Investigating ISO 14001 for developing green supply chain performance

Ramneet Sidhu

A Thesis

in the

Concordia Institute for Information Systems Engineering

Presented in Partial Fulfilment of the Requirements

For the Degree of

Master of Applied Science (Quality System Engineering) at

Concordia University

Montreal, Quebec, Canada

May 2015

CONCORDIA UNIVERSITY

School of Graduate Studies

This is to certify that the thesis prepared

By: Ramneet Sidhu

Entitled: **Investigating ISO 14001 for developing green supply chain performance**

and submitted in partial fulfillment of the requirements for the degree of

Masters of Applied Science (Quality System Engineering)

complies with regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the final examining committee:

_____
Prof. M. Mannan (Chair)

_____
Prof. P. Pillay (External Examiner)

_____
Prof. A. Hammad (Internal Examiner)

_____
Prof. A. Awasthi (Co- Supervisor)

_____
Prof S.S. Chauhan (Co- supervisor)

Approved by

_____
Chair of Department or Graduate Program Director

_____ 2015

_____
Dean of faculty

ABSTRACT

Investigating ISO 14001 for developing green supply chain performance

Ramneet Sidhu

Delivering superior performance than competitors has always been the significant force for any company's success and companies are constantly endeavoring for different initiatives to gain advantage over their competitors. Recently, green supply chain management has been receiving great interest from researchers and practitioners. Consideration has been given to consider environmental factors in entire supply chain starting from the procurement, production, transportation, consumption, and post disposal of products for making the whole product life cycle green. The main objective of the study is to identify the relationship between ISO 14001 and green supply chain management and how it can be used for green supply chain planning. The thesis is divided into two parts. In the first part, we decide whether ISO 14001 practice is beneficial to make supply chain green and in the second part we identify the customer and the technical requirements for green supply chain planning on the basis of ISO 14001, investigate their relationships, and propose a QFD based approach for selecting best green supply chain initiative(s) for organizations.

The data for the study is collected from published reports of 20 different companies belonging to three sectors namely food and beverage, transportation, and retail that are implementing green practices in their supply chain. The proposed approach has strong practical applicability for organizations considering investing in ISO 14001 for improving green supply chain performance.

Keywords:

Green Supply Chain Management, Quality Function Deployment, ISO 14001, EMS (Environmental Management System), Rough set theory, Fuzzy logic

ACKNOWLEDGMENTS

The success and final outcome required conscientious guidance, imperturbable supervision and sincere assistance and I am thankful to my thesis supervisor Dr. Anjali Awasthi who was abundantly helpful and offered invaluable assistance, support and guidance with her unsurpassed knowledge. With her suggestions, I have enhanced my research abilities, and knowledge related to sustainability.

I also take the opportunity to express gratitude to my parents and my husband who have always motivated and helped me in all situations and provided me unconditional support.

I would like to acknowledge the financial, academic and administrative staff of Concordia University for providing the knowledge, facilities, and financial support for this research.

Table of contents

List of Tables x

List of Figures xiii

List of Abbreviations xiv

Chapter 1 1

1.1. Background 1

1.2. Problem Statement 1

1.3. Thesis contribution 2

1.4. Thesis Outline 2

Chapter 2 4

2.1. ISO 4

2.1.1. ISO 14001 5

2.1.2. Drivers for ISO 14001 implementation 6

2.1.3. Barriers in ISO 14001 implementation 8

2.1.4. Benefits of ISO 14001 implementation 9

2.1.5. Steps to ISO 14001 implementation 10

2.1.6. Impacts of ISO 14001 implementation 11

2.2. What is green supply chain? 14

2.2.1. Stakeholders of green supply chain 16

2.2.2. Difference between green supply chain and traditional supply chain 17

2.3. Data sources and Data Collection 18

2.4. ISO 14001 and green supply chains 20
2.5. Green Supply Chain Management 27
2.5.1. Definitions of GSCM 27
2.5.2. Elements of green supply chain 28
2.5.3. Barriers in green supply chain 29
2.5.4. Drivers and enablers of green supply chain 31
2.5.5. Measuring GSCM 32
2.5.5.1. Metrics 32
2.5.6. Impact of green supply chain on performance 34
2.5.7. Modelling techniques for green supply chain 37
2.5.8. Justification of techniques 38
Chapter 3 40
3.1. Checklist 41
3.2. Rough Set Theory 44
3.3. Fuzzy Logic 45
3.4. QFD 47
3.4.1. Identifying customer needs 50
3.4.2. Voice of the customer (VOC) 50
3.4.3. Customer Requirements and Technical Requirements 52
3.5. Summarization of corporate reports for GSCM 52
3.6. Top trucking companies 55

3.6.1. Identifying Customer requirements for trucking companies 55
3.6.2. Identifying Technical requirements for top trucking companies 57
3.7. Food and Beverage companies 58
3.7.1. Identifying Customer Requirements for food and beverage companies . 59
3.7.2. Identifying Technical Requirements for food and beverage companies . 61
3.8. Retail Sector 62
3.8.1. Identifying Customer Requirements for retail companies 62
3.8.2. Identifying Technical Requirements for retail companies 64
Chapter 4 66
4.1. Rough Set based QFD Application 66
4.1.1. Importance Rating for Customer Requirements 66
4.1.2. Relationship between the customer and the technical requirements 68
4.1.3. Correlation Matrix 70
4.1.4. Importance of HOWs 73
4.2. Fuzzy Logic QFD Application 74
4.2.1. Importance Rating of Customer Requirements 75
4.2.2. Relationship between customer and technical requirements 77
4.2.3. Correlation matrix 79
4.2.4. Importance of HOW's 80
Chapter 5 82

5.1. Conclusions 82

5.2. Future Works 83

5.3. Bibliography 85

5.4. Appendix 105

List of Tables

Table 2.1: Drivers of ISO 14001 7

Table 2.2: Barriers of ISO 14001 9

Table 2.3: Benefits of ISO 14001 10

Table 2.4: Impacts of ISO 14001 12

Table 2.5: Technique and factors for GSCM 24

Table 2.6: Definitions of GSCM 28

Table 2.7: Barriers of green supply chain 30

Table 2.8: Drivers of green supply chain 31

Table 2.9: Identified metrics and measures 34

Table 2.10: Impact of GSCM 36

Table 3.1: Checklist for ISO 14001 43

Table 3.2: Linguistic ratings and crisp values 46

Table 3.3: Corporate Summary 54

Table 3.4: Checklist of ISO 14001 for top trucking companies 57

Table 3.5: Technical requirements for J. B. Hunt Transport services 58

Table 3.6: Checklist of ISO 14001 for food and beverage companies 60

Table 3.7: Technical requirements for DANONE Company 62

Table 3.8: Checklist of ISO 14001 for retail companies 64

Table 3.9: Technical requirements for Best Buy 65

Table 4.1: Rating for decision maker's importance 67

Table 4.2: Quantification of customer survey data 68

Table 4.3: Decision maker's evaluations 69

Table 4.4: WHAT and HOW relationship 70

Table 4.5: Assessments on the correlations between HOWs 71

Table 4.6: Correlations between HOW's with rough numbers 72

Table 4.7: Importance of How's 74

Table 4.8: Importance rating by decision makers 76

Table 4.9: Aggregate of weights in fuzzy numbers 76

Table 4.10: Relationship between WHATs and HOWs through linguistic variables 78

Table 4.11: Fuzzy values for weight of the relationship between HOW's and WHAT's 78

Table 4.12: Correlation between HOW's 79

Table 4.13: Correlation between HOW's with crisp number 80

Table 4.14: Final score index 81

Table 4.15: Final ranking 81

Table 5.1: Technical requirements for UPS 106

Table 5.2: Technical requirements for FedEx 107

Table 5.3: Technical requirements for YRC Worldwide 107

Table 5.4: Technical requirements for DHL 108

Table 5.5: Technical requirements for Atlas Van Lines 108

Table 5.6: Technical requirements for Penske Logistics 109

Table 5.7: Technical requirements for Swift Transportation 110

Table 5.8: Technical requirements for United Van Lines 110

Table 5.9: Technical requirements for C and K trucking company 111

Table 5.10: Technical requirements for Kellogg Company 111

Table 5.11: Technical requirements for Molson Coors Brewing Company 112

Table 5.12: Technical requirements for PepsiCo 113

Table 5.13: Technical requirements for Starbucks Corporation 113

Table 5.14: Technical requirements for Tim Horton's 114

Table 5.15: Technical requirements of Loblaw's 115

Table 5.16: Technical requirements for Rona 115

Table 5.17: Technical requirements for Canadian Tire 116

List of Figures

Figure 2.1: Requirements of ISO 14001 6

Figure 2.2: Drivers of ISO 14001 8

Figure 2.3: Impacts of ISO 14001 13

Figure 2.4: Green supply chain management 15

Figure 2.5: Impact of ISO 14001 on GSCM 26

Figure 2.6: Distribution of definitions of GSCM 28

Figure 2.7: Elements of green supply chain 29

Figure 2.8: Articles analyzed 37

Figure 3.1: Different certifications by various companies 55

List of Abbreviations

AHP - Analytic Hierarchy Process

ANP - Analytic Network Process

ANZIC - Australian and New Zealand Intensive Care Society

BFR - Brominated Flame Retardants

CR - Customer Requirements

CTQ - Critical to Quality

DM - Decision Maker

EMAS - European Eco- Management and Audit Scheme

EPA - Environmental Protection Agency

EPEAT - Electronic Product Environmental Assessment Tool

EMP - Environmental management Practices

EMS - Environmental Management Systems

EU - European Union

FIR - Final Importance Rating

GREEN - Global Risk Evaluation for Environment

GRI - Global Reporting Initiative

GSCM- Green Supply Chain Management

ISO -International Standards Organization

IR - Importance Rating

JIT - Just In Time

LCA - Life Cycle Analysis

LED - Light Emitting Diode

LEED - Leadership in Energy and Environmental Design

NA - Not Available

OHSAS - Occupational Health and Safety Advisory services

PDCA - stands for PLAN-D0-CHECK-ACT

PVC - Poly Vinyl Chloride

QM - Quality Management

SIA - Subaru Indiana Automotive

SEDEX - Supplier Ethical Data Exchange

SmartWay - It is an EPA Program that reduces transportation- related emission by creating incentives to improve supply chain fuel efficiency

SME - Small and Medium- sized Enterprise

TQM - Total Quality Management

TR - Technical Requirements

QFD - Quality Function Deployment

VOC - Voice of Customer

Chapter 1

Introduction

1.1. Background

Green supply chain management involves a thinking of supply chain management with concern of environment factors from green purchasing to the end of the product cycle including product design, manufacturing, distribution, final delivery of products, use, reuse and recycle i.e. reducing packaging and waste, developing green suppliers and developing more eco-friendly products and reducing carbon dioxide emissions in all of the supply chain processes. In recent years, greening the supply chain has become a progressive concern for the success of companies and a challenge for logistic managers because the traditional approaches to supply chain management are not enough to be effective in today's market. Thousands of companies get ISO 14001 certified because of growing demand from government, customers, increased competition to be green and the need to reduce cost. To prosper in today's environment, managers need to integrate their goals with the demands of customers and environmental regulations so it is necessary at this point to know how different practices such as ISO 14001 influence green supply chain management.

1.2. Problem Statement

The thesis has the following research objectives:

1. Investigate the relationship between ISO 14001 and green supply chain.

2. Identify factors that help to gain green supply chain. Investigating green supply chain practices in three different sectors: trucking companies, retail sector, food and beverage sector.

3. Identification of customer and technical requirements for green supply chain planning. Investigating the relationship between customer requirements and technical requirements, technical requirements and technical requirements.

4. Selection of best initiatives for green supply chain planning based on customer and technical requirements.

1.3. Thesis contribution

This thesis contributes to the following important issues related to green supply chain:

- Investigates the influence of ISO 14001 for GSCM.
- Customer and technical requirements are listed using checklist and voice of the customer studies.
- Identification of green initiatives using sustainability reports published by companies.
- Identification of the relationship between customer and technical requirements and evaluation of green initiatives using QFD.

1.4. Thesis Outline

This thesis includes four chapters:

Chapter 1 includes the introduction, background, problem statement, and thesis contribution.

Chapter 2 includes literature review on difference between traditional and green supply chain, definition and stakeholders for green supply chain, factors to achieve green supply chain. It also includes definitions, processes involved, barriers, enablers of green supply chain. Moreover, it also contains the justification for using QFD, rough set theory, fuzzy logic and embellishment of other techniques which could be used as a substitute of QFD.

Chapter 3 introduces the solution approach for developing a green supply chain through checklist, rough-set theory based QFD and Fuzzy theory based QFD approach.

Chapter 4 introduces a numerical application of the proposed approach for company J. B. Hunt. Other examples can be implemented following the same step by step procedure.

Chapter 5 summarizes the results, limitations, future works, references and appendices.

Chapter 2

Literature Review

In this chapter, we present a detailed literature review on ISO 14000, steps for ISO 14001 implementation, benefits, drivers, barriers, and metrics for assessing its impact on green supply chain performance.

2.1. ISO

The International Standard organization (Foster, 2010): ISO has developed a series of standards for quality systems for organizations.

ISO 9000-2000 Quality Management System for fundamentals and vocabulary

ISO 9001-2000 Quality Management System – Requirements

ISO 9004-2000 Quality Management System – Guidelines for performance improvement

ISO 14000- International standard for Environment Compliance.

ISO14000 series contains a set of guidelines for developing systems and practices in environment area. It has six sectors, each having one or more standards;

1) ISO 14001 and ISO 14004: Environmental Management Systems.
2) ISO 14010 to ISO 14012: Environmental Auditing.
3) ISO 14020 to ISO 14025: Environmental Labels and Declarations.
4) ISO 14031: Environmental Performance Evaluation.
5) ISO 14040 to 14043: Life Cycle Assessment.
6) ISO 14060: Environmental Aspects in Product Standards.

This study is mainly focusing on ISO 14001, so we will explore ISO 14001 in detail. ISO 14001 is related to ISO -14000 but contains the actual requirements that a company has to comply to become ISO-14000, internationally recognized standard for environment management. ISO 14001 is the only standard of ISO 14000 series, which is certifiable and rest others are describing supporting functions which help to maximize the effectiveness of the ISO 14001 EMS.

2.1.1. ISO 14001

The standard ISO 14001: 2004 Environmental management System is a framework that assists companies to manage impact of their activities on the environment in a better way. This framework is based on Plan-Do-Check-Act cycle which means that companies must focus on identifying and continuously improving their environmental performance. Specifically, organizations implementing ISO 14001 standard have to meet certain requirements or key elements that can be classified into five main categories as shown in figure 2.1 (MacDonald, 2005). A third party certification is needed to evaluate the organization's procedures and site visits to check conformance with respect to implementing ISO 14001.

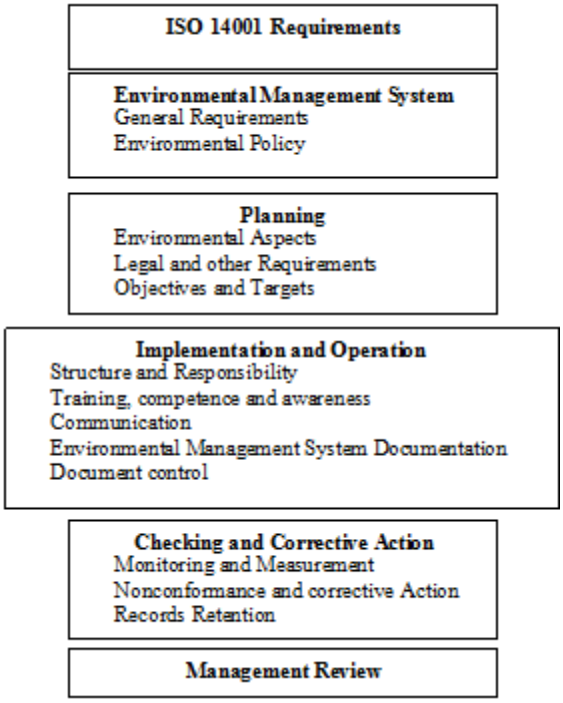

Figure 2.1: Requirements of ISO 14001

2.1.2. Drivers for ISO 14001 implementation

The drivers to implementing ISO 14001 are summarized in Table 2.1. The results are discussed in Fig 2.2 below.

Author(s)	Drivers
(Barmasse, 2002)	Customer demand, Cost efficiency, Regulatory relief, Public pressure, Competitive advantage, Government requirement, Streamline existing programs, Improve EMS, Corporate requirement, Globalization.
(Nawrocka, Brorson, & Lindhqvist, 2009)	Comply with legal requirements, Systematic management system, Comply with customer's environmental requirements, Improve market image, Market advantage, Public pressure, Satisfying customer requirements, Financial benefits, Increased awareness and a positive change in employees.
(Morrow & Rondinelli, 2002)	Satisfy customer pressure, reduce costs of energy, material, fines and penalties, growing interests of stakeholder's, improving company image, external pressure of environmental laws and regulatory, commitment to environmental improvement, opportunity to attain corporate goals and objectives, economic benefits and improved business performance.

(Massoud et al., 2010)	Government regulations, Improved environmental performance, High competition, enhance company image, Reduce operational costs, Export barrier overcome, Marketing tool, Customer Requirements and stakeholder demands, Accommodation of international regulations, and meet company requirements.
(Turk, 2009)	Globalization, desire of firms to develop EMS, desire of firm to change and development, for obligations in tender specifications, common opinion that ISO 14000 EMS to be mandatory in the near future, clients request to ISO 14001, competitors have ISO 14001.

Table 2.1: Drivers of ISO 14001

If the driver was found in more than one paper, it was considered a significant driver and therefore 8 significant drivers are listed below as shown in fig 2.2. For calculating the influence of the drivers of ISO 14001, some terms are taken as common or same like customer demand/requirement/client request or satisfying customer requirements are taken same, cost efficiency/financial benefits/ reducing cost of material, penalties and reduce cost of energy are taken as same. Similarly regulatory relief/ comply with legal requirements are taken same, public pressure/stakeholder requirement are common, competitive advantage/market advantage/high competition/ marketing tool and economic benefits are taken as same. Corporate Requirement/ improve corporate image/ company requirement are taken same. Likewise, globalization/ international regulation accommodation/ overcome export barrier are taken same and systematic management system or improve business performance are taken same become either directly or indirectly there result is same.

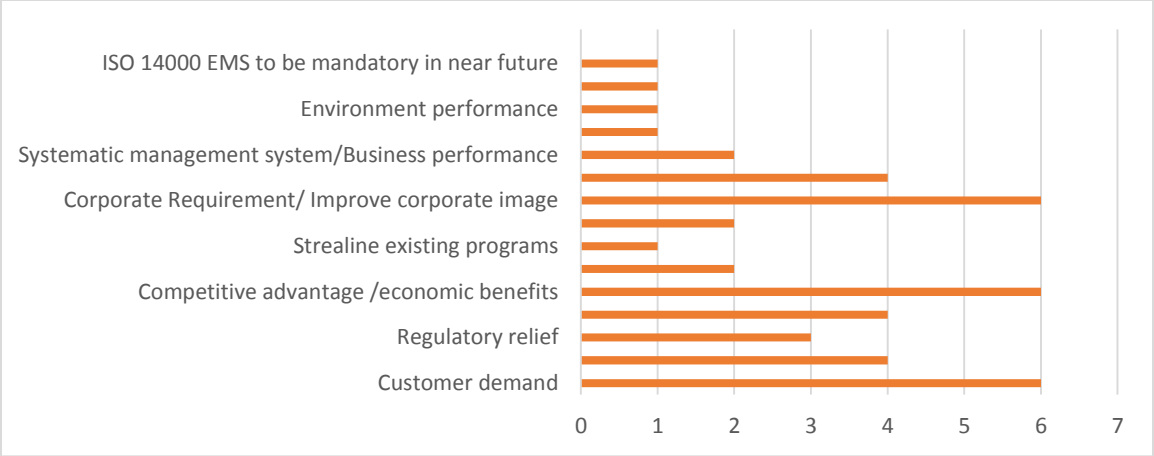

Figure 2.2: Drivers of ISO 14001

2.1.3. Barriers in ISO 14001 implementation

The main barriers for implementation of ISO 14001 are identified from various research papers. The results are shown in table 2.2.

Author(s)	Barriers	Significant barriers
(Barmasse, 2002)	Cost of implementation, Lack of customer demand, Lack of manpower/resources, Lack of technical expertise, ISO 14001 does not add value, Other EMS's in place & difficult to change from existing EMS's, Legal liabilities, Limited companies implementing ISO 14001.	Customer Demand, improvement of existing EMS's and Competitiveness/ Globalization
(Balzarova & Castka, 2008)	Lack of knowledge, unfollowed procedures, problem with identification and adoption of new legislation, lack of resources, lack of clear strict legislative framework, absence of central source of information, unawareness of environmental legislation, resistance to change, lack of technical staff, lack of training, preventive actions are often overlooked, procedures for emergency preparedness become lengthy and difficult to follow, mismatch between beliefs and actions, absence of a single authority body to interpret ISO 14001.	ALL
(Massoud et al., 2010)	Not a legal requirement, no demand from customers or stakeholders, lack of incentives, lack of government support, lack of resources, cost, duration,	Lack of government support, not legal

	creates competitive disadvantage, lack of knowledge and skills	requirement, benefits not clear, no customer demand, not required for export, cost of certification, not seen as priority by management, lack of knowledge and time demand
(Turk, 2009)	Lack of government support, lack of client support, failure to provide control of the sub- contractor, lack of qualified personnel, need of recognition of firm in terms of management, difficult in understanding the terminology of EMS, lack of information of certificate, size of firm, high implementation cost, increased amount of paper work, long period of certification process, lack of top management openness to research and criticism.	Lack of top management openness to research and criticism, Lengthy registration process, Increased paper work, and Increase ISO 14001 expenses.

Table 2.2: Barriers of ISO 14001

2.1.4. Benefits of ISO 14001 implementation

The benefits of ISO 14001 implementation are presented in table 2.3.

Author(s)	Benefits
(Barmasse, 2002)	Competitive advantage, Pollution Reduction, Relaxed regulatory requirements, Reduce environmental liability, Improved public relations, Preference bank loans, Increased compliance with regulatory requirements, Cost saving, Reduced customer audits, Sentencing mitigation, Reduced insurance costs, Reduction in energy consumption, Stepping stone for sustainable development, Satisfying investor criteria.
(Darnall, 2006)	Continual improvement, Pollution prevention, reducing risk of costly environmental accidents, lowering corporate liability exposure, improving access and competitiveness in the market, improve relations with environmental regulators, improve internal efficiencies.
(Davies & Webber, 2007)	Lower cost of capital, high economic performance, continual improvement in environmental, financial and operational performance, reduced environmental incidents, globalization, competitive advantage.
(Morrow & Rondinelli,	Reduced environmental risks, liabilities and incidents, increase operational efficiency, increasing awareness of environmental impacts, strong corporate

2002)	image, competitive advantage, regulatory relief, reduce costs, improve maintenance, conformance to policy and better meet vendor requirements, continual improvement, meet consistently and effectively the requirements of the corporate EMS, better communication of environmental achievements and procedures to adopt, improvement in employees awareness
(Massoud et al., 2010)	Operational efficiency, productivity improvement, cost savings, profitability and competitive product/ services, market expansion, improve company image, enhanced stakeholders relationship
(Turk, 2009)	Improves environmental awareness, improves standardization in environmental management, decrease adverse impacts on environment, provides sustainable development in environment, enhances company's image, decreases complaints against the company about environmental problems, increase self-confidence of the company, enlarge market share, improves client satisfaction, gives more stringent recognition of the company

Table 2.3: Benefits of ISO 14001

2.1.5. Steps to ISO 14001 implementation

The process of implementing ISO 14001 EMS can be done in a step by step approach. It involves 15 different steps which are summarized below. These steps are used for the integration and implementation of ISO 14000 family but in this paper it is used specifically for the implementation of ISO 14001 for better EMS practices in the business (Ball, 2002). The steps of ISO 14001 implementation are listed as follows:

1. Obtain top management commitment
2. Set up an environmental steering committee
3. Understand the company's and ISO 14001 Requirements
4. Train the environmental team and employees
5. Establish an effective environmental management system
6. Establish environmental policies and procedures
7. Create sound environmental management programs

8. Maintain documentation and make it accessible
9. Establish a functional process of recording for the EMS
10. Review of EMS by management
11. Initiate and conduct environmental auditing
12. Select ISO 14001 standard
13. Decide on a registration strategy and get registered
14. Maintain your management system

2.1.6. Impacts of ISO 14001 implementation

The first question arises is that "Does ISO 14001 has any impact on business performance or environment performance". For this, we have analyzed the top 100 sustainable companies of 2014 listed by the corporate knights. From these 100 companies, we have seen 90% of these companies were ISO certified either fully or partially. We have also seen that in 2010 about 14000 companies have registered to ISO 14001 throughout the world with Japan 2600 companies, Germany 1600 companies, UK 1200 companies, Sweden 650 companies, Taiwan 500, USA 590, Netherlands 475, Korea 460, Switzerland 400 companies and followed by France 360. Moreover, the twenty companies that were listed in three sectors were also majorly certified as ISO 14001. To depict the positive or negative impact of ISO 14001, the existing literature has been reviewed and the variables are marked as performance indicators in table 2.4. The environmental performances were included are emissions of pollutions, use of recycled materials, scrap management, energy saving etc. and the business performances are the stakeholder benefits, financial benefits, operational and organizational benefits.

Author(s)	Impact	Performance indicator
(Ann, Zailani, & Wahid, 2006; Cañón-de-Francia & Garcés-Ayerbe, 2009; Gavronski, Ferrer, & Paiva, 2008; Newbold, 2006; Perez, Amichai- Hamburger, & Shterental, 2009; Summers Raines, 2002; Turk, 2009; S. Wu, Chu, & Liu, 2007; Yin & Ma, 2009; Zutshi & Sohal, 2004)	Stakeholder benefits external	Competitiveness, customer satisfaction, exports, corporate image, globalization, market position, market share, marketing, supplier relationship, customer complaints, relationship with regulators, regulatory compliance.
(Ann et al., 2006; Cañón-de-Francia & Garcés-Ayerbe, 2009; Melnyk, Sroufe, & Calantone, 2003; Summers Raines, 2002; Zutshi & Sohal, 2004)	Financial benefits external	Cash flow, commercial performance, earnings growth, sales and sales growth
(Ann et al., 2006; Link & Naveh, 2006; Newbold, 2006; Radonjič & Tominc, 2007; Summers Raines, 2002; Turk, 2009; Zutshi & Sohal, 2004)	Environmental benefits external	Scrap management, waste management (recycling, waste reduction, and reuse etc.), raw material usage, emissions, energy usage, air pollution, resource usage, green space preservation, wildlife habitat restoration, and accidental events.
(Melnyk et al., 2003; Newbold, 2006; Perez et al., 2009; Radonjič & Tominc, 2007; Zutshi & Sohal, 2004)	Operational benefits internal	Cycle time, efficiency, flexibility, cost, plant safety, overall productivity, product quality, product innovation, product performance, defects, quality assurance, and process optimization.
(Newbold, 2006; Perez et al., 2009; Summers Raines, 2002; Zutshi & Sohal, 2004)	Organizational benefits	Commitment to improve, discipline and order, employee awareness, job flexibility, management control, problem solving, quality awareness, shared vision, training and education, work procedures, employee turnover rate, employee commitment, targets, corporate culture, employee motivation, health morale, working atmosphere, and environmental awareness.

Table 2.4: Impacts of ISO 14001

Figure 2.3 is developed to depict the positive/ negative or no impact of ISO 14001. The figure shows that most of the studies report positive relationship between ISO 14001 adoption and environmental performance and/or business performances.

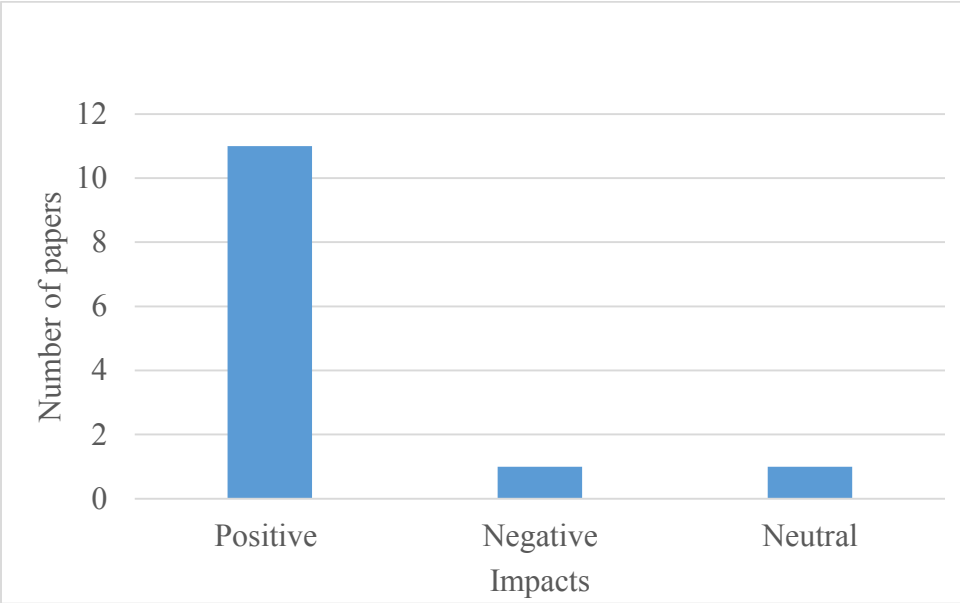

Figure 2.3: Impacts of ISO 14001

Out of the 13 papers that were read for determining the impact of ISO 14001, 11 papers report positive impact of ISO 14001 on environment and business indicators and 1 paper found to be negative. This result shows that ISO 14001 is helpful in gaining environmental performance as well as other performances too, even though these studies might have some constraints of ISO 14001 implementation such as depending on strong internal motivation, top management commitment, length of time ISO 14001 was implemented or mechanism of implementation. There was overlapping too like one paper was talking positive about environmental performance but negative about financial performance, while another discusses positive influence of environmental performance but was neutral in regard to financial performance. And some of the papers do not discuss

about some performances while were positive about environmental performance. The fact is that most of the companies believe that there is an increase in expenditure for effectively managing their operations to reduce the impact on environment and to maintain their standardization but the result is different. The expenditure on improving or maintain ISO 14001 positively also affects organizational efficiency at last leading to business performances. Many companies like Danona, Unilever, and Ford etc. have changed their perceptions in regard to this and claim that the relationship between environmental performance and business performance are positive.

There are many differences among the approaches to quality management along the supply chain. However, rather than focusing on variables, we will be focusing on ISO 14001 as there are lots of studies related to quality management variables but only few studies have focused on ISO and green supply chain but no research study has focused all the three together. So, we will study literature review and find how ISO 14001 as a quality management practice is good to implement green supply chain management and then we will study this technique in context to three different areas.

2.2. What is green supply chain?

Green supply chain planning involves examining the alternatives and possibilities of reducing carbon emissions throughout the entire supply chain from raw material to transportation to warehousing. The green supply chain is divided into different parts which are explained in figure 2.4

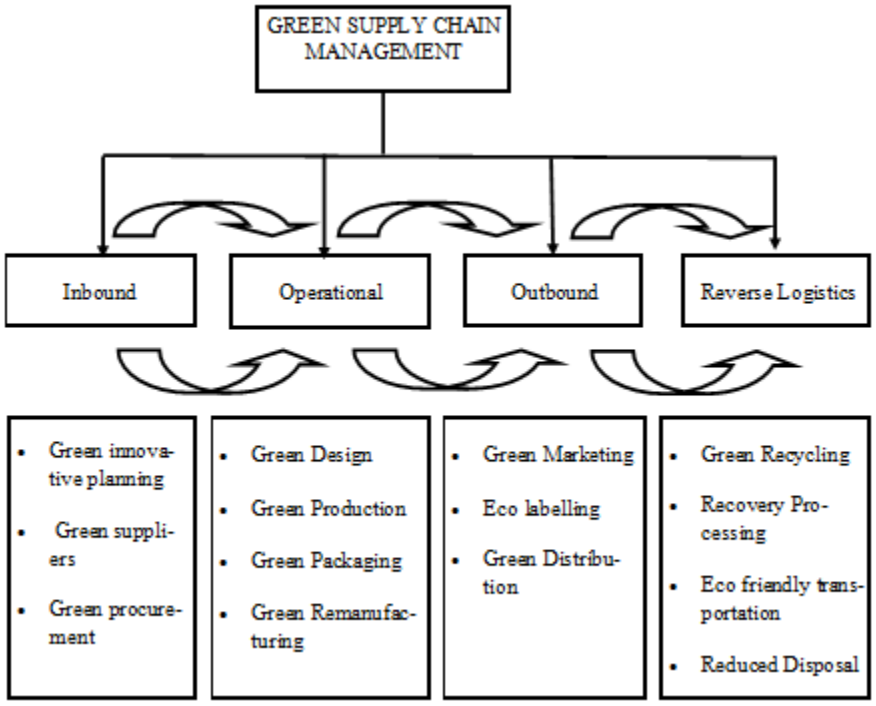

Figure 2.4: Green supply chain management

INBOUND GSCM: The path to a greener supply chain starts from the purchasing and acquisition of raw materials according to the needs of the company with the integration of suppliers focusing on environmental friendly ideas to the transportation of goods towards production. This practice aims to reduce waste through purchasing or procurement of raw materials, green supplier selection, green supplier development, and decrease of consumption energy, harmful material and resources.

OPERATIONAL GSCM: This activity is in between the inbound and outbound logistics that means here raw material is transformed into consumer useable goods through production. So, green operational activity starts with green design activity which involves reuse, recycle, remanufacturing design, with an objective of green life cycle design and followed by green production where vital point is to reduce the amount of material,

energy, and resources and lastly green packaging involves use of reusable material for packing and eco-friendly packing.

OUTBOUND GSCM: This part's main function is to deliver the goods to the customers at all corners so it needs good design for network of distribution. When we talk for green distribution then it means reducing carbon emissions and higher fuel efficiency usage followed by green marketing and eco-labelling.

REVERSE LOGISTICS: This part of GSCM repair, reuse, refurbish, and recycle the material, products, and components back to the supply chain instead of throwing up in landfills. Reverse logistics help companies to have green supply chain because only that product goes to market that can be refurbished or re-used.

2.2.1. Stakeholders of green supply chain

Any person, group or organization that has interest in other organization is considered to be the stakeholder for that company (Gaur, 2013). And different stakeholders have different concerns towards the organization. There are mainly two types of stakeholders namely primary and secondary. Primary stakeholders are the one who has direct impact on organization and the secondary stakeholders are the one who does not have anything to do with supply chain transactions, but still can affect the supply chain activities (Hussain, 2011).

Primary stakeholders for green supply chain are: customers, employees, owners, management, shareholders, suppliers, distributors, manufactures, retailers, recyclers, waste management organizations, financers, and partners.

Secondary stakeholders for green supply chain are: competitors, Government, NGOs, local community, social activists, interest groups, media, scientific community, safety advocates, and environmental groups.

2.2.2. Difference between green supply chain and traditional supply chain

The green supply chain aims to reduce the consumption of resources, energy, waste and emissions of hazardous material, maximize economic benefits while traditional supply chain aims to lower cost, and improve profitability and efficiency in supply chain to maximize economic benefits (CCICED, 2011).

Secondly, in green supply chain environment performance is included in its internal and external management system. Moreover, environment protection and safety is included in its entire supply chain from raw material to design, production and delivery (CCICED, 2011)

Thirdly, green supply chain includes the products assessment from cradle to grave and the waste is reused if possible which becomes the raw material again. While in traditional supply chain the products are assessed from cradle to grave but they are not reused again, rather disposed off without thinking of carbon emissions and environment protection (CCICED, 2011).

Lastly, green supply chain is promoted by green government programs, companies fulfill their corporate social responsibility and follow only green practices while in traditional it is governed by consumer interests and business activities (CCICED, 2011).

2.3. Data sources and Data Collection

Our main source for data collection was Science direct website with additional searches on the databases of Emerald insight, Wiley inter science, and Concordia library. The books referred were ISO 14001 Environmental systems handbook by Ken Whitelaw, Green supply chain: An action manifesto by Emmett & Sood, Managing Quality: Integrating the supply chain by Foster. S. Thomas. The requirements, drivers, barriers, benefits, impact and steps to implementation of ISO 14001 were identified by the review of the literary references found through various research papers. In several cases, the same factor was listed in conflicting categories like customer demand was listed in driver as well as in barrier. So it was listed in both because customer demand can act as both driver and barrier at a same time. Moreover, if we take same example then in calculating the drivers influence many terms whose meaning or result was same, either directly or indirectly has been taken as one driver. For example, customer demand or customer requirement or client request or satisfying customer need was taken as one driver. And for green supply chain the difference, stakeholders, factors & techniques, definition, elements, barriers, enablers, impacts are collected from a high advisory Chinese body for environment, the referred books and other databases like science direct, emerald , Wiley inter science and Concordia library. And for calculating the impact of GSCM, first of all many papers were read about all the techniques like six sigma, kaizen, ISO 14001, benchmarking, lean. But most of the papers were focusing on ISO 14001 to make a supply chain green followed by lean. So, ISO 14001 was chosen to study in detail for green supply chain. And then all the papers related to GSCM and ISO 14001 was shortlisted to analyze its impact on GSCM.

Studied sector and sample selection

In order to collect data from companies, the online annual report, or sustainability reports were analyzed of all the short listed companies from Maclean website. And from sustainability or annual reports, the green initiatives were bowed into technical requirements and transformed into tables for each company. As there was no specific criteria for selecting Customer requirements for all green companies, so to have fixed criteria for green company's customer requirements, we transmuted the checklist of ISO 14001 published by (*Australian government ICT sustainability plan 2010-2015*.2011) as customer requirement and on reviewing each companies report, each initiative of the company was allocated in checklist under one of the ten main elements of the checklist. If the checklist has any option which was not taken by company then it was marked as "NO"- means it doesn't took the action or "NOT AVAILABLE"- means the information is missing or not available in the report. And to deal with the missing information, vague or imprecise numbers in QFD rough number set theory was used. Altogether ten companies were listed in Maclean website and 10 were listed in green chip stock website where five companies belong to retail and five companies belong to food and beverage in Maclean and ten companies were listed of trucking in green chip stock website. The voice of customer was collected from various books, websites and brain storming. Summarization of corporate report was done for all the companies to show the precise information about green initiatives of the companies and the indicators are used in describing the metrics of GSCM with some other published journals. Only one example

is taken in application part because similar methodology can be used for other companies to calculate the results.

2.4. ISO 14001 and green supply chains

There are many other techniques that can be used to gain green supply chain management like kaizen, six sigma, benchmarking, lean (Hervani, Helms, & Sarkis, 2005; Kainuma & Tawara, 2006; Martínez-Jurado & Moyano-Fuentes, 2014) but most of the papers have focused on ISO 14001. Many papers talk about its positive effect while many say it doesn't play any role while some of it say that it has negative impact. Therefore to analyze its impact from various angles, we constructed table 2.5 to provide more details.

Authors	Area	Issues addressed in the paper	Main Findings	Conclusion Related to GSCM
(Welch, Mori, & Midori, 2002)	Chemical, electronics, electric machinery & electric power	1) Factors contributing in adopting ISO 14001 in Japan. 2) Differentiate 1st stage and 2nd stage adopters and non-adopters, 3) 3) Differentiate adoption behavior among these industries.	Main factors were regulatory advantage, competitive market, social responsibility and organizational factors. The early adopters tend to be larger, greener, less driven by pressures and vice versa for the 2nd tier firms. Electric power industry tends to be more social responsible.	Results do not clearly show the linkage between ISO adoption and greening activity. Nevertheless, ISO adoption is related to environmental action.
(Testa & Iraldo, 2010)	Manufacturing	1) Focused on internal strategic motivations that motivate GSCM. 2) Analyze the determinants and effects of GSCM on environmental and business performance.	1) Reputation-led is the most effective in stimulating, Followed by innovation-led but for the companies that has market image are provoked with the request of clients. But for small producers that co-operates in a network of suppliers for large company they suffer the limitations. 2) Cost efficient is a very weak driver for GSCM. Business partners should be involved more and more to achieve expected results and performance.	The relationship between EMS and GSCM practices is positive for an organization's environmental performance.
(Nawrocka et al., 2009)	Manufacturing companies of Swedish.	To communicate, control and verify the requirements to the supplier, motivate and enable the supplier to comply with the requirements.	1) Companies focus on direct environmental aspects in first phase of implementation of ISO 14001. 2) Coordination between the environmental, R&D and purchasing departments has a vital influence on the product improvement activities and to avoid many environmental complications in the later stages of product life cycle. 3) An environmental audit of supplier is an effective and useful method for control of compliance audits.	A win-win situation can be created by implementation of ISO 14001 if same type of EMS applied, worked with repeated improvement. ISO certified companies are more active in supply chain initiatives than non-certified.
(Comoglio & Botta, 2012)	Production sector for Manufacture of motor components(first tier suppliers)	1) Which operational performance indicator are used to assess continual improvement and to monitor environmental aspects in EMS. 2) Whether the EMS implementation has contributed to an increased commitment 3) What the entity of the obtained improvement is?	1) Survey results indicated that the environmental aspects to which most companies would have committed themselves even without an EMS are local issues (noise) and waste management (55.6%), use of resources and emission to air (42.2%). These aspects are the same to which the companies declared the highest commitment with ISO 14001 certification, with different ranking. 2) Yes, EMS contributes to commitment towards environmental performances as EMS represents as a driver.	The EMS implementation lead to higher commitment from companies, number of environmental aspects involved and higher investments towards environmental improvement.

(Prajogo, Tang, & Lai, 2012)	Manufacturing sector under ANZIC code and non-Manufacturing sector	The study examines the relationship between internal and external organizational adoption motives with triple bottom line benefits (environmental, social , market) on the adoption of ISO 14001	The results indicate that external motives (customer demand, government and competitor) improve social and market positioning whereas internal motives (environmental performance, efficiency and control in operations, synergies among management systems) assist environmental benefits (reduced pollution, energy& material consumption and reduced risk of environmental hazards).	Firms get what they want from ISO 14001 adoption. Firms that were more internally driven in adopting the standard had more tangible and sustainable benefits than those who did just for compliance to external demands.
(Boiral, 2011)	Production	Why ISO management systems are used and to show how ISO generic management system is used to improve in-house practices and avoid most observed pitfalls.	The main pitfalls in ISO implementation were found to be: Inappropriate or excessive documentation, lack of follow up and system continuity, search for commercial certification, scarce resources, externalization of the implementation process and critical success factors of ISO implementation were showing managerial conviction and support, clearly explaining the reason for certification, mobilizing the employees and knowledge, adapting the standard to the organization, integrating the organization's fundamental goals.	While managers often adopt management standards in response to external pressures but the fundamental purpose of these standards is to improve in house practices. The main model for ISO is PDCA cycle
(Neugebauer, 2012)	Research was done at German automotive and engineering industry.	1) Why companies adopt both EMAS and ISO 14001 2) It is argued that EMAS and ISO 14001 are substitutes or complementary. 3) What is the future of EMAS and ISO 14001	ISO 14001 is often done in response to external pressure, EMAS tends to be more motivated internally. And presently EMAS and ISO 14001 are in direct competition but may turn into complementary in future. In future ISO 14001 would develop as global standard while EMAS would become a premium standard for SME and non- industrial organizations.	ISO 14001 is adopted in response to external pressure like organizational field, institutional environment of a firm and complementary standards such as ISO 9001.

(Boiral, 2007)	Manufacturing.	To what extent ISO 14001 certified organizations had actually integrated the requirements of the standard into their daily activities and how individuals perceived the changes.	1) The main driving force to adopt ISO 14001 standard was found to be institutional legitimacy. It was also confirmed that some of the companies just validate this standard to only give a legitimate appearance. 2) The strongest pressure to adopt ISO was from internal. But this also not mean that external factors does not enforce at head offices.	This study indicate that ISO 14001 is adopted as managerial fad and fashion to sustain the image, legitimacy and rationality of Environmental management.
(Eltayeb, Zailani, & Ramayah, 2011)	Manufacturing.	Find out actual environmental, intangible and economic outcome after adopting green supply chain initiatives (Eco design, green purchasing, and reverse logistics).	Of the 3 types green supply chain initiatives, only eco design shows significant effect on economic outcomes, intangible outcomes and green purchasing and reverse logistics have quite less effect on the internal performance of the firm and benefits are reflected first on external parties, later on firm performance.	Green supply chain initiatives helps to achieve the triple bottom line of social, environmental and economic benefits. ISO helps to take green initiatives.
(Wiengarten & Pagell, 2012)	Operations	Explore the role of quality management (ISO 9000, supplier certification, Statistical process control and TQM) performance (Cost, quality, delivery and flexibility).	Environmental practices are more strongly associated with cost, flexibility and performance when investments in QM practices are relatively high. However, QM does not interact with environmental management to drive quality performance, although each individual set of practices is positively related to quality performance.	Companies gain higher performance benefits when EMP are present in terms of cost, flexibility and delivery performance in quality management practices.
(Schroeder & Robinson, 2010)	Manufacturing of automobiles	To document the Steps taken to achieve Zero- landfill and competitive advantage gained in the process by SIA	1) Green is free as cleaning at later stage is expensive then not creating chaos in the first place is cheaper 2) The leadership's vision, support, and commitment is important. 3) The company's green success was due to the involvement of its front line associates. Green supply chain is necessary to go beyond in progress. 4) All wastes are a potential raw material for another process.	We can be green by engaging front-line workers into all of its processes and operations. Because front line workers handle the waste at the point where it is created.

(Zhu & Sarkis, 2004)	Chinese suppliers	1) To evaluate the relationship between GSCM practices and performances. 2) Investigate how QM and JIT practices influence the relationship between GSCM and performance.	1) GSCM practices are beneficial for both environment and economic performance 2) QM has positive influence when used together with external GSCM and internal management programs. 3) When implementing JIT in internal environment management practice, special care is required to ensure that performance is not affected.	Globalization pressure helped Chinese suppliers to become green and improve environmental performance.
(Barla, 2007)	Pulp and Paper industry	Test whether adopting ISO 14001 significantly impacts environmental performance in Quebec's pulp and paper industry	1) Following certification helped in reducing discharge of biological oxygen but not in suspended solid emissions or waste water. 2) Group of plants that adopt norms did not experience a significant negative trend in emissions over sampled period.	The results were variable depending upon adopting plants as most adopters either maintain or increase emissions after being ISO certified
(Brouwer & van Koppen, 2008)	Chemical, Food and Environmental	1) Which internal and external factors influence the process of improvement? 2) How companies and auditors assess continual improvement 3) In what ways does the ISO 14001 standard provide an incentive for continual improvement?	1) Continual improvement is assessed mainly by operational performance indicator followed by management or strategic indicator. 2) Improvements by ISO 14001 are small. It was difficult to measure aspects for continual improvement 3) Internal motivation is the main driver and soul of continual improvement.	Continual improvement is ill defined in ISO 14001.

Table 2.5: Technique and factors for GSCM

Many other studies were also conducted on green supply chain like considering green supply chain management drivers, as a strategic organizational development approach at Malaysian perspective (Hajikhani, Wahiza Binti Abdul Wahat, & Bin IDRIS, 2012), the impact of green supply chain practices on supply chain performance (Rha, 2010), the integration of green practices in supply chain environment: the practices of inbound, operational, outbound and reverse logistics (Choudhary & Seth, 2011), the influence of green practices on supply chain performance as a case study approach (Azevedo, Carvalho, & Cruz Machado, 2011).

After studying these papers we got to know that ISO 14001 helps to gain GSCM if management supports, strong commitment, organization thinks in that way, or company's want to be ISO 14001 certified due to their internal reasons and strong commitments, then it helps the organization to be more profitable in long run otherwise if companies take actions due to internal pressures, external pressures, customer demands, and government regulations, or to maintain reputation. Then, in first phase of implementation they show concerns related to environment and decrease in the end after getting certified because this standard do not impose any specific standards on organization, it only specifies the important requirements to identify, control and monitor the environmental aspects of an organization.

In figure 2.5 we can see the impact of ISO 14001 on GSCM with indeed 11 out of 14 studies shows positive impact, 2 shows neutral impact and only 1 shows negative impact.

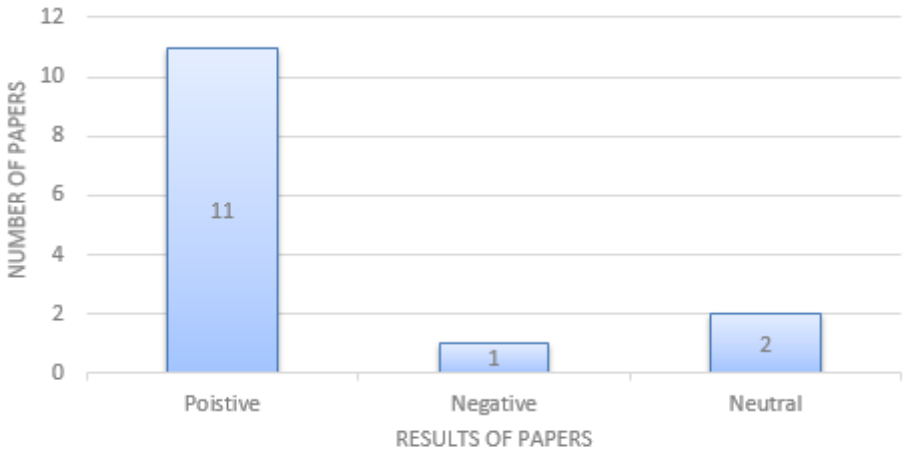

Figure 2.5: Impact of ISO 14001 on GSCM

The negative is due to unavailability of internal commitment and rather the certification was done due to legitimacy and to sustain the image. And the drivers suggest that the certification should be attained if the company's top management support is available, strong commitment, well- defined responsibilities, internal motivation, stakeholder involvement, training and education etc. Similarly, the papers showing neutral results say that the results were variable depending upon adopting plants as most adopters either maintain or increase emissions after being ISO certified, the others say that ISO 14001 is dependent on the PDCA cycle and we learn from pitfalls which also means that if we show continuous improvement then we can have positive results.

From the past studies, we can see that many studies were conducted on Quality management practices and green supply chain management individually, only few studies have been conducted on QM and supply chain management. Therefore, in this paper we will focus on these areas to know the impact of Quality management practices (ISO 14001) on green supply chain management.

2.5. Green Supply Chain Management

A number of authors have referred to green supply chain management term over the past decade, so not to be dependent on one definition we have reviewed number of published papers to make the definition more clear.

2.5.1. Definitions of GSCM

Various definitions of GSCM exist in the literature. The purpose of table 2.6 is to have better understanding of the definition from published papers (Ahi & Searcy, 2013). In this table, even if the definition is used somewhere else, its original source is referred. A total of six definitions are explained in the table. A summary of some of the definitions that have appeared in the literature is provided in table 2.6.

Author(s)	Definition	Business sustainability Focus
(Zhu, Sarkis, & Geng, 2005)	An important new archetype for enterprises to achieve profit and market share objectives by lowering their environmental risks and impacts while raising their ecological efficiency	Environmental focus, Economic Focus
(Hervani et al., 2005)	Adding the green component to supply chain management and closing the loop of reverse logistics. GSCM = Green Purchasing + Green Manufacturing/ Material Management + Green Distribution/Marketing + reverse logistics	Long term Focus and Environmental focus
(Srivastava, 2007)	Integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life	Environmental focus, Long term Focus, Stakeholder focus
(Lee & Klassen, 2008)	A buying organizations plans and activities that integrate environmental issues into the supply chain management in order to improve the environmental performance of suppliers and customers	Environmental focus, Stakeholder focus
(Gavronski, Klassen,	The complex of mechanisms implemented at the corporate and plant level to assess or improve the	Environmental focus, Long term Focus,

Vachon, & Nascimento, 2011)	environmental performance of a supplier base.	Stakeholder focus
(Andiç, Yurt, & Baltacıoğlu, 2012)	Minimizing and preferably eliminating the negative effects of the supply chain on the environment	Environmental focus

Table 2.6: Definitions of GSCM

Green supply chain definitions were not just focused on environment concerns but were also related to social, long-term, economic and stakeholder focused. Figure 2.6 explains how each was related to different focused areas.

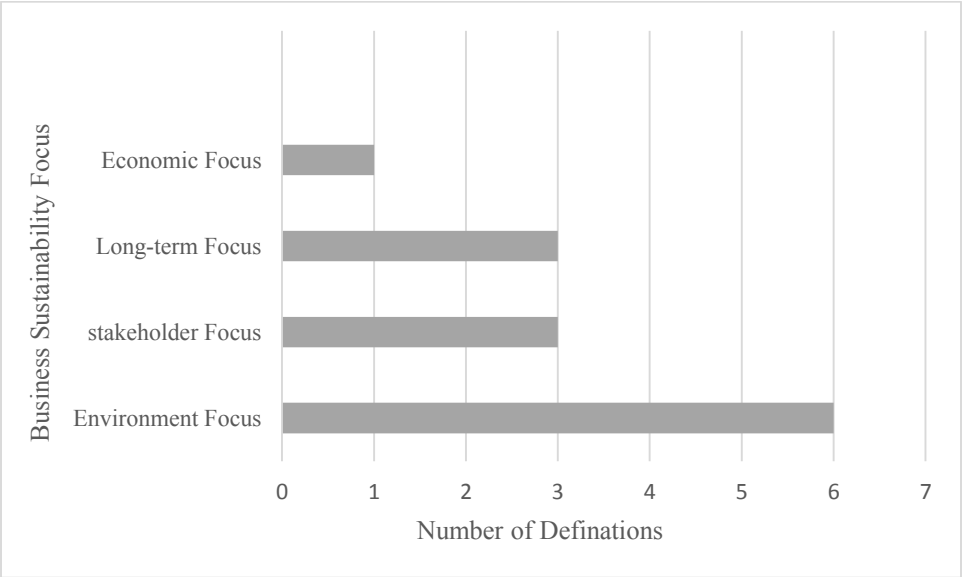

Figure 2.6: Distribution of definitions of GSCM

2.5.2. Elements of green supply chain

The conceptual framework was developed by (Hervani et al., 2005) who postulate green supply chain management elements as green procurement, green manufacturing, green operations, reverse logistics and waste management. In recent years, a more extensive approach has been emerged where firms extend their environmental responsibility

beyond its boundaries and therefore various elements that help in the implementation of GSCM were identified by (Emmett & Sood, 2010) in its book based on green supply chain and therefore its elements are explained in figure 2.7.

Figure 2.7: Elements of green supply chain

2.5.3. Barriers in green supply chain

The barriers in GSCM implementation are presented in table 2.7.

Authors	Barriers
(Mathiyazhagan et al., 2013)	Problems in maintaining the environmental awareness of suppliers, complex to measure and monitor the environmental practice of suppliers, lack of government support to adopt environmental friendly policies, fear of failure on adopting GSCM, lack of effective environmental measures, lack of human resources, lack of technical expertise, complex in design to reuse or recycle the product, Lack of new technology, materials and resources, lack of awareness about reverse logistics adoption, disbelief about the environmental benefits , Perception of " out- of- responsibility zone, Lack of Environmental knowledge,, lack of green system exposure professionals, high investments and less return – on – investments,

	Non-availability of bank loans to encourage green products/processes, financial constraints, high cost for disposing hazardous waste, lack of training, lack of customer awareness and pressure, lack of corporate social responsibility, less involvement in environmental related programs and meetings, restrictive company policies toward product/process stewardship, Poor supplier commitment, lack of inter-department co-operation in communication, lack of top management involvement.
(Walker, Di Sisto, & McBain, 2008)	Internal: Costs, lack of understanding of how to incorporate green into buying, focus on cost reductions at expense of green practices, lack of management commitment, lack of buyer awareness, lack of training, lack of training and commitment, costs hinder greening in forest industry, accounting methods limit green reporting, costs specially for SMEs, pressure of lower prices, lack of legitimacy, PR exercise as greenwash External: Regulation, inhibits innovation, poor supplier commitment, unwilling to exchange information, industry specific barriers.
(Govindan et al., 2014)	This paper identified a total of 47 barriers from various papers and then 26 common barriers are divided into five categories namely outsourcing (lack of government support, complexity of measuring and monitoring environmental practices of suppliers, problems in maintaining environmental suppliers), involvement and support (lack of training, lack of customer awareness and pressure, lack of corporate social responsibility, lack of top management involvement, restrictive company policies towards product/process stewardship, poor supplier commitment, lack of inter-department co-operation, less involvement in environmental related programs and meetings), technology (lack of technology, material and processes, complexity to design, reuse/recycle product, lack of technical expertise, lack of human resources lack of effective environmental measures, fear of failure), knowledge (lack of professional exposed to green systems, lack of environmental knowledge, perception of "out- of-responsibility" zone, disbelief about environmental benefits and lack of awareness about reverse logistics) and financial (high cost for hazardous waste disposal, financial constraints, non- availability of bank loans to encourage green product/processes, high investments and less return-on-investments). And the result shows that lack of technology is the most important barrier (the involvement and support barrier is not essential). When compared individually measuring/monitoring environmental practices of suppliers is an essential barrier.
(Giunipero, Hooker, & Denslow, 2012)	Lack of clarity, Cost and economic conditions, lack of sustainability standards and regulations, Misalignment of short term and long-term strategic goals.

Table 2.7: Barriers of green supply chain

2.5.4. Drivers and enablers of green supply chain

The drivers of green supply chain management are very significant from the point of view of their influence for the implementation of GSCM. And to involve major drivers of GSCM it is crucial to do a literature review study. The drivers affecting the implementation of GSCM under the study are listed in table 2.8.

Study	Motives and Drivers
(Diabat & Govindan, 2011)	Drivers of green supply chain are Certification of suppliers Environmental Management System, Environmental collaboration with suppliers, Collaboration between product designers and suppliers to reduce and eliminate product environmental impacts, Government regulation and legislation, Green design, ISO 14001 certification, Integrating quality environmental management into planning and operation process, Reducing energy consumption, Reusing and recycling materials and packaging, Environmental collaboration with customers, Reverse logistics
(Walker et al., 2008)	This paper divided drivers into internal and external drivers. The internal drivers were related to Organizational factors (employee involvement, desire to reduce cost, investor pressure, improve quality, values of owner, managers improving position in company and managing economic risk). The external drivers were Regulation, Customers (pressure by customers, customer demand, market pressure, e-logistics and environment, collaborate with customers), Competition (gaining competitive advantage and improve firm performance), Society (stakeholders can encourage environmental strategy, potential for receiving publicity, public pressure, reduce risk of consumer criticism, pressure by environmental advocacy groups) and Suppliers (collaboration with suppliers and integration of suppliers).
(Zhu et al., 2005)	The main drivers for green supply chain management are regulations, market supply drivers and internal incentive gains.
(Emmett & Sood, 2010)	Regulatory stakeholders, Consumers, Organizational stakeholders, Community groups, Environmental organizations, Media are the drivers of the green supply chain
(Giunipero et al., 2012)	Government Regulation, Customer Demand, ISO certification, Competitive advantage, Financial benefits, Involvement of top management.

Table 2.8: Drivers of green supply chain

2.5.5. Measuring GSCM

Environmental performance measures are significant requirement of a green supply chains when evaluating environmental performances, initiatives. Selected measures and metrics must be implemented in order to gain the objectives of green supply chain.

2.5.5.1. Metrics

Table 2.9 presents a list of selected metrics of environmental initiatives from sustainable reports of companies and from published journals with an objective of collecting metrics from air emissions to conservation of energy, standards applicable for environment and recycling. A number of studies has focused on proposing metrics like (Ahi & Searcy, 2014; Azevedo et al., 2011; Hassini, Surti, & Searcy, 2012; Hervani et al., 2005; Rha, 2010), but only few has focused on collecting the metrics from the company's reports in which you can collect real metrics from companies green initiatives. So in this study we will propose some new metrics with few important proposed metrics from journals. And if the author has distinguished between social, environments, economic and operational measures then only environmental measures and metrics are used in table 2.9.

Paper/ Report	Measures and Metrics
(Hervani et al., 2005)	Fugitive non-point air emissions on-site and off-site energy recovery, on-site and off-site recycling, on-site or off-site treatment, non-production releases, source reduction activities, spill and leak prevention, inventory control, stack or point air emissions, discharge to receiving streams and water bodies, underground injection on-site, release to land on-site, discharge to publicly owned treatment works, other off-site transfers, raw material modification, cleaning and decreasing, surface preparation and finishing, product modification, pollution prevention opportunity audits, materials balances audits, employee and participative management, publicly available missions and values statement, management system pertaining to social and environmental performances, magnitude and nature of penalties for non-compliance, number, volume and nature of accidental or non-routine releases to land, air and water, costs under applicable laws and regulations, major awards received, total energy use, total electricity used, total fuel used, other energy use, total material use except fuel, total water use, quantity of non-product output returned to process or market by recycling or reuse, major environmental, social, economic impacts associated with the life

	cycle of products and services, formal and written commitments, programs and procedures to prevent or minimize potentially adverse impacts of products and services, procedures to assist product and service designers to create products and services with reduces adverse life cycle impact.
(Ahi & Searcy, 2014)	Quality, air emissions, energy use, greenhouse gas emissions, energy consumption, recycling, solid waste, flexibility, environmental management system, customers satisfaction, carbon footprint, life cycle assessment, profit, cost, water consumption, product characteristics, energy efficiency, environmental costs, market share, reduction of air emissions, reduction of solid waste, return on investment, operational cost, ISO 14001 certification, level of process management, carbon emission, water waste.
(Azevedo et al., 2011)	Three measures emissions, business waste, green image were target in environment parameter. And the metrics are energy consumption, greenhouse gas emissions, air emissions, solid and liquid waste, total flow quantity of scrap, percentage of materials remanufactured, percentage of material recycled or reused returning customers ration, hazardous and toxic material output, amount of waste disposed, number of fairs/symposiums related to environmental conscious manufacturing in which the organization participates.
From reports of all the companies	
UPS	Total weight of waste and recycled, disposal method, total number of emissions , reduction of energy, water and fuel consumption, Supplier environmental assessment, LCA, third party verification, Risk analysis and training, Advanced technology vehicles, alternative fuels, Renewable energy.
FedEx	Greening Fleet and facilities, Reduction of carbon emissions by weight, reduce waste, paper & packaging, total volume of energy and fuel consumption, % of recycled input materials, extent of impact mitigation, disposal method, education and training.
YRCW	Efficiency optimization, emission reduction, recycling, energy conservation, reduce paper use, alternate use of paper, new technology vehicles.
DHL	Climate protection, % of CO_2 efficiency improvement, % of waste reduction, Green freight, air fleet replacement with fuel efficient & quieter models, training, and % increase of renewable energy, supplier assessment & environmental standards compliance.
Atlas Van Lines	Conserving water and energy, alternative fuels, reducing waste Re-purposing oils, high tech fuels, reduce paper use, training.
Penske Logistics	Alternative fuels, reduce use of fuels, training, reduce waste and initiate recycling programs, reduce direct and indirect emissions, high tech vehicles.
Swift Transport	Long life equipment's, Reduce carbon footprints, number of clean fleet used, maximum fuel efficiency vehicles, conserve energy removing fluid waste, refurbishing trailers.
United Van Lines	Reduce use of paper, emission reduction, conserve energy, recycling and reuse.
J. B. Hunt	Empty mile reduction, conserving energy, carbon calculator, supplier ISO 14001 certification, route optimizing, vehicle inspections, engine emission control label, efficient carriers, inter model efficiency training, friendly fuels.
C & K	40% reduction on carbon, reduce empty miles, calculation of fuel, idle time, and driver efficiency metrics, conserve energy, reduce paper use.
DANONE	Reduce CO_2 footprints, water and energy consumption, % of materials used, and energy intensity, improve collection and % of recycling, biomass packaging, sustainable procurement, promote renewable energies, reusing package material & waste water after cleaning, new technology fleet, external auditing, GREEN, LCA.
Kellogg	Reduce energy use, waste sent to landfill greenhouse gas, water use par metric tons, training, recycling, conserving natural resources and packaging of recycled material, sustainable procurement, sustainable packaging, and responsible sourcing.
Molson Coors	Improve energy, water efficiency, reduce GHG intensity, and reduce packaging weight, zero landfill, responsible sourcing & retailing, digital marketing, efficient use of resources (tons).
PepsiCo	Total weight of waste by type & disposal method, % of materials recycled, reduction of GHG, energy consumption, total water withdrawal by source, training, alternative energy sources, turning waste into energy, landfill elimination, water recycling.

Starbucks	Ethical sourcing, reduce water consumption, energy consumption, packaging material, 100% purchasing renewable energy, front-of-store recycling, green building.
Tim Horton's	% reduction in water consumption, packaging material, fleet fuel efficiency, minimizing environmental footprints, GHG emissions, energy and waste, sustainable and ethical supply chain practices, third party verification, waste diversion, green building.
Best Buy	% of energy saved, waste water, solid waste, energy consumption, use renewable energy, total water withdrawal, reduce GHG emissions by weight, mitigate environmental impacts, auditing of suppliers, training, pollution prevention, responsible recycling, waste diversion, energy efficient products.
Loblaw's	% of reduce waste from landfill, stores, and distribution centers, % reduce in water, energy, fuel and food waste, reduce packaging and sustainable packaging, % reduction in non-recyclable packaging, % of increase in fleet efficiency.
Rona Inc.	GHG reduction, waste reduction, source reduction, LCA, recycling and recovery of waste, responsible procurement, reduced paper consumption, eco responsible product offering, eco labels
Canadian Tire	Overall reduction in energy use, GHG, packaging, transportation fuel and energy, waste diversion, water saving by weight, product damage reduction.

Table 2.9: Identified metrics and measures

The main metrics which are used in all the papers and by the companies were found to be Greenhouse gas emissions, recycling, training, reduction of energy, water and fuel consumption.

2.5.6. Impact of green supply chain on performance

On the subject of green supply chain, the table 2.10 has focused on the impact of green supply chain on various performances it can deliver when implemented effectively. Green initiatives are considered to be present when implementing GSC to receive the expected results of various performances.

Author(s)	Year	Journals	Green initiatives	Outcomes	Impact
(Eltayeb et al., 2011)	2011	Resources, Conservation, Recycling	Eco-design, Green Purchasing, Reverse logistics	Environmental, Economic, Operational, Intangible	Significant direct impact on firm's performance and external environment
(Zhu, Sarkis, & Lai, 2007)	2007	Journal of Environmental Management	Internal environmental management, Green purchasing, Customer cooperation, Investment recovery and Eco-Design	Environmental, Economic, operational	GSCM is positively associated with performance improvement, the strength of association may depend upon how long and how well is the implementation.

(Testa & Iraldo, 2010)	2010	Journal of Cleaner Production	EMS adopter, Encourage supplier to adopt environmental measures, Encouraged by corporate image or cost saving strategy, follower strategy or product development strategy.	Environmental, Competitive, Business	Reputation–led/ corporate image strategy is most effective in stimulating GSCM practices. The relationship between EMS and GSCM practices is positive for an organization's environmental performance.
(Rao & Holt, 2005)	2005	International Journal of Operations and Production management	Inbound logistics, Production or internal supply chain, Outbound logistics, Reverse logistics	Economic, Competitivenes s	Greening different phases of the supply chain lead to integrated GSC which lead to economic and competitiveness performances
(Shang, Lu, & Li, 2010)	2010	Journal of Environmental management	Green manufacturing and packaging, environmental participation, green marketing, green suppliers, green stock and green eco-design	Firm performance	Green marketing is the best for corporate image improvement, environmental regulation, market share, sales, customer satisfaction and loyalty.
(Handfield et al., 1997)	1997	Journal of Operations management	Product design, procurement, manufacturing, packaging, logistics and distribution.	Environmental	Environmental management strategies must be integrated in all stages of value chain to get results.
(Zhu, Sarkis, & Lai, 2008)	2008	International Journal of Production Economics	Internal Environmental management, Green Purchasing, Cooperation with Customers including environmental requirements, Eco-design, Investment recovery	Environmental performance, Economic performance and operational performance	All measurement items underlying Internal Environmental management, Green Purchasing, Cooperation with Customers including environmental requirements, Eco-design, Investment recovery are critical to receive all the benefits for GSCM performances.
(Chen et al., 2012)	2010	Organizational Dynamics	Energy conservation, eliminate the need for material, Recycling, Reusing, Reducing, Zero landfill. Integrating green into daily operations	Environmental , Financial benefits	Green is free. The leadership's vision, support and commitment is vital, involvement of front-line workers is essential. All wastes are potential products, green leadership creates hidden advantages ISO 14001 certification and kaizen practices.
(Rao, 2002)	2002	International Journal of Operations and Production management	Environmentally friendly raw material, substitution of environmentally questionable raw material, taking environment criteria into consideration,	Environmental performance, Economic performance, Competitivenes s,	Greening of suppliers is significant. Environmental initiatives are important environment performance and SCEM. Environment performance has link with competitiveness and SCEM but no link with economic

			optimization of process to reduce solid waste, optimization of process to reduce air emissions, optimization of process to reduce noise and use of cleaner technology process to make savings. Greening of suppliers		performance while competitiveness has a link with economic performance.
(Azevedo et al., 2011)	2011	Transportation Research Part E: Logistics and Transportation	Environmental collaboration with suppliers and customers, Encouraging them to adopt environmental friendly behavior, and promoting ISO 14000 certification of suppliers. Developing environmentally friendly products, implementing environmental friendly operations, minimization of waste, obtaining, getting recognition (ISO 14001 certification, green innovation, EMS, TQM), Reverse logistics.	Operational, Economic, Environmental	Reverse logistics, ISO 14001 certification, and minimizing waste are considered to be significant for GSCM.
(G. Wu, Ding, & Chen, 2012)	2012	International Journal of Production Economics	Green purchasing, Cooperation with customers, Eco design, and Investment recovery	Involvement in more environmental practices, competitive advantage.	GSCM practices are positively affected by its drivers except investment recovery. IR is positively affected by organizational support. Market pressure has no impact while competitive pressure has negative impact on GSCM drivers and practices. And regulatory pressure has positive relationship with green practices and drivers.
(Zhu et al., 2010)	2010	Management science and operations	Internal environmental management, Green purchasing, Cooperation with customers, Eco design, and Investment recovery	Environmental, financial, operational	Japanese companies have significant improvements in environmental and financial performances. Companies can green their supply chain by building win-win relationships with customers and suppliers. Regulations and policies are critical for GSCM.

Table 2.10: Impact of GSCM

Figure 2.8 provides the results for the impact of GSCM published in various databases and its distribution of reviewed articles in different journals which covers a wide range of areas. The figure highlights the multidisciplinary approach used in reviewing the impact of GSCM.

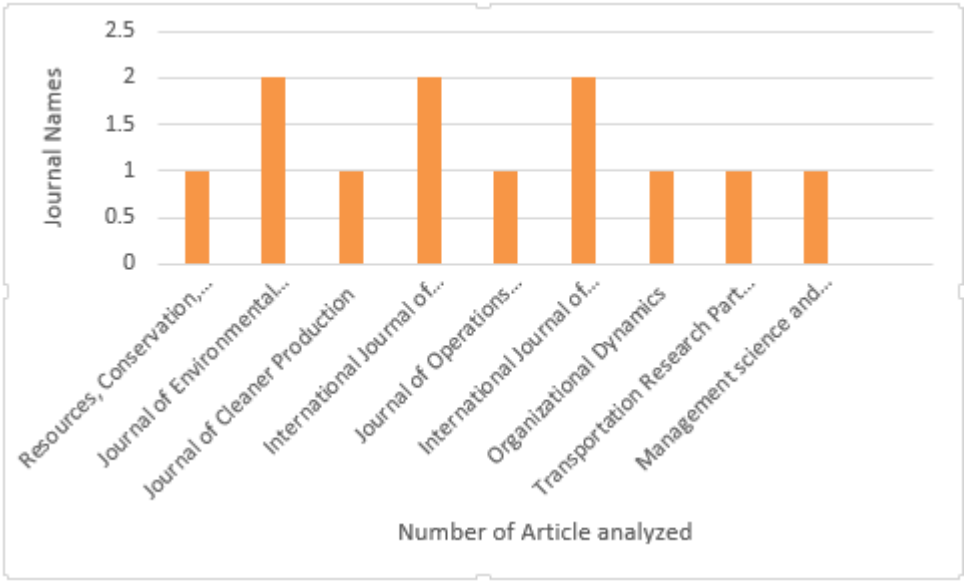

Figure 2.8: Articles analyzed

2.5.7. Modelling techniques for green supply chain

Supply chain can be made green by implementing reverse logistics, green packaging, joint operations, green design, use of computerized systems and technology, motivating and encouraging stakeholders, and implementing green methodologies. So, in different areas of supply chain different techniques are used to make it green. Due to governmental legislations, environmental concerns and customer awareness, more and more companies are taking steps to follow green practices and is becoming important area to study for the forward-thinking companies. Only few techniques have been implemented on green supply chain in order to reduce waste and by products of supply chain the studies that have been done or can be advanced includes AHP/ANP (Chen et al., 2012; Dou, Zhu, &

Sarkis, 2014), Regression (Zhu & Sarkis, 2004), Simulation (New et la., 2010), Game theory (Tian, Govindan, & Zhu, 2014; Zhao et la., 2012), Interpretive Structural Modeling technique (Luthra et., 2011), DEA (Azadi, Shabani, Khodakarami, & Farzipoor Saen, 2014) and Descriptive statistics (based on group surveys (Zailani et al., 2012) interviews (Azevedo et al., 2011) and systematic literature reviews (Ahi & Searcy, 2014). A little is done related to linear programing (Shaw et al., 2012) and non-linear programing. Some other techniques which could be used to replace our existing technique ISO 14001 and QFD are AHP, simulation etc. which are referred in above papers and few are discussed in these papers (Chin, Chiu, & Rao Tummala, 1999; Darnall, Jolley, & Handfield, 2008; Geldermann, Spengler, & Rentz, 2000). QFD is a popularly used technique to improve customer satisfaction but not much can be seen related to green supply chain and QFD.

2.5.8. Justification of techniques

In recent years, there have been studies on application of QFD for sustainable planning (Shang et al., 2010) used QFD and fuzzy logic to integrate the environmental considerations. Another study (Dai & Blackhurst, 2012) used AHP and QFD in sustainability perspective, four phase study for supplier assessment (Zhang, 1999). It used a life cycle approach for environmentally conscious manufacturing by integrating LCA and LCC into QFD matrices to develop a new green QFD II. All these papers used these famous techniques for developing green supply chain but none used rough set-based QFD for developing green supply chain. Another paper used (Yang, Khan, Sadiq, & Amyotte, 2011) rough set theory based QFD is used for environmental performance evaluation which gave an idea to generate rough set-based QFD to develop green supply chain.

In this paper, rough set based QFD and Fuzzy logic based QFD is implemented to determine the key factors for developing the green supply chain in three major areas like top trucking companies, retail sector and food and beverage companies. A rough set theory based QFD was developed to handle the uncertainties in decision makers evaluation and Fuzzy theory was used to handle the inherent imprecision and vagueness of decision- relevant inputs. Fuzzy theory can be used to handle inexact information and linguistic variables in a mathematical way. Another reason to implement QFD is because this methodology is a proven methodology for achieving total customer satisfaction. It is used by abundant companies with excessive success. No study has taken to make the supply chain green but the present study aims to investigate three different fields for study. It is also the first time that QFD is coupled together with rough sets and fuzzy theory to explore green supply chain.

Chapter 3

Solution Approach

The Quality function deployment (QFD) or "House of Quality" is the most commonly used technique to convert customer requirements into specifications for developing innovative ideas in new product and services. In this study, a solution approach based on QFD is proposed for green supply chain planning. The proposed approach of QFD for selecting best initiatives for the green supply chain planning consists of:

1) Identification of customer requirements (HOW's) and technical requirements (WHAT's).
2) Identification of correlations between HOW's and WHAT's.
3) Selecting the highest ranked technical requirement.

Conventional mathematical logic was not able to manipulate the subjective data or vague data in QFD analysis. In this respect, Fuzzy logic and Rough set theory are used in this thesis to deal with the approximations and generate reasonable results from vague and imprecise information. The uncertainties that may arise from four different sources are fuzziness, heterogeneity, fluctuation, and incompleteness. Fuzziness accounts for the imprecise nature or vagueness of the customer's understanding of the customer requirements. Heterogeneity comes from the different viewpoints or tastes of multiple customers. Fluctuation comes with the change of customer requirements and incompleteness comes from the lack of information or limited information. So, heterogeneity and fluctuation in customer requirement was not there in this theis because

we have chosen a mandatory plan from Australian government due to which our customer requirements did not change from company to company. Another reason is that many studies are focusing on various techniques to quantify the vague and uncertain design information. Among these techniques (like MCDM, Robust QFD, grey theory, the fuzzy number and rough set theory), the implemented techniques has received the most attention due to its ability in handling vagueness and uncertainty.

The customer requirements are in general qualitative in nature. For example, requirements for implementing ISO 14001 are provided in qualitative form. For effectively implementing ISO 14001, we need to know what would be the best way to do so (HOW's) and how importantly is it associated (strong, somewhat or weakly associated). First method is Rough set theory which is used to deal with approximating vague descriptions such as (strong, somewhat or weakly associated) by means of the boundary region of a set. The rating done by the decision makers may not be accurate or might be inconsistent so to deal with imprecise descriptions of customer requirements and technical requirements we have used rough set theory. And the second method is fuzzy logic, used to handle the vague description such as Very Low, Low, Medium, High or Very High important which is converted into crisp number. And to transform into a crisp number we use the fuzzy triangular number. This method is very useful for solving the uncertain data collected from group decision makers. Therefore, both the techniques are able to tolerate and handle ambiguities that are used in QFD.

3.1. Checklist

The checklist in table 3.1 includes a series of questions emphasizing on the key elements that are essential to implement ISO 14001. All the companies can focus on the

information provided in each question in the checklist to comply with the standard and to align their certification (*Australian government ICT sustainability plan 2010-2015.*2011) . In thesis, we will use this checklist as a standard customer requirement for all the companies, no matter in which field it belongs so as to identify the activities or issues that must be implemented to reach favorable outcomes.

Company Name:		
Period:	**Title of Report:**	
ISO 14001 Checklist		**Addressed (Yes/No/NA)**
1. General requirements: **a) Is the scope clearly defined, documented, maintained with all the environmental aspects included or excluded?** **b) Are the requirements contained in ISO 14001 established and maintained by the company?**		
2. Environmental Policy: **a) Is the company having Environment policy?** **b) Is it sanctioned by top management?** **c) Is it publicly available?** **d) Is it communicated to all employees?** **e) Is the environmental policy:** **I. Relevant to the scope?** **II. Appropriate to the nature and scale of the company** **f) Is it committed to:** **I. Continual improvement?** **II. Prevention of pollution?** **III. Laws and regulations**		
3. Environmental aspects, impacts and legal obligations: **a) Has a procedure been established, implemented and maintained to identify the environmental aspects of its current and relevant past activities?** **b) Has the company established procedures:** **I. To identify laws, regulations and other requirements relevant to the organizations environmental aspects, document them and keep it up to date?** **II. To identify the potential for and respond to accidents and emergencies?** **III. To prevent and mitigate impacts of accidents and emergencies.**		
4. Objectives, Targets and Programs: **a) Are they established at each relevant function and level in the organization?** **b) Are they documented?** **c) Did the company taken into account the significant environmental aspects, legal, business requirements, and adequate technology** **d) Did the company established, implemented programs with responsibilities at each level, time frames and the means to achieve its objectives and targets.**		

5. A Documented System: **a) Document has:** **I. Has environmental policy, objectives, targets, scope?** **II. The description and interaction of main elements with their references.** **III. Documents and records for effective planning, operation and control of activities linked with its environmental aspects** **b) Has the procedures documented and implemented for controlling ISO 14001 documents to ensure that they are up to date, accurate, and easily accessible with different versions and maintenance of archives of old version and external documents?**	
6. Roles, Accountability and Responsibility: **a) Has the responsibilities and authorities for EMS been defined, documented and communicated?** **b) Are the required resources provided for implementation, maintain, control and improvement of EMS?** **c) Identified personnel to report the EMS function and performance to top management?**	
7. Awareness, training and Communication: **a) Communicate the environmental policy with all employees?** **b) Informed all roles and responsibilities to the employees?** **c) Identify general EMS awareness/training needs for all employees and managers and ensure that employees involved in work that contributes to significant environmental aspects are trained?** **d) Communicate relevant requirements to suppliers, contractors and other external stakeholders regarding significant environmental aspects?**	
8. Monitoring, Measurement and Reporting: **a) Are documented procedures established, implemented and maintained to periodically evaluate compliance with environmental legislation and other requirements?** **b) Has the procedure been documented and implemented to monitor , measure and report:** **I. Significant environmental aspects and impacts, operational controls and performance toward objectives and targets?** **II. EMS non conformances and corrective and preventative actions?** **III. The planning and undertaking of internal audits, assessments or inspections, as well as selection of auditors and training?**	
9. Management Review: **a) Do periodic review take place for ensuring of proper structure, performance and effectiveness?** **b) Do the management review:** **I. Identify and document opportunities for improvements and changes to the EMS?** **II. Consider the effectiveness of actions and recommendations resulting from prior management review.**	
10. Assessment Outcome	

Table 3.1: Checklist for ISO 14001

3.2. Rough Set Theory

Rough set theory (Yang et al., 2011) is a mathematical approach to generate reasonable solutions from vague or imprecise information. In this mathematical approach, a boundary region is used to express imprecise information with (U, R) as approximation space, where U is the universe of finite set of objects and R is an Equivalence relation on U.

Let X be a subset of U, i.e. $X \subseteq U$. By the relation $R \subseteq U \times U$, we mean the relation R is an indiscernibility relation which means that we lack a knowledge about the universe U and by $R(C_i)$, we denote the equivalence class of R is known by element C_i. The equivalence relation R represents an elementary portion of knowledge so we are not able to observe individual objects from U only some knowledge is described by this relation.

- The lower approximation consists of a set of all objects that are certainly (probability = 1) identified as members of set X with respect to R.
- The upper approximation consists of a set of all objects that are possible (probability = nonzero) identified as members of set X with respect to R.
- The boundary region consists of members that can neither be ruled in nor be ruled out as members of set X with respect to R.

Now, if a boundary region of a set is non-empty then it implies that the knowledge about the set is inexact or rough. So, X in this case is known as Rough set with respect to R.

And if the boundary region of a set is empty then a set X is known as crisp or exact with respect to R. Thus C_i can be represented by a rough number (RN) with Lower limit

$\underline{Lim}\ (C_i) = 1/\ M_L \sum R(Y) \mid Y \in \underline{Apr}\ C_i$

And Upper limit, $\bar{Lim}(C_i) = 1/M_U \sum R(Y) \mid Y \in \overline{Apr}\, C_i$,

Where Y is arbitrary object of U, M_L is the number of objects contained in the lower approximations of C_i, M_U is the number of objects contained in the upper approximations of C_i $\underline{Apr}\ C_i = \cup \{Y \in U/R(Y) \leq C_i\}$ and $\overline{Apr}\ C_i = \cup \{Y \in U/R(Y) \geq C_i\}$. The interval between the lower limit $\underline{Lim}\ (C_i)$ and the upper limit $\bar{Lim}\ (C_i)$ is the rough boundary interval of C_i which is denoted as:

$RBnd\ (C_i) = \bar{Lim}\ (C_i) - \underline{Lim}\ (C_i)$,

Therefore, the rough number will be denoted as follows:

$RN\ (C_i) = [\underline{Lim}\ (C_i), \bar{Lim}\ (C_i)]$

3.3. Fuzzy Logic

When the decision makers are at the point of making the decision, they often face the problems of doubts, vagueness and uncertainties. To muddle through such kind of problems of uncertainties and inaccurate information, we resort to fuzzy logics (Awasthi, Noshad, & Chauhan, 2014). The fuzzy logic is suitable for uncertain or appropriate reasoning and its interpretation is easy and simple. There are various types of fuzzy numbers, but in this paper we use triangular fuzzy numbers. And to transform fuzzy number into crisp number we use the following equations:

$\alpha = \min(\alpha 1, \alpha 2, \alpha 3)$; $\beta = \text{average}(\beta 1+\beta 2+\beta 3)/3$; $\gamma = \max(\gamma 1, \gamma 2, \gamma 3)$

$a = (a_1+a_2+a_3)/3$

For example, for a fuzzy triangular number $DM_1 = (9, 9, 9)$, $DM_2 = (7, 9, 9)$, $DM_3 = (5, 7, 7)$, the crisp output is

$\alpha = 5$; $\beta = 25/3 = 8.34$; $\gamma = 9$

$a = 22.34/3 = 7.45$

Let the rating used in QFD be a set U = {VL, L, M, H, VH} be a linguistic set used to express opinions in relationship matrix with VL= very low, L= low, M = medium, H= High, and VH= very high. We use VH = very high, M= medium scale for correlation table and for negative correlation, values will be negative but scale will be same. Table 3.2 demonstrates the various linguistic ratings, Fuzzy triangular numbers used for QFD and their associated crisp values (Awasthi et al., 2014) are calculated using the above equation:

Linguistic Rating	**Fuzzy triangular number**	**Crisp number**
Very low (VL)	(1, 1, 3)	1.67
Low (L)	(1, 3, 5)	3
Medium (M)	(3, 5, 7)	5
High (H)	(5, 7, 9)	7
Very High (VH)	(7, 9, 9)	8.34

Table 3.2: Linguistic ratings and crisp values

What are linguistics variables?

The linguistic variables are the words used by the experts in expressing what they perceive. For example, expressing the relationship very important or expressing the correlation in HOW's strong relationship. Often, these terms are misleading, imprecise and vague. So, it appropriate to treat them as fuzzy rather than precise. Fuzzy set theory is designed to deal with such vague, subjective and imprecise information termed as linguistic variables.

3.4. QFD

The QFD or House of Quality (Evans & Lindsay, 2005; Foster, 2010; Yang et al., 2011) is used to convert the customer's need into technical specifications**.** The customer requirements (also known as voice of customer) is the primary input to the QFD process and the translation of customer requirements" what customer wants" into technical requirements "how the company will give" helps the top management to stimulate new ideas. Building the house of quality consists of six steps:

1) Identify customer requirements
2) Identify technical requirements
3) Relationship between the customer requirements and technical requirements
4) Conduct an evaluation of competing products and services
5) Evaluate technical requirements and develop targets
6) Determine which technical requirements to set up

A set of six matrixes is used to relate the voice of customer with the technical requirements. And these six steps will be repeated with different approaches namely rough set theory and fuzzy logic one by one in the next chapter.

1) Identify customer requirements

The first matrix or room is the primary matrix for the input into QFD the voice of customer. The techniques used in this paper to collect customer demands are voice of customer and checklist for assessing their green initiatives. Importance rating of each customer requirement is also added in this matrix with 1-10 rating (With 10 as most important and 1 as least important). The highest rating requirements are known as critical

to quality parameters (CTQ CRs).These CTQs are named as C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9 and C_{10} and due to long sentences they can be referred to checklist table 3.1.

2) Identify technical requirements

Second matrix or room contains the technical requirements which are actually the customer requirements but expressed in terms of engineer's language. Technical requirements are referred as HOW's and they must be measurable and customer requirements are referred as WHAT's. And in this thesis HOW's are named as T_1, T_2, T_3, T_4, T_5, T_6, T_7, and T_8. These are the technical requirement which are referred to green initiatives taken by the companies. These are listed in table 3.5, table 3.7, table 3.9 and tables in appendix. As we have taken one example to explain, so we can refer to table 3.5 of technical requirement for J. B. Hunt. On the top of the roof of QFD is the correlation matrix which shows the degree of interdependence among the technical requirements. Again, we will be using 9 as strong positive correlation, 3 as positive correlation, -3 as negative correlation, and -9 as strong negative correlation or some symbols (○ for + 3, ● for + 9, *for -9, × is for -3) can also be used to denote the relationship according very strong, strong, weak, etc.

3) Relationship between the customer requirements and technical requirements

Third room or matrix is the relationship matrix which shows whether how much the technical requirement adequately address the customer requirements. This assessment is based on expert experience, customer responses or controlled experiments. It uses values varies from 1 - weak association, 3 - somewhat associated, 9 - strongly associated and a missing value indicate that the decision maker is unable to select a suitable value. As we

are using a rough set theory with QFD to handle vague descriptions, uncertain values and inconsistency in QFD analysis. So, we will be using 1 at a time 9 another time for missing values to calculate the lower approximations and upper approximations in case of any missing value.

4) Conduct an evaluation of competing products and services

This step identifies importance rating for all the customer requirements and helps in evaluating competitors' products or services but in this paper this is excluded because we are not doing benchmarking.

5) Evaluate technical requirements and develop targets

Fifth matrix or room will be for the importance ranking of technical requirements that are of critical importance to satisfy the customer requirements. It consists of absolute importance, relative importance and rank order of technical requirements. Generally absolute importance is calculated by first multiplying the numerical value in each of the cells of the relationship matrix by the associated CR's importance rating. Then, we sum up column wise to give the importance absolute rating. For Relative Importance Rating we normalized on a scale from 1 to 0 and expressed as a percentage of 100. For this we sum up all the absolute importance rating and then we take the absolute number and divide by the sum (total of all absolute importance rating), multiplying by 100. Lastly we order the technical requirement from highest ranking to lowest by ranking from 1 to n (n is the number of HOW's).

6) Determine which technical requirements to set up

The relative weight and the absolute weight are evaluated for the technical requirements to reach at the end decision for deciding improvement. This is done by calculating relative ranking or a percentage weight factor.

3.4.1. Identifying customer needs

The techniques used for determining the needs of the customer are Brainstorming, own experience, focus on groups, checklists voice of customer, websites, published papers and sustainability reports of companies from their websites.

3.4.2. Voice of the customer (VOC)

VOC (Emmett & Sood, 2010) specifies the detailed set of customer wants and needs. They are generally collected at the start of the process to better understand the customer demands**.** In this thesis, the customer will be the company who is seeking to take steps for becoming "green" or its stakeholders who want to reduce the waste and hazardous emissions throughout the supply chain. The customer preferences for use in QFD for VOC s are hypothetical in this thesis. Our focus will be to make traditional supply chain into green supply chain to improve various performances of the company.

1) Proper planning for purchasing, specifications, and purchase orders.
2) Identify opportunities to purchase green products and services.
3) Need to create a list of green products and specifications.
4) Need for gaining knowledge of green products and services.
5) Preferring to buy raw materials from ISO certified suppliers or with eco- labeled raw material.

6) Initiatives to reduce supplier waste and surpluses.

7) Need of support and commitment from management.

8) Participation of employees in green programs.

9) Selecting Green purchasing team

10) Need to communicate the environmental requirements for raw material with suppliers.

11) Need to communicate greening strategies and decisions among employees and stakeholders.

12) Considering environmental issues before designing to reduce environmental impact.

13) Need to know about the end- results of purchasing before actual procurement of raw material.

14) Minimal usage of raw material.

15) Easy availability of green products and services.

16) Easier compliance with government regulations.

17) Providing environmental friendly packages.

18) Reduce package material.

19) Identify various alternatives of packaging.

20) Identify various methods of transportation of raw materials and disposable materials.

21) Right disposal methods for hazardous material.

22) Efforts to create new, innovative products and services with reduced environmental impacts.

23) Improved image, brand and goodwill.

3.4.3. Customer Requirements and Technical Requirements

Customer requirements will fall under the following requirements of the checklist of ISO 14001 that will help to make the supply chain into green supply chain. Sustainability reports of various companies have been reviewed, analyzed and technical requirements are listed from them. The top companies are selected on the basis of three sectors trucking, food and beverage sector and retail sector. The technical requirements are collected from the sustainability reports according to the processes and initiatives that are taken by the company towards green supply chain and the customer requirements are collected according to the checklist of ISO 14001.

3.5. Corporate reports data for identifying GSCM requirements

Table 3.3 summarizes the data collected from companies. Some of the company's reports are prepared in accordance to the guidelines of global reporting initiatives. Global reporting initiatives frameworks help these companies to assess their economic, social, and environmental impacts and performances better. Therefore, we used their environmental framework from GRI to collect information, initiatives and indicators, if available. Few papers were studied on how to summarize the corporate reports like (Delai & Takahashi, 2013; Roca & Searcy, 2012; Turker & Altuntas, 2014)

Firm	Title of Report	Period	Certification	Indicators of GSCM
UPS	Sustainability Report	2013	ISO 14001, EPA SmartWay Program	Total weight of waste and recycled, disposal method, total number of emissions , reduction of energy, water and fuel consumption, Supplier environmental assessment, LCA, third party verification, Risk analysis and training, Advanced technology vehicles, alternative fuels, Renewable energy.
FedEx	Global Citizenship report	2013, 2012	ISO 14001	Greening Fleet and facilities, Reduction of carbon emissions by weight, reduce waste, paper & packaging, total volume of energy and fuel consumption, % of recycled input materials, extent of impact mitigation, disposal method, education and training.
YRCW	Annual Report	2013	ISO 9001: 2008, SmartWay Transport program	Efficiency optimization, emission reduction, recycling, energy conservation, reduce paper use, alternate use of paper, new technology vehicles.
DHL	Corporate Responsibility Report	2013	ISO 14001, ISO 13485, ISO 9001	Climate protection, % of CO_2 efficiency improvement, % of waste reduction, Green freight, air fleet replacement with fuel efficient & quieter models, training, and % increase of renewable energy, supplier assessment & environmental standards compliance.
Atlas Van Lines	Amplifier Uninterrupted Leadership	Not Available	ISO 14001,	Conserving water and energy, alternative fuels, reducing waste Re-purposing oils, high tech fuels, reduce paper use, training.
Penske Logistics	3PL CEO Sustainability	2010	SmartWay Transport, EPA Green Power Partner	Alternative fuels, reduce use of fuels, training, reduce waste and initiate recycling programs, reduce direct and indirect emissions, high tech vehicles.
Swift Transport	Corporate Responsibility		Six Sigma Lean Initiatives, SmartWay Partner	Long life equipment's, Reduce carbon footprints, number of clean fleet used, maximum fuel efficiency vehicles, conserve energy removing fluid waste, refurbishing trailers.
United Van Lines	Sustainability Report	2013	ISO 9001: 2008, SmartWay Partner	Reduce use of paper, emission reduction, conserve energy, recycling and reuse.
J. B. Hunt	Sustainability Innovations		SmartWay transport Partner, Supplier ISO certification	Empty mile reduction, conserving energy, carbon calculator, supplier ISO 14001 certification, route optimizing, vehicle inspections, engine emission control label, efficient carriers, inter model efficiency training, friendly fuels.
C & K	Environmental Report	2011	SmartWay transport partnership	40% reduction on carbon, reduce empty miles, calculation of fuel, idle time, and driver efficiency metrics, conserve energy, reduce paper use.
DANONE	Sustainability Report	2013	ISO 22000:2005, ISO 9001 and ISO 14001	Reduce CO_2 footprints, water and energy consumption, % of materials used, and energy intensity, improve collection and % of recycling, biomass packaging, sustainable procurement, promote renewable energies, reusing package material & waste water after cleaning, new

				technology fleet, external auditing, GREEN, LCA.
Kellogg	Corporate Report	2013, 2012	ISO 14001, OHSAS 18001	Reduce energy use, waste sent to landfill greenhouse gas, water use par metric tons, training, recycling, conserving natural resources and packaging of recycled material, sustainable procurement, sustainable packaging, and responsible sourcing.
Molson Coors	Sustainability Report	2014	ISO 14001	Improve energy, water efficiency, reduce GHG intensity, and reduce packaging weight, zero landfill, responsible sourcing & retailing, digital marketing, efficient use of resources (tons).
PepsiCo	Environmental Sustainability	2013	ISO 14001:2004, SmartWay Partnership, LEED	Total weight of waste by type & disposal method, % of materials recycled, reduction of GHG, energy consumption, total water withdrawal by source, training, alternative energy sources, turning waste into energy, landfill elimination, water recycling.
Starbucks	Global Responsibility Goal & progress	2013	ISO 14001	Ethical sourcing, reduce water consumption, energy consumption, packaging material, 100% purchasing renewable energy, front-of-store recycling, green building.
Tim Horton's	Corporate Responsibility	2013	LEED	% reduction in water consumption, packaging material, fleet fuel efficiency, minimizing environmental footprints, GHG emissions, energy and waste, sustainable and ethical supply chain practices, third party verification, waste diversion, green building.
Best Buy	Corporate Environment and Sustainability	2014	ISO 14001	% of energy saved, waste water, solid waste, energy consumption, use renewable energy, total water withdrawal, reduce GHG emissions by weight, mitigate environmental impacts, auditing of suppliers, training, pollution prevention, responsible recycling, waste diversion, energy efficient products.
Loblaw's	Corporate Social Responsibility	2013	Aquaculture Stewardship Council	% of reduce waste from landfill, stores, and distribution centers, % reduce in water, energy, fuel and food waste, reduce packaging and sustainable packaging, % reduction in non- recyclable packaging, % of increase in fleet efficiency.
Rona Inc.	Sustainable development Report	2013	LEED	GHG reduction, waste reduction, source reduction, LCA, recycling and recovery of waste, responsible procurement, reduced paper consumption, eco responsible product offering, eco labels
Canadian Tire	Business sustainability Corporate and Supply Chain	2014, 2013	ISO 9001:2000, ISO 14001	Overall reduction in energy use, GHG, packaging, transportation fuel and energy, waste diversion, water saving by weight, product damage reduction.

Table 3.3: Corporate Summary

It was desirable to investigate which companies have implemented which certification or standard to reduce their environmental impact. Therefore figure 3.1 gives a clear view

about the information that which certification has more impact or we can say that which standard was more used by the companies.

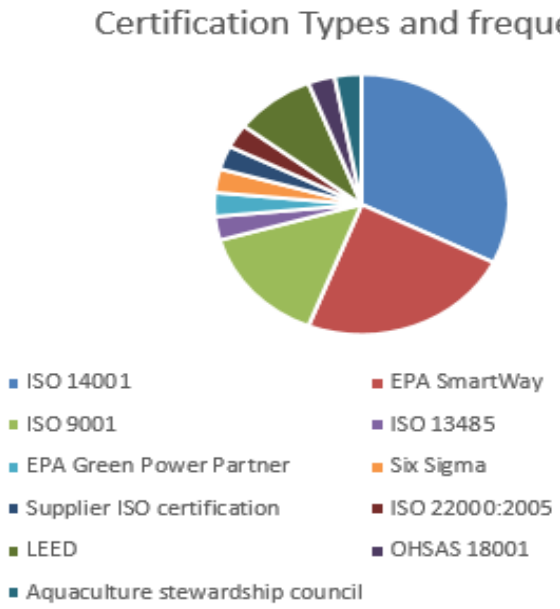

Figure 3.1: Different certifications by various companies

3.6. Top trucking companies

Many trucking companies have started going green and Green chip stock website (Lesser, 2012) articles are written by Shawn Lesser. He writes various published articles related to cleantech and are known as “top 10” series.

3.6.1. Identifying Customer requirements for trucking companies

Identifying customer requirements is the first step in the process of QFD which was explained above and now we are applying it on the companies selected. These customer requirements are collected according to the format of the checklist provided in table 3.1. Here 1-a), 1-b), 2-a)….so on are referred to each question in the checklist. And to construct table 3.4, data is extracted from all the companies report’s according to the

green initiatives they took and according to what the checklist requires. In the table 3.4 "Yes" means it was available, "NA" means it was not available or missing information, and "NO" means it didn't took that initiative. Only the green initiatives were used while constructing technical requirements and social issues were ignored.

This step will be used common for both rough set theory and fuzzy logic technique.

Checklist (Refer to points from checklist)	Top trucking companies Addressed(Yes/No/NA)									
	UPS	FedEx	YRC Worldwide	DHL	Atlas Van Lines	Penske Logistics	Swift transportation	United Van Lines	J.B Hunt	C& k
1-a)	Yes	Yes	No	Yes	No	No	No	Yes	No	No
1-b)	Yes	Yes	No	Yes	Yes	No	No	No	No	No
2-a)	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
2-b)	Yes	Yes	No	Yes	NA	No	No	Yes	No	No
2-c)	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
2-d)	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
2-e)-I	Yes	Yes	No	Yes	NA	No	No	Yes	No	No
2-e)-II	Yes	Yes	No	Yes	NA	No	No	Yes	No	No
2-f)-I	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
2-f)-II	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
2-f)-III	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
3-a)	Yes	Yes	No	Yes	No	No	No	No	No	No
3-b)-I	Yes	Yes	No	Yes	NA	No	No	Yes	No	No
3-b)-II	Yes	Yes	No	Yes	NA	No	No	Yes	No	No
3-b)-III	Yes	Yes	No	Yes	NA	No	No	No	No	No
4-a)	Yes	Yes	No	Yes	NA	No	No	NA	No	No
4-b)	Yes	Yes	No	Yes	No	No	No	Yes	No	No
4-c)	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
4-d)	Yes	Yes	No	Yes	NA	No	No	NA	No	No

5-a)-I	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
5-a)-II	**NA**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**No**	**No**	**No**
5-a)-III	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**No**	**No**	**No**
5-b)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**No**	**No**	**No**
6-a)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
6-b)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
6-c)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**NA**	**No**	**No**
7-a)	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**No**	**No**	**Yes**	**No**	**No**
7-b)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**NA**	**No**	**No**
7-c)	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**No**	**No**	**Yes**	**No**	**No**
7-d)	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**No**	**No**	**NA**	**No**	**No**
8-a)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
8-b)-I	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**NA**	**No**	**No**
8-b)-II	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
8-b)-III	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**NA**	**No**	**No**
9-a)	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
9-b)-I	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**
9-b)-II	**Yes**	**Yes**	**No**	**Yes**	**NA**	**No**	**No**	**NA**	**No**	**No**
10)	**Yes**	**Yes**	**NA**	**Yes**	**NA**	**No**	**No**	**Yes**	**No**	**No**

Table 3.4: Checklist of ISO 14001 for top trucking companies

3.6.2. Identifying Technical requirements for top trucking companies

Identifying technical requirements was the second step of QFD explained in earlier chapter. Technical requirements are collected from the sustainability, environmental or annual reports of all the companies. And are placed in QFD as the same numeric order as T_1, T_2, T_3 so on until we have the technical requirements for each company because of the length of the technical requirements. As we have taken one example as illustration, so

we can refer to table 3.5 for the technical requirements. And the eight technical requirement that are listed in the table are marked as T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8. Each company's green initiatives were turned into technical requirements in terms of engineer's language. This step will be used common for techniques namely rough set theory and fuzzy logic.

J.B. Hunt transport Services

Data is collected from the website (J.B.Hunt) and is presented in table 3.5 as technical requirements.

S.No	Technical Requirements
1.	Increasing fuel efficiency by reducing empty miles between each delivery pulled, Reducing idling of tractor engine, Governing speeds, Training to drivers, new tire technology, using latest technologies for fleets fuel efficiency, RFID to bypass certain en-route stops, and safety performances
2.	Designing best route by route optimizing to save fuel, reduce GHG emissions
3.	Usage of alternative fuels when possible by burning bio diesel fuels
4.	Conserving energy by utilizing radio frequency identification methods like toll booths.
5.	Partnership with EPA SmartWay to reduce emissions in transport
6.	Encourage suppliers to improve environment performance
7.	Reducing carbon emission by using of Intermodal shipments
8.	Suppliers ISO14001 certification

Table 3.5: Technical requirements for J. B. Hunt Transport services

3.7. Food and Beverage companies

Food and beverage companies started focusing on making their supply chain green due to many drivers or pressures faced by the companies. Maclean has listed 50 socially responsible companies and in which food and beverage sector is focused. (Geddes et al., 2014)

3.7.1. Identifying Customer Requirements for food and beverage companies

Identifying customer requirements is the first step in the process of QFD which was explained above and in this chapter we are applying it on the companies selected. The customer requirements are collected from all the companies' reports and Global report index, if it was available. Then the format of the checklist provided in table 3.1. Here 1-a), 1-b), 2-a)….so on is referred for each question and is entered in the checklist given in table 3.6. Data is arranged according to the green initiatives these company's took and according to what the question in the checklist is demanding. In the table 3.6 "Yes" means it was available, "NA" means it was not available or missing information, and "NO" means it didn't took that initiative. This step will be used common for all the techniques namely rough set theory and fuzzy logic.

Checklist (Refer to points from checklist)	Food and Beverage Companies					
	DANONE	Kellogg	Molson Coors	PepsiCo	Starbucks	Tim Horton's
1-a)	Yes	Yes	Yes	Yes	Yes	Yes
1-b)	Yes	Yes	Yes	Yes	Yes	No
2-a)	Yes	Yes	Yes	Yes	Yes	No
2-b)	Yes	Yes	Yes	NA	NA	Yes
2-c)	Yes	Yes	Yes	Yes	No	Yes
2-d)	Yes	Yes	Yes	Yes	Yes	Yes
2-e)-I	Yes	Yes	Yes	Yes	Yes	Yes
2-e)-II	Yes	Yes	Yes	Yes	Yes	Yes
2-f)-I	Yes	Yes	Yes	Yes	Yes	Yes
2-f)-II	Yes	Yes	Yes	Yes	Yes	Yes
2-f)-III	Yes	Yes	Yes	Yes	Yes	Yes

3-a)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
3-b)-I	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
3-b)-II	**Yes**	**Yes**	**Yes**	**Yes**	**NA**	**NA**
3-b)-III	**Yes**	**Yes**	**Yes**	**Yes**	**NA**	**NA**
4-a)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**NA**
4-b)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
4-c)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
4-d)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
5-a)-I	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
5-a)-II	**Yes**	**Yes**	**Yes**	**NA**	**NA**	**NA**
5-a)-III	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
5-b)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**NA**
6-a)	**Yes**	**Yes**	**Yes**	**NA**	**Yes**	**Yes**
6-b)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
6-c)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**NA**
7-a)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**NA**
7-b)	**Yes**	**Yes**	**NA**	**NA**	**Yes**	**NA**
7-c)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
7-d)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
8-a)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
8-b)-I	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
8-b)-II	**Yes**	**Yes**	**Yes**	**Yes**	**NA**	**NA**
8-b)-III	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
9-a)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
9-b)-I	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
9-b)-II	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
10)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Table 3.6: Checklist of ISO 14001 for food and beverage companies

3.7.2. Identifying Technical Requirements for food and beverage companies

Identifying technical requirements was the second step in QFD as explained above. Technical requirements are identified for three sectors. For food and beverage sector, they are collected from the sustainability or environmental reports and GRI of all the companies, if it was available. All companies green initiatives were turned into technical requirements in terms of engineer's language and social issues that were related to green initiatives were ignored. Technical requirements are then used in QFD as the same numeric order as T_1, T_2, T_3 so on until we have the technical requirements for each company. This step will be used common for all the techniques namely rough set theory and fuzzy logic.

DANONE

Data is collected from the sustainability report which also contains GRI indicators (Danone, 2013). The green initiatives are turned into technical requirements into the language of designers to draw QFD which are presented in table 3.7.

S,No	Technical Requirements
1.	Engagement of employees in environment issues
2.	Sourcing of raw materials in a sustainable way
3.	Waste management and recycling by using 100% recycled paper for packaging, initiatives to develop plastic from biomass, engage consumers to reduce waste, providing guidelines for water wastage
4.	Reducing greenhouse gas emission and uncoupling from volume growth
5.	Conservation of water throughout life cycle of product- recycling and reusing of water, four way approach to measure footprints in a water cycle approach, protect, reduce consumption and waste by implementing corporate standards, monitor
6.	Developing and deploying a measurement tool which is then integrated into the existing information system with SAP to measure carbon footprint for entire life cycle of product.
7.	Initiatives to mitigate environmental impact of products and services, and extent of impact mitigation.
8.	Promoting renewable energies and reducing energy intensity by installing biomass burner and supporting natural refrigerants refrigerators, using thermal energy and even purchasing of energy from 100% renewable sources.

9.	Transforming waste into a resource, using material made from sustainable resources and percentage of material used that are recycled
10.	Reduce packaging by Optimizing the weight of packaging material
11.	Commitment with agriculture sector players to promote and encourage sustainable agriculture.
12.	Initiatives to increase the percentage and total volume of water recycled and reused
13.	Working with other companies to encourage sustainable milk production
14.	Involvement of panel of experts and external stakeholders to define its long term goals, road map and organize its strategic thinking.
15.	Training to employees to raise awareness.
16.	Releasing Environment Guideline to guide environment claims for encouraging responsible communication.
17.	Analyzing current documentation to identify and resolve issues related to environment.
18.	Sharing of issues with stakeholders.
19.	Ranking the issues on based of importance and impacts and then assessing in accordance to different criteria's like company reputation, employee's satisfaction, regulatory and financial impacts, environmental impact etc.
20.	Transparent and consistent environment guidelines for guidance to subsidiaries
21.	Integrate sustainable strategic priorities into new acquired subsidiaries.
22.	Seek areas of improvement through comparison and motivating them through awards
23.	Deployment of GREEN program
24.	ISO 14001 certification
25.	Internal audit programs to check their compliance with standards.
26.	Packaging in accordance with eco- design principles.
27.	Reducing energy intensity, optimizing resources, supplier involvement.
28.	Reducing environmental impact from transport
29.	Product life cycle analysis.

Table 3.7: Technical requirements for DANONE Company

3.8. Retail Sector

The retail sector accounts for 50 to 55 percent of Canadian household consumption which makes it essential to do research on this area. Maclean has listed 50 socially responsible companies from which retail sector is focused.

3.8.1. Identifying Customer Requirements for retail companies

Identifying customer requirements is the first step in the process of QFD which was explained above and in this chapter we are applying it on the companies selected. The customer requirements are collected from all the companies' reports and Global report index, if it was available. And to construct a table 3.8 of customer requirements, we have

used the ISO checklist as a reference and companies are selected from the website (Geddes et al., 2014) and the details about green initiatives of these companies are reviewed and are entered into the table 3.8 according to the format of table 3.1 with each set of question was taken into justification. In this table "Yes" means it was available, "NA" means it was not available or missing information, and "NO" means it didn't took that initiative. This step will be used common for all the techniques namely rough set theory and fuzzy logic.

Checklist (Refer to pints from checklist)	**Retail companies**			
	Best Buy	**Loblaw's**	**Rona Inc.**	**Canadian Tire**
1-a)	**Yes**	**Yes**	**No**	**Yes**
1-b)	**Yes**	**No**	**No**	**Yes**
2-a)	**Yes**	**NA**	**Yes**	**Yes**
2-b)	**Yes**	**Yes**	**Yes**	**Yes**
2-c)	**Yes**	**NA**	**Yes**	**Yes**
2-d)	**Yes**	**Yes**	**Yes**	**Yes**
2-e)-I	**Yes**	**NA**	**NA**	**Yes**
2-e)-II	**Yes**	**NA**	**Yes**	**Yes**
2-f)-I	**Yes**	**Yes**	**Yes**	**Yes**
2-f)-II	**Yes**	**Yes**	**Yes**	**Yes**
2-f)-III	**Yes**	**Yes**	**Yes**	**Yes**
3-a)	**Yes**	**Yes**	**Yes**	**Yes**
3-b)-I	**Yes**	**Yes**	**Yes**	**Yes**
3-b)-II	**Yes**	**Yes**	**NA**	**NA**
3-b)-III	**Yes**	**Yes**	**NA**	**NA**
4-a)	**Yes**	**Yes**	**NA**	**NA**
4-b)	**Yes**	**Yes**	**NA**	**Yes**
4-c)	**Yes**	**Yes**	**NA**	**Yes**

4-d)	Yes	Yes	NA	Yes
5-a)-I	Yes	NA	NA	Yes
5-a)-II	Yes	NA	NA	Yes
5-a)-III	Yes	Na	NA	Yes
5-b)	Yes	Yes	NA	Yes
6-a)	Yes	NA	NA	Yes
6-b)	Yes	NA	NA	Yes
6-c)	Yes	NA	Yes	Yes
7-a)	Yes	NA	Yes	NA
7-b)	Yes	Yes	Yes	NA
7-c)	Yes	Yes	Yes	NA
7-d)	Yes	Yes	Yes	Yes
8-a)	Yes	Yes	NA	Yes
8-b)-I	Yes	Yes	Yes	Yes
8-b)-II	Yes	NA	Yes	NA
8-b)-III	Yes	Yes	Yes	Yes
9-a)	Yes	Yes	Yes	Yes
9-b)-I	Yes	Yes	Yes	Yes
9-b)-II	Yes	Yes	Yes	Yes
10)	Yes	Yes	Yes	Yes

Table 3.8: Checklist of ISO 14001 for retail companies

3.8.2. Identifying Technical Requirements for retail companies

Identifying technical requirements is the second step in the process of QFD which was explained earlier. Technical requirements are collected from the sustainability or environmental reports and GRI of all the companies of retail sector, if it was available. All companies green initiatives were turned into technical requirements in terms of

engineer's language and social issues that were related to green initiatives were ignored. Technical requirements are then used in QFD as the same numeric order as T_1, T_2, T_3 so on until we have the technical requirements for each company. All the technical requirements are collected in different tables for each company listed in Retail Company's list. This step will be used common for the techniques namely rough set theory and fuzzy logic.

Best Buy Co. Inc.

Data is collected from the report of Best Buy and GRI index of environment was also used to configure the technical requirements in table 3.9 from the green initiatives of Best Buy (Best Buy, 2014).

S.No	Technical Requirements
1.	Partnership with Environmental Protection Agency SmartWay and Green power partnership
2.	Engagement of stakeholder in achieving environment goals.
3.	Offering selection for energy efficient products to help customers save energy.
4.	Reducing green gas emission by using smaller vehicles when possible, Efficient routing system, ENERGY STAR certification of products.
5.	EPEAT tool to customers for independent verification of environmental performance for the product they are buying.
6.	Reducing use of energy at stores and other initiatives to reduce direct or indirect energy consumption.
7.	EPA green power partnership for renewable energy.
8.	ISO 14001 certification for managing environmental goals and ensuring compliance.
9.	Helping customers to recycle their electronics.
10.	Collecting waste from stores for recycling or reusing.
11.	Working with waste management companies to increase landfill diversion.
12.	Minimize impact through building design, operational monitoring and usage reduction.
13	Engagement of peers to improve social and environmental performance.
14.	Training to suppliers and filling a survey from current suppliers to know their performance and understanding their sustainability practices.
15.	Supplier evaluation and development program for evaluating and auditing of suppliers for environmental performance and reliable supply chain.
16.	Initiatives to mitigate environmental impacts of products and services, and it's extend.

Table 3.9: Technical requirements for Best Buy

Chapter 4

Numerical Application

This section describes the application of the proposed rough set and fuzzy theory based QFD methodology for selecting best green supply chain initiative for organizations. All the steps that are discussed in solution approach should be implemented for all the three selected sectors. We provide one example for implementation of the proposed QFD.

4.1. Rough Set based QFD Application

A series of QFD are used to translate the qualitative requirements into quantitative specifications. So firstly, we will be calculating weights of WHATs i.e. the importance for each of customer's needs using rough numbers with 10 point scale assessment.

Let DM_1, DM_2, DM_3 be the three decision makers and C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9 and C_{10} (Refer to table 3.1 and table 3.4 for details of customer requirements) be the customer requirements for J.B. Hunt as an example. The customer and technical requirements are numbered 1, 2, 3 .and so on to use short forms for these tables. In the table 4.1, three decision makers assign their importance rating for each of the customer requirement identified with 1-10 assessment scale.

4.1.1. Importance Rating for Customer Requirements

Customer Requirements (CR)	Importance Rating		
	DM_1	**DM_2**	**DM_3**
C_1	9	7	9
C_2	7	9	9
C_3	7	9	7

C_4	7	5	7
C_5	9	9	9
C_6	9	7	7
C_7	9	9	5
C_8	5	9	7
C_9	9	9	9
C_{10}	9	7	7

Table 4.1: Rating for decision maker's importance

In table 4.2, using rough numbers we calculate the final importance rating. Taking C_1 as an example, we have two classes namely '7' and '9' and using rough set theory formulas stated above we can calculate lower and upper limits of class 7.

$\underline{\text{Lim}}\ (C_i) = R\ (C_2) = 7$

$\bar{\text{L}}\text{im}\ (C_i) = (R\ (C_1) + R\ (C_2) + R\ (C_3))/3 = 8.33$

Rough number = $\lceil \underline{\text{Lim}}\ (C_i), \bar{\text{L}}\text{im}\ (C_i) \rfloor = \lceil 7, 8.33 \rfloor$

In table 4.2, Final importance rating is obtained by aggregating the individual evaluations into group as $FIR_i = 1/n \sum_{j=1}^{n} IRj$

where FIR_i denotes the weight of each WHAT, n is the total number of decision makers and IR is the importance rating of each WHAT firmed by the j^{th} decision maker, FIR is the final importance rating which is quantified into rough numbers.

$FIR_1 = (\lceil 8.33, 9 \rfloor + \lceil 7, 8.33 \rfloor + \lceil 8.33, 9 \rfloor)/3 = \lceil 7.88, 8.77 \rfloor$

And final FIR is obtained by rounding it to make one digit number.

Using rough number theory set explained above we quantify table 4.1 into rough number as following in table 4.2:

Quantification of customer survey data using rough numbers

Customer Requirements (CR)	Importance Rating				
	DM_1	DM_2	DM_3	(FIR)	Round off FIR
C_1	⌈8.33,9 ⌋	⌈7,8.33 ⌋	⌈8.33,9 ⌋	⌈7.88,8.77⌋	⌈8, 9⌋
C_2	⌈7,8.33⌋	⌈ 8.33,9⌋	⌈ 8.33,9⌋	⌈7.88,8.77⌋	⌈8, 9⌋
C_3	⌈7,7.66 ⌋	⌈7.66,9⌋	⌈7,7.66 ⌋	⌈7.22,8.1⌋	⌈7, 8⌋
C_4	⌈6.33, 7⌋	⌈ 5,6.33⌋	⌈ 6.33,7⌋	⌈5.88,6.77⌋	⌈6, 7⌋
C_5	⌈9,9 ⌋	⌈9,9 ⌋	⌈9,9 ⌋	⌈9,9⌋	⌈9, 9⌋
C_6	⌈7.66,9⌋	⌈7,7.66 ⌋	⌈7,7.66 ⌋	⌈7.22,8.1⌋	⌈7, 8⌋
C_7	⌈7.66,9⌋	⌈7.66,9⌋	⌈ 5,7.66⌋	⌈6.77,8.55⌋	⌈7, 9⌋
C_8	⌈7,7 ⌋	⌈ 7,7⌋	⌈ 7,7⌋	⌈7,7⌋	⌈7, 7⌋
C_9	⌈9,9 ⌋	⌈ 9,9⌋	⌈ 9,9⌋	⌈9,9 ⌋	⌈9, 9⌋
C_{10}	⌈7.66,9 ⌋	⌈7,7.66 ⌋	⌈7,7.66 ⌋	⌈7.22,8.1 ⌋	⌈7, 8⌋

Table 4.2: Quantification of customer survey data

4.1.2. Relationship between the customer and the technical requirements

This is third step of QFD to implement as explained in chapter 3. To draw the relationship matrix, we need to specify each "HOW's" which are the customer requirements for satisfying "WHAT's" which are the technical requirements as relationship matrix describes the degree of impact of each HOW's on the achievement of each WHAT's.

Let us assume as T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8 as the HOW's representing various technical requirements (refer to table 3.5 for technical requirements) that are needed to fulfill the customer requirements. Three decision makers evaluate the relationship between each of HOW's and WHAT's which is shown in table 4.3 and then rough number is calculated in same way as shown by an example above in table 4.4.

Three decision maker's evaluation are taken in table 4.3 to draw the relationship between the customer requirements which means "HOWs" and the technical requirements which means "WHAT's". We do not have a missing information but if there is missing

information then we will put 1 at a time and other time we put 9 and then we calculate the rough number same way it is discussed above.

Rating by decision makers on the relationship between HOWs and WHATs

Customer Requirements (CR's)		Relationship Matrix							
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
C_1	DM_1	3	3	3	1	1	3	1	9
	DM_2	3	3	1	1	1	9	3	9
	DM_3	9	9	1	1	1	3	1	9
C_2	DM_1	9	9	1	9	9	1	1	9
	DM_2	9	9	3	9	9	3	3	9
	DM_3	3	3	1	3	9	9	3	9
C_3	DM_1	3	3	1	3	3	9	3	3
	DM_2	3	3	1	3	9	9	3	3
	DM_3	3	1	1	3	3	3	1	9
C_4	DM_1	9	9	9	9	9	9	9	9
	DM_2	9	3	3	3	9	9	9	9
	DM_3	9	9	3	3	3	3	3	9
C_5	DM_1	3	1	1	1	9	3	1	3
	DM_2	1	3	1	1	3	1	1	1
	DM_3	3	1	1	1	3	1	1	1
C_6	DM_1	3	1	1	1	9	3	9	3
	DM_2	3	3	3	1	3	1	3	9
	DM_3	9	1	1	1	3	1	3	9
C_7	DM_1	9	1	1	1	9	9	3	9
	DM_2	9	1	1	3	3	9	3	9
	DM_3	9	1	1	1	3	3	1	3
C_8	DM_1	9	3	1	1	3	1	1	3
	DM_2	3	3	1	1	3	3	3	9
	DM_3	3	3	1	1	3	3	3	3
C_9	DM_1	9	1	1	1	3	1	1	1
	DM_2	9	1	1	1	3	3	1	3
	DM_3	3	1	1	1	1	3	1	1
C_{10}	DM_1	3	1	1	1	3	3	1	3
	DM_2	1	3	1	1	9	9	1	9
	DM_3	3	3	1	1	9	3	3	3

Table 4.3: Decision maker's evaluations

Using rough number theory set explained above we quantify the relationship matrix table 4.3 into rough number in table 4.4. Table 4.4 is round off to a zero level and can be represented as "R'_{ij}" for the adjusted relationship between the i^{th} WHAT and the j^{th} HOW.

WHAT and HOW relationship represented by rough number

CR'S	Relationship Matrix							
	T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
C_1	⌈4,6⌋	⌈4,6⌋	⌈1,2⌋	⌈1,1⌋	⌈1,1⌋	⌈4,6⌋	⌈1,2⌋	⌈9,9⌋
C_2	⌈6,8⌋	⌈6,8⌋	⌈1,2⌋	⌈6,8⌋	⌈9,9⌋	⌈2,6⌋	⌈2,3⌋	⌈9,9⌋
C_3	⌈3,3⌋	⌈2,3⌋	⌈1,1⌋	⌈3,3⌋	⌈4,6⌋	⌈6,8⌋	⌈3,3⌋	⌈4,6⌋
C_4	⌈9,9⌋	⌈6,8⌋	⌈4,6⌋	⌈4,6⌋	⌈6,8⌋	⌈6,8⌋	⌈6,8⌋	⌈9,9⌋
C_5	⌈2,3⌋	⌈1,2⌋	⌈1,1⌋	⌈1,1⌋	⌈4,6⌋	⌈1,2⌋	⌈1,1⌋	⌈1,2⌋
C_6	⌈4,6⌋	⌈1,2⌋	⌈1,2⌋	⌈1,1⌋	⌈4,6⌋	⌈6,8⌋	⌈4,6⌋	⌈6,8⌋
C_7	⌈9,9⌋	⌈1,1⌋	⌈1,1⌋	⌈1,2⌋	⌈4,6⌋	⌈6,8⌋	⌈2,3⌋	⌈6,8⌋
C_8	⌈4,6⌋	⌈3,3⌋	⌈1,1⌋	⌈1,1⌋	⌈3,3⌋	⌈2,2⌋	⌈2,3⌋	⌈4,6⌋
C_9	⌈6,8⌋	⌈1,1⌋	⌈1,1⌋	⌈1,1⌋	⌈2,3⌋	⌈2,3⌋	⌈1,1⌋	⌈1,2⌋
C_{10}	⌈2,3⌋	⌈2,3⌋	⌈1,1⌋	⌈1,1⌋	⌈6,8⌋	⌈4,6⌋	⌈1,2⌋	⌈4,6⌋

Table 4.4: WHAT and HOW relationship

4.1.3. Correlation Matrix

The correlation matrix defines the relationship between HOW's. Table 4.5 provides the correlation between HOWs. We can use symbols too instead of numbers and then put the values and convert them into rough numbers, but we are using numbers for assigning the correlation between HOW's.

Assessments on the correlations between HOWs

Technical Requirements (TR's)	Correlation Matrix							
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
T_1	9 9 9	9 9 3	9 3 3	3 3 3	9 9 9	3 3 3	3 3 3	
T_2	9 9 3	9 9 9	3 3 3		9 9 9	3 3 3	9 9 9	3 3 3
T_3	9 3 3	3 3 3	9 9 9		9 9 9	3 3 3	9 9 9	3 3 3
T_4	3 3 3			9 9 9	3 3 3			
T_5	9 9 9	9 9 9	9 9 9	3 3 3	9 9 9	9 9 3	9 9 9	9 9 9
T_6	3 3 3	3 3 3	3 3 3		9 9 3	9 9 9	3 3 3	9 9 9
T_7	3 3 3	9 9 9	9 9 9		9 9 9	3 3 3	9 9 9	9 3 3
T_8		3 3 3	3 3 3		9 9 9	9 9 9	9 3 3	9 9 9

Table 4.5: Assessments on the correlations between HOWs

The unfilled values are not treated as missing values because these are the relation that either we have some relation or we doesn't have it. So, they will not be deal by the upper formula of missing information. And there is no negative value associated with it. Otherwise, it would have marked as negative too. It may vary from organization to

organization that they want to consider only the strong relations or all relations while deciding the output.

Table 4.6 is the rough number representation of table 4.5. In this, we calculate the rough number as explained above in methodology. But here as with traditional QFD, we have a scale with 3 positive relation, 9- strong positive relation, -3 negative relation and -9 strong negative relation for showing the correlation. So, we calculated the rough number according to the majority of decision makers. For example, if the decision makers mark (3, 3, 9), we calculated the rough number as (3, 3).

Correlations between HOWs represented by Rough numbers

(TR's)	**Correlation Matrix**							
	T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
T_1	[9,9]	[9,9]	[3,3]	[3,3]	[9,9]	[3,3]	[3,3]	
T_2	[9,9]	[9,9]	[3,3]		[9,9]	[3,3]	[9,9]	[3,3]
T_3	[3,3]	[3,3]	[9,9]		[9,9]	[3,3]	[9,9]	[3,3]
T_4	[3,3]			[9,9]	[3,3]			
T_5	[9,9]	[9,9]	[9,9]	[3,3]	[9,9]	[9,9]	[9,9]	[9,9]
T_6	[3,3]	[3,3]	[3,3]		[9,9]	[9,9]	[3,3]	[9,9]
T_7	[3,3]	[9,9]	[9,9]		[9,9]	[3,3]	[9,9]	[3,3]
T_8		[3,3]	[3,3]		[9,9]	[9,9]	[3,3]	[9,9]

Table 4.6: Correlations between HOW's with rough numbers

4.1.4. Importance of HOWs

The HOW's (technical requirements) are prioritized according to their importance of rating in table 4.7 and the importance ratings are calculated according to the following steps as discussed below:

Step 1: Aggregation

Absolute importance is calculated by first multiplying the numerical value in each of the cells of the relationship matrix by the associated CR's importance rating. Then, we sum up column wise to give the importance absolute rating.

$I_j^{bn} = \sum_{i=1}^{m}(FIRi * R'ij)$ where I_j^{bn} is the absolute importance of the j^{th} HOW, FIR is the weight of the i^{th} WHAT, R'_{ij} is the adjusted relationship between the i^{th} WHAT and the j^{th} HOW and *m* is the number of WHAT's. (i=1, 2, 3….m; j= 1, 2, 3…n)

Step 2: The absolute factor

The absolute factor is calculated by the method:

(Absolute rating lower limit of each HOW's)
(Aggregate of all absolute rating's lower limit)

(Absolute rating upper limit of each HOW's)
(Aggregate of all absolute rating's upper limit)

For example 360+ 197+ 93+147+ 317+ 279+ 155+ 384 = 1932, lower limit aggregate

507+ 303+ 144+ 206+ 462+471+ 255+ 535 = 2883, upper limit aggregate

T_8 absolute factor will be calculated as:

383/ 1932 = .198, lower limit

535/ 2883= .1856, upper limit

Importance of How's in terms of rough number

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
Absolute Importance	[360, 507]	[197, 303]	[93, 144]	[147, 206]	[317, 462]	[279, 471]	[155, 255]	[384, 535]
Absolute Factor	[0.19, 0.18]	[0.1, 0.11]	[0.05, 0.05]	[0.08, 0.07]	[0.16, 0.16]	[0.14, 0.16]	[0.08, 0.09]	[0.2, 0.19]

Table 4.7: Importance of How's

The highest ranking is of T_8 which comes out to be Supplier ISO 14001 certification followed by T_1. The relative weight and relative factors are not calculated because we have not taken account the sales and target values (benchmarking). By looking on correlation matrix in table 4.6, we can see that it has very strong relationship between T_5 (Partnership with EPA SmartWay) and T_6 (Encourage suppliers to improve environment performance) technical requirement.

4.2. Fuzzy Logic QFD Application

Research on fuzzy- QFD has received a certain amount of interest from various researchers in supply chain (Awasthi et al., 2014; Bevilacqua, Ciarapica, & Giacchetta, 2006; Bottani & Rizzi, 2006; Celik et al., 2009; Sohn & Choi, 2001) and made significant progress aim to do rating for HOW's. This study propose for the first time a fuzzy- QFD for green supply chain planning. Fuzzy logic uses human linguistic variable to express the knowledge and give a quantitative value. The whole procedure of QFD will be followed step wise as was followed in rough set theory based QFD, only the scale used

will be different. The scale for fuzzy logic is discussed and shown in table 3.2 because fuzzy numbers deals with linguistic variables and has a defined scale from (Awasthi et al., 2014) but the general procedure of basic QFD will be followed in the same way. The steps of rating the importance of the customer requirements, the rating of relationship between customer requirements and the technical requirements, the correlation of technical requirements have been made by decision makers and in this study an unreal data is used just to show how we can implement the technique in green supply chain planning.

The first two step of identifying the customer requirements and the technical requirements are common for both techniques.

The difference in among the approaches comes in dealing with the rating for these steps, but the overall procedure remains same:

1) Importance rating of customer requirements
2) Relationship between customer and technical requirements
3) Importance of HOW's

4.2.1. Importance Rating of Customer Requirements

The three decision maker contribute in giving the importance for each WHAT by means of a linguistic variable. Five different ranks are used for rating the importance of customer requirements indicated as VL= very low, L= low, M = medium, H= High, and VH= very high. The outcome is shown in table 4.8.

Customer Requirements (CR)	Importance Rating		
	DM_1	**DM_2**	**DM_3**
C_1	VH	H	VH
C_2	H	VH	VH
C_3	H	VH	H
C_4	H	M	H
C_5	VH	VH	VH
C_6	VH	H	H
C_7	VH	VH	M
C_8	M	VH	H
C_9	VH	VH	VH
C_{10}	VH	H	H

Table 4.8: Importance rating by decision makers

The linguistic variables are converted into fuzzy numbers by triangular fuzzy number described (Bevilacqua et al., 2006) above in chapter 3. Where VL= (1, 1, 3), L= (1, 3, 5), M= (3, 5, 7), H= (5, 7, 9), VH= (7, 9, 9) and the equation

α = Min ($DM_{\alpha 1}$, $DM_{\alpha 2}$, $DM_{\alpha 3}$); β = Average ($DM_{\beta 1} + DM_{\beta 2} + DM_{\beta 3}$)/3;

γ = Max ($DM_{\gamma 1}$, $DM_{\gamma 2}$, $DM_{\gamma 3}$)

Then, the weights will be calculated by the equation $W_{in} = (\alpha + \beta + \gamma)/3$, n is the number of customer requirements. The weights obtained by aggregating the opinions expressed by each decision maker are shown in table 4.9.

Customer Requirements (CR)	Importance Rating			
	α	β	γ	W_{in}
C_1	5	8.34	9	7.45
C_2	5	8.34	9	7.45
C_3	5	7.67	9	7.23
C_4	3	6.34	9	6.12
C_5	7	9	9	8.34
C_6	5	7.67	9	7.23
C_7	3	7.67	9	6.56
C_8	3	7	9	6.34
C_9	7	9	9	8.34
C_{10}	5	7.67	9	7.23

Table 4.9: Aggregate of weights in fuzzy numbers

4.2.2. Relationship between customer and technical requirements

It is the third step as explained in chapter 3. To draw the relationship matrix, the three decision makers expressed their opinions using linguistic variables for each customer requirements and considering each technical requirement. The opinions are expressed in table 4.10. And the linguistic variables are converted in triangular numbers using the same formula as discussed earlier

α = Min ($DM_{\alpha 1}$, $DM_{\alpha 2}$, $DM_{\alpha 3}$)

β = Average ($DM_{\beta 1}$ + $DM_{\beta 2}$ + $DM_{\beta 3}$)/3

γ = Max ($DM_{\gamma 1}$, $DM_{\gamma 2}$, $DM_{\gamma 3}$) Where VL= (1, 1, 3), L= (1, 3, 5), M= (3, 5, 7), H= (5, 7, 9), VH= (7, 9, 9) (Awasthi et al., 2014)

Customer Requirements (CR's)		**Relationship Matrix**							
		T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
C_1	**DM_1**	L	VL	L	VL	VL	M	VL	H
	DM_2	H	L	VL	VL	VL	H	L	VH
	DM_3	M	M	VL	VL	VL	M	VL	H
C_2	**DM_1**	H	VH	VL	M	H	VL	VL	H
	DM_2	VH	H	L	M	VH	M	L	VH
	DM_3	M	H	VL	L	VH	M	L	H
C_3	**DM_1**	M	L	VL	L	M	M	L	H
	DM_2	L	L	VL	L	M	M	L	M
	DM_3	L	VL	VL	L	L	L	VL	M
C_4	**DM_1**	VH	VH	M	H	VH	M	M	H
	DM_2	VH	M	L	M	H	M	M	M
	DM_3	H	H	L	M	H	L	L	H
C_5	**DM_1**	L	VL	VL	VL	M	L	VL	L
	DM_2	VL	L	VL	VL	L	VL	VL	VL
	DM_3	L	VL	VL	VL	L	VL	VL	VL

C_6	**DM_1**	H	VL	VL	VL	M	L	M	M
	DM_2	M	L	L	VL	L	VL	L	H
	DM_3	H	VL	VL	VL	L	VL	L	H
C_7	**DM_1**	VH	VL	VL	VL	H	H	L	VH
	DM_2	H	VL	VL	L	M	H	L	H
	DM_3	H	VL	VL	VL	M	M	VL	H
C_8	**DM_1**	H	M	VL	VL	L	VL	VL	M
	DM_2	M	L	VL	VL	M	L	L	H
	DM_3	M	L	VL	VL	M	L	L	L
C_9	**DM_1**	H	VL	VL	VL	L	VL	VL	VL
	DM_2	H	VL	VL	VL	L	L	VL	L
	DM_3	M	VL	VL	VL	VL	L	VL	VL
C_{10}	**DM_1**	M	VL	VL	VL	L	VL	VL	L
	DM_2	VL	L	VL	VL	M	M	VL	M
	DM_3	L	L	VL	VL	M	L	L	H

Table 4.10: Relationship between WHATs and HOWs through linguistic variables

$W_{ij} = (\alpha + \beta + \gamma)/3$ and are represented in table 4.11 and will be repeated k number times. Where i= k and j = m and k is the number of WHAT's, n is the number of decision makers and m is the number of HOW's. The output is shown in table 4.11 and is round off to level zero.

CR's	**Relationship Matrix**							
	T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
C_1	5	4	3	2	2	6	3	7
C_2	6	7	3	4	7	4	3	7
C_3	4	3	2	3	4	4	3	6
C_4	7	6	4	6	7	4	4	6
C_5	3	3	2	2	4	3	2	3
C_6	6	3	3	2	4	3	4	6
C_7	7	2	2	3	6	6	3	7
C_8	6	4	2	2	4	3	3	5
C_9	6	2	2	2	3	3	2	3
C_{10}	4	3	2	2	4	4	3	5

Table 4.11: Fuzzy values for weight of the relationship between HOW's and WHAT's

4.2.3. Correlation matrix

The correlation between the HOW's are contained on the top of the roof of the house of quality. This step helps to compare the relationship between each HOW's to track if there is a need of parallel improvement of any HOW's or how one "HOW's" will affect the other and the correlation among HOW's are shown in table 4.12.

TR's		**Correlation Matrix**							
		T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
T_1	DM_1	VH	VH	M	M	VH	M	VH	
	DM_2	VH	VH	M	M	VH	M	M	
	DM_3	VH	M	M	M	M	M	M	
T_2	DM_1	VH	VH	M		VH	M	VH	M
	DM_2	VH	VH	M		VH	M	M	M
	DM_3	M	VH	M		M	M	M	M
T_3	DM_1	M	M	VH		VH	M	VH	M
	DM_2	M	M	VH		M	M	VH	M
	DM_3	M	M	VH		VH	M	VH	M
T_4	DM_1	M			VH	M			
	DM_2	M			VH	M			
	DM_3	M			VH	M			
T_5	DM_1	VH	VH	VH	M	VH	VH	VH	VH
	DM_2	VH	VH	M	M	VH	VH	VH	VH
	DM_3	M	M	VH	M	VH	M	M	M
T_6	DM_1	M	M	M		VH	VH	M	VH
	DM_2	M	M	M		VH	VH	M	VH
	DM_3	M	M	M		M	VH	M	VH
T_7	DM_1	VH	VH	VH		VH	M	VH	M
	DM_2	M	M	VH		VH	M	VH	M
	DM_3	M	M	VH		M	M	VH	M
T_8	DM_1		M	M		VH	VH	M	VH
	DM_2		M	M		VH	VH	M	VH
	DM_3		M	M		M	VH	M	VH

Table 4.12: Correlation between HOW's

The unfilled values are not treated as missing values because these are the relation that either we have some relation or we doesn't have it. So, they will not be handled by the upper formula of missing information.

Table 4.13 is the crisp number representation of table 4.12. In this, we calculate the fuzzy number and then turn it into crisp number by using a formula (a + b + c)/3 as explained above in methodology. But here, we have used VH and medium as a scale to represent the relation as with traditional QFD we have used 3 as positive relation, 9 as strong positive relation, -3 as negative relation and -9 as strong negative relation for showing the correlation.

(TR's)	**Correlation Matrix**							
	T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
T_1	8.34	6.56	5	5	6.56	5	6.12	
T_2	6.56	8.34	5		6.56	5	6.12	5
T_3	5	5	8.34		6.56	5	8.34	5
T_4	5			9	5			
T_5	6.56	6.56	6.56	5	8.34	6.56	6.56	6.56
T_6	5	5	5		6.56	8.34	5	8.34
T_7	6.12	6.12	8.34		6.56	5	8.34	5
T_8		5	5		6.56	8.34	5	8.34

Table 4.13: Correlation between HOW's with crisp number

4.2.4. Importance of HOW's

Averaging the importance rating of WHAT's and averaging the weight of WHAT's and HOW's considering the HOW's, we now complete the house of quality in table 4.14 by Relationship matrix (table 4.11) * Importance rating (table 4.9). Absolute factor is calculated by dividing each technical requirement by sum of all weights of technical requirements as shown in table 4.14.

TR's	Final Score Index (Absolute weight)		
	Without round off	With round off	Absolute Factor
T_1	387.2839506	387	0.18
T_2	249.0864198	249	0.116
T_3	153.6049383	154	0.072
T_4	179.8271605	180	0.084
T_5	319.6296296	320	0.149
T_6	274.6419753	275	0.128
T_7	195.0123457	195	0.091
T_8	389.2592593	389	0.181
Totals of all HOW's		**2149**	

Table 4.14: Final score index

These fuzzy rating produce the final ranking orders for the technical requirements as shown in table 4.15.

TR's	Absolute weight	Absolute Factor	Final Ranking
T_1	387	0.180	2
T_2	249	0.116	5
T_3	154	0.072	8
T_4	180	0.084	7
T_5	320	0.149	3
T_6	275	0.128	4
T_7	195	0.091	6
T_8	389	0.181	1

Table 4.15: Final ranking

So, the final out comes out to be T_8 which is supplier ISO 14001 certification followed by T_1 and T_5. Our output did not changed with the change in the method. When looking on correlation table 4.14, we can see that T_5 has strong relationship and T_6 with little less strong relationship and this depends upon organization to organization whether they want to consider only strong correlations or they want to consider all relations.

Chapter 5

Conclusions and Future Works

5.1. Conclusions

In this thesis, we present a hybrid approach integrating Rough set theory and Fuzzy theory with QFD for investigating the impact of ISO 14001 in developing green supply chains. We use the Australian government ICT sustainability plan 2010- 2015 mandatory guidelines as a standard format for customer requirements. Using the sustainability reports of companies from their websites, we extracted the customer requirements and green initiatives. Using rough numbers, three decision maker's imprecise information was converted to rough boundary intervals bounded by upper and lower limits, which can be directly computed from raw data without any need for subjective adjustments or assumptions. The rough set theory also controlled the enlargement of rough boundary intervals in QFD analysis. The fuzzy logic helps the decision makers to eliminate the problem associated with the subjective and ambiguous nature of the information available to us. We used three different areas naming top trucking, retail and food and beverage companies for making their traditional supply chain into green supply chain. One company was used as an example to explain the implementation procedure. Through the proposed work, we are able to make more reliable decisions for green supply chain planning and thus improve the quality of decision making in green supply chain. Then, the widely used fuzzy number and rough set theory has also some limitations or drawbacks like the information inserted into QFD is highly based on experts subjective knowledge and experience, which may not be a good agreement with actual facts.

Secondly the boundary intervals may expand rapidly and ultimately influence the decision making in QFD.

The results of our study show that the technical requirements "Supplier ISO 14001 certification" comes out to be the best with very little difference or high correlation of "partnership with EPA SmartWay (defined in abbreviations) to reduce emissions in transport or gain green supply chain. But this priority can be changed with different companies and areas. Secondly, out of twenty companies, majority were ISO 14001 certified and made their supply chain green but few others implemented different certifications to become green and socially responsible. The main limitation of this research is that the result may change from sector to sector like in trucking company (J. B. Hunt) supplier ISO 14001 certification and partnership with EPA SmartWay may be the best solution to achieve green supply chain because it is only a transport company but for the food and beverage sector - recycling and reusing might come out to be the best option.

5.2. Future Works

There are several opportunities to extend the research presented in this paper. Fundamentally, there is a need to develop overall result for each area in trucking, retail, food and beverage companies that tell which factors help to gain green supply chain. Another research can be on comparative analysis for different areas. Data collection can also be increased in either ways. A model can also be developed for making the supply chain green for each sector. Other sectors can also be selected for the study like brewing companies because a lot of waste is produced during brewing beers and wine and very less companies are green in that sector. Also, analysis can be done on each area of green

supply chain. For example, measuring the impact on green purchasing instead of whole green supply chain. This technique can also be implemented by companies in which the end users want to reduce waste or hazardous emissions in the supply chain. For example, customers, employees, owners, management, shareholders, suppliers, distributors, manufacturers, retailers, recyclers, waste management organizations, financial organizations, partners, competitors, government, NGOs, local community, social activists, interest groups, media, scientific community, safety advocates, environmental groups etc. The customer requirements will be the demands and needs of these customers to reduce waste or hazardous emissions in the supply chain through specifications known as technical requirements. Companies can focus on each sub element or whole of supply chain to identify if a more environmentally sound approach can help to cure the inefficiencies like where raw materials are wasted, resources are underutilized and unnecessary energy is used due to inefficient equipment's and can come out with best approach similar to the proposed QFD methodology. There is no rule on the number of decision makers. The only limitation is decision making software requirements such as ANP which can handle only limited number of pairwise comparison matrices obtained from decision makers.

5.3. Bibliography

Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production, 52*(0), 329-341.

Ahi, P., & Searcy, C. (2014). An analysis of metrics used to measure performance in green and sustainable supply chains. *Journal of Cleaner Production, 86*(0), 360-377.

Andiç, E., Yurt, Ö., & Baltacıoğlu, T. (2012). Green supply chains: Efforts and potential applications for the Turkish market. *Resources, Conservation and Recycling, 58*(0), 50-68.

Ann, G. E., Zailani, S., & Wahid, N. A. (2006). A study on the impact of environmental management system (EMS) certification towards firms' performance in Malaysia. *Management of Environmental Quality, 17*(1), 73-93.

Atlas. (2014). http://www.atlasvanlines.ca/the-environment.html Retrieved on September 15, 2014.

Atlas World Group. (2014). http://www.atlasvanlines.com/atlas/amplifier/article/2009/08/05/one-atlas-brand---many-shades-of-green Retrieved on September 15, 2014.

Australian government ICT sustainability plan 2010-2015. (2011). http://www.environment.gov.au/sustainability/government/ictplan/guidance-materials Retrieved on September 15, 2014.

Awasthi, A., Noshad, K., & Chauhan, S. S. (2014). Supplier performance evaluation using a hybrid fuzzy data envelopment analysis approach. *Performance measurement with fuzzy data envelopment analysis* (pp. 271-285) Springer.

Azadi, M., Shabani, A., Khodakarami, M., & Farzipoor Saen, R. (2014). Planning in feasible region by two-stage target-setting DEA methods: An application in green supply chain management of public transportation service providers. *Transportation Research Part E: Logistics and Transportation Review, 70*(0), 324-338.

Azevedo, S. G., Carvalho, H., & Cruz Machado, V. (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.

Ball, J. (2002). Can ISO 14000 and eco-labelling turn the construction industry green? *Building and Environment, 37*(4), 421-428.

Balzarova, M. A., & Castka, P. (2008). Underlying mechanisms in the maintenance of ISO 14001 environmental management system. *Journal of Cleaner Production, 16*(18), 1949-1957.

Barla, P. (2007). ISO 14001 certification and environmental performance in Quebec's pulp and paper industry. *Journal of Environmental Economics and Management, 53*(3), 291-306.

Barmasse, M. (2002). Implementation of the ISO 14001 environmental management system can be feasible at small U.S chemical companies. Thesis. Rochester Institute

of Technology. http://scholarworks.rit.edu/cgi/viewcontent.cgi?article=1545&context=theses Retrieved on October 13, 2014

Best Buy. (2014). https://corporate.bestbuy.com/wp-content/uploads/2014/06/csr-2014-final.pdf Retrived on Sept 23, 2014

Bevilacqua, M., Ciarapica, F. E., & Giacchetta, G. (2006). A fuzzy-QFD approach to supplier selection. *Journal of Purchasing and Supply Management, 12*(1), 14-27.

Birkland, C. (2014). http://www.fleetequipmentmag.com/top-green-shop-award-winner-swift-transportation-memphis-shop/ Retrieved on Sept 17, 2014

Boiral, O. (2007). Corporate greening through ISO 14001: A rational myth? *Organization Science, 18*(1), 127-146.

Boiral, O. (2011). Managing with ISO systems: Lessons from practice. *Long Range Planning, 44*(3), 197-220.

Bottani, E., & Rizzi, A. (2006). Strategic management of logistics service: A fuzzy QFD approach. *International Journal of Production Economics, 103*(2), 585-599.

Brouwer, M. A. C., & van Koppen, C. S. A. (. (2008). The soul of the machine: Continual improvement in ISO 14001. *Journal of Cleaner Production, 16*(4), 450-457.

C & K Trucking. (2014). http://corp.canadiantire.ca/EN/CorporateCitizenship/BusinessSustainability/Docume

nts/2013%20Q4%20and%20Year-End%20Performance%20Report_Feb%2012_EN_Final.pdf Retrieved on September 15, 2014.

Canadian Tire. (2013). http://corp.canadiantire.ca/EN/CorporateCitizenship/BusinessSustainability/Documents/2013%20Q4%20and%20Year-End%20Performance%20Report_Feb%2012_EN_Final.pdf Retrieved on September 17, 2014.

Cañón-de-Francia, J., & Garcés-Ayerbe, C. (2009). ISO 14001 environmental certification: A sign valued by the market? *Environmental and Resources Economics, 44*(2), 245-262.

CCICED. (2011). http://www.cciced.net/encciced/event/AGM_1/2011agm/proceeings/201205/P020120524364301295038.pdf Retrieved on October 12, 2014.

Celik, M., Cebi, S., Kahraman, C., & Er, I. D. (2009). An integrated fuzzy QFD model proposal on routing of shipping investment decisions in crude oil tanker market. *Expert Systems with Applications, 36*(3, Part 2), 6227-6235.

Chen, C., Shih, H., Shyur, H., & Wu, K. (2012). A business strategy selection of green supply chain management via an analytic network process. *Computers & Mathematics with Applications, 64*(8), 2544-2557.

Chin, K. -. Chiu, S., & Rao Tummala, V. M. (1999). An evaluation of success factors using the AHP to implement ISO 14001-based EMS. *International Journal of Quality and Reliability Management, 16*(4), 341-361.

Choudhary, M., & Seth, N. (2011). Integration of green practices in supply chain environment: The practices of inbound, operational, outbound and reverse logistics. *International Journal of Engineering Science and Technology, 3*(6), 4985.

Comoglio, C., & Botta, S. (2012). The use of indicators and the role of environmental management systems for environmental performances improvement: A survey on ISO 14001 certified companies in the automotive sector. *Journal of Cleaner Production, 20*(1), 92-102.

Coors, M. (2014). http://www.molsoncoors.com/en/Responsibility/Reports.aspx Retrieved on September 17, 2014.

Dai, J., & Blackhurst, J. (2012). A four-phase AHP–QFD approach for supplier assessment: A sustainability perspective. *International Journal of Production Research, 50*(19), 5474-5490.

Danone. (2013). http://media.corporate-ir.net/media_files/IROL/95/95168/Danone_Sustainability_Report_2013.pdf Retrieved on September17, 2014.

Darnall, N., Jolley, G. J., & Handfield, R. (2008). Environmental management systems and green supply chain management: Complements for sustainability? *Business Strategy and the Environment, 17*(1), 30-45.

Darnall, N. (2006). Why firms mandate ISO 14001 certification. *Business and Society, 45*(3), 354-381.

Davies, C., & Webber, P. (2007). ISO 14001 registration: The process, the benefits and the choice of registrar. *Environmental Quality Management, 8*(2), 55-64.

De Vries, H. J., Bayramoglu, D. K., & van der Wiele, T. (2012). Business and environmental impact of ISO 14001. *International Journal of Quality and Reliability Management, 29*(4), 425-435.

Delai, I., & Takahashi, S. (2013). Corporate sustainability in emerging markets: Insights from the practices reported by the Brazilian retailers. *Journal of Cleaner Production, 47*(0), 211-221.

DHL, D. P. (2013). http://cr-report2013.dpdhl.com/cr-strategy-measures/cr-management-process/ Retrieved on September 17, 2014.

DHL, D. P. (2014). http://www.dpdhl.com/en/responsibility/environmental-protection.html Retrieved on September 17, 2014.

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.

Dou, Y., Zhu, Q., & Sarkis, J. (2014). Evaluating green supplier development programs with a grey-analytical network process-based methodology. *European Journal of Operational Research, 233*(2), 420-431.

Eltayeb, T. K., Zailani, S., & Ramayah, T. (2011). Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resources, Conservation and Recycling, 55*(5), 495-506.

Emmett, S., & Sood, V. (2010). *Green supply chains: An action manifesto*. Chichester, West Sussex, U.K.: Wiley.

Evans, J. R., & Lindsay, W. M. (2005). *An introduction to six sigma & process improvement*. Mason, Ohio: Thomson/South-Western.

FedEx. (1995-2014). http://www.fedex.com/gb/about/sustainability/environment.html Retrieved on September 18, 2014.

FedEx. (2012). http://about.van.fedex.com/sites/default/files/fedex_environmental_sustainabily_report_sg_hr.pdf Retrieved on September 17, 2014

FedEx. (2012). http://about.van.fedex.com/assets/_pdf/2012_FedEx_Global_Citizenship_Goals_Progress.pdf Retrieved on September 17, 2014.

FedEx. (2013). http://about.van.fedex.com/gcr2014/pdf/FedEx_GCR13.pdf Retrieved on September 17, 2014.

Foster, S. T. (2010). *Managing quality: Integrating the supply chain* (4th ed.). Boston: Prentice Hall.

Gaur, V. (2013). Understand your stakeholders. *International Journal of Advancement in Research and Technology, 2*(2)

Gavronski, I., Ferrer, G., & Paiva, E. L. (2008). ISO 14001 certification in Brazil: Motivations and benefits. *Journal of Cleaner Production, 16*(1), 87-94.

Gavronski, I., Klassen, R. D., Vachon, S., & Nascimento, L. F. M. d. (2011). A resource-based view of green supply management. *Transportation Research Part E: Logistics and Transportation Review, 47*(6), 872-885.

Geddes, J., Scott, F., Kingston, A., Mamahon, T., Taylor, N., Teital, E., Wherry, A. (2014). http://www.macleans.ca/work/bestcompanies/top-50-socially-responsible-corporations-2014/ . The list Retrieved on September 12, 2014.

Geldermann, J., Spengler, T., & Rentz, O. (2000). Fuzzy outranking for environmental assessment. Case study: Iron and steel making industry. *Fuzzy Sets and Systems, 115*(1), 45-65.

Giunipero, L. C., Hooker, R. E., & Denslow, D. (2012). Purchasing and supply management sustainability: Drivers and barriers. *Journal of Purchasing and Supply Management, 18*(4), 258-269.

Govindan, K., Kaliyan, M., Kannan, D., & Haq, A. N. (2014). Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Economics, 147, Part B* (0), 555-568.

Hajikhani, M., Wahiza Binti Abdul Wahat, N., & Bin IDRIS, K. (2012). Considering on green supply chain management drivers, as a strategic organizational development approach, Malaysian perspective. *Australian Journal of Basic and Applied Sciences, 6*(8), 146.

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.

Hassini, E., Surti, C., & Searcy, C. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics, 140*(1), 69-82.

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

Tim Hortons. (2013). http://sustainabilityreport.timhortons.com/pdf/2013_summary_report_28pages.pdf Retrieved on September 15, 2014.

Hussain, M. (2011). *Modelling the enablers and alternatives for sustainable supply chain management*. Montréal, Québec: Concordia University.

J.B.Hunt. (2014). http://www.jbhunt.com/responsibility/sustainability/ Retrieved on September 17, 2014.

Jamshidi, R., Fatemi Ghomi, S. M. T., & Karimi, B. (2012). Multi-objective green supply chain optimization with a new hybrid memetic algorithm using the taguchi method. *Scientia Iranica, 19*(6), 1876-1886.

Kainuma, Y., & Tawara, N. (2006). A multiple attribute utility theory approach to lean and green supply chain management. *International Journal of Production Economics, 101*(1), 99-108.

Kellogg. (2012). http://www.kelloggcompany.com/en_US/corporate-responsibility.html Retrieved on September 17, 2014.

Kellogg. (2013). http://www.kelloggcompany.com/en_US/corporate-responsibility.html Retrieved on September 17, 2014.

Kuo, T., Wu, H., & Shieh, J. (2009). Integration of environmental considerations in quality function deployment by using fuzzy logic. *Expert Systems with Applications, 36*(3, Part 2), 7148-7156.

Lee, S., & 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.

Lesser, S. (2012). Green chip stocks http://www.greenchipstocks.com/articles/eco-friendly-trucking-companies/1480 Retrieved on September 17, 2014.

Lesser, S. (2012). Green chip stocks http://www.greenchipstocks.com/articles/eco-friendly-trucking-companies/1480 Retrieved on September 17, 2014.

Lieb, R. C., & Lieb, K. J. (2010). Penske logistics http://www.penskelogistics.com/newsroom/2010_4_22_logistics_sustainability.html Retrieved on September 17, 2014.

Link, S., & Naveh, E. (2006). Standardization and discretion: Does the environmental standard ISO 14001 lead to performance benefits? *Engineering Management, IEEE Transactions on, 53*(4), 508-519.

Loblaw. (2010). http://www.loblaw.ca/files/6304_LoblawSeafood2013_Design_V8.pdf Retrieved on September 17, 2014.

Loblaw. (2013). http://www.loblaw.ca/files/6.%20Responsibility/Loblaw_eng_2013_CSR_May_20.pdf Retrieved on September 17, 2014.

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-n/a.

MacDonald, J. P. (2005). Strategic sustainable development1 using the ISO 14001 standard. *Journal of Cleaner Production, 13*(6), 631-643.

Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2014). Lean management, supply chain management and sustainability: A literature review. *Journal of Cleaner Production, 85*(0), 134-150.

Massoud, M. A., Fayad, R., El-Fadel, M., & Kamleh, R. (2010). Drivers, barriers and incentives to implementing environmental management systems in the food industry: A case of Lebanon. *Journal of Cleaner Production, 18*(3), 200-209.

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*(0), 283-297.

Melnyk, S. A., Sroufe, R. P., & Calantone, R. (2003). Assessing the impact of environmental management systems on corporate and environmental performance. *Journal of Operations Management, 21*(3), 329-351.

Morrow, D., & Rondinelli, D. (2002). Adopting corporate environmental management systems: Motivations and results of ISO 14001 and EMAS certification. *European Management Journal, 20*(2), 159-171.

Nawrocka, D., Brorson, T., & Lindhqvist, T. (2009). ISO 14001 in environmental supply chain practices. *Journal of Cleaner Production, 17*(16), 1435-1443.

Neugebauer, F. (2012). EMAS and ISO 14001 in the German Industry – Complements or Substitutes? *Journal of Cleaner Production, 37*(0), 249-256.

Newbold, J. (2006). Chile's environmental momentum: ISO 14001 and the large-scale mining industry – case studies from the state and private sector. *Journal of Cleaner Production, 14*(3–4), 248-261.

Nwe, E. S., Adhitya, A., Halim, I., & Srinivasan, R. (2010). Green supply chain design and operation by integrating LCA and dynamic simulation. *Computer Aided Chemical Engineering, 28*(0), 109-114.

Penske. (2014). http://www.penskelogistics.com/company/leadership.html Retrieved on September 15, 2014.

Pepsico. (2013). http://www.pepsico.com/Purpose/Environmental-Sustainability Retrieved on September 15, 2014.

Pepsico. (2013). http://pepsico.ca/en/downloads/PEPC_PwP_Environment_EN_FINAL%202013.pdf Retrieved on September 15, 2014.

Perez, O., Amichai- Hamburger, Y., & Shterental, T. (2009). The dynamic of corporate self - regulation: ISO 14001, environmental commitment, and organizational citizenship behavior. *Law & Society Review, 43*(3), 593-630.

Prajogo, D., Tang, A. K. Y., & Lai, K. (2012). Do firms get what they want from ISO 14001 adoption? : An Australian perspective. *Journal of Cleaner Production, 33*(0), 117-126.

Radonjič, G., & Tominc, P. (2007). The role of environmental management system on introduction of new technologies in the metal and chemical/paper/plastics industries. *Journal of Cleaner Production, 15*(15), 1482-1493.

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.

Rha, J. S. (2010). *The impact of green supply chain practices on supply chain performance.* (Masters of Arts, The College of Business Administration at the University of Nebraska). *Dissertations and Thesis from the College of Business Administration, 11*. http://digitalcommons.unl.edu/businessdiss/11 Retrieved on March 5, 2014.

Roca, L. C., & Searcy, C. (2012). An analysis of indicators disclosed in corporate sustainability reports. *Journal of Cleaner Production, 20*(1), 103-118.

Rona. (2015). http://www.rona.ca/corporate/corporate-responsibility Retrieved on September 15, 2014.

Schroeder, D. M., & Robinson, A. G. (2010). Green is free: Creating sustainable competitive advantage through green excellence. *Organizational Dynamics, 39*(4), 345-352.

Shang, K., Lu, C., & Li, S. (2010). A taxonomy of green supply chain management capability among electronics-related manufacturing firms in Taiwan. *Journal of Environmental Management, 91*(5), 1218-1226.

Shaw, K., Shankar, R., Yadav, S. S., & Thakur, L. S. (2012). Supplier selection using fuzzy AHP and fuzzy multi-objective linear programming for developing low carbon supply chain. *Expert Systems with Applications, 39*(9), 8182-8192.

Sohn, S. Y., & Choi, I. S. (2001). Fuzzy QFD for supply chain management with reliability consideration. *Reliability Engineering & System Safety, 72*(3), 327-334.

Srivastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*(1), 53-80.

Starbucks. (2015). http://www.starbucks.com/responsibility/environment Retrieved on September 15, 2014.

Starbucks. (2013). http://globalassets.starbucks.com/assets/98e5a8e6c7b1435ab67f2368b1c7447a.pdf Retrieved on September 15, 2014.

Starbucks. (2015). http://www.starbucks.com/responsibility/environment Retrieved on September 15, 2014.

Summers Raines, S. (2002). Implementing ISO 14001- An International survey assessing the benefits of certification. *Corporate Environmental Strategy, 9*(4), 418-426.

Swift. (2015). http://swifttrans.com/about/details/ Retrieved on September 15, 2014.

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*(10–11), 953-962.

Tian, Y., Govindan, K., & Zhu, Q. (2014). A system dynamics model based on evolutionary game theory for green supply chain management diffusion among Chinese manufacturers. *Journal of Cleaner Production, 80*(0), 96-105.

Turk, A. M. (2009). The benefits associated with ISO 14001 certification for construction firms: Turkish case. *Journal of Cleaner Production, 17*(5), 559-569.

Turker, D., & Altuntas, C. (2014). Sustainable supply chain management in the fast fashion industry: An analysis of corporate reports. *European Management Journal, 32*(5), 837-849.

UniGroup. (2013). http://www.unigroupinc.com/sustainability/commitment-1 Retrieved on September 15, 2014.

UPS. (2013). http://sustainability.ups.com/media/UPS-2013-Corporate-Sustainability-Report.pdf Retrieved on September 15, 2014.

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.

Welch, E. W., Mori, Y., & Midori, A. (2002). Voluntary adoption of ISO 14001 in japan: Mechanisms, stages and effects. *Business Strategy and the Environment, 11*(1), 43-62. doi:10.1002/bse.318

Whitelaw, K. (2004). Chapter 1 - Concepts and the 'spirit' of ISO 14001. In K. Whitelaw (Ed.), *ISO 14001 environmental systems handbook (second edition)* (pp. 1-21). Oxford: Butterworth-Heinemann.

Whitelaw, K. (2004). Chapter 2 - Implementation of ISO 14001. In K. Whitelaw (Ed.), *ISO 14001 environmental systems handbook (second edition)* (pp. 22-104). Oxford: Butterworth-Heinemann.

Whitelaw, K. (2004). Chapter 3 - The assessment process. In K. Whitelaw (Ed.), *ISO 14001 environmental systems handbook (second edition)* (pp. 105-122). Oxford: Butterworth-Heinemann.

Wiengarten, F., & Pagell, M. (2012). The importance of quality management for the success of environmental management initiatives. *International Journal of Production Economics, 140*(1), 407-415.

Wu, S., Chu, P., & Liu, T. (2007). Determinants of a firm's ISO 14001 certification: An empirical study of Taiwan. *Pacific Economic Review, 12*(4), 467-487.

Wu, G., Ding, J., & Chen, P. (2012). The effects of GSCM drivers and institutional pressures on GSCM practices in Taiwan's textile and apparel industry. *International Journal of Production Economics, 135*(2), 618-636.

Wu, K., Liao, C., Tseng, M., & Chiu, A. S. F. (2015). Exploring decisive factors in green supply chain practices under uncertainty. *International Journal of Production Economics, 159*(0), 147-157.

Yang, M., Khan, F. I., Sadiq, R., & Amyotte, P. (2011). A rough set-based quality function deployment (QFD) approach for environmental performance evaluation: A case of offshore oil and gas operations. *Journal of Cleaner Production, 19*(13), 1513-1526.

Yen, Y., & Yen, S. (2012). Top-management's role in adopting green purchasing standards in high-tech industrial firms. *Journal of Business Research, 65*(7), 951-959.

Yin, H., & Ma, C. (2009). International integration: A hope for a greener china? *International Marketing Review, 26*(3), 348-367.

YRC Worldwide. (2013). http://files.shareholder.com/downloads/YRCW/3255337110x0x735266/34BB6B2C-C4D0-4E85-BCE7-842953DAE7C1/YRC_AR.PDF Retrieved on September 15, 2014.

YRC Worldwide. (2014). http://www.yrcw.com/green/ Retrieved on September 15, 2014.

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International Journal of Production Economics, 140*(1), 330-340.

Zhang, Y. (1999). Green QFD-II: A life cycle approach for environmentally conscious manufacturing by integrating LCA and LCC into QFD matrices. *International Journal of Production Research, 37*(5), 1075-1091.

Zhao, R., Neighbour, G., Han, J., McGuire, M., & Deutz, P. (2012). Using game theory to describe strategy selection for environmental risk and carbon emissions reduction in the green supply chain. *Journal of Loss Prevention in the Process Industries, 25*(6), 927-936.

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

Zhu, Q., Geng, Y., & Sarkis, J. (2013). Motivating green public procurement in china: An individual level perspective. *Journal of Environmental Management, 126*(0), 85-95.

Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management, 22*(3), 265-289.

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.

Zhu, Q., Sarkis, J., & Lai, K. (2007). Green supply chain management: Pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production, 15*(11–12), 1041-1052.

Zhu, Q., Sarkis, J., & Lai, K. (2007). Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *Journal of Environmental Management, 85*(1), 179-189.

Zhu, Q., Sarkis, J., & Lai, K. (2008). Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics, 111*(2), 261-273.

Zsidisin, G. A., & Hendrick, T. E. (1998). Purchasing's involvement in environmental issues: A multi-country perspective. *Industrial Management & Data Systems, 98*(7), 313-320.

Zutshi, A., & Sohal, A. (2004). Environmental management system adoption by Australasian organizations: Part 1: Reasons, benefits and impediments. *Technovation, 24*(4), 335-357.

5.4. Appendix

Trucking Sector

Many trucking companies have started going green. So, from green chip stock website the top ten companies of trucking were selected and their initiatives were turned into technical requirement for QFD. Out of the ten which were analyzed, one is taken as an example and the rest are listed in the following tables.

United Parcel Service

The data is collected from its sustainability report of UPS for the green initiatives it has taken. They are referred as technical requirements in table 5.1 and it also contains GRI index (UPS, 2013).

S.No	Technical Requirements
1.	Adding fuel efficient ground and air fleet by operating latest technology fuel efficient fleet, add winglets to aircraft, computer- optimized flight plans, Use bio-diesel in ground support equipment, installation of cleaner engines, and avoid miles driven.
2.	Deploying noise and emission reduction technologies by contraflow approaches (flying over less populated areas of the city) and continuous descent arrivals (planes use idle power to glide down).
3.	Availability of parking facility for planes next to docking
4.	Usage of electric powered equipment's for loading and unloading
5.	Conserving fuels by using biofuels, solar energy, Bio-methane, slowing down flights from 2-11 minutes deploying surface management system and using continuous descent arrivals when landing in lieu of stepping down altitudes, advanced technology, vehicles intermodal shifting, telematics, hub and spoke strategy to gather packages from different locations.
6.	Back-up generators burning fossil fuels
7.	Substituting of fiberglass containers that affect air quality by using polycarbonate air containers to transport packages.
8.	Reducing of volatile organic compound emissions by Jet-A fuel tanks with internal floating roof that reduces VOC.
9.	Using environmentally paint for aircrafts that avoid coatings and pre-coatings (process called PreKote is done in UPS).
10.	Working together with partners, stakeholders, employees, labor unions, designers, manufacturers, suppliers, customers, Green power partnership with U.S Environmental Protection Agency NGO's, regulators, and industry consortium.
11.	Controlled (security, humidity and temperature, packaging) door – door methods for delivery for transporting heath care parcels
12.	Recovering of biogas from waste, lighting upgrades i.e. generating solar energy, automatic switching-off computers and lights when not in use, and purchasing green energy by implementing energy generation and conservation techniques.
13.	Life cycle analysis for understanding the total sustainability impact of commercial transportation

	fuels
14.	Sensors and GPS in vehicles, better optimization and navigation system which employs advanced algorithms to determine optimal delivery route, using telematics for better designing of routes for mileage and fuel reduction, greenhouse gas reduction, operational improvement.
15.	Implementing Telematics for calculating driver's performance, timely maintenance.
16.	Water risk management and Implementing water conservation techniques.
17.	Third party verification, comprehensive measurement and reporting for evaluating and controlling greenhouse gas emissions.
18.	Environmental guidance statements and policy
19.	Monitor and maintain environmental performance and regulations.
20.	Waste management, recycling programs, waste reduction model, zero waste initiatives.
21.	EMS (ISO 14001).

Table 5.1: Technical requirements for UPS

FedEx

The data is collected from the reports (FedEx, 1995-2014; FedEx, 2012a; FedEx, 2012b; FedEx, 2013). It also contains GRI index. The technical requirements are listed in table 5.2.

S.No	Technical Requirements
1.	Continual improvement in environmental management
2.	Evaluation of environmental impact, emergency preparedness.
3.	Improvements in environmental performance by employee's involvement
4.	Recycling program, Prevention of pollution, efficient use of natural sources.
5.	Auditing progress, setting and reviewing objectives and targets, reporting for measuring environmental performances.
6.	Developing environmental policy
7.	Environmental laws and regulations compliance
8.	Use of new technology fleets emitting less pollution and are fuel efficient by using electric and hybrid electric vehicle and train.
9.	Reducing Papers
10.	Initiating eco driving programs
11.	Use of route optimization and decision support technology for proper delivery planning
12.	Generating energy from solar powers
13.	Procurement of renewable energy
14.	Implementing strategies for fuel efficient, less polluting, right sizing, cleaner vehicles, using hybrid vehicles and routing by right application of vehicles.
15.	Partnering with EPA SmartWay Transport to implement more fuel efficient transportation, reduce fuel consumption and emissions.
16.	Engaging employees, suppliers, contractors in environment awareness
17.	Implementing low flow plumbing fixtures for reducing water use.
18.	LEED certification for building green stores, warehouse and distribution Centre's.
19.	Automated shipping tool
20.	ISO 14001 certification.
21.	Following detailed policies, procedure, training and recognition.

Table 5.2: Technical requirements for FedEx

YRC worldwide

Data is collected from two websites and is presented in table 5.3 and there is no GRI index available (YRC Worldwide, 2013; YRC Worldwide, 2014).

S.No	Technical Requirements
1.	Implementing empty mile and large scale network optimization strategies.
2.	Use network optimization techniques.
3.	Use of intermodal for emission reduction.
4.	Need of support from government- Triple lane operation.
5.	Implementing fleet strategies to reduce emissions like new equipment with emission control technology, cleaner burning fuels, use of alternative fuels, hybrid vehicles to reduce carbon footprints made from fleet.
6.	Limiting speed of trucks, new technology vehicles, using hotels instead of idling of trucks overnight, buying fuel efficient tires, and heavyweight shipments for green-house gas reduction.
7.	Partnership with other companies to implement environment sensitive supply chain solutions
8.	Chemical recovery and repackaging, Tire recycling, light bulb fixtures using long life lubricants and oils, proper draining and crushing of oil filters and batteries, scrap metal for waste reduction and recycling programs.
9.	Implementing E-commerce for managing shipping to reduce paper consumption
10.	Alternative use of fuel, shifting to 5W full synthetic motor oil to improve the fuel efficiency of its fleet and reduce motor oil waste, adding wind skirts to its 53 foot trailers.
11.	Compliance with environmental rules and regulations.
12.	ISO 9001:2000

Table 5.3: Technical requirements for YRC Worldwide

DHL

Data is collected from the DHL website and the report. The technical requirements are presented in the table 5.4 (DHL, 2013; DHL, 2014).

S. No	Technical Requirements
1.	Compliance with rules and regulations
2.	Involvement of stakeholders in program even customers like GoGreen programs
3.	Measurement of greenhouse gas emissions using standardized programs
4.	Modernizing of air fleets, Using high technology like telematics, hybrid drive systems, energy efficient lightening, refurbishment of heating and cooling systems for energy conservation
5.	Use of green electricity, biogas and initiatives of energy saved.
6.	Develop, implement and take corrective actions for targeted measures and risk to reduce fuel and energy.
7.	Online transparency in carbon reports, optimization service to simulates the best combination of transport mode and product for reducing carbon footprint
8.	Generating joint initiatives to develop sustainable logistic models

9.	Waste reduction by type and recycling programs
10.	Sharing of environment responsibility with partners, suppliers and customers
11.	Green carrier scorecard/ implementing effective tool for steering and implementing efficiency measures.
12.	Working with airline partners to establish a standardized platform for the efficiency of air transport
13.	Reducing total carbon footprints
14.	Initiatives to mitigate environmental impact of products and services
15.	ISO 14001, ISO 9001, ISO 13485 certification
16.	Setting targets to reduce carbon throughout its process
17.	Reduced percentage of material
18.	Reclaimed package material

Table 5.4: Technical requirements for DHL

Atlas Van Lines

Data is collected from its website and a document downloaded from its site. It doesn't have GRI index.(Atlas, 2014; Atlas Van Lines, ; Atlas World Group, 2014). The initiatives are termed as technical requirement and are in table 5.5.

S. No	Technical Requirements
1.	Commitment to reduce environmental impact
2.	Waste reduction
3.	Recycling of packaging material, cartridges, tires, batteries, paper, cartoons, reuse of motor oil, powering heaters re-use and recycling.
4.	Reduce disk space requirements, powering down computers, heating and cooling energy audit and adjustments to thermostat, smart policies for data retention to reduce power loads on server sensors for automatic switching of lights for energy reduction and efficient use
5.	Installation of on- board information systems to reduce carbon and fuel efficiency.
6.	Awaking employees to reduce impact on environment through training.
7.	Development of environment policy
8.	Measuring impact on environment.
9.	Establish goals and objectives related to environment impacts.
10.	Partnership with stakeholders
11.	Reporting of performance.
12.	Fully implemented EMS and pollution prevention program
13.	Reducing the use of paper
14.	High tech conservation tools and fleet for operations.
15.	Alternative use of energy and hybrid vehicles by using solar energy and low Sulphur diesel fuel.
16.	Saving energy by using pre-pass for toll booths, powering down computers, lights.
17.	Allowing software's to run several applications with same hardware for Server virtualization.
18.	Protecting ground water by using biodegradable soaps, double hulled tanks.
19.	Registration of ISO 14001, ISO 9000.
20.	Compliance with laws and regulatory requirements
21.	Continuous improvement process to lessen impact on environment.

Table 5.5: Technical requirements for Atlas Van Lines

Penske Logistics

Data is collected from its website and it doesn't contain GRI index (Lieb & Lieb, 2010; Penske, 2014). And the technical requirements are delineated in table 5.6.

S. No	Technical Requirements
1.	Alternative fuels, Limiting speed of trucks, Reduce empty miles, proper tire inflation, Idle control, Provide larger trucks with diesel engines fuel saving technologies and onboard technologies to improve fuel efficiency and fleet's efficiency.
2.	Involve employees in green initiatives.
3.	Centralizing all inbound material handling.
4.	Implementing efficient inbound material strategy through network design optimization.
5.	Implementing carrier and freight management system.
6.	Achieving real time visibility of supply chain shipments, schedules, and orders by implementing Information technology system.
7.	Provide trucks with their body made of recyclable material.
8.	Reduce greenhouse gas emissions by renting new trucks with latest emission control technologies.
9.	Use recyclable packaging material.
10.	Reduce tire waste.
11.	Partnership with EPA SmartWay
12.	Improve driving performance
13.	Commitment to reduce indirect emissions from electricity usage.
14.	Collaboration with EPA green power partnership.
15.	Training initiatives related to environment.

Table 5.6: Technical requirements for Penske Logistics

Swift Transportation

Data is collected from its website and there was no GRI index and report but corporate responsibility issues were discussed on one of the webpage (Birkland, 2014; Swift, 2015). The technical requirements are presented in table 5.7.

S. No	Technical Requirements
1.	SmartWay transportation partnership Collaboration
2.	Building own recycling programs and spill prevention, control and countermeasure training program.
3.	Deploy the latest technology fleet to reduce carbon footprints and energy made from fleet.
4.	Using electric boost-off equipment's rather fuel-powered battery boost for saving energy from fleet.
5.	Reduce process output variation and enabling green initiatives through Six sigma lean initiatives
6.	Refurbishing trailers and steel wheel for longer service
7.	Physical changes in the building and turning off lights during day in fleets to conserve energy.

Table 5.7: Technical requirements for Swift Transportation

United Van Lines

Data is collected from the report available on the website and it also contains GRI index. (UniGroup, 2013) and the technical requirements are formulated in table 5.8.

S.No	Technical Requirements
1.	Developing environmental guidelines to improve environmental performance
2.	Forming team for sustainability and responsibility
3.	Compliance with laws and regulations of environment
4.	Providing Environmental guidelines, making them accessible, updating regularly, revising and transparent
5.	Management participation in sustainability initiatives.
6.	Reduce the use of paper by circulating electronically.
7.	Recycling cell phones, rechargeable batteries, tires and cartoons, Printing cartridges
8.	Disposing light bulbs properly
9.	Reselling furniture and recycling electronics and computers
10.	Reducing emissions caused by excessive traveling through conference calls.
11.	Minimizing usage of lights when not used, Installing solar panels, Installing induction lights in parking areas, Equipping new materials and appliance that are energy star to conserve energy.
12.	Conserving energy by driving on variable speed for heating and cooling systems.
13.	Using cleaners that are green and Initiating steps to reducing waste and use recyclable material.
14.	Stakeholder engagement in green initiatives
15.	Implementing green cafeteria
16.	Supporting composite

Table 5.8: Technical requirements for United Van Lines

C and K trucking Company

Data is collected from the website, mainly from the environmental report and there is no GRI index available (C & K Trucking, 2014). The technical requirements of C & K trucking company are presented in table 5.9.

S.No	Technical Requirements
1.	Commitment to reduce carbon footprints
2.	Partnership with Environmental Protection Agency SmartWay transport program
3.	Developing backhauls to Reduce empty miles
4.	Implementing speed management policies, reducing idle time, retrofitting engines, purchasing new tractors and tires.
5.	Opening recycle centers at offices
6.	Encouraging employees to use paper efficiently.
7.	Reducing travelling for employees by video conferencing to save fuel, cost, reduce carbon

	emission.
8.	Conserving energy by replacing light bulbs with compact fluorescent light bulbs
9.	Implementing software on tractors to track driver and monitoring fleet for miles per gallon
10.	Implementing software to track and monitor fuel efficiency metrics to increase fuel efficiency.

Table 5.9: Technical requirements for C and K trucking company

Food and Beverage sector

Out of the six companies that were analyzed, five companies technical requirement are listed below and one is used in chapter 3 as an example.

Kellogg Company

Data is collected from its website and there was no GRI index available. All the green initiatives were considered while constructing technical requirements but social issues were ignored (Kellogg, 2012; Kellogg, 2013) and are presented in table 5.10.

S.No	Technical Requirements
1.	Supporting the growth of suppliers
2.	Clarify the standards for suppliers related to quality, integrity, heath, safety and environment.
3.	Auditing of suppliers and EHS audits on timely basis.
4.	Reduce energy and water use
5.	Reduce greenhouse gas emission
6.	ISO 14001 certified and OHSAS 18001
7.	Engaging with the growers to drive sustainability
8.	Providing training to the farmers
9.	Engagement of stakeholders on the issue of palm oil to reduce sustainability
10.	Sourcing of palm oil only from sustainable sources.
20.	Encouraging consumers for recycle the products after use.
21.	Collection of waste for recycling
22.	Environmental, health and safety (EHS) strategy with goal to zero injuries, negative impacts to planet and communities.
23.	Using How2Recycle label outside the packaging for recycling.

Table 5.10: Technical requirements for Kellogg Company

Molson Coors Brewing Company

Data was collected from its website and there was no GRI index was used while constructing technical requirements (Coors, 2014) and depicted in table 5.11.

S.No	Technical Requirements
1.	Meeting local regulatory and self-regulatory standards.
2.	Improving energy efficiency by converting brewery waste water to biogas energy for using in heating processes and electricity
3.	Improving water efficiency by anaerobic digestion waste water treatment technology, working with LEAF to develop water management techniques.
4.	Reducing Green House gas emissions
5.	Developing global waste reduction strategies and targets
6.	Evaluating alternative materials, optimizing designs for packaging to reduce, reuse, refill and recycle packaging
7.	Suppliers compliance with companies supplier standards
8.	Deployment of Sedex to evaluate suppliers based on environment, social, and economic risks.
9.	Engagement of stakeholders
10.	Joint partnerships to save water, energy, and packaging
11.	Assessment of risks associated with resources used and waste generation.
12.	Minimizing use of natural resources
13.	Lifecycle analysis to reduce greenhouse gas emissions from design to packaging finalization., distance to transport, recycle content, recovery value, energy or recyclability innovation different from industry standards.
14.	Procuring sustainable packaging material
15.	Providing guidelines to suppliers and sourcing from suppliers that meet sustainability standards.

Table 5.11: Technical requirements for Molson Coors Brewing Company

PepsiCo, Inc.

Data is collected from the website and the reports from the same website . GRI index is also used to convert green intiatives into technical rreqirements (Pepsico, 2013a; Pepsico, 2013b) and delineated in table 5.12.

S.No	Technical Requirements
1.	Setting goals to guide strategies and operations.
2.	Engagement of stakeholders and having feedback from them
3.	Implementing specialized membrane bloreactor technology with low pressure reverse-osmosis to protect, conserve, distribute, and purify global water supplies.
4.	Innovative packing strategies to minimize its impact on environment and its calculation for material recycled
5.	Deploy a convenient recycle solution and programs to Eliminate solid waste to landfills from production
6.	Improve energy use and conversion to renewable forms of energy
7.	Implementing anti idling and speed limiting system to increase energy efficiency in fleets
8.	Implementing sustainable farming initiative program and addressing accountability, engagement, risk assessment and mitigation with suppliers.
9.	Partnership with all sectors to deliver innovative solutions for climate change, water scarcity, and food security.
10.	Reduce packaging weight by light-weight packaging initiatives
11.	Converting PET bottles to light weight bottles to avoid use of plastic
12.	Implementing biomass boilers, solar thermal systems getting certified from SmartWay company

	to conserve energy and use renewable energy.
13.	Providing training and education to stakeholders.
14.	Opening LEED certified warehouse and distribution centers.
15.	Reduction in greenhouse gas emissions.
16.	Responsible marketing and labelling
17.	Report processes, policies and achievement to the highest governance body with respect to environmental concerns.
18.	Initiatives for water and access to clean and reuse.
19.	Calculation of total weight of waste by type and disposal method.

Table 5.12: Technical requirements for PepsiCo

Starbucks Corporation

Data is collected from the website of Starbucks and the responsibility report of Starbucks which was also available at its website (Starbucks, ; Starbucks, 2013; Starbucks, 2015)and are in table 5.13.

S.No	Technical Requirements
1.	Development and implementation of green stores by collaborating with Green building council (U.S).
2.	Implementing energy management system to reduce energy use and support renewable energy.
3.	Purchasing renewable energy by purchasing Green- E certified renewable energy certificates.
4.	Reduce water consumption by efficient fixtures and equipment that monitors the consumption of water usage and identify spikes, upgrading water filtration systems.
5.	Reuse and recycling of cups, milk jugs bottles, cardboard boxes, plastic lids, packaging, and front of door and change of material that's recyclable.
6.	Partnership with businesses and organizations to improve climate changes.

Table 5.13: Technical requirements for Starbucks Corporation

Tim Horton's Inc.

Data is collected from Tim Hortons's sustainability report (Hortons, 2013) and elucidated in table 5.14.

S.No	Technical Requirements
1.	Engage stakeholders to understand issues, impacts, risks and opportunities
2.	Make long term commitments but also make short term goals and review them on timely basis.
3.	Reusing of water
4.	Technical training to farmers for farm management to plan on lifespan of projects.
5.	Do not allow use of banned pesticides.
6.	Reusing of blueberry pails.
7.	Partnership with abnormal communities and coffee blending to support sustainability.
8.	Third party verification in terms of social, economic and environmental by setting some comprehensive key performance indicators.

9.	Educating farmers for sustainable farming techniques.
10.	Reduce packaging by setting benchmarks.
11.	Developing strategies for waste reduction.
12.	Recycling of cans, bottles cardboard, packaging by designing better packaging, reducing material, increasing recycle content, using new material types and sources.
13.	Validating waste baseline data and performing waste audits/ implementing LED lightning system in restaurants.
14.	Upgrading fleet and trailers, using more efficient automatic transmission trucks for increasing fuel efficiency.
15.	Aiming to reduce energy and water usage through LEED certification of restaurants
16.	More efficient routing and trailer cube utilization by implementing centrally route and optimization system.
17.	Purchasing of raw food from the suppliers who have transition to open housing
18.	Control greenhouse gas emissions by focusing on majorly emitting areas.
19.	Track waste from all aspects of operations
20.	Using pallets for re-use and recycling of wood
21.	Resizing and reconfiguring for pallet optimization
22.	Partnership with recycling companies.
23.	Using jute bags for holding coffee, Using waste product from coffee as soil additive in farms
24.	Water and Energy conservation.

Table 5.14: Technical requirements for Tim Horton's

Retail Sector

Out of the four companies that were listed, the three companies technical requirements are listed below and one is used in chapter 3.

Loblaw Companies Limited

Data is collected from the two pdf reports of Loblaw's (Loblaw, 2010; Loblaw, 2013) and summarized in table 5.15.

S.No	Technical Requirements
1.	Diverting waste from landfill
2.	Eliminating, reducing or changing the non-recyclable packaging components to a recycled one.
3.	Initiating waste -to -energy program by generating steam from waste to generate electricity
4.	Initiating the use of reusable bags and packaging material
5.	Recycling of plastic, cardboard, wood pallets, metal, electronics etc.
6.	Turning organic waste into fertilizer
7.	Converting waste oils and grease into biodiesel
8.	Producing electricity from organics and grease
9.	Reducing carbon emissions by installation of new lighting, heating, air conditioning systems and refrigeration technologies that save energy, optimizing energy management system, expanding waste diversion program.
10.	Using solar panels to produce electricity as renewable energy.
11.	Replacing older trucks by newer with more efficient models to reducing emissions and

	increasing fuel efficiency.
12.	Using hybrid trucks burning liquefied natural gas that emits less greenhouse gas.
13.	Reducing paper use.
14.	Creating sustainable seafood sourcing framework and certification of Marine Stewardship Council and Aquaculture Stewardship.
15.	Sustainable procurement by stopping selling of at-risk species until sustainable sources are found.
16.	Encouraging suppliers to source palm oil from sustainable source.
17.	Sustainable procurement.
18.	Auditing of suppliers.
19.	Implementing pilot programs to achieve 100% diversion from landfill at one store and distribution Centre.
20.	Increasing rail use for reduction of greenhouse gas emission.
21.	Reducing driver idle time to increase fuel efficiency

Table 5.15: Technical requirements of Loblaw's

Rona Inc.

Data is collected from Rona's website. We found no report related to sustainability but initiatives were found on the website (Rona, 2015) and are summarized in table 5.16.

S.No	Technical Requirements
1.	Sustainable procurement by procuring eco- responsible products or materials derived from recovery.
2.	Highlighting the environmental attributes of products for consumers.
3.	Offering large varieties of product that are certified as energy efficient, water consumption efficient, GreenGuard certified cleaning products.
4.	Collaboration with other company on the life cycle approach for eco- responsibility and product assessment program.
5.	Using eco-labels.
6.	Partnership with suppliers and stakeholders.
7.	Partnership with other companies to execute best practices for optimizing packaging
8.	Sustainable procurement sources by eliminating excess packaging, and packaging material that contains Oxo-degradable, biodegradable, hazardous material and packaging that release harmful chemical substances, eliminating waste generated by packaging.
9.	Guidelines for procurement policy specifying procurement policies and ways of reducing environmental impacts.
10.	Supplier certifications to adopt best practices related to environment
11.	Improving recyclability, communications and recovery
12.	Sustainable procurement of paper
13.	Implementing management and communication practices that help to reduce consumption of paper
14.	Optimizing lighting system, reducing levels of heating and cooling, optimizing transportation routes
15.	Implementing a recovery and recycling program.
16.	Implementing a recovery and recycling program of fluorescent light bulbs.
17.	Collaboration with other companies for proper management of company's hazardous waste.

Table 5.16: Technical requirements for Rona

Canadian tire Corp. Ltd.

Data is collected from the sustainabilty report of Canadian tire (Canadian Tire, 2013) and its initiatives are in table 5.17.

S.No	Technical Requirements
1.	Right sizing of product packaging, reduces product damage and improving operational footprints.
2.	Reducing energy use in transportation by using long combination vehicles.
3.	Reducing energy use in buildings and operations by installation of LED lightening and sensors, demand control ventilations, roofing retrofits, cooler retrofits etc.
4.	Initiating water saving program by installation of smart controllers and hardware for water systems.
5.	Proper packaging and handling of products.
6.	Reducing carbon emission.
7.	Using alternative renewable energy.
8.	Engaging employees into sustainability practices.
9.	Initiating waste diversion program.
10.	Reduce waste from landfills.
11.	Eliminating the use of paper.
12.	Continuous improvement

Table 5.17: Technical requirements for Canadian Tire