014), Beamon (1999), Ravi et al. (2005)
18	B18	Lack of demand	0.181	0.022	0.828	Ojo et al. (2014), Balasubramanian (2012), Luthra et al. (2014), Mudgal et al. (2010)
19	B19	Lack of corporate social responsibility	0.181	0.022	0.851	Mathiyazhagan et al. (2013), Govindan et al. (2014), Luthra et al. (2014), Mudgal et al. (2010)
20	B20	Lack of long-term strategic planning or short term perception	0.136	0.017	0.868	Sourani (2011), Raju et al. (2016), Luthra et al. (2014), Mudgal et al. (2010)
21	B21	Lack of new technology, process or materials	0.136	0.017	0.885	Mathiyazhagan et al. (2013), Govindan et al. (2014), Luthra et al. (2014)

22	B22	Environmental thinking not a part of organization's vision, objectives and decision making.	0.136	0.017	0.902	Ojo et al. (2014), Govindan et al. (2014), Mathiyazhagan et al. (2013), Balasubramanian (2012), Luthra et al. (2014)
23	B23	Poor organizational culture	0.136	0.017	0.919	Bhatele et al. (2016), Balasubramanian (2012), Ravi et al. (2005), Hsu et al. (2008), Lin et al. (2008)
24	B24	Difficulty in identifying environmental opportunities	0.090	0.011	0.930	Govindan et al. (2014), Theyel (2000)
25	B25	Tight and fixed deadlines by the stakeholders	0.090	0.011	0.942	Balasubramanian et al. (2017), Hwang et al. (2012)
26	B26	Unskilled/semiskilled HR personals	0.081	0.010	0.952	Bhatele et al. (2016), Govindan et al. (2014), Mathiyazhagan et al. (2013), Lin et al. (2008), Hsu et al. (2008)
27	B27	Fear of failure	0.081	0.010	0.9625	Govindan et al. (2014), Mathiyazhagan et al. (2013), Revell et al. (2003), Rao et al. (2005)
28	B28	Disbelief in environmental benefits	0.081	0.010	0.972	Mathiyazhagan et al. (2013), Govindan et al. (2014), Walker et al. (2008), Revell et al. (2003)
29	B29	Research and development not sufficient	0.054	0.006	0.979	Sourani (2011), Arif et al. (2009)
30	B30	Lack of markets for recyclable materials	0.054	0.006	0.986	Ojo et al. (2014), Raju et al. (2016)

31	B31	General perspective that complex sustainability leads to greater effort or is too complex	0.045	0.005	0.992	Raju et al. (2016)
32	B32	Vagueness in definitions and various interpretations	0.027	0.003	0.995	Sourani (2011)
33	B33	Lacking integration in industry	0.027	0.003	0.9988	Sourani (2011), Luthra et al. (2014), Mudgal et al. (2010)
34	B34	Lacking in energy & waste management of an Organization.	0.009	0.001	1	Bhatele et al. (2016)

2.5 Opportunities in GSCM in construction industry

Mostly the management decisions give rise to the opportunities in an organization. Sustainability related opportunities may provide solution to the existing problems (Stefan Schaltegger et al., 2014b). By concentrating more on greening the procedures, products and management innovation can lead to better competitive advantages along with improving the status of firm. Also, to enter the new markets through innovative green products along with the better quality of products. Another possible benefit of greening is that it makes the entry for other competitors difficult. Moreover, reduction in hazardous waste and pollution can increase the efficiency while decreasing the cost of disposing harmful waste material. Therefore environmental management must be implemented by organizations and integrated in business strategies in order to develop and maintain competitive advantages (Chiou et al., 2011). Opportunity oriented supply chains require (Testa et al., 2010):

1. Replacement of old SCs with the new GSCs
2. Should include products eco-design
3. Detailed education and specific training for innovation in an organization.
4. Supplier development and training

Some of opportunities that are extracted from literature and are ranked in the same way as barriers are given in Table 2.5. The top 4 most significant opportunities with the same score are improved reputation, potential for cost reduction, increase profitability and reduction in environmental risks. Concentrating more on greening the procedures, products and management innovation can lead to better competitive advantages along with improving the status of firm. As a result, it facilitate the firm to enter new markets through better quality and innovative products (Chiou et al., 2011). Beamon (1999) showed that approximately 75% of users purchasing power can be influenced by the environmental reputation of a firm and 80% will be willing to pay higher for environment friendly products. Recent findings show that the product innovations and optimum planning in some cases can reduce cost dramatically (Ho et al., 2009). Therefore, environmental management must be implemented by organizations and integrated in business strategies to develop and maintain competitive advantages and also to achieve high profits (Testa et al., 2010). Successfully implementing only a few green practices in SCs can reduce hazardous waste and pollution which increases the efficiency while decreasing the cost of disposing harmful waste material. On the other hand,

opportunities like increase in staff satisfaction, shorter production times and knowledge multiplication are among the least significant due to lower literature score.

Table 2.5: Opportunities in GSCM

#	Code	Factor	Literature Score	Normalized Score	Accumulated Score	Selected references
1	O1	Improved reputation	0.7	0.107	0.107	Harms et al. (2013), Wittstruck et al. (2012), Testa et al. (2010), Markley et al. (2007), Chiou et al. (2011), Ho et al. (2009)
2	O2	Potential for cost reduction	0.7	0.107	0.214	Harms et al. (2013), Testa et al. (2010), Arif et al. (2009), Cote et al. (2008), Chiou et al. (2011), Ho et al. (2009)
3	O3	Increase profitability	0.7	0.107	0.321	Beamon (1999), Arif et al. (2009), Markley et al. (2007), Chiou et al. (2011), Ho et al. (2009)
4	O4	Reduction in environmental risks	0.7	0.107	0.428	Sarkis et al. (2006), Testa et al. (2010), Arif et al. (2009), Cote et al. (2008), Chiou et al. (2011), Ho et al. (2009)
5	O5	Reduction of production waste	0.5	0.076	0.504	Wittstruck et al. (2012), Cote et al. (2008), Ho et al. (2009)
6	O6	Reduction of energy consumption	0.4	0.061	0.565	Wittstruck et al. (2012), Arif et al. (2009), Ho et al. (2009)
7	O7	Reduction of material consumption	0.4	0.061	0.626	Wittstruck et al. (2012), Arif et al. (2009), Cote et al. (2008), Ho et al. (2009)
8	O8	Differentiation in competition / competitive advantages	0.4	0.061	0.688	Wittstruck et al. (2012), Markley et al. (2007), Chiou et al. (2011)
9	O9	Improve product quality	0.3	0.045	0.733	Ho et al. (2009), Chiou et al. (2011)
10	O10	Emission reduction	0.3	0.045	0.779	Wittstruck et al. (2012), Cote et al. (2008), Ho et al. (2009)
11	O11	Product innovations	0.2	0.030	0.810	Wittstruck et al. (2012), Testa et al. (2010)
12	O12	Minimization of transport time	0.2	0.030	0.840	Wittstruck et al. (2012), Cote et al. (2008)
13	O13	Increased health and safety and	0.2	0.030	0.871	Wittstruck et al. (2012), Ho et al. (2009)

		knowledge about it				
14	O14	Reuse product	0.2	0.030	0.902	Cote et al. (2008), Ho et al. (2009),
15	O15	Transparency and performance and transparent flow of goods	0.12	0.018	0.920	Wittstruck et al. (2012)
16	O16	Employer attractiveness	0.1	0.015	0.935	Harms et al. (2013)
17	O17	Potential for innovation	0.1	0.015	0.951	Harms et al. (2013)
18	O18	Increased knowledge about legal compliance	0.1	0.015	0.966	Wittstruck et al. (2012)
19	O19	Strengthen leadership	0.1	0.015	0.981	Testa et al. (2010)
20	O20	Improved customer retention	0.06	0.009	0.990	Wittstruck et al. (2012)
21	O21	Increase in staff satisfaction	0.02	0.003	0.993	Wittstruck et al. (2012)
22	O22	Shorter production times	0.02	0.003	0.996	Wittstruck et al. (2012)
23	O23	Knowledge multiplication	0.02	0.003	1	Wittstruck et al. (2012)

Chapter 3

Research Methodology

The findings of literature review provide an overview of GSCM, work done in various sectors on GSCM, barriers and opportunities related to it. Methodology of this research is given in detail in this chapter which helps in defining a way to achieve objectives as stated in Chapter 1. The research is done in four distinct phases as described in detail in the subsequent section. Graphical represented of research methodology is given in Figure 3.1.

3.1 Initial study

To begin with, a large set of articles were reviewed to find the research gap. Recent articles published on sustainability and value engineering guided the way towards GSCM. After doing basic research to understand the fundamentals of GSCM, its role in construction industry, barriers related to its implementation and opportunities not only environmental but also financial and organizational that can be obtained by its successful implementation, it was revealed that insufficient literature is reported for the developing countries and most particularly construction sector despite the benefits it offers. In the light of this limitation, it was found necessary to investigate the barriers hindering the developing countries from implementing GSCM practices and finding related opportunities that facilitate its adoption. This gave rise to the objectives of this study which involve finding the significant barriers and opportunities in the implementation of GSCM practices, and developing a causal loop framework which shows the interconnectedness of individual opportunities and barriers.

3.2 Review and synthesis of literature

This phase includes the identification of barriers and opportunities through extensive review of literature. For this purpose, articles were searched on the online libraries such as ScienceDirect, Scopus, Mendeley, Microsoft Academic and Google Scholar with keywords of ‘GSCM’, ‘barriers’ and ‘opportunities’. A large number of articles were retrieved and the most relevant ones were carefully selected on the basis of title and abstract. These articles were then analyzed and after elimination of irrelevant papers, a total of 31 were found to meet the requirement of this research. These 31 papers were extensively reviewed and, as a result, 34 barriers and 23 opportunities were identified from them for further consideration. In the next step, content analysis was performed on the selected papers to find the significance of the identified barriers and opportunities using the methodology previously explained.

3.3 Data collection

This phase includes the development of data collection instrument and collection of expert opinion on the criticality of identified barrier and opportunities. Questionnaire prepared for data collection comprised of two sections; first for barriers and the other for opportunities. Respondents were asked to assign an impact value to each factor on a 5-point Likert scale where 1= very low and 5=very high. The respondents were also encouraged to provide any additional barriers or opportunities. Respondents were selected by keeping in view their qualification and working experience and were then requested to fill the questionnaire. Minimum 16 years of education was compulsory to fill the questionnaire. The questionnaire was then circulated to the academicians and industry professionals in various developing countries included Pakistan, India, Iran, Kuwait, Qatar, UAE, Saudi Arabia, Yemen, Ghana, Somalia, Argentina, Egypt and Bangladesh through web based social networks. Taking responses through emails and social media is quite quick and suitable way for research purpose (Saunders et al., 2009). To get good response rate considerable efforts were made to prepare the questionnaire that the respondents would be comfortable to answer. It was made clear and precise for the respondents to fill in, as suggested by (Wu et al., 2011).

3.4 Analysis and results

After collecting responses, Cronbach's alpha test coefficient method was applied to address the reliability of the data. Shapiro-Wilk test was applied to check the normality of data. These collected responses were then analyzed and significance of each factor was found using relative importance index (RII) to identify the present industry trends regarding critical barriers and opportunities. *RII* was calculated using the formula given in Equation 2, where *W* is the weight (impact) assigned to each factor, *N* is total sample size and A is the highest impact, that is 5 in this case.

$$RII = \frac{\sum W}{N * A} \qquad (0 \leq RII \leq 1) \qquad\qquad Equation\ 2$$

Since the RII reports the latest opinion of industry experts and academicians on the state of barriers and opportunities, a need was felt to merge this opinion with what is reported in the literature. For this purpose, the final score (*FS*) for each factor was obtained using the formula given in Equation 3, where *LS* represents the literature score for each factor and *RII*

represents the importance index obtained through survey response. The final score was used to rank the identified barriers and opportunities. This ranking is at the crossroads between academic experts and industry practitioners, reflecting upon practical and educational preferences.

$$FS = (0.3\text{x}LS) + (0.7\text{x}RII) \qquad Equation\ 3$$

Further, the survey results were segregated into three categories representing one full set of gathered data and two substantial subsets from India and Pakistan. In doing so, RII was separately calculated for all three categories of responses. It is pertinent to mention that the Indo-Pak categorization was done in order to observe the difference in opinion of respondents and draw meaningful conclusions between apparently similar countries.

In order to statistically observe and validate the difference in response from the three categories of respondents, statistical analyses such as ANOVA and t-test were performed on the gathered data. After finding the difference and figuring out the most critical barriers and opportunities through *FS*, they were used to develop matrices to determine barrier-barrier, opportunity-barrier and opportunity-opportunity relationships. These matrices present the contextual relationship among each individual barrier and opportunity which further helped develop a causal loop framework. Field experts and practitioners with over 15 years industry experience were contacted through both online sources and physically approached to provide their opinion regarding these matrices. The result was then incorporated to develop a causal loop framework. VENSIM® PLE, a system dynamics tool, was used to generate the model which shows the relationships not only among barriers and opportunities but also with themselves and provide links to determine the root barriers amongst the top ones. Keeping in view the cause-effect relationships, implementation strategies were recommended by the field experts that will help to effectively address the barriers so that various opportunities can be exploited.

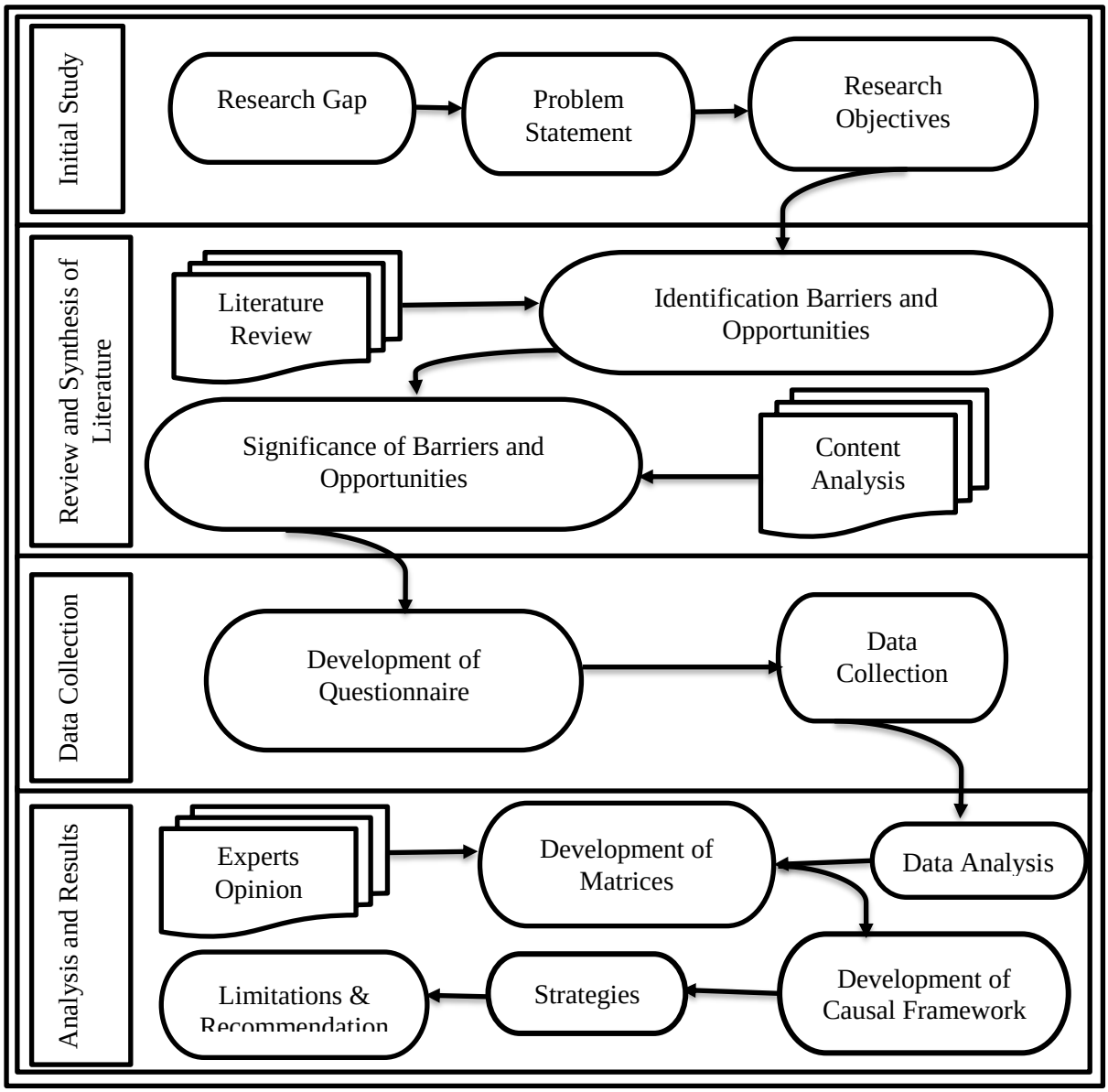

Figure 3.1: Geographical representation of research methodology

Chapter 4

Analysis and Results

4.1 Responses from survey

The questionnaire was circulated to various developing countries through online sources including official email, professional networks such as LinkedIn, research networks such as ResearchGate, and social networks such as Facebook. medium was primarily used. About 700 researchers and field personals were contacted and a total of 163 valid responses were collected giving a response rate of 23%. These responses were received from countries including Pakistan, India, Bangladesh, Qatar, Iran, Kuwait, Saudi Arabia, Egypt, UAE, Yemen, Ghana, Somalia and Argentina. Out of which 72 responses were from Pakistan and 59 from India which together makes the majority.

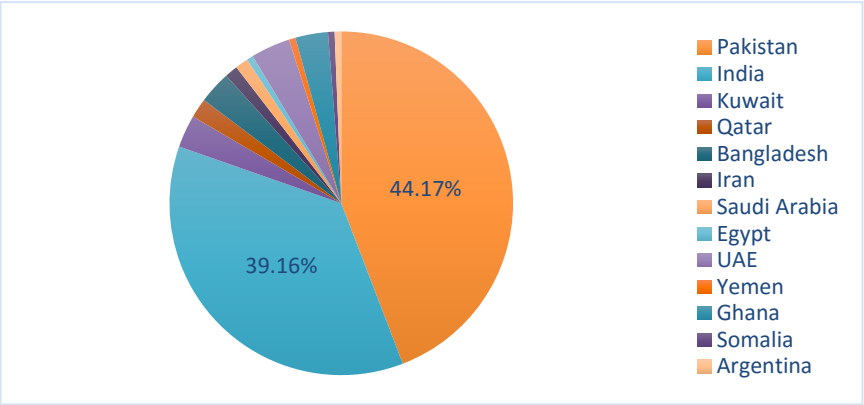

Figure 4.1: Regional distribution of response

Responses were collected from different level of experienced industry professionals as well as researchers with a minimum of 16 years education as shown in Table 4.1. It can be observed that most of the respondents' despite of having minimum education of 16 years in the related field had no understanding regarding GSCM and some having slight knowledge which is mainly because this approach is not common among the developing countries so most of the professionals may not know about it. While on the other hand respondents with exceptional knowledge are also there which points out the fact that industry is taking interest and trying to get knowledge in this field of work.

Table 4.1: Information about respondents

Years of Experience	**From 1 to 5**	**From 6 to 10**	**From 11 to 15**	**From 16 to 20**	**From 21 and Above**
Respondents	59%	13%	7%	8%	13%
Qualification	**B.Sc/ B.Engg**	**M.Sc/M.Engg/PgDip**	**PhD**	**Others**	
Respondents	45%	30%	18%	7%	
Understanding Of GSCM	**No understanding**	**Slight**	**Somewhat**	**Moderate**	**Exceptional**
Respondents	8%	23%	28%	33%	8%

4.2 Reliability and Normality check

For checking the reliability of the data collected on Likert scale Cronbach's Alpha method was used. If this value is greater than 0.7, the data is reliable (Gliem et al., 2003). Further, if the value is greater than 0.9, the data is highly consistent for use. The value of Cronbach's Alpha came out to be 0.94 for barriers and 0.96 for opportunities which shows that the data is reliable for further analysis. Before proceeding further, the normality of data was checked using Shapiro-Wilk test as it is the most powerful test for all types of distribution and sample sizes ranging from 10 to 2000. The value of test lies between zero and one where small values lead to rejection of normality (Razali et al., 2011). After running the test, values were zero showing a non-normal distribution means the data is non-parametric.

4.3 RII calculation

After collecting responses RII is calculated for each barrier and opportunity as described in detail in the previous section. Furthermore, RII for Pakistan and India is also calculated as they formed the majority that is approximately 83% of the total responses. These barriers and opportunities along with their ranking are given in Table 4.2 and 4.3.

Table 4.2: Barriers ranking with respect to RII

Code	**Barriers**	**Global**	**Pakistan**	**India**
B2	Lack of awareness or knowledge	1	3	1
B1	Insufficient policies, incentives, regulations or commitment by leaders or top management	2	1	9

B5	Lack of legal enforcement by the government for GSCM or government support	3	7	2
B9	Lack of public awareness / interest	4	2	7
B15	Insufficient training and guidance	5	4	3
B10	Lack of technical expertise i.e. green professionals	6	9	5
B3	Lack of funds or resources	7	12	4
B7	Lack of information distribution or understanding among construction organizations and suppliers or stakeholders i.e. stakeholders' engagement and collaboration	8	8	13
B4	General perspective that sustainability leads to greater costs / financial implications	9	21	8
B20	Lack of long-term strategic planning or short-term perception	10	5	17
B8	Problem in maintaining environmental suppliers or shortage of green suppliers	11	19	14
B21	Lack of new technology, process or materials	12	6	20
B22	Environmental thinking not a part of organization's vision, objectives and decision making.	13	10	21
B16	Non-involvement or less time to address issues related to sustainability	14	14	10
B14	Resistant towards change	15	13	11
B12	Lack of organizational support	16	15	19
B6	Lack of IT support system or technology infrastructure	17	18	25
B11	Transport and logistics issues or lack of knowledge	18	22	12
B23	Poor organizational culture	19	11	26
B18	Lack of demand	20	2	15
B29	Research and development not sufficient	21	17	27
B13	Competitive nature of market & uncertainty	22	31	6
B24	Difficulty in identifying environmental opportunities	23	20	18
B30	Lack of markets for recyclable materials	24	23	28

B34	Lacking in energy & waste management of an Organization.	25	28	24
B17	Difficulty in reusing / recycling the product	26	26	16
B33	Lacking integration in industry	27	25	29
B19	Lack of corporate social responsibility	28	16	32
B28	Disbelief in environmental benefits	29	30	23
B26	Unskilled/semiskilled HR personals	30	29	31
B31	General perspective that complex sustainability leads to greater effort or is too complex	31	27	30
B25	Tight and fixed deadlines by the stakeholders	32	33	22
B32	Vagueness in definitions and various interpretations	33	32	34
B27	Fear of failure	34	34	33

Table 4.3: Opportunities ranking with respect to RII

Code	Opportunities	Global	Pakistan	India
O4	Reduction in environmental risks	1	6	2
O6	Reduction of energy consumption	2	1	3
O5	Reduction of production waste	3	2	7
O10	Emission reduction	4	5	1
O3	Increase profitability	5	7	12
O8	Differentiation in competition / competitive advantages	6	4	8
O2	Potential for cost reduction	7	9	17
O14	Reuse product	8	8	5
O1	Improved Reputation	9	16	21
O9	Improve product quality	10	18	6

O13	Increased health and safety and knowledge about it	11	12	11
O11	Product innovations	12	3	10
O7	Reduction of material consumption	13	10	22
O23	Knowledge multiplication	14	11	4
O20	Improved customer retention	15	14	9
O18	Increased knowledge about legal compliance	16	19	13
O17	Potential for innovation	17	17	14
O19	Strengthen leadership	18	13	20
O12	Minimization of transport time	19	21	23
O22	Shorter production times	20	15	16
O16	Employer attractiveness	21	20	19
O21	Increase in staff satisfaction	22	22	15
O15	Transparency and performance and transparent flow of goods	23	23	18

4.4 Statistical analysis

Since the differences between barrier and opportunity rankings obtained through various global and regional datasets seem marginal, statistical analyses in the form of ANOVA and t-test are performed to find the difference between the 3 datasets. Although the data was non-parametric, there are several reasons to use these parametric tests. Firstly, these tests can perform well for non-normal data if minimum sample size 20 for each group. Secondly, parametric tests have more statistical power that efficiently detect a significant effect. Before carrying out these tests, the null hypothesis (H_0) was postulated that there is no difference between the means of three data sets; $H_0 = \mu_a = \mu_b = \mu_c$. The alternate hypothesis is that there should be at least one inequality and is represented by H_a. Results will either reject the null hypothesis and accept the alternate one or will do not reject the null hypothesis. After performing the analysis, the results declare that $F < F_{critical}$ that is $0 < 3.088$. This provides the evidence that $H_0$is not rejected. $F_{critical}$ is the region beyond which H_0 gets rejected. Another

evident reason to not reject H_0 is that p-value $\nleq \alpha$ $(1 \nleq 0.05)$. So, H_0 is not rejected which shows that there is no significant difference between these datasets. Further, t-test was performed between data of Pakistan and India. The test results show that p-values (0.5 and 1) were not less than $\alpha(0.05)$. So, these statistics support the fact that there is no significant difference between these datasets. Same tests were performed for the opportunities and the results favored to not reject the null hypothesis.

From RII as well as statistics it is evident that there is no significant difference between the 3 data sets. For examples, lack of awareness (B2) is ranked 1st globally as well as in India but it is on 3rd rank in Pakistan. However, if second barrier (B1) is considered, it is found that India's opinion is quite different from Pakistan as well as other developing countries. Insufficiency of policies is not considered as much of a problem in Indian industry as compared to others. It is mainly because rapidly developing countries like India and China are now incorporating green practices (Dubey et al., 2017) and developing policies for their successful implementation. So, this barrier is addressed in these countries, but other developing countries are behind in this concept.

Moving further, major differences were not observed until B4 which occupies 9th rank globally, but has obtained 21st rank in Pakistan and 8th in India. This ranking shows that India and other developing countries have similar perception regarding the general perspective that sustainability leads to greater costs and is considered quite significant, whereas it is considered among least significant ones in Pakistan. Significance of this factor can be verified from the literature score where this factor secured 4th position and most of the studies that presented this barrier originated in India (Bhatele et al., 2016; Luthra et al., 2014; Mathiyazhagan et al., 2013; Raju et al., 2016) and other developing countries (Balasubramanian, 2012; Balasubramanian et al., 2017). Same is the case with lack of long-term strategic planning or short-term perception (B20) as its ranking globally and most particularly in Pakistan shows that it is considered quite a significant one as compared to many others, whereas in India it has attained very low rank (17) which again can be verified from the literature score where its ranking (20) is obtained mostly by the Indian studies (Luthra et al., 2014; Mudgal et al., 2010; Raju et al., 2016). Similarly, for other barriers, some are quite similar in ranking while some are showing differences due to difference in GSCM understanding and perception along with the difference in the level of green adoption, affecting the assessment.

In case of barriers lack of awareness or knowledge attained first rank both globally and in India while it's on third rank in Pakistan. Whereas in Pakistan insufficient policies, incentives, regulations or commitment by leaders or top management is ranked first and is globally on second position but it lies on 9th position in India which shows that this barrier is less significant in India as compare to Pakistan and rest of the developing countries. Furthermore, lack of government support came out to be a significant barrier globally and in India by attaining 3rd and 2nd rank respectively and 7th in Pakistan. Lack of public awareness lies on 4th position globally while 2nd and 7th in Pakistan and India.

Similar to barriers, a regional analysis of opportunities reveals no significant difference among top four opportunities from global ranking. This shows that respondents from all the developing regions have more or less similar opinion regarding O4, O6, O5 and O10. Moving towards increase profitability (O3), where Pakistan and global ranking are much closer while India lies at a distance. This is because in India, general perspective that sustainability leads to greater costs/financial implications is considered a major barrier as evident from literature as well as industry score. So, increased profitability by greening their practices may not seem a significant opportunity to the local industry. Same is the case with O2 where exactly the same situation is repeating itself even with much greater difference.

4.5 Categorization

These barriers and opportunities are classified into various categories depending upon their nature along with their RII ranking and the results are given in Tables 4.4 and 4.5.

Table 4.4: Barriers categories with RII ranking

Involvement and support		**Knowledge and awareness**	
B1	2	B2	1
B5	3	B11	18
B9	4	B29	21
B15	5	B24	23
B7	8	B28	29
B20	10	B31	31
B22	13	B32	33
B16	14	**Technological**	
B14	15	B10	6

B12	16	B21	12
B23	19	B6	17
B18	20	B34	25
B13	22	B17	26
B30	24	B26	30
B33	27	B27	34
B19	28	**Financial**	
B25	32	B3	7
Outsourcing		B4	9
B8	11		

When all barriers are divided into various categories, it can be seen that most of the barriers fall under 'involvement and support' category. The involvement and support can be of management, government and public. The top 4 barriers, except the first one, fall under this category which makes it an important issue in adopting GSCM. First one in this category is insufficient policies and lack of commitment by top management (B1). Mudgal et al. (2010) stated that the environmental management and investment unavoidably depends upon attitude of management towards these issues. Green practices require essential changes in both outlook and practice which demand total management commitment for progressing further. The second most significant barrier in this category is government support (B5). Encouraging and discouraging the innovative adoption depends upon the regulations set by the government (Scupola, 2003). In this respect, the encouragement of old practices is the major barrier on a government's behalf (AlKhidir et al., 2009) which supports the fact that it is a top ranked barrier while implementing GSCM in construction firms. The next major barrier in involvement and support category is lack of public awareness/interest (B9). If public, including costumers, are aware of the benefits of green products and demand them, then it can become the most crucial type of external pressure which may force the companies to change their policies and technology according to innovative green products (Luthra et al., 2011). Barrier attaining the fifth position overall and fourth in this particular category is insufficient training and guidance (B15). For achieving success in any organization, training and guidance are major requirements. With each new or refurbished technology, the employees should be given proper training regarding this innovative process and technology for its successful implementation (Ravi et al., 2005) as different skills regarding new

processes, continuous change and development, and close link among the activities are required for manufacturing an environment conscious product (Sarkis et al., 2006).

Look further at the 'involvement and support' category, not only it encompasses the maximum of top barriers but the least significant barriers also fall under this category which makes it uniquely versatile. Least significant barriers mostly include the ones showing unsupportive nature of market like uncertainty related to market (B13), lack of market for recyclable material (B30) and lacking integration in industry (B33). Firms cannot directly evaluate the market demand for green products and processes unless customers demand them as they are the core of any business and the most significant driving force for firms to get involved in environment management (Chen et al., 2006). Therefore, it is essential for the costumers to know about the material type, its production process, energy and water usage for its production, its transportation and distribution methods as well as its impact after usage (Luthra et al., 2011). Awareness and presence of public demand will force firms to develop eco-friendly products and processes and make their position in market and industry. The second last barrier under this category is lack of CSR (B19). CSR shows the firm's willingness to go beyond the agreement and consider the consequences of organizational activities on public. This can be done by voluntarily adopting practices like elimination of physical waste, modifying processes that might threaten the environment and informing costumers regarding environmental effects of the products (Mudgal et al., 2010). So, it basically reflects the firm's commitment to develop policies that support long term planning, and allot and use resources accordingly which takes it back to the very first barrier in this category; insufficient policies (B1). This shows that if a top barrier is sufficiently addressed, it may help in removing other barriers down the line. The least significant barrier is tight and fixed deadlines by the stakeholders (B25) that will stream downward in the supply chain, thus compromising the efforts of all stakeholders. Again, this barrier can be eradicated by having supportive and understanding environment.

After 'involvement and support', another major category of barriers is 'knowledge and awareness'. The most significant barrier that attained the highest rank in this category is lack of awareness and knowledge regarding GSCM practices (B2). Knowledge is power and in situations where environmental impacts of construction are not known, precautions cannot be taken (Ojo et al., 2014). Therefore, awareness and knowledge are essentially needed. Also, it is evident from numerous studies in construction literature (Balasubramanian et al., 2017; Sourani, 2011; Zhang et al., 2011) that a lack of awareness and knowledge about green

practices and its benefits is a major barrier hindering organizations from taking up green practices. Further in this category lie the factors that have attained low ranks such as ambiguity in definitions and various interpretations (B32), pointing at the dependency upon the top ranked barrier. It suggests that if work is done on the top most barrier, it will help in removal of various other barriers that fall in the same category.

Next in the line is 'technological' category and the top most barrier in this category is lack of technical expertise (B10) which has obtained 6th position overall and the next one placed on 12th position is lack of new technology, process or materials (B21). Implementation of green practices requires professionals having technical expertise and their lack is considered as one of the major barriers towards greening of construction sector (Balasubramanian et al., 2017; Ofori et al., 2002). Green professionals as well as efficient information and technology system are an important need to support various stages in GSCM implementation. Lack of green professionals and expertise in tackling the environmental issues results in reactive rather than proactive responses to these issues which may cause negligence towards various important aspects (Revell et al., 2003). Furthermore, new technology and process may enhance SC performance by using various software which can be beneficial for data and information exchange processes (Bhatele et al., 2016). It is because these systems are required to track and trace the information related to the products, and also to handle the flow of information related to forward and backward flow of material and other resources for efficient GSCM (AlKhidir et al., 2009; Ravi et al., 2005).

The next category is 'financial' and both the barriers under this category are ranked among top ten barriers. Finance is a crucial part to support the informative, infrastructural and manpower requirement of GSCM. Therefore, firms need funds and other resources for the implementation of GSCM practices. Generally, a big pressure in GSCM as compared to conventional SCM is high cost (Ho et al. (2009). Sometime, in spite of known savings over the lifetime, firms are not able to afford the upfront cost, and end up buying cheaper as well as less environment friendly products and services (Arif et al., 2009). Efficient information and technological systems, hiring good quality workers, motivation and training of workforce, development of green products, green procurement, distribution and reverse logistics are some of the basic enablers of GSCM and these practices require some sort of initial funding for their successful adoption (Luthra et al., 2011; Mudgal et al., 2010; Ravi et al., 2005).Therefore, this additional cost for successful implementation of green practices is highlighted as a significant barrier by various studies carried out in construction and other

sectors (Balasubramanian et al., 2017; Liu et al., 2012; Zhang et al., 2011). However, it has also been pointed out that accurate lifecycle costing models need to be developed to remove the perception of higher cost for green construction practices (Arif et al., 2009).

The last category of barriers is 'outsourcing' and the only barrier under this category is shortage of green suppliers (B8). Overall performance of supply chain is contributed by the suppliers as for the implementation of green practices, firms require green materials provided by the suppliers. Hence, if the material is not available through standard distribution network, firms will be reluctant to implement green practices. This is because of the fact that with unknown suppliers, firms cannot ensure delivery assurance, flexibility in payment and reasonable prices (Shi et al., 2013). Whereas on supplier's part, there occurs lack of preparedness due to lack of time, knowledge and awareness regarding benefits of green practices. Therefore, it requires the suppliers to gain knowledge and understanding regarding environmental concerns in the business practices or it will hinder the successful realization of GSCM practices (Mudgal et al., 2010).

From above discussion, it is obvious that the barriers are intricately connected and if the top most barriers in each category are removed, it will help in eradication of other barriers which will eventually help in successful adoption of GSCM practices.

Table 4.5: Opportunities categories with RII ranking

Organizational		**Environmental**	
O8	6	O4	1
O14	8	O6	2
O1	9	O5	3
O9	10	O10	4
O11	12	O7	13
O20	15	**Financial**	
O17	17	O3	5
O19	18	O2	7
O12	19	**Knowledge**	
022	20	O13	11
O16	21	O23	14
O21	22	O18	16
O15	23		

Eyeing the opportunities obtained by the successful implementation of GSCM practices, they can be categorized into 4 types; 'environmental', 'financial', 'organizational' and 'knowledge related' opportunities, as shown in Table 8. GSCM is a good way to create balance between environmental, economic and social benefits (Diabat et al., 2011). Looking at the environmental category, it is evident from the ranking that the top 4 opportunities of GSCM are placed here. In order to create real changes, firms need to focus on innovations that consume fewer resources, generate less waste and cause less harm to the environment. This can be done by acquiring knowledge and its effective exchange regarding product, process and material characteristics, and related technology to create beneficial and profitable innovative product (Hervani et al., 2005). While talking particularly about the construction industry, a wide range of negative impacts on humans as well as environment are contributed through the remains of construction process such as Sick Building Syndrome (SBS), use of wasteful land, non-renewable energy consumption and ozone depletion (Ho et al., 2009). SBS is a condition in which building occupants suffer from various health condition due to unhealthy finishing materials such as adhesives, paints, etc. which may lead to chills, fever, coughing, muscle ache and other respiratory diseases. In such a situation, green design can significantly diminish or eliminate the adverse impact of a building and enhance the health and comfort level of occupants. It is also argued that technology is negatively influencing the design; the older buildings used to have natural and elaborated arrangements for air conditioning and ventilation. But with the change in technology and design, central heating and cooling systems have been introduced that are not only increasing the carbon footprint of buildings but have various financial implications as well (Arif et al., 2009). Similarly, other phases of GSCM can significantly reduce the environmental risk, energy consumption and emissions such that emissions can be reduced to 18% by using the recycling process.

Analyzing the financial opportunities that GSCM offers such as increased profitability (O3) and potential for cost reduction (O2), it is found that O3 obtained 5th and O2 obtained 7th rank. Some small firms in developing countries, due to their limited choices to handle wastes, cause an outbreak of diseases which ultimately leads to their closure. Conversely, through proper GSCM practices, such as waste prevention and management, this waste can be converted into profit (Ho et al., 2009). Firms, through pollution prevention, can attain significant savings, obtaining cost advantages as compare to other competitors (Markley et al., 2007). Recent literature on environment management suggests that an open and informed

relationship between manufacturers and suppliers may eventually lead to innovative and cost effective products that can reduce the operating costs through significantly reduced utility and liability costs (Ho et al., 2009). Construction professionals need to know about the whole-life cost and environmental impact of a construction project so that they can encourage the stakeholders to adopt more sustainable practices. In a study carried out in UK, it was found that cost consultants have a general perception that energy efficient and environment friendly buildings cost more than 5 to 10% when built from the beginning. However, as stated by Bartlett et al. (2000), integrating environment friendly practices in the design right from the start and managing them proactively will result in lower capital costs. The additional cost should not be more than 1% even if the design with the eco-friendly features is exuberant. The same study presented the practical picture through a case study to demonstrate a reduced impact up to 22 ± 12% due to environment friendly material, with a significant cost reduction.

The next level where opportunities can be exploited from GSCM practices is in the form of 'organizational' category. Various opportunities fall under this category ranging from highest to lowest according to ranking. This large number shows how a firm can create beneficial opportunities by adopting green practices. The highest ranked opportunities in this category include competitive advantages (O8), product reuse (O14), improved product quality (O9) and improved reputation (O1). To obtain the organizational benefits, firms need to work closely with the suppliers. This will help in improving communication, building trust, and concentrating on every part and process to improve product design and increase its efficiency which will lead to waste reduction. By doing so, benefits can be generated for both firm and supplier. For example, a survey carried in US found that 75% respondents acknowledged pollution prevention as a major component of firm's performance and 49% of these firms confirmed that the key component for pollution reduction is suppliers. In doing so, company's reputation will be enhanced along with gaining other competitive advantages which can be obtained by improving firm's efficiency and quality, increasing productivity and cost saving (Rao et al., 2005). Firms with enhanced reputation and competitive advantages will become a source of attractiveness for the employers, resulting in increased staff satisfaction.

The last category is 'knowledge' regarding the whole process of GSCM including the legal compliance and health and safety issues related to the alarming environmental conditions. Knowledge is power and nothing can be done without it. This makes knowledge and learning

an essentially important opportunity to be benefited from. A high level of mutual learning and knowledge sharing within a company's network will accelerate the flow of goods and increase the transparency of whole process that will provide organizational benefits at various levels (Wittstruck et al., 2012). Thus, this whole opportunity exploitation process from GSCM shows that, for the sake of gaining knowledge, firms will acquire various organizational benefits not only in terms of profit but also in terms of improved reputation, product quality and other competitive advantages which will ultimately lead to a better environment with reduced risks and emissions, less energy consumption and lesser amount of waste.

4.6 Matrices and Causal loop framework development

After selecting top 5 barriers and opportunities through RII calculations, these were then used for influence matrices development. A total of 15 responses were collected for these matrices from industry professionals and practitioners having 15 years of experience in the related field through online sources and physically approached. Due to the conflict among the respondent's responses depending upon their thinking regarding relations, the relationship between factors was determined on majority basis. The summary of these matrices is shown in Table 4.6, 4.7and 4.8.

Table 4.6: Inter-barrier influence matrix

	B1	**B9**	**B2**	**B15**	**B5**
B1	-	X	X	X	A
B9	X	-	A	O	X
B2	X	V	-	X	A
B15	X	O	X	-	A
B5	V	X	V	V	-

V- Barrier in column will lead to barrier in row
A-Barrier in row will lead to barrier in column
X- Both will lead to each other
O- Both are unrelated

Table 4.7: Inter-opportunity influence matrix

	O10	**O4**	**O6**	**O3**	**O5**
O10	-	V	A	O	A
O4	A	-	X	O	A
O6	V	X	-	V	V
O3	O	O	A	-	A
O5	V	V	A	V	-

V- Opportunity in column will lead to opportunity in row
A- Opportunity in row will lead to opportunity in column
X- Both will lead to each other
O- Both are unrelated

Table 4.8: Barrier-opportunity influence matrix

	B1	**B9**	**B2**	**B15**	**B5**
O10	A	O	A	A	A
O4	A	O	A	A	A
O6	A	O	A	A	A
O3	A	O	A	A	A
O5	A	O	A	A	A

V- Opportunity will lead to barrier removal
A- Barrier removal will lead to opportunity
X- Both will lead to each other
O- Both are unrelated

For better understanding the results obtained from these matrices are used to develop causal loop framework showing the connections between barriers and opportunities in graphical form on VENSIM PLE a system dynamics software. Graphical representation of barrier-barrier relation is shown in Figure 4.2.

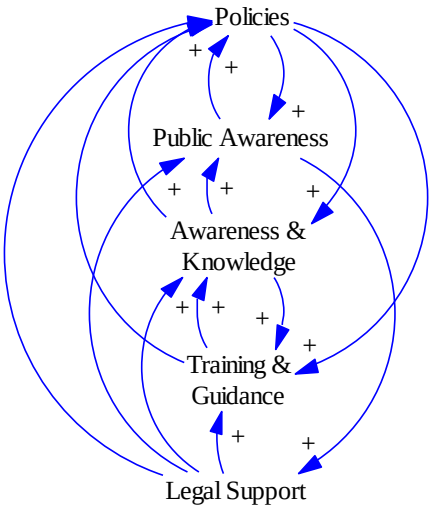

Figure 4.2: Inter-barrier causal loop framework

From the figure 4.2 it can be clearly seen how one barrier can lead to removal of another barrier. For instance, the policies and commitment by top management can help develop public interest in GSCM by witnessing benefits that can be obtained by adopting these practices and will increase public awareness thereby removing the public awareness barrier (Ojo et al., 2014) . This increased public awareness will in return put pressure on firms to develop such policies and show their commitment towards implementing green practices that may result in a positive outcome (Balasubramanian, 2012). Hence, both the barriers are affecting each other in a positive manner that is working on one may help in removal of the other. Furthermore, after policies development firms will be under huge pressure to gain knowledge regarding the processes to successfully implement GSCM according to the policies. For that training and guidance will also be required resulting in removal of this barrier as well. Regular training sessions will also create awareness regarding GSCM practices that will encourage organizations to adopt these practices (Luthra et al., 2011). Whereas, legal authorities can also play a vital role as these authorities can put pressure on firms to implement GSCM practices so, the firms will develop policies to respond to that external pressure (Raju et al., 2016). Positive relationship of legal support with increased knowledge and training is showing that if regulatory authorities put pressure on firms to implement GSCM practices, firms will start gaining knowledge about green processes and will start providing training and guidance regarding these to get several benefits so the

process of gaining knowledge and training will increase. Another obvious relation is between legal support and public awareness that is legal support can increase public awareness and vice versa. If public demands green products then regulatory authorities would have to bring firms under pressure to fulfil public's requirement and start greening their process and products. Reverse is the case, if regulatory authorities are being active and are taking firms under pressure to green their products and services and firms are also showing interest and are acquiring knowledge about that, this may also build public's interest regarding green processes. So, this causal loop framework shows the links between barriers and hence showing the most important barrier that needs to be worked on. For instance, legal support barrier is the one that is affected only by public awareness but is affecting all the other barriers in the framework if not completely but will partially help in their removal makes it an effective link. If this link is removed that is by making laws with the will of implementation that will force firms to make efforts for adopting GSCM there by resolving the policies barrier. If firms start making policies, qualified personnel's will be hired to provide knowledge and training and thus removing various interconnected barriers without specifically working on them because some major barriers are the root cause of others. By removing the most important ones will result in removal of various interconnected barriers without specifically working on them because the major ones are the root cause of other barriers hence results in achieving all the possible opportunities. Next is the graphical representation of opportunity-opportunity relation and is shown in Figure 4.3.

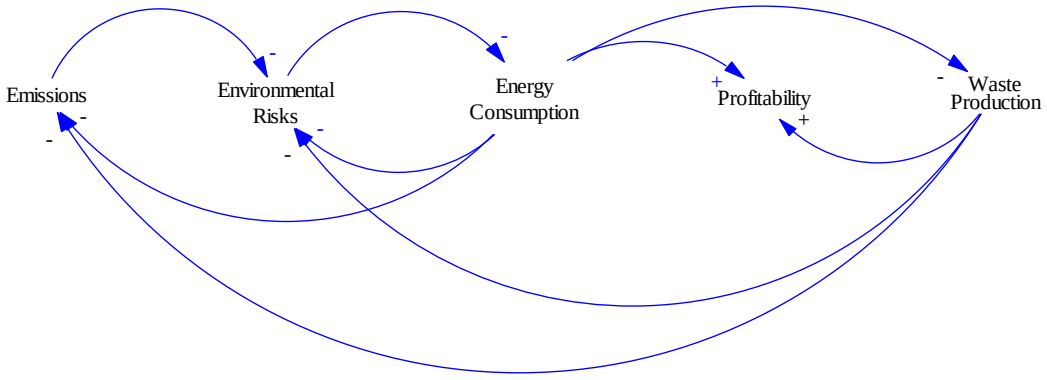

Figure 4.3: Inter-opportunity causal loop framework

Now talking about opportunities, successful removal of barriers will help achieve diversified opportunities ranging from environmental and financial to organizational ones. One of the top environmental opportunity as manifested from Figure 4.3 is reduction in harmful emissions to

the environment ultimately destroying our own habitat. By successfully decreasing the emission levels will also help to reduce environmental risks. In order to reduce emission, energy consumption needs to be reduced and less waste should be produced. This reduced energy consumption and less waste production also comes under environmental benefits and will eventually help achieve financial benefits. If not properly dealt with this increasing environmental risks may result in such a drastic climatic change that it will result in abrupt increase in energy cost, usage and energy wastage as 15% increase in energy cost in U.K is stated by Cote et al. (2008). All these connections illustrate that in zest of gaining a particular benefit, other related benefits can also be achieved without being the focused ones. The only need is to identify and analyze these potential opportunties that could save firms not only money but will improve their environemtal performance as well.

After these individual relations, a whole causal loop framework representing barrier-barrier, opportunity-opportunity and barrier-opportunity realtion is shown in Figure 4.4.

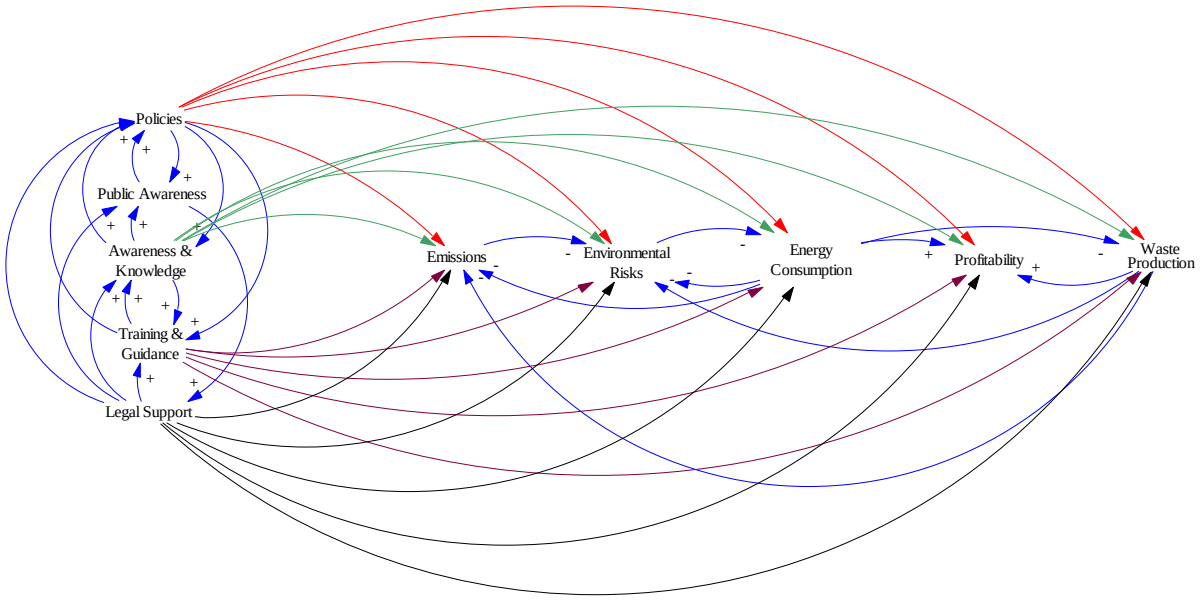

Figure 4.4: GSCM causal loop framework

This causal framework in Figure 4.4 is representing a chain of relations which shows how one barrier affects the other barriers and opportunties and how removal of a single barrier may help in removing various other barriers and achieving several opportunities at the same time. For instance by developing laws and regulations for GSCM practices, firms will be under humongous pressure to implement these practices in response to that skilled and high

quality human resources will be hired, that will not only provide knowledge and awarness regarding these green process and their benefits but will also provide training for its successful implementaion. This successful implementation will help achieve opportunities like emission and environmental risk reduction, less energy consumption and less waste waste production which at the end brings financial benefits to the organization.

4.7 Strategies to implement GSCM practices

After underlining the relationships between GSCM factors, field experts were asked to suggest practicable strategies that may help in removal of barriers and successful implementation of GSCM. Out of 15 experts who were engaged for this purpose, 5 suggested different strategies. Different respondents provided various strategies the summary of that is presented in Table 4.9.

Table 4.9: Strategies for successful implementation of GSCM

Strategies	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
Strategy 1	✓	✓	✓	✓	✓
Strategy 2	✓	✓	✓	✓	✓
Strategy 3	✓		✓		✓
Strategy 4	✓		✓		✓
Strategy 5		✓	✓		✓

By properly organizing, rephrasing and compiling the suggestions of experts, appropriate strategies were formulated. As an example, the proposal which were formed into Strategy 1 included the following suggestion. *"If we are able to establish the law with a will of enforcement, companies will start to work on green procurement. But the result will only become fruitful if companies able to see competitive advantages, which is again linked to government supports"* (Expert 1). Further, Expert 2 opined that *"the importance of legislation and regulation to Green Supply Chain Management implementation, the fear of legislation associated with compliance with environmental standards and regulations is clearly the most important driver for these organizations"*. Along the similar lines, Expert 3 suggested that *"legal enforcement of policies is imperative for GSCM"* which was resonated by Expert 5, *"laws should be made to implement green supply chain management"*. The role of government was also sufficiently emphasized as Expert 4 said *"government support is*

necessary for GSCM. Government can support firms by allocating incentives and also by giving funds". These suggestions were converted into a mind map shown in Figure 4.5.

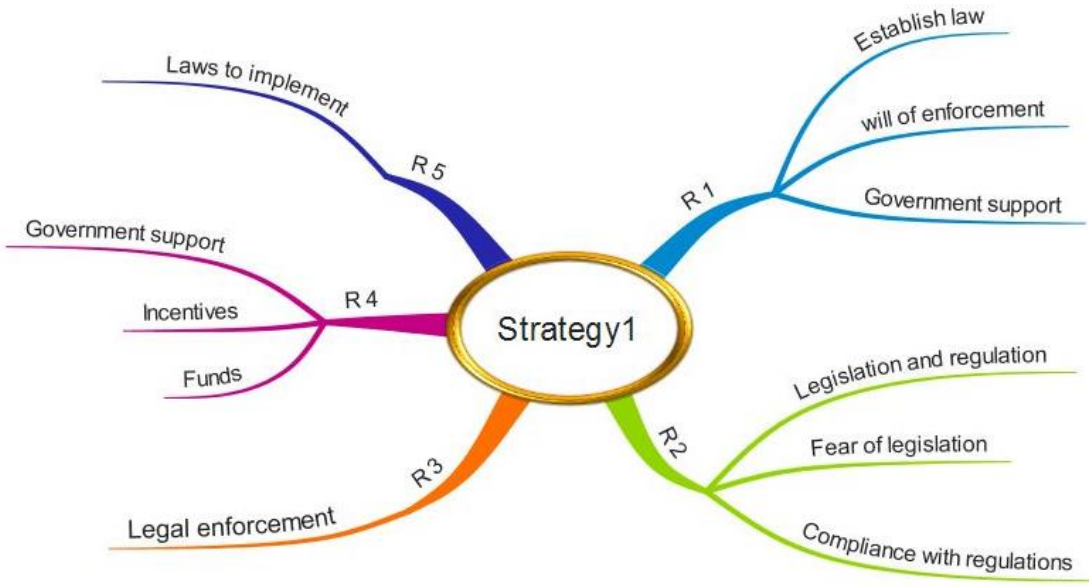

Figure 4.5: Mind map for Strategy 1

The same procedure was followed for all the proposals and their mind maps were developed. Using this detailed method, the strategies were formulated as given subsequently.

1) Legal enforcement of policies is imperative for GSCM. If laws are made with a will of enforcement, then companies will start implementing green practices due to fear of legislation. Furthermore, government can also provide support by providing funds and allocating incentives to the firms that are successfully implementing GSCM.
2) Top management should make polices, and show commitment and support towards the implementation of GSCM by hiring well aware and suitable human resources.
3) Regular training programs should be encouraged that will provide knowledge and awareness among organizations.
4) Special campaigns and welfare programs should be organized for public awareness as their requirement to provide green products can positively impact a firm's decisions.
5) Awareness of potential opportunities through research and knowledge must be spread which will ensure successful implementation of GSCM.

Chapter 5

Conclusions and Recommendations

5.1 Conclusion

GSCM has been recognized as an emerging approach to improve environmental performance of processes and products (Luthra et al., 2011). The most important challenge for changing the behavior of industry in this context is to develop knowledge and then transform it into action to get the desired results. GSCM implementation in industries is quite crucial and requires coordination at all levels (Govindan et al., 2014; Walker et al., 2008; Zhu et al., 2010). Looking at the construction sector, where no holistic study was present for GSCM practices and most particularly for developing countries, this research may provide an insight to barriers and opportunities. The findings of this research can be used as a good starting point for policymakers and practitioners to start implementing these processes and minimize the negative environmental impacts apart from saving money.

For this purpose, 34 barriers and 23 opportunities were extracted from literature and their rank was determined. Data was later collected from industry on the extracted barriers and opportunities to present the industry trends about their perceived criticality in various developing countries. After combining the industry and literature scores, the top barriers and opportunities were incorporated into influence matrices which were then used to develop a causal loop framework showing clear picture of interconnection among the barriers and opportunities. This causal framework pointed out the main element which influence multiple other factors and eliminating this factor at crossroad will break the loop and address many other factors. Keeping the framework in mind, strategies are proposed that can help in successful implementation of GSCM practices. These strategies include policies made by top management to incorporate practices like innovative green design, green procurement, green packing, green distribution and even end of life management which plays a vital role in emission reduction.

It is recommended that firms should also start ad-campaigns for environment friendly products to increase awareness of customers and general public. Aware customers will be attracted more towards green services that will improve a firm’s reputation, offering competitive advantages in the market. Moreover, improved environmental performance will reduce waste, thereby lowering not only waste costs but also the environmental compliance

costs. The government support is absolutely essential in achieving all of this in the form of funds, laws and their enforcement.

In Pakistan, as a very first step, Pakistan Engineering Council (PEC) should take an initiative and show commitment towards GSCM practices. For that purpose, a team must be formed both from academic and industrial sides. This team should gain the knowledge regarding GSCM practices and the associated benefits with their successful implementation and then should train the industry professionals by conducting seminars and outreach events. This will increase the knowledge and awareness of firms and will encourage them to introduce green practices in their processes. And the successful implementation and opportunity exploitation would help them achieve competitive advantages. By witnessing their success, other firms will also get attracted towards GSCM, thus promoting the culture of green practices.

5.2 Limitations and Recommendations

Despite some strengths, this study has a few limitations as well. Data was collected from different countries for the framework development, but there was lack of consensus among the expert opinion. Since the experts were only consulted once due to lack of resources and time, and feedback techniques like Delphi were not used, the relationship with maximum number of responses was considered final. For future studies number of experts can be reduced but a feedback system is recommended to achieve consensus upon the results. For this purpose, use of Delphi technique is recommended. Furthermore, this study is qualitative in nature so future studies may incorporate some quantitative analysis. For industry professionals to implement GSCM practices one of the most important strategy is to develop the policies by keeping in view the opportunities that can be exploited.

References

Akintoye, A., McIntosh, G., & Fitzgerald, E. (2000). A survey of supply chain collaboration and management in the UK construction industry. *European journal of purchasing & supply management, 6*(3), 159-168.

Al-Werikat, G. (2015). Supply Chain Management In Construction Revealed. *International Journal of Scientific & Technology Research, 4*(8), 106-110.

Albaloushi, H., & Skitmore, M. (2008). Supply chain management in the UAE construction industry. *International Journal of Construction Management, 8*(1), 53-71.

Albino, V., Balice, A., & Dangelico, R. M. (2009). Environmental strategies and green product development: an overview on sustainability-driven companies. *Business strategy and the environment, 18*(2), 83-96.

AlKhidir, T., & Zailani, S. (2009). Going green in supply chain towards environmental sustainability. *Global Journal of Environmental Research, 3*(3), 246-251.

Ametepey, S. O., & Ansah, S. K. (2014). Impacts of construction activities on the environment: the case of Ghana. *Journal of Construction Project Management and Innovation, 4*(Supplement 1), 934-948.

Arif, M., Egbu, C., Haleem, A., Kulonda, D., & Khalfan, M. (2009). State of green construction in India: drivers and challenges. *Journal of Engineering, Design and Technology, 7*(2), 223-234.

Azevedo, S. G., Carvalho, H., & Machado, V. C. (2011). The influence of green practices on supply chain performance: a case study approach. *Transportation research part E: logistics and transportation review, 47*(6), 850-871.

Balasubramanian, S. (2012). A hierarchical framework of barriers to green supply chain management in the construction sector. *Journal of Sustainable Development, 5*(10), 15.

Balasubramanian, S., & Shukla, V. (2017). Green supply chain management: an empirical investigation on the construction sector. *Supply Chain Management: An International Journal, 22*(1).

Bartlett, E., & Howard, N. (2000). Informing the decision makers on the cost and value of green building. *Building Research & Information, 28*(5-6), 315-324.

Beamon, B. M. (1999). Designing the green supply chain. *Logistics information management, 12*(4), 332-342.

Bhatele, P., Sohani, N., & Laad, V. (2016). Analysis of Barriers to Implement Green Supply Chain Management in an Automobile Industry. *Imperial Journal of Interdisciplinary Research, 2*(8).

Bhool, R., & Narwal, M. (2013). An analysis of drivers affecting the implementation of green supply chain management for the Indian manufacturing industries. *International Journal of Research in Engineering and Technology, 2*(11), 2319-1163.

Blengini, G. A. (2009). Life cycle of buildings, demolition and recycling potential: a case study in Turin, Italy. *Building and Environment, 44*(2), 319-330.

Büyüközkan, G., & Çifçi, G. (2012). A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. *Expert Systems with Applications, 39*(3), 3000-3011.

Chen, Y.-S., Lai, S.-B., & Wen, C.-T. (2006). The influence of green innovation performance on corporate advantage in Taiwan. *Journal of business ethics, 67*(4), 331-339.

Chiou, T.-Y., Chan, H. K., Lettice, F., & Chung, S. H. (2011). The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan. *Transportation research part E: logistics and transportation review, 47*(6), 822-836.

Chun, S.-H., Hwang, H. J., & Byun, Y.-H. (2015). Green supply chain management in the construction industry: case of korean construction companies. *Procedia-Social and Behavioral Sciences, 186*, 507-512.

Cote, R. P., Lopez, J., Marche, S., Perron, G. M., & Wright, R. (2008). Influences, practices and opportunities for environmental supply chain management in Nova Scotia SMEs. *Journal of Cleaner Production, 16*(15), 1561-1570.

Dashore, K., & Sohani, N. (2008). Green supply chain management: A hierarchical framework for barriers. *Journal of Sustainable Development (Vol. 5), 5*, 2011.

Deif, A. M. (2011). A system model for green manufacturing. *Journal of Cleaner Production, 19*(14), 1553-1559.

Demeter, K., Simpson, D., Power, D., & Samson, D. (2007). Greening the automotive supply chain: a relationship perspective. *International Journal of Operations & Production Management, 27*(1), 28-48.

Diabat, A., & Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, conservation and recycling, 55*(6), 659-667.

Ding, G. K. (2008). Sustainable construction—The role of environmental assessment tools. *Journal of environmental management, 86*(3), 451-464.

Doloi, H., Sawhney, A., Iyer, K., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management, 30*(4), 479-489.

Dubey, R., Dubey, R., Gunasekaran, A., Gunasekaran, A., Papadopoulos, T., & Papadopoulos, T. (2017). Green supply chain management: theoretical framework and further research directions. *Benchmarking: An international journal, 24*(1), 184-218.

Durdyev, S., & Ismail, S. (2012). Role of the construction industry in economic development of Turkmenistan. *Changes*, *64*, 0.

Farooqui, R., & Ahmed, S. (2008). Assessment of Pakistani construction industry–current performance and the way forward. *Journal for the Advancement of Performance Information & Value, 1*(1).

Gliem, J. A., & Gliem, R. R. (2003). *Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales*.

Govindan, K., Kaliyan, M., Kannan, D., & Haq, A. (2014). Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Economics, 147*, 555-568.

H'Mida, S., & Lakhal, S. Y. (2007). A model for assessing the greenness effort in a product supply chain. *International journal of global environmental issues, 7*(1), 4-24.

Handfield, R. B., Walton, S. V., Seegers, L. K., & Melnyk, S. A. (1997). 'Green'value chain practices in the furniture industry. *Journal of Operations Management, 15*(4), 293-315.

Harms, D., Hansen, E. G., & Schaltegger, S. (2013). Strategies in sustainable supply chain management: an empirical investigation of large German companies. *Corporate Social Responsibility and Environmental Management, 20*(4), 205-218.

Hervani, A. A., Helms, M. M., & Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An international journal, 12*(4), 330-353.

Ho, J. C., Shalishali, M. K., Tseng, T., & Ang, D. S. (2009). Opportunities in green supply chain management. *The Coastal Business Journal, 8*(1), 18-31.

Hsu, C.-W., & Hu, A. H. (2008). Green supply chain management in the electronic industry. *International Journal of Environmental Science & Technology*, *5*(2), 205-216.

Hung Lau, K. (2011). Benchmarking green logistics performance with a composite index. *Benchmarking: An international journal, 18*(6), 873-896.

Hwang, B.-G., & Tan, J. S. (2012). *Sustainable project management for green construction: challenges, impact and solutions.* Paper presented at the World Construction Conference 2012–Global Challenges in Construction Industry.

Khan, R. A. (2008). Role of Construction Sector in Economic Growth: Empirical Evidence from

Pakistan Economy. *Proceedings of the First International Conference on Construction in Developing Countries (ICCIDC), Karachi, Pakistan*, 279-290.

Khattak, S., Hussain, I., Shah, S., Ullah, M., Nawaz, R., & Hussain, A. (2013). Assessment of Construction Industry from Supply Chain Perspective-Part-1.

Lakhal, S. Y., H'Mida, S., & Islam, M. R. (2007). Green supply chain parameters for a Canadian petroleum refinery company. *International journal of environmental technology and management, 7*(1-2), 56-67.

Lakshmimeera, B., & Palanisamy, C. (2013). A conceptual framework on green supply chain management practices. *Industrial Engineering Letters, 3*.

Lee, S. Y., & Klassen, R. D. (2008). Drivers and enablers that foster environmental management capabilities in small-and medium-sized suppliers in supply chains. *Production and Operations management, 17*(6), 573-586.

Lin, C.-Y., & Ho, Y.-H. (2008). An empirical study on logistics service providers' intention to adopt green innovations. *Journal of Technology Management & Innovation, 3*(1), 17-26.

Liu, X., Yang, J., Qu, S., Wang, L., Shishime, T., & Bao, C. (2012). Sustainable production: practices and determinant factors of green supply chain management of Chinese companies. *Business strategy and the environment, 21*(1), 1-16.

Lo, S. M.-S. (2013). Effects of supply chain position on the motivation and practices of firms going green. *International Journal of Operations & Production Management, 34*(1), 93-114.

Luthra, S., Garg, D., & Haleem, A. (2014). Green supply chain management: Implementation and performance–a literature review and some issues. *Journal of Advances in Management Research, 11*(1), 20-46.

Luthra, S., Kumar, V., Kumar, S., & Haleem, A. (2011). Barriers to implement green supply chain management in automobile industry using interpretive structural modeling technique: An Indian perspective. *Journal of Industrial Engineering and Management, 4*(2), 231-257.

Malviya, R. K., & Kant, R. (2015). Green supply chain management (GSCM): a structured literature review and research implications. *Benchmarking: An international journal, 22*(7), 1360-1394.

Markley, M. J., & Davis, L. (2007). Exploring future competitive advantage through sustainable supply chains. *International Journal of Physical Distribution & Logistics Management, 37*(9), 763-774.

Mathiyazhagan, K., Govindan, K., NoorulHaq, A., & Geng, Y. (2013). An ISM approach for the barrier analysis in implementing green supply chain management. *Journal of Cleaner Production, 47*, 283-297.

Mitra, S. (2014). *A Framework for Research on Green Supply Chain Management.* Paper presented at the Supply Chain Forum: An International Journal.

Mitra, S., & Datta, P. P. (2014). Adoption of green supply chain management practices and their impact on performance: an exploratory study of Indian manufacturing firms. *International Journal of Production Research, 52*(7), 2085-2107.

Morledge, R., Knight, A., Grada, M., & Pryke, S. (2009). The concept and development of supply chain management in the UK construction industry. *Construction Supply Chain Management, 3*, 23.

Mudgal, R. K., Shankar, R., Talib, P., & Raj, T. (2010). Modelling the barriers of green supply chain practices: an Indian perspective. *International Journal of Logistics Systems and Management, 7*(1), 81-107.

Ninlawan, C., Seksan, P., Tossapol, K., & Pilada, W. (2010). *The implementation of green supply chain management practices in electronics industry.* Paper presented at the Proceedings of the international multiconference of engineers and computer scientists.

Ofori, G. (2000). Greening the construction supply chain in Singapore. *European journal of purchasing & supply management, 6*(3), 195-206.

Ofori, G., Gang, G., & Briffett, C. (2002). Implementing environmental management systems in construction: lessons from quality systems. *Building and Environment, 37*(12), 1397-1407.

Ojo, E., Mbohwa, C., & Akinlabi, E. (2013). GREEN SUPPLY CHAIN MANAGEMENT IN DEVELOPING COUNTRIES. *SB13*, 119.

Ojo, E., Mbowa, C., & Akinlabi, E. T. (2014). *Barriers in implementing green supply chain management in construction industry.* Paper presented at the Paper Presented at the 2014 International Conference on Industrial Engineering and Operations Management, Bali, Indonesia.

Papadopoulos, G. A., Zamer, N., Gayialis, S. P., & Tatsiopoulos, I. P. (2016). Supply Chain Improvement in Construction Industry. *Universal Journal of Management, 4*(10), 528-534.

Raju, R., & Mittapalli Dashratha, L. (2016). An Investigation on Green Supply Chain Management in the Construction Sector within Maharashtra. *International Research Journal of Engineering and Technology, 3*(7).

Rao, P. (2002). Greening the supply chain: a new initiative in South East Asia. *International Journal of Operations & Production Management, 22*(6), 632-655.

Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations & Production Management, 25*(9), 898-916.

Ravi, V., & Shankar, R. (2005). Analysis of interactions among the barriers of reverse logistics. *Technological Forecasting and Social Change, 72*(8), 1011-1029.

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. *Journal of statistical modeling and analytics, 2*(1), 21-33.

Revell, A., & Rutherfoord, R. (2003). UK environmental policy and the small firm: broadening the focus. *Business strategy and the environment, 12*(1), 26.

Sarkis, J., Hasan, M. A., & Shankar, R. (2006). *Evaluating environmentally conscious manufacturing barriers with interpretive structural modeling.* Paper presented at the Optics East 2006.

Sarkis, J., Zhu, Q., & Lai, K.-h. (2011). An organizational theoretic review of green supply chain management literature. *International Journal of Production Economics, 130*(1), 1-15.

Saunders, M., Lewis, P., & Thornhill, A. (2009). Understanding research philosophies and approaches. *Research methods for business students, 4*, 106-135.

Scupola, A. (2003). The adoption of Internet commerce by SMEs in the south of Italy: An environmental, technological and organizational perspective. *Journal of Global Information Technology Management, 6*(1), 52-71.

Segerstedt, A., & Olofsson, T. (2010). Supply chains in the construction industry. *Supply Chain Management: An International Journal, 15*(5), 347-353.

Seman, N. A. A., Zakuan, N., Jusoh, A., Arif, M. S. M., & Saman, M. Z. M. (2012). Green supply chain management: a review and research direction. *International Journal of Managing Value and supply chains, 3*(1), 1-18.

Sheu, J.-B., Chou, Y.-H., & Hu, C.-C. (2005). An integrated logistics operational model for green-supply chain management. *Transportation research part E: logistics and transportation review, 41*(4), 287-313.

Shi, Q., Zuo, J., Huang, R., Huang, J., & Pullen, S. (2013). Identifying the critical factors for green construction–an empirical study in China. *Habitat international, 40*, 1-8.

Sourani, A. (2011). Barriers to addressing sustainable construction in public procurement strategies. *Engineering sustainability, 164*, 1-8.

Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews, 9*(1), 53-80.

Stefan Schaltegger, P. R. B., Dr, Beske, P., & Seuring, S. (2014a). Putting sustainability into supply chain management. *Supply Chain Management: An International Journal, 19*(3), 322-331.

Stefan Schaltegger, P. R. B., Dr, Schaltegger, S., & Burritt, R. (2014b). Measuring and managing sustainability performance of supply chains: Review and sustainability supply chain management framework. *Supply Chain Management: An International Journal, 19*(3), 232-241.

Testa, F., & Iraldo, F. (2010). Shadows and lights of GSCM (Green Supply Chain Management): determinants and effects of these practices based on a multi-national study. *Journal of Cleaner Production, 18*(10), 953-962.

Theyel, G. (2000). Management practices for environmental innovation and performance. *International Journal of Operations & Production Management, 20*(2), 249-266.

Tommelein, I. D., Akel, N., & Boyers, J. (2003). *Capital projects supply chain management: SC tactics of a supplier organization.* Paper presented at the Construction Research Congress: Wind of Change: Integration and Innovation.

Ullah, F., Thaheem, M. J., Siddiqui, S. Q., & Khurshid, M. B. (2017). Influence of Six Sigma on project success in construction industry of Pakistan. *The TQM Journal, 29*(2), 276-309.

Wahga, A., Blundel, R., & Schaefer, A. (2015). *Human Capital and Environmental Engagement of SMEs in Pakistan: A Comparative Analysis of the Leather Industry*. Paper presented at the ISBE Annual Conference 2015,Glasgow

Walker, H., Di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of purchasing and supply management, 14*(1), 69-85.

Wee, H.-M., Lee, M.-C., Jonas, C., & Wang, C. E. (2011). Optimal replenishment policy for a deteriorating green product: Life cycle costing analysis. *International Journal of Production Economics, 133*(2), 603-611.

Wittstruck, D., & Teuteberg, F. (2012). Understanding the success factors of sustainable supply chain management: empirical evidence from the electrics and electronics industry. *Corporate Social Responsibility and Environmental Management, 19*(3), 141-158.

Wooi, G. C., & Zailani, S. (2010). Green supply chain initiatives: investigation on the barriers in the context of SMEs in Malaysia. *International Business Management, 4*(1), 20-27.

Wu, Z., & Pagell, M. (2011). Balancing priorities: Decision-making in sustainable supply chain management. *Journal of Operations Management, 29*(6), 577-590.

Yan, H., Shen, Q., Fan, L. C., Wang, Y., & Zhang, L. (2010). Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong. *Building and Environment, 45*(4), 949-955.

Zhang, X., Shen, L., & Wu, Y. (2011). Green strategy for gaining competitive advantage in housing development: a China study. *Journal of Cleaner Production, 19*(2), 157-167.

Zhu, Q., Geng, Y., Fujita, T., & Hashimoto, S. (2010). Green supply chain management in leading manufacturers: Case studies in Japanese large companies. *Management Research Review, 33*(4), 380-392.

Zhu, Q., Sarkis, J., & Geng, Y. (2005). Green supply chain management in China: pressures, practices and performance. *International Journal of Operations & Production Management, 25*(5), 449-468.

Zsidisin, G. A., & Siferd, S. P. (2001). Environmental purchasing: a framework for theory development. *European journal of purchasing & supply management, 7*(1), 61-73.

ANNEXURE-I

Barriers and opportunities in green supply chain management: Cause and effect analysis

Respected Sir/Madam,

This survey is being carried out as part of MS research titled "Barriers and opportunities in green supply chain management: Cause and effect analysis". The objective of this research is to identify and assess the significance of barriers and opportunities in implementation of green supply chain management (GSCM) practices in construction industry. And to propose strategies to avoid significant barriers and exploit the opportunities.

This elementary questionnaire survey will help to identify the importance of various barriers and opportunities in green supply chain management. Your contribution will be highly appreciated. Please be assured that the data will only be used for study purpose and no personal information will be disclosed at any forum/level. Please remember to click submit at the end. In case of any inquiry, please feel free to contact.

Regards, Maria Ahmed

Post Graduate Student,

Dept. of Construction Engineering & Management, National Institute of Transportation,

School of Civil & Environmental Engineering,

National University of Sciences & Technology (NUST), Islamabad, Pakistan

Email: maria.cem15@nit.nust.edu.pk

1. Organization/ Institute: _____
2. Email address: _____
3. Years of professional experience:

From 0 to 5	From 6 to 10	From 11 to 15	From 16 to 20	From 21 and above

4. Field of work: _____

5. Job title: _____

6. Highest academic qualification

B.Tech B.Sc./B.Eng.	M.Sc./M.Eng/M.Tech/P.G.Dip	PhD/D.Eng	Other:

7. Understanding of green supply chain management:

No understanding at all	Slight	Somewhat	Moderate	Exceptional

8. Country: _____

Barriers in GSCM in construction industry

To what extent the following barriers hinder the application of GSCM practices.

Numbers	Equivalent to
0	No effect
1	Very low
2	Low
3	Medium
4	High
5	Very High

9. Mark only one option per row

	0	1	2	3	4	5
Insufficient policies, incentives, regulations or commitment by leaders or top management						
Lack of awareness or knowledge						
Lack of funds or resources						
General perspective that sustainability leads to greater costs						

/ financial implications						
Lack of legal enforcement by the government for GSCM or government support						
Lack of IT support system or technology infrastructure						
Lack of information distribution or understanding among construction organizations and suppliers or stakeholders i.e. stakeholders' engagement and collaboration						
Problem in maintaining environmental suppliers or shortage of green suppliers						
Lack of public awareness / interest						
Lack of technical expertise i.e. green professionals						
Transport and logistics issues or lack of knowledge						
Lack of organizational support						
Competitive nature of market & uncertainty						
Resistant towards change						
Insufficient training and guidance						
Non-involvement or less time to address issues related to sustainability						
Difficulty in reusing / recycling the product						
Lack of demand						
Lack of corporate social responsibility						
Lack of long-term strategic planning or short-term perception						
Lack of new technology, process or materials						
Environmental thinking not a part of organization's vision, objectives and decision making						
Difficulty in identifying environmental opportunities						
Poor organizational culture						
Tight and fixed deadlines by the stakeholders						
Unskilled/semiskilled HR personals						
Fear of failure						
Disbelief in environmental benefits						
Research and development not sufficient						
Lack of markets for recyclable materials						
General perspective that complex sustainability leads to greater effort or is too complex						

Vagueness in definitions and various interpretations						
Lacking integration in industry						
Lacking in energy & waste management of an Organization.						

10. Any additional barrier? (other than the mentioned above):

Opportunities in GSCM in construction industry

To what extent the following opportunities can be exploited through GSCM implementation.

Numbers	Equivalent to
0	No effect
1	Very low
2	Low
3	Medium
4	High
5	Very High

11. Mark only one option per row

	0	1	2	3	4	5
Improved reputation						
Potential for cost reduction						
Increase profitability						
Reduction in environmental risks						
Reduction of production waste						
Reduction of energy consumption						
Reduction of material consumption						
Competitive advantages						
Improve product quality						
Emission reduction						
Product innovations						
Minimization of transport time						

Increased health and safety and knowledge about it						
Reuse product						
Transparency and performance and transparent flow of goods						
Employer attractiveness						
Potential for innovation						
Increased knowledge about legal compliance						
Strengthen leadership						
Improved customer retention						
Increase in staff satisfaction						
Shorter production times						
Knowledge multiplication						

12. Any additional opportunity? (other than the mentioned above):