CARBON FOOTPRINT IN MANUFACTURING & SUPPLY CHAIN OF PET BOTTLES

Dissertation submitted to Collage of Management & Economics Studies for the partial fulfillment of the degree of

MBA (LOGISTICS & SUPPLY CHAIN)

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April, 2015

CERTIFICATE

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the dissertation report on “CARBON FOOTPRINT IN MANUFACTURING & SUPPLY CHAIN OF PET BOTTLES” completed and submitted to University of Petroleum and Energy Studies, Dehradun by Ashutosh Chakradhar in partial fulfillment of the provisions and requirements for the award of degree of MASTER OF BUSINESS ADMINISTRATION (LOGISTICS AND SUPPLY CHAIN MANAGEMENT), 2013-2015 is a bonafide work carried by the scholar under my supervision and guidance.

To the best of my knowledge and belief the work has been based on investigation made, Case studies and analyzed by the scholar, and this work has not been submitted anywhere else for any other university or institution for the award of any degree/diploma.

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ACKNOWLEDGEMENT

First and foremost, I would like to thanks my respective mentor "Dr. Saurabh Tiwari" (Lecturer - CMoES) for his valuable guidance and encouragement throughout my research project on "CARBON FOOTPRINT IN MANUFATURING & SUPPLY CHAIN OF PET BOTTLES". His expertise, enthusiasm, and dedication for work have been constant source of motivation for me.

I would like to express my deep gratitude to "University of Petroleum and Energy Studies" for extending the opportunity of undergoing the project and providing with all necessary resources and expertise needed for completion of the project.

I also convey special thanks to "Dr. Neeraj Anand –Head of Department (MBA-Logistics and Supply Chain Management)" for his extended support throughout the project.

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EXECUTIVE SUMMARY

Plastic product can be made more suitable by reducing carbon dioxide emission. Solid waste generation & pollution during production of plastic products. Life Cycle Assessment) is used to compare the carbon emission and waste generation while producing plastic products. The environmental impact of plastic bags manufacturing is compared to the impact of paper bag manufacturing.

Plastic bag manufacturing emits less carbon dioxide, consumes less energy, produce much less waste, and require significant less water than paper bag manufacturing.

Plastic manufacturing operation can meet Californias 50% diversion rate requirement by utilizing post industrial and post consumer plastics. Plastics manufacturing plants can certify their carbon reduction and waste diversion performance through a nonprofit organization that performs energy and waste audit at the manufacturing operation. Increased recycling can provide carbon credits for manufacturing companies.

Global consumption of polyethylene terephthalate (PET) packaging is forecasted to reach 19.1 million tonnes by 2017, with a 5.2% increase per annum between 2012 and 2017.

This rapid increase in PET bottle consumption has also led to the emergence of various issues. These include environmental pollution, health concerns for scavengers, and low utilization efficiency for reclaimed PET bottles.

Even though PET bottles are graded in number one category of recyclable products but are not risk free.

Long periods of use or exposure to sunlight can cause PET bottles to leach toxic carcinogens. In light of growing concerns over environmental protection, resource conservation, and the development of recovery technology, recycling has become a key factor in the supply chain of PET bottles

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REFRENCES

Website:

(http://www.epa.gov/epawaste/conserve/tools/warm/pdf/plastics.pdf)Date Retrieval 4/4//2015

(http://www.apics.org/) Date of Retrieval 6/2/2015

http://www.plasticbottleseurope.org/ghg/emission) Date of Retrieval 4/4//2015

http://www.sustainablegreenproducts.org/plastic.pdf

https://www.google.co.in/search?q=green+supply+chain+management&num=100&tbm=isch&tbo=u&source=univ&sa=X&ei=AFIhVY3gAsagugTW0IDgBg&ved=0CCIQsAQ&biw=1366&bih=643#imgdii=_3/2/2011

http://www.cognizant.com/InsightsWhitepapers/Creating_a_Green%20Supply_Chain_WP.pdf

http://www.airccse.org/journal/mvsc/papers/3_26/2/2011

http://www.nestle-watersna.com/en/water-sustainability/reducing-our-carbon-footprint

https://www.google.co.in/search?num=&source=hp&q=carbon+emission+in+manufacturing+of+bottles)

http://www.knowtheflow.com/2012/getting-it-straight-exact-carbon-emissions-from-one-bottle-of-wine/ http://www.epa.gov/climateleadership/documents/managing_supplychain_ghg.pdf

https://www.google.co.in/search?num=100&q=carbon+footprint+in+the+supply+chain)

Articles, Books, Newsletters:

1) Akerlof, G. A. (1970). "*The Market for" Lemons*": Quality Uncertainty and the Market Mechanism." The Quarterly Journal of Economics.

2) Babiker, M. H. (2005). "*Climate change policy, market structure, and carbon leakage.*" Journal of International Economics.

3) Beamon, B. M. (1999). "*Designing the green supply chain*." Logistics Information Management

4) Beamon, B. M. (1999). "*Measuring supply chain performance.*" International Journal of Operations and Production Management.

5) Bohringer, C. (2003). "*The Kyoto Protocol: A Review and Perspectives*." Oxford Review of Economic Policy.

6) British Standards Institute (2007). PAS 2050 - Specification for the Measurement of the Greenhouse Gas Emissions in Products and Services. London, British

7) Standards Institute. Caplice, C. and Y. Sheffi (1994). "*A review and evaluation of logistics metrics.*" The International Journal of Logistics Management.

8) Caplice, C. and Y. Sheffi (1995). "*A review and evaluation of logistics performance measurement systems*." The International Journal of Logistics Management.

9) Carbon Trust (2006). *The Carbon Emissions Generated in All That We Consume*. London, UK.

10) Carbon Trust (2007). Carbon Footprint Measurement Methodology. London, UK, The Carbon Trust.

11) Caswell, J. A. and D. I. Padberg (1992). "Toward a More Comprehensive

12) Hua Zhang, Zong-Guo Wena (2013), "The consumption and recycling collection system of PET bottles: A case study of Beijing, China",*Waste management.*

13) Michiko A., 2004. "*PET bottle system in Sweden and Japan: an integrated analysis from a life-cycle perspective*"

http://www.lumes.lu.se/database/alumni/03.04/theses/amano _michiko.pdf> (accessed 13.08.13)

14) NAPCOR, 2012. "PET is the most widely recycled plastic in the world". <http://www.napcor.com/PET/landing_ petrecycling.html>.(Accessed 5.08.13).

15) Martin Christopher, 2011. "Logistics and supply chain management", Fourth edition, Pearson education limited.

16) Kannan Govindan, Maria Nicoleta Popiuc (2013), "*Reverse supply chain coordination by revenue sharing contract: A case for the persona computers industry*", European Journal of Operational Research 2013.

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

18) Ali Diabata, Kannan Govindanb (2011), "*An analysis of the drivers affecting the implementation of green supply chain*" Management Resources, Conservation and Recycling 55, 659–667

19) Srivastava KS (2007). Green supply-chain management: a state-of-the-art literature review. International Journal of Management Reviews 2007, 9(1), 53–80.

20) Rajesh Attri, Nikhil Dev and Vivek Sharma (2013) "*Interpretive Structural Modelling (ISM) approach: An Overview*", Research Journal of Management Sciences Vol. 2(2), 3-8.

21) Ahuja V, Yang J, Shankar R (2009) "*Benefits of collaborative ICT adoption for building project management*" Constr Innov 9(3), 323–340

22) Kannan G, Haq A.N., (2007) "*Analysis of interactions of criteria and sub-criteria for the selection of supplier in the built-in-order supply chain environment*". International Journal of Production Research 45, 1–22.

23) S. Suh and G. Huppes, "*Methods for life cycle inventory of a product*,"*J. Cleaner Prod.*, vol. 13, no. 7, pp. 687–697, 2005.

24) A. Tukker, P. Eder, and S. Suh, "*Environmental impacts of products: Policy relevant information and data challenges*," *J. Ind. Ecology*, vol.10, no. 3, pp. 183–198, 2006.

25) Y. A. Huang, M. Lenzen, C. L.Weber, J. Murray, and H. S. Matthews, "*The role of input-output analysis for the screening of corporate carbon footprints*," *Econ. Syst. Res.*, vol. 21, no. 3, pp. 217–242, 2009a.

26) Y. A. Huang, C. L. Weber, and H. S. Matthews, "*Categorization of scope 3 emissions for streamlined enterprise carbon footprinting*," *Environ. Sci. Technol.*, vol. 43, no. 22, pp. 8509–8515, 2009b.

27) J. C. Minx *et al.*, "Input-output analysis and carbon footprinting: A review of applications," *Econ. Syst. Res.*, vol. 21, no. 3, pp. 187–216, 2009.

28) T. Wiedmann, "Carbon footprint and input-output analysis—An introduction," *Econ. Syst. Res.*, vol. 21, no. 3, pp. 175–186, 2009.

29) *Carbon Footprints in the Supply Chain: The Next Step for Business*. London, U.K.: Carbon Trust, 2006.

30) McKinsey, Unlocking Energy Efficiency in the US Economy McKinsey & Company Report, McKinsey & Company, 2009a.

31) McKinsey, "Pathways to a low carbon economy," McKinsey & Company, New York, McKinsey & Company Report, 2009b.

GLOSSARY

CO_2-eq	Carbon dioxide equivalents
ELV	End-of-life vehicles
EPS	Expanded polystyrene foam
EU	European Union
GHG	Greenhouse gases
GWP	Global Warming Potential
HDPE	High-density polyethylene
HIPS	High-impact polystyrene
LCA	Life cycle assessment
LDPE	Low-density polyethylene
LLDPE	Linear low-density polyethylene
PA	Polyamide
PE	Polyethylene
PET	Polyethylene terephthalate
GSC	Green Supply Chain
PLA	Polylactic acid
PMMA	Poly (methyl methacrylate)
PS	Polystyrene
PUR	Polyurethane
PVC	Polyvinyl chloride

CHAPTER – 1

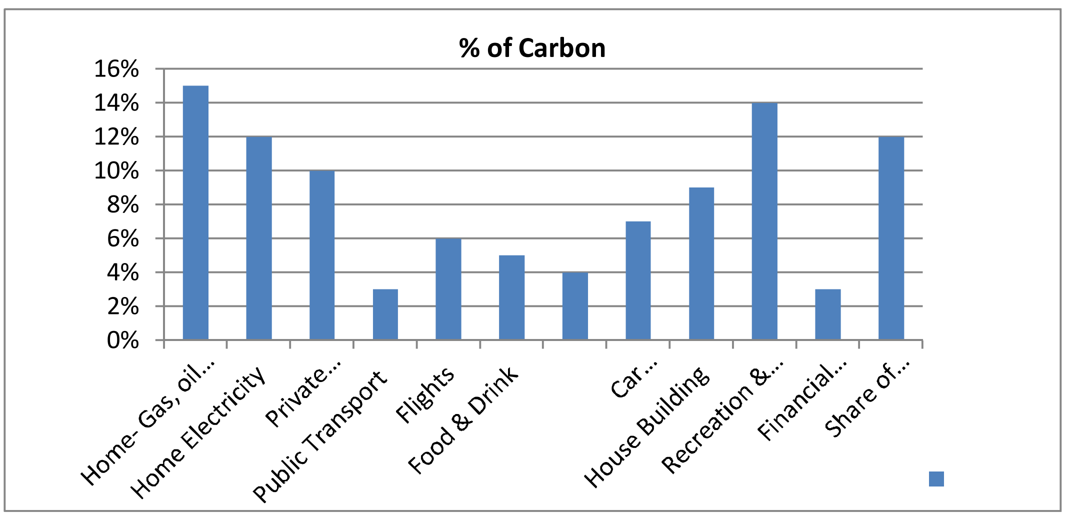
INTRODUCTION

1.1 Issue under study

Carbon footprint' has become a widely used term and concept in the public debatd the responsibility and reducing the threat of global climate change action. It was huge increase in public appearance in the past months and years and is now a buzzword widely used in the media, the government and the business world.

Context

A carbon footprint is a measure of theimpact of our activities on the environment andin particular climate change. It relates to the quantity of GHGS p roduced in our daythe day of lives through the combustion offossil fuels for electricity, heating andtransport, etc. The carbon footprint is a measure of all GH GS we produce individuallyand has units of tones (or kg) of carbon dioxide equiv alent.



Source: www.carboncontrol.us.com

Carbon foot print is made up of 2 parts. Primary Footprint & Secondary footprint.

1. The **primary footprint** The direct emission of Co2 is from the burning of fossile fules including domestic energy consumption.

2 Secoundry Footprint: the measure of indirect Co2 emission from lifecycle of the product – this emission is associated with the manufacturers and eventual breakdown.

"The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."

The increasing interest in 'carbon footprinting' comes as a result of growing public awareness of global warming. The global community now recognizes the need to reduce greenhouse gas emissions to mitigate climate change. Countries, organizations and individuals alike are starting to take responsibility. Businesses and services that are not currently regulated under the *Kyoto protocol* may wish to preempt future regulations, and may find marketing advantages in being 'green'. Calculating a carbon footprint can be a valuable first step towards making quantifiable emissions reductions. This in turn can lead to long term financial savings as well as reducing climate-change impact.

1.3 Rationale of Research

PET income in India has increased considerably in line with economic growth over the last decades. The ministry of statistics and programme implementation (MOSPI) reports that urban wages have been rising by 17.38 % between 2000 and 2005.1 In line with wages also household expenditure has been rising especially in the urban areas were richer households are located. We expect a large share of plastic bottles to pass the critical income level of 2 Dollars per day and we expect that carbon emissions from Indian households will account for a significant share of global greenhouse gas emissions (GHG) in the future. This rise in carbon emissions will be correlated with increasing direct and indirect energy requirements of households. However, energy consumption and carbon footprints vary with what and how households consume. Therefore, we first identify what we consider the Indian middle class in terms of their income and second we identify consumption patterns, their dynamics, and their respective carbon intensities for the different groups of households.

1.4 Scope of research

This study covers various processes and practices for Carbon Footprint and evaluation being currently used and attempts to identify the most suitable ones for PET bottle supply chain. Manufacturing firms can make their Supplier Relationship management more robust by utilizing the right technique. As companies commit to reduce the carbon footprints of the products and services they provide, they look to their suppliers to align their efforts with the company's sustainability goals. All companies interviewed believe that they can reduce GHG emissions far more by engaging their supply chain.

CHAPTER – 2

LITERATURE REVIEW

Jhon O.L., (1986) described that 'Polymers' is a general term for all plastic materials and means that they are organic, carbon based compounds whose molecules are linked together in long chain patterns. Later on in this book we will look more closely at the molecular structure of plastics so that we can understand how we can make this work to our advantage when designing and making things. When we talk about plastics in general we will call them polymers, and when we talk about specific plastic materials we will give them their real names, such as nylon or polythene. In the face of global climate change altering the physical and business landscapes, the question for the PET bottle industry is no longer whether or not to develop a corporate climate change policy, but what that policy should be and how it should be implemented. A comprehensive carbon management strategy requires consideration of a company's full emissions, including direct emissions from operations, indirect emissions from energy production, and all other indirect emissions from a company's value chain.

According to **Heywood V.,(1989- 1990)** The Carbon Trust recently published a report titled 'The carbon emissions generated in all that we consume'. This report turns the traditional view of business carbon emissions on its head by showing that all the emissions across the economy are generated to meet the needs of the end consumer. For example, iron ore is not made into steel because steel bars themselves are useful but because they, in turn, can be made into components for the televisions we all watch and the buildings we all live in.

Hermann, J.W., Hodgson, B., (2001), That report shows how all emissions sources can be tied back to the provision of different products and services to meet the needs of the end consumer. It also shows the importance of linking all the supply chain steps together to look at the problem as a whole. The report concludes that companies can use a supply chain approach to look for new ways of reducing carbon emissions, just as they have been using supply chain analysis to deliver financial benefits for decades. To demonstrate the practical value that can be gained by business from supply chain analysis both financial and environmental the Carbon Trust has created a business tool for carbon management across the supply chain. A methodology has been developed to build the carbon footprint of different products by analyzing the carbon emissions generated by energy use across the supply chain. This has been successfully piloted with the supply chains of different newspaper and snack foods products. The methodology developed and the results of the pilot studies are presented in this report.

Yasser, Dessouky, G., (2002) In his report he states that, The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which **commits** its Parties by setting internationally binding emission reduction targets. Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities."

Kyoto Gases	GWP	Example Sources
Carbon dioxide (CO2)	1	Burning fossil fuel
Methane (CH4)	23	Cattle, landfill sites, mines, burning fossil fuel
Nitrous oxide (N20)	296	Emission of fertilized soil
Sulpher Hexafluoride (SF6)	22,200	Electrical & Electronic Industries
Perfluro Carbon (PF6)	4,800-9,200	Electronic Industries
Hydrofluro Carbon (HFC)	12-12,000	Air conditioning & Refrigeration system

The Kyoto Protocol is an international agreement to UNFCCC. It was adopted at COP3 held in Kyoto, Japan in December 1997 (with 84 signatures) and entered into force in February 2005. The detailed rules for the implementation of the Protocol were adopted at COP7 in Marrakesh in 2001, and are called the 'Marrakesh Accords.' Today the Protocol counts with 193 Parties (192 States and 1 regional economic integration organization) to the Kyoto Protocol to the UNFCCC.

Jakubski, P.J.S., (2004-2005) defined carbon footprint factors for The GHG Protocol uses five guiding principles when developing a footprint: completeness, consistency, relevance, accuracy, transparency Highlighting two of these principles, consistency is important because a consistent methodology will be needed as your operations change over time. Transparency is important so that you can disclose assumptions and make references for a clear audit trail. The GHG protocol requires six gases to be reported: (1) carbon dioxide (CO_2), (2) methane (CH_4), (3) nitrous oxide (N_2O), (4) hydro fluorocarbons (HFCs), (5) per fluorocarbons (PFCs), and (6) sulfur hexafluoride (SF_6). These are the same six gases that were identified during the development of the Kyoto Protocol. Of the six, only CO_2, CH_4, N_2O (all three are products of combustion) and HFCs (refrigerants) would typically apply to printing operations. The GHG Protocol divides the types of emission sources into three scopes.

Scope 1 sources are direct emissions from the facility, such as:

_ Emergency generators
_ Gas boilers/water heaters
_ Company-owned or leased vehicles
_ Propane forklifts/clamp trucks
_ Refrigerants (HFCs)

Scope 2 is the electricity purchased for your facility. Both Scope 1 and Scope 2 must be included in your calculations per the GHG Protocol.

Scope 3 covers the indirect emissions from your operations, such as:
_ Product materials produced by your suppliers (newsprint/paper, ink, etc.)
_ Contractor delivery vehicles
_ Employee commuting to/from work
_ Business air travel

Scope 3 emissions are optional and are not required to be reported per the GHG Protocol. Some have argued that including these would be double counting your emissions, since your Scope 3 emission sources could be considered somebody else's Scope 1 sources.

Stueland V. J.,(2004) quoted that For experts working with detailed LCA, it is a thought-provoking idea that problems could be captured in a single indicator. Focusing on GWPs alone is a crude approach that may give a misleading picture of the impacts in certain
Cases compared to the multiple-indicator approach in LCA. One example could be bio fuels, for which a low carbon footprint could give the impression of a truly eco-friendly product, despite its negative land use impacts, ultimately increasing the pressure on rainforests and other rich habitats. Still, the carbon footprint could be a valid indicator when one wants to compare different types of bio fuels or the impact from different food products. Because the carbon footprint includes global warming, at least some impacts of land use change are covered by this approach. These impacts from land use may also be proportional to energy use. This is even the case in fisheries, given that the impacts on the seafloor generally are highest for those fisheries that are also the most energy intensive. Basically the same friction causes the damage to the seafloor habitats and the consumption of fuel. Within the LCA community, we have known for many years that the environmental impacts from energy-related emissions are an important factor (if not *the* most important) that contributes to the overall impact potential for most products. There certainly will be cases in which a carbon footprint indicator can be misleading or is interpreted incorrectly Gordon

Brighter Planet (American Carbon Footprint)., (2007) says that Greenhouse gases released by human activities (including feeding 6 billion people) are building up in the atmosphere, trapping heat that would otherwise escape into space and altering the fundamental climate processes that drive global weather patterns. Runaway climate

change poses serious threats to humanity and the natural world, but with deliberate and concerted efforts to reduce our emissions, these consequences can be largely avoided. Whether you live to eat or eat to live, one thing is sure: staying fed represents a substantial portion of your total impact on the climate. The greenhouse gas impacts of food are complex and far-reaching, as every bite of food you eat takes energy to grow, process, store, transport, sell, cook, and discard. But by understanding how your eating habits affect global warming, you gain the power to reduce those impacts through conscious daily living. (The social and environmental impacts of food extend far beyond climate change; our food system also affects biodiversity, water quality, ecosystem functions, human health, and human rights, to name a few, but these impacts are beyond the scope of this paper.) Your "carbon foodprint" is the sum of all the greenhouse gases your meals produce as they wind their way through the food system. Three main gases comprise the vast majority of food-related emissions: carbon dioxide, methane, and nitrous oxide.

1 Carbon dioxide (CO_2) is released whenever fossil fuels like coal, gasoline, or natural gas are burned to generate energy. CO_2 accounts for about 71%of your total food impact.

2 Methane (CH_4) is released when food scraps and packaging decompose in landfills, and during livestock digestion and manure treatment. While methane is released in relatively low volumes, it is 25 times as potent as carbon dioxide. In all, it accounts for about 13% of your total food emissions.

3 Nitrous oxide (N_2O) comes predominantly from chemical fertilizers used on crops. Although little nitrous oxide is released, each pound has a global warming impact equivalent to 300 pounds of carbon dioxide. N_2O makes up about 15% of the average American's foodprint.

4 The remaining 1% of food's global warming impact comes from a number of gases that are released in very small quantities, primarily SF_6 from electricity production and HFCs from refrigeration systems.

5 To simplify things, we combine all of these gases and their relative potencies into a single comprehensive measure of the climate impact of a given activity, called carbon dioxide equivalent (CO_2 e). When we talk about "CO_2 e," "carbon emissions," "climate impact, or foodprints, we're referring to the combined impact of the various greenhouse gases.

Coca-Cola PET Bottle Technology.,(2009) Coca-Cola introduced PlantBottle packaging the first-ever fully recyclable PET plastic bottle made partially from plants in

2009 and has since distributed more than 15 billion of the breakthrough bottles in 25 countries. Approximately 8% of the company's PET plastic bottles last year contained PlantBottle technology.

"Thomas Edison said the power of an idea is in its use," says Scott Vitters, who manages the PlantBottle platform at Coca-Cola. "Making PlantBottle real has been our mantra since day one, because the true benefits of a sustainable innovation are only fully realized once it reaches the marketplace and is used. PlantBottle packaging is making a difference our consumers can reach out and touch today."

In addition to eliminating the equivalent of approximately 140,000 metric tons of CO2 emissions from the company's PET plastic bottles, to date, the innovation has boosted sales of key brands like Dasani. PlantBottle also has strengthened Coke's competitive advantage with key customers, racked up headlines and sustainable and innovation awards, and caught the collective eye of the supply chain and investor community. But the Plant Bottle journey is just beginning, Vitters insists.

"This is not a pilot test, nor are we limiting this technology to a niche brand," he says. "We have committed publicly to convert all of our PET plastic bottles to Plant Bottle packaging by 2020."

Plant Bottle packaging offers the same functionality and recyclability as traditional PET plastic, but with a lighter carbon footprint and reduced dependence on fossil fuels. The packaging uses natural sugars found in plants to make ingredients identical to fossil-based ingredients traditionally used in polyester fibers and resin for bottles. Working together with environmental organizations and academic researchers, Coca-Cola has been careful to identify current and future plant sources that truly deliver improved sustainability performance and do not compete with food crops.

Green within green.,(2009) No brand has done this more effectively than Dasani, which used Plant Bottle to reverse several years of volume decline in the U.S. at the height of the recession. In 2009, several retailers decided not to carry multiple waters after struggling to see differentiation from brand to brand.

"With Plant Bottle, we saw an opportunity to engage with consumers and build love for the Dasani brand while making a difference with a better designed bottle," said Geoff Henry, Dasani's brand director for North America. "After a successful pilot, we rolled it out nationally during Earth Month in April 2011."

The brand created a bold, eye-catching visual identity for Plant Bottle – including an image of a big leaf and green closures that played up both the packaging's connection to plants and nature, and Dasani's clean, crisp taste.

"We used the visual of the bottle rising out of a plant to help consumers understand the Plant Bottle technology, and how Dasani was giving them an opportunity to make an environmentally responsible choice without raising the price of the product or compromising quality," Henry adds.

PlantBottle packaging resonated with Dasani drinkers, who saw the brand as a sustainable packaging leader. More people started buying Dasani – and more often. Dasani volume in the U.S. increased 12 percent in 2011, outpacing the bottled water category by more than 2.5 times, and brand health metrics also improved.

Aside from giving consumers more reasons to buy Dasani, PlantBottle also gave retailers more reasons to stock – or restock – the brand. "PlantBottle provided us with both a compelling brand story and category growth story to share," Henry says.

Shawan.,N.B.,(2010) Manufacturing process consumes a lot of energy acquired from burning various natural resources such as coal, coke and natural gas and combustion causes air pollution. Manufacturing systems evolution is a function in multiple external and internal factors. With today's global awareness of environmental risks as well as the pressing needs to compete through efficiency, manufacturing systems are evolving into a new paradigm. The main goal of green manufacturing is to save energy via new technologies or by supplying greener source of Energy by extending the life cycle of pollutants and wastes and increase the production efficiency via new processes.

A successful green manufacturing technology masters the following key factors:

The amount of energy and resource utilization, Green degree of energy Amount of hazardous waste & Number of reuses of Hazardous waste

Carbon Footprint (CFP) Calculation:

ISO- 14064 common method for the calculation of carbon footprint of Home, Small scale firm or Organization

Calculation Methodology:-

1. Electricity = Input Value (in KWh/yr) X 0.85 (Emission Factor)
2. Petrol = Input Value (in liters/yr) X 2.65 (Emission Factor)
3. Diesel = Input Value (in liters/yr) X 2.65 (Emission Factor)
4. LPG = Input Value (in Kg/yr) X 2.98 (Emission Factor)

Add (1+2+3+4) = Output value in (Kg of CO2)

Note: The Emission Factors (EF) are generalized by Govt. of India. The central electricity authority & GHG protocol.

Energy Source	**Annual Total**		**Factor**	**Kg of CO_2 released**
Electricity		kWhr	0.85	
Gas (Heating)		kWhr	0.20	
Oil (Kerosene)		liters	2.52	
Oil (Gasoil)		liters	2.67	
Gas (Prop/but)		liters	1.50	
Coal		kilogram's	2.46	
Peat		kilogram's	1.36	
Wood		kilogram's	1.04	
Bus		kilometers	0.08	
Train		kilometers	0.04	
Air		kilometers	0.05	
Air (No. of oneway flights per)		number	5.60	

TOTAL CO2 released per year: **0.0 (tonnes/product)**

Annex I countries – industrialized countries and economies in transition – Annex I countries which have ratified the Protocol have committed to reduce their emission levels of GHG to targets that are mainly set below their 1990 levels. They may do this by allocating reduced annual allowances to the major operators within their borders. These operators can only exceed their allocations if they buy emission allowances, or offset their excesses through a mechanism that is agreed by all the parties to UNFCCC. They include the 24 original OECD members, the European Union, and 14 countries with economies in transition. Croatia, Liechtenstein, Monaco, and Slovenia joined Annex 1 at COP-3 in 1997 in Kyoto Japan and the Czech Republic and Slovakia replaced Czechoslovakia.

Annex II countries – developed countries which pay for costs of developing countries - Annex II countries are a sub-group of the Annex I countries. They comprise the OECD members, excluding those that were economies in transition in 1992. Annex II Parties include the 24 original OECD members plus the European Union.

CHAPTER – 3

Research Methodology

3.1 Objectives:

1. To examine the processes and techniques used in the manufacturing of PET Bottles.
2. To compare various articles & case studies used for the reduction of Carbon & GHG emission during the supply chain of PET
3. To investigate major causes of GHG emission in the atmosphere during the Supply chain of PET bottles, also to determine the carbon emission percentage released during manufacturing of bottles.

3.2 Research Design

The research is descriptive as it examines carbon emission in the atmosphere which is a major concern. Case study method has been used for the research work. Existing literature on the subject available on the internet and secondary data of carbon footprint has been used. Comparative study of practices adopted by PET bottle manufacturing industries

Data Collection:

1.3.1 **Type of Data: Secondary data.**

1.3.2 **Sources of Data:** Secondary data has been collected from following sources:-

1. Internet: Websites of Carbon Footprint being studied, Website of Research companies eg. Coca-Cola PET technology ' websites etc.

2. Journals: various Management journals have been reffered for research papers on the subject e.g. Journal of bottles supply chain management-2005.

3. Conferences: Conference proceedings of International Association of Carbon Control & Mgmt Conference, United Kingdom-1999, 2004, 2006)

4. Articles: Various Articles on the subject has been referred are:

- “Carbon Footprint in supply chain” by Carbon Trust, UK (2009).
- “Impact of Carbon Footprint on SCM of Light Goods” by Jacquelin W. Wang and D.V. Shalonil.
- “Green manufacturing of plastic”: the art of planning for success” by Hiroyuki Sato, Japan (2012).
- “Emission of GHG & Management of SC” by Saif Benjaafar.

CHAPTER – 4

Carbon Footprint and Reduction Technique

Distillation of review of literature has brought out that following are the major tools and techniques of carbon footprint and reduction which have evolved over a period of time.

Carbon dioxide is a greenhouse gas. Greenhouse gases play an important role in helping the earth trap and retain heat for life as we know it, however, an increase in the amount of carbon dioxide in our atmosphere could lead to overall warming of our climate. Reducing our carbon footprints will reduce the amount of carbon dioxide that is emitted into the atmosphere as a result of our activities.

- Take a leadership position on the issue of climate change - creating value for your business.
- Have a competitive edge over other businesses by demonstrating your commitment to sustainability and carbon management.
- Enhance your reputation and increase customer loyalty.
- Better prepare your business for a regulated carbon future.
- Communicate and promote your positive climate change action to your staff and customers.

A. Model I: A Single Firm With Strict Carbon Caps

Consider the problem faced by a firm that must determine, over a specified planning horizon consisting of multiple periods with known demand, when and how much to order or when and how much to produce. In the absence of carbon emission considerations, the firm makes ordering decisions to minimize the sum of its fixed and variable ordering or production costs, inventory holding costs, and inventory shortage costs. Fixed ordering costs may correspond to transactions costs associated with placing an order with an outside supplier, such as transportation costs, or with initiating production internally, such as process setup costs. Variable costs may correspond to either unit purchasing or unit production costs. Inventory shortage costs are costs incurred if demand in one period cannot be fulfilled from inventory in that period, and can be in the form of either backorder costs or lost sales costs. In the presence of carbon emission considerations, the firm must account for the emissions associated with various decisions regarding ordering, production, and inventory holding. In particular, there may be emissions associated with placing an order with an outside supplier (e.g., emissions due to transportation) or with initiating production

3) Note that when the price ceiling is set sufficiently low, the price at which carbon is bought and sold becomes essentially fixed. This is also the case when there are both a price ceiling and price floor and the difference between the two is relatively small.

C) Build on communications to deliver performance. Communications are important to convey a company's intentions, as well as its commitment to sustainability. Companies that openly and transparently report significant emissions reductions and quantifiable savings are far more likely to not only meet their sustainability targets, but also get credit from stakeholders for doing so.

D) Set the right targets. Companies and their suppliers should distinguish between absolute emission reduction targets those based on a year-over-year decline in overall emissions and intensity reduction targets those reflecting emissions per unit of product or sales. Absolute emission reduction targets may initially appear to be more desirable because climate change will continue even if emissions per unit of product sold declines and a company just manufactures

B. Modal – II: Carbon Tax or Carbon offset

An alternative to strict caps on emissions is not to restrict emissions but instead to penalize emissions using a *carbon tax*. A carbon tax can take on a variety of forms. In its simplest, the tax is a financial penalty linear in the number of carbon units emitted. An alternative policy to either imposing strict caps or applying a carbon tax is a system whereby firms are allowed to emit more than their prescribed caps but are penalized for doing so, with penalties increasing in the amount of emissions that exceed the cap. Firms are also rewarded for emitting less than their caps by receiving payments increasing in the difference between their caps and their actual emissions. This system of penalties and rewards can be implemented directly by a regulating agency or indirectly via a trading market for carbon emissions, in which firms can buy and sell the right to emit. Both cases can be viewed as allowing the sale and purchase of emission permits at a price. An important difference is that in the case of carbon trading:

1) Price is affected by market dynamics and

2) The total amount of carbon that can be bought and sold is limited by the sum of the caps imposed on the participating firms. Variations on these two schemes are possible, including hybrid policies, where price is allowed to fluctuate but the regulating agency guarantees a price ceiling, a price floor, or both for further discussion.

more product. But companies can meet absolute targets by selling emissions-intensive operations or through outsourcing. Intensity targets, on the other hand, factor in real growth and emissions performance.

E) Integrate information management into sustainability initiatives. Companies should link existing IT systems to carbon management and other sustainability initiatives not only to monitor their own progress, but also to help suppliers meet stated objectives. Integrated information management guides risk assessment, and helps ensure sustainability performance within required tolerance levels. This becomes especially important as the level of knowledge about GHG emissions and the opportunities for improvement increase each year.

F) Focus on performance improvement, not compliance. Companies that move beyond compliance and risk mitigation to identify opportunities for improvement are far more likely to engage and collaborate with suppliers. Companies that succeed in this area will invest in partnerships with suppliers; explore new business models with them, including the important and growing eco-friendly consumer niche; and work in concert with suppliers to build a business case centered on sustainability.

G) Alignment with sustainability commitment: As companies commit to reduce the carbon footprints of the products and services they provide, they look to their suppliers to align their efforts with the company's sustainability goals. All companies interviewed believe that they can reduce GHG emissions far more by engaging their supply chain. For most of them, supply chain emissions surpass their combined Scope 1 and 2 emissions purchasing firm by each individual supplier. This method if implemented properly leads to substantial cost savings and also it allows an organization to compare various purchasing policies with one another. Some companies have corporate GHG goals that explicitly include supply chain reductions. For example, Coca-Cola set a goal to reduce its carbon footprint by 50 percent of 2008 levels by 2020, including reductions in its supply chain.

Chapter 5

PET Bottle Manufacturing

5.1 Introduction:

PET Bottles are used to packing of Edible oils, jams and sauces, Butter, syrups, Drinking water etc having the capacity from 500ml to 2 liters. PET resin are extruded and converted to pre-forms and later molding is done to make the PET Bottles by using the pre-forms. Major application areas of PET bottles are carbonated soft drinks, Mineral water packing, Syrups, Edible oil packing, Butter and Mayonnaise, Wine, Liquor and spirit packing, Sauce, jam and squashes packaging, Agro chemical packaging and house hold containers.

Market:

Pet bottles are replacing glass bottles because of the high rate of breakage and the inconvenience of returning the empty bottle after consumption. The consumption pattern is tending to converge with the international patterns and this is how new categories such as sports drinks, juices and non-returnable (PET bottles and cans) are catching up in the local market.

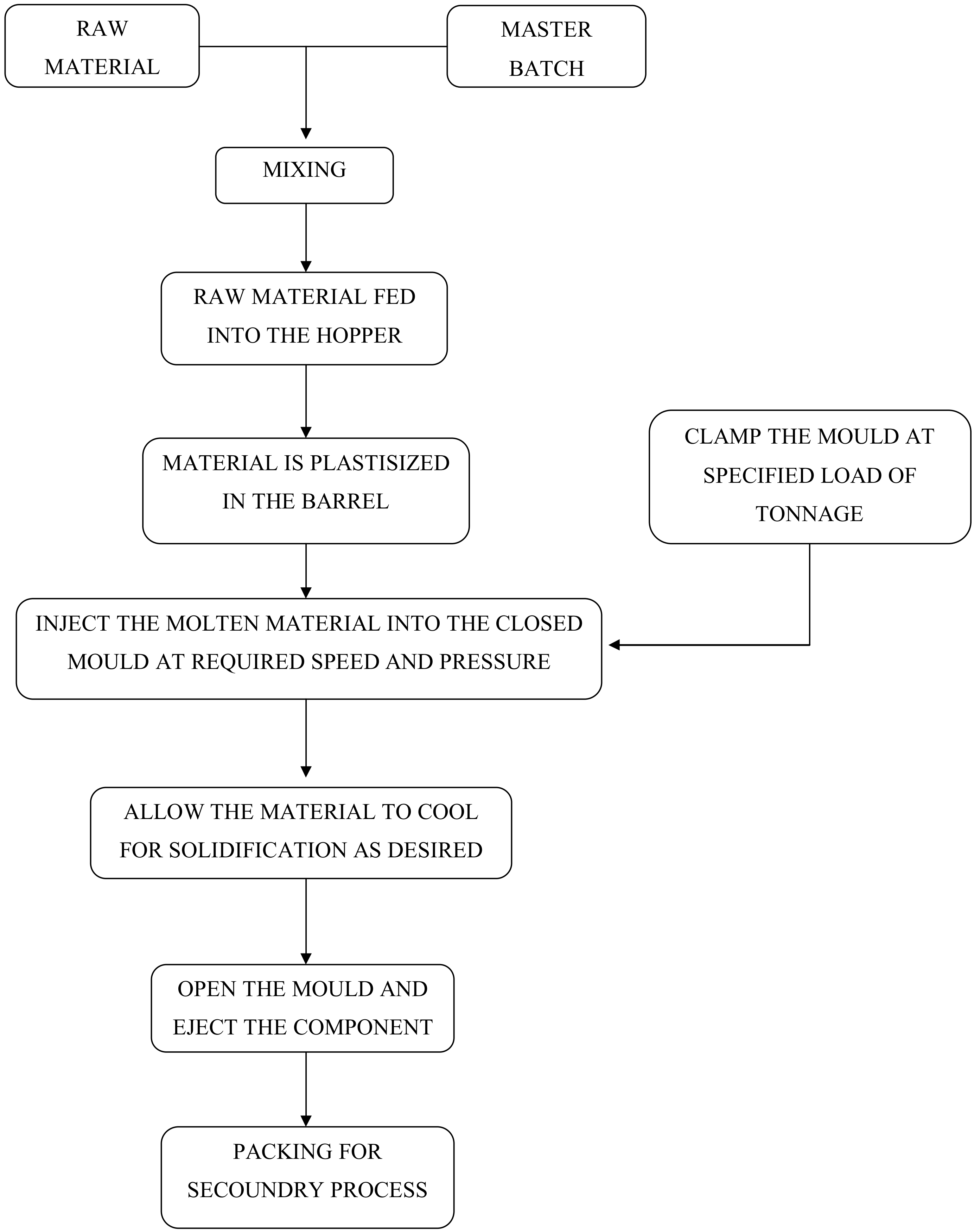
Raw Material Used:

The raw material used in manufacturing of PET Bottles/ Preforms is Polyethylene Teraphthalate. Polyethylene tetra phthalate is a polymer that is formed by combining two monomers called modified ethylene glycol and purified teraphthalic acid.

Manufacturing Process & Technology

Production of PET Performs and PET Bottles involves the conversion of PET Granules to Performs and later converting to PET Bottles through moulding process. The step wise production process is explained in the following process flow diagram:

The technology/Machinery required for manufacturing of the Pet Bottles are three Nos. of Injection Molding Machines, one Color mixer, one Chilling Water plant, a Scrap Grinder and a Centralized Pulley laminating and printing machine. The word plastic itself comes from the Greek word plasticos, which means to be able to be shaped or moulded by heat. As we will see, shaping plastics by using heat is a basic part of nearly all plastics manufacturing processes.


RAW MATERIAL
MASTER BATCH
MIXING
RAW MATERIAL FED INTO THE HOPPER
MATERIAL IS PLASTISIZED IN THE BARREL
CLAMP THE MOULD AT SPECIFIED LOAD OF TONNAGE
INJECT THE MOLTEN MATERIAL INTO THE CLOSED MOULD AT REQUIRED SPEED AND PRESSURE
ALLOW THE MATERIAL TO COOL FOR SOLIDIFICATION AS DESIRED
OPEN THE MOULD AND EJECT THE COMPONENT
PACKING FOR SECOUNDRY PROCESS

Like timbers, which can be divided into hardwoods and softwoods, and metals that can be divided into ferrous and nonferrous metals, plastics can also be divided into categories:

Natural plastics - these are naturally occurring materials that can be said to be plastics because they can be shaped and moulded by heat. An example of this is amber, which is a form of fossilized pine tree resin and is often used in jewellery manufacture.

Semi synthetic plastics - these are made from naturally occurring materials that have been modified or changed but mixing other materials with them. An example of this is cellulose acetate, which is a reaction of cellulose fibre and acetic acid and is used to make cinema film.

Synthetic plastics - these are materials that are derived from breaking down, or 'cracking' carbon based materials, usually crude oil, coal or gas, so that their molecular structure changes. This is generally done in petrochemical refineries under heat and pressure, and is the first of the manufacturing processes that is required to produce most of our present day, commonly occurring plastics.

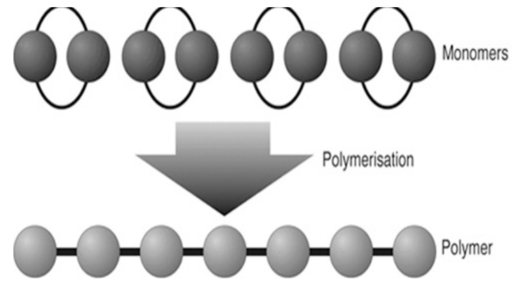
Thermoplastics - these are plastics that can be softened and formed using heat, and when cool, will take up the shape that they have been formed into. But if heat is reapplied they will soften again. Examples of thermoplastics are acrylic and styrene, probably the most common plastics found in school workshops.

Thermosetting plastics - these are plastics that soften when heated, and can be moulded when soft, and when cool they will set into the moulded shape. But if heat is reapplied they will not soften again, they are permanently in the shape that they have been moulded into. Why this happens we will look at later. Examples of thermosetting plastics are polyester resins used in glass reinforced plastics work, and melamine formaldehyde used in the manufacture of Formica for kitchen work surfaces.

'Polymers' is a general term for all plastic materials and means that they are organic, carbon based compounds whose molecules are linked together in long chain patterns. Later on in this book we will look more closely at the molecular structure of plastics so that we can understand how we can make this work to our advantage when designing and making things. When we talk about plastics in general we will call them polymers, and when we talk about specific plastic materials we will give them their real names, such as nylon or polythene.

Structure of Polymer:

To understand how plastics are made, and why certain plastics are suitable for some uses, and others not, we have to understand a little about the structure of polymers. Polymers are large molecules made up of many smaller molecules. 'Poly' means many and 'mer' means units. These smaller units are called monomers (mono = one, mer = unit) and are joined together through polymerization to form polymers.



A polymer contains hundreds of thousands of monomers. Polymerization, which means the linking of monomers to form polymers results from two kinds of chemical reaction called condensation and addition. Polymers fall into two distinct groups, thermosetting plastics and thermoplastics.

Thermosetting polymers are converted into their final form by heat and once set cannot be softened by further heating. Thermoplastics however are softened and become fused or 'plastic' by moderate heating and then harden again on cooling. This process can be repeated many times without radically altering the thermoplastic properties. If the chains run parallel to each other the structure is said to be crystalline (made of crystals).

This contrasts with the disorder of tangled chains in an amorphous (shapeless) structure. Many polymers have both crystalline and amorphous regions, and the proportion of crystalline and amorphous regions in a polymer depends on its chemical composition, molecular arrangement and how it has been processed. Crystallization is one of the two principles that have been used to produce strong, stiff polymers (e.g. polythene and nylon), the other is the formation of strong bonds between the chains which is a process known as cross linking.

“Emission of Carbon in PET Bottle Manufacturing”

In one year alone, from 1995 – 96, plastic packaging increased by 1,000,000,000 lbs. And despite recycling efforts, for every 1 ton increase in plastic recycling, there was a 14 ton increase in new plastic production. I tried to explain some of the roadblocks to plastic recycling efforts. We have all heard that recycling is good for the environment, and it’s hard to argue with the intuitively correct reasoning that if we recycle we reduce our dependence on foreign oil, we conserve energy and emissions and we keep bottles out of the landfills. And what about the lighter weight of plastic bottles? Surely there are benefits in shipping lighter weight bottles giving plastic bottles a lower overall carbon footprint? Well, here's the thing: there are environmental tradeoffs, just like in life. Even if we accept that plastics are more carbon efficient than alternative materials (glass) in transportation, we're still talking about vast amounts of carbon emissions.

Plastics use releases at least 100 million tons of CO2 some say as much as 500 million tons into the atmosphere each year. That's the equivalent of the annual emissions from 10 – 45% of all U.S. drivers. Plastic manufacturing also contributes 14% of the national total of *toxic* (i.e., other than CO2) releases to our atmosphere; producing a 16 oz PET bottle generates more than 100 times the amount of toxic emissions than does making the same size in glass. But the critical point is that it's definitely cheaper to ship liquids in plastic rather than in glass. And it's also cheaper for manufacturers to use virgin plastic than a recycled plastic.

These rather alarming CO2 numbers could be much lower, we understand, if only Americans recycled more than the paltry 7% of plastic which is recycled today. We could cut our usage of virgin material by one third and that means an annual savings of 30 to 150 million tons of CO2. For the plastic manufacturing firm India has set a standard of carbon emission i.e 1.06 kgCo2/Product

Country	No. of Facility	Kg Co2/bottle	Total Capacity	Total Co2 Emission in tones		
				Per year	Per month	Per day
USA	29	3.4	51,59,000	1,75,40,600	14,00,000(Apx)	3,835
China	60	3.14	1,96,60,000	6,68,44,000	55,70,000	15,260
Russia	42	2.02	85,00,000	17,17,000	14,30,800	3,920
Japan	18	3.01	50,00,000	1,50,50,000	12,54,166	3,436
India	15	3.10 (Apx)	1,20,00,000	3,72,00,000	31,00,000	8,490 (Apx)

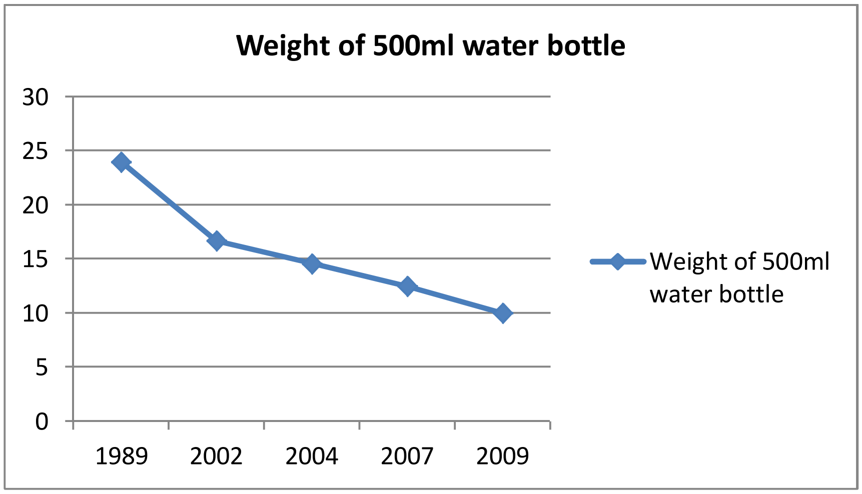
Countries contributing in carbon emission *(source: www.carbonstatics.com)*

In United States of America in the year 2004 the bottled water usage was marked as **26,000,000,000 (liters)**, which is nearly **28,000,000,000** plastic bottles in a year of which 86% that end up as garbage. The manufacture of every ton of PET produces around 3 tons of carbon dioxide (CO_2). Bottling water thus created more than 2.5 million tons of CO_2 in 2006.

PET is globally recognized as a safe, recyclable packaging material. PET does not contain bisphenol-A (BPA).

- In Canada, PET container recycling rates range from 60–80% depending on the province.
- In Toronto, single-use PET bottles comprise less than 1% of the city's municipal solid waste. Every year, Toronto recycles about 3 600 tonnes of single-use PET bottles, of which 30% are water bottles.
- Plastic makes up about 12% of all the municipal solid waste generated in the United States.
- In the United States, 31% of PET plastic soft drink bottles are recycled.
- On average, it takes 70% less energy to produce a product from recycled plastic than from raw materials.
- Recycling 1 tonne of PET bottles saves the energy equivalent of 318 gallons (1203 liters) of gasoline.
- In 1989, 500 ml water bottles were composed of 24 grams of PET resin. Today, less than 10 grams of PET are used in 500 ml water bottles.
- PET and HDPE bottles comprise 95.8% of the plastic bottle market and 99.1% of the bottles recycled.

❖ PET Bottle getting Lighter & Lighter



Source: Association of plastic manufactures

Nearly 50 billion new PET (polyethylene terephthalate) plastic bottles were produced in 2005 from virgin rather than recycled materials.

The Pacific Institute estimated that approximately one million tons of PET were produced to make the plastic bottles consumed in the United States in 2007 and three million tons were produced globally.

In 2004, only 14.5 percent of non-carbonated beverage bottles made from PET were recycled.

The Earth Policy Institute reported in 2007 that manufacturing the 29 billion plastic bottles used for water in the United States each year requires the equivalent of more than 17 million barrels of crude oil.

There are three possible environmental problems to be considered. Firstly, plastics are mostly made from oil, natural gas or coal, and these are all limited natural resources that must be conserved.

Secondly, the manufacture of plastics produces a lot of harmful pollutants which manufacturing companies need to deal with properly. Thirdly, old and unwanted plastics are not always easy to dispose of. Buried in landfill sites they will take a very long time to rot. To reduce these problems plastics must be 'designed' (for example as biodegradable), manufactured, used and disposed of considerately. The very properties, which have made plastics such a necessity to modern living, may well present problems once their useful life has finished. Plastics are used as paints, cable coverings and window frames as they do not rot, and they are

therefore very difficult to degrade when their useful life is over. Plastics which are used in motor vehicles are very durable and corrosion resistant which also means they are very resistant to degradation.

Plastic food packaging increases the shelf life of foods, and provides a cheap, hygienic and very versatile range of wrappings. Although there are obvious advantages for the food industry, the huge increase in plastic packaging has greatly increased plastic waste, and consequently, litter.

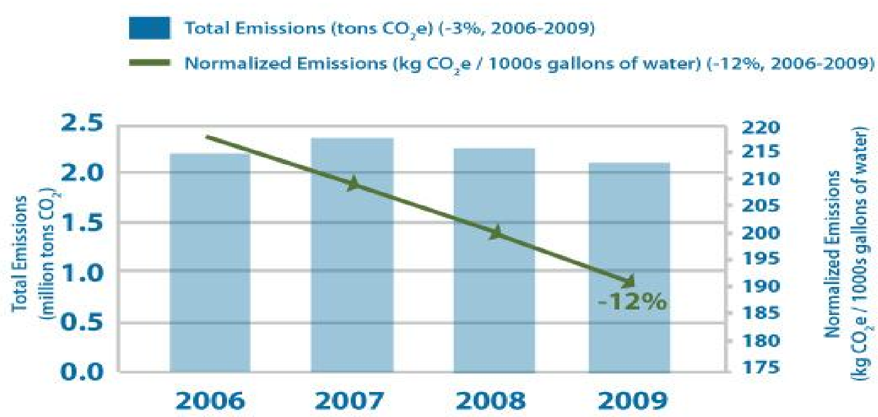
In the manufacturing process a certain amount of waste plastics are produced as sprues and runners, (the inlets into injection moulds) and other forms of excess material. To reduce waste, this material can be reground and added back to new raw stock. Though this is possible with most thermoplastic materials, the same is not true for thermosetting materials as the addition of even quite small quantities of re-ground material can reduce the quality of the final mouldings.

Article: Nestle- Committed to reduce carbon footprint

At every step in our bottled water production process, or Product Value Chain, we look for ways to trim our carbon footprint. In 2007, we conducted our first Greenhouse Gas (GHG) Inventory.

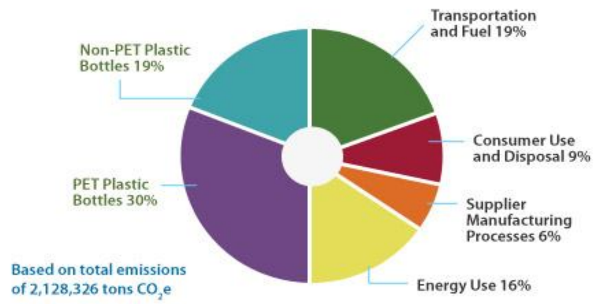
We looked at the Product Value Chain of our entire operation -- from upstream suppliers, to how we source, to our products, all the way through transportation. We also included impacts from contract carriers and estimated the carbon embedded in the plastic of our bottles.

The study indicated that Nestlé Waters North America's GHG emissions in 2008 were 2.128 million tons of CO2e. This is 0.03% of all the emissions in America in that year. Since then, we've significantly reduced our carbon footprint. The charts below show where we are today, but we're not done. We're continually evaluating our process to go even further. Over the period of 2006-2009, our carbon emissions decreased 3% despite an increase in our business. On a normalized basis (adjusted for growth), our carbon emissions actually decreased 12%.



The facts about how Nestlé Waters North America uses its energy

We found that many of our bottled water operations are already pretty efficient. Here's the breakdown. Our GHG study indicated that the majority of our carbon emissions come from packaging materials. That's just one reason we're continuing to take steps to reduce the amount of plastic we use. Nestlé Waters North America Carbon Emissions Breakdown, 2010



The production of PET bottles has three main phases. First, the polymer is synthesised from crude oil usually using antimony trioxide as a catalyst and pure PET flakes are produced. Then, small and dense test-tube like pre-forms which weigh the same as the final bottle are injection moulded from the PET flakes. Finally, the bottles are formed by stretch-blow moulding of these pre-forms7 . These industrial processes require energy derived from electricity or other fuels, and therefore will have CO2 emissions associated with them. When PET bottles are made from recycled PET flakes instead of virgin PET, less energy is required, as the first phase (crude oil synthesis) is avoided. The Association of Plastic

Environmental Metrics for Bottled Water Manufacturing Facilities

Focusing on water sustainability has helped us make key improvements in our facilities. Since 2008, these changes have helped us decrease our footprint, while our overall volume has actually increased by 5%. The facts about bottled water production improvements serve as examples:

- Through light weighting, among other projects, we've decreased our material consumption by 6%.
- Through improvements to both our supply chain and efficiency, we've trimmed our energy use (per liter) by 13% and our water use (per liter) by 1%.
- Through changing our utility setup, we've discontinued using natural gas on-site to produce electricity.
- Through a variety of changes, we're now recycling facility solid waste at a rate of 98% for 2010 (that's up 13% from 2008). And our actual waste sent to landfills has decreased 75% from these efforts.

Manufacturers in Europe holds data on the average fuel mix and fuel quantity used to obtain the energy required to make PET bottles within Europe. These data were used to determine the amount of CO2 emissions arising from the manufacture of a 54g PET bottle. On average, the production of a 54g PET bottle in Europe emits 222gCO2. This includes extraction and transport of raw materials as well as material and energy inputs and outputs in the form of emissions to air. This total increases to 223gCO2 per bottle when use of tertiary packaging to transport bottles from the manufacturer to the bottler is included in the calculations. The PET bottles are manufactured in the UK by Amcor and shipped to the bottling plant at Corby where they are filled. As PET is shatter proof, accidental breakage during filling is avoided. However, there is a 2% loss of bottles during filling due to under-filling (1%), as it is not practical to remove the bottle cap once it has been applied, and to scuffing (1%)8 . These losses are not included in this analysis since they are equal to the losses occurring during glass bottle filling. Amcor produced PET bottles are palletized using High Density Polyethylene (HDPE) pallets which are returned to the manufacturing plant for reuse. According to Amcor, HDPE pallets have a useful lifetime of fifty cycles, that is, they can be reused up to fifty times. The CO2 emissions arising from the manufacture of the HDPE pallets used by Amcor is included in the total emissions arising from manufacturing PET bottles. Return transport of the pallets is not included in this analysis as data were incomplete for pallets used in transporting glass bottles.

CHAPTER 6

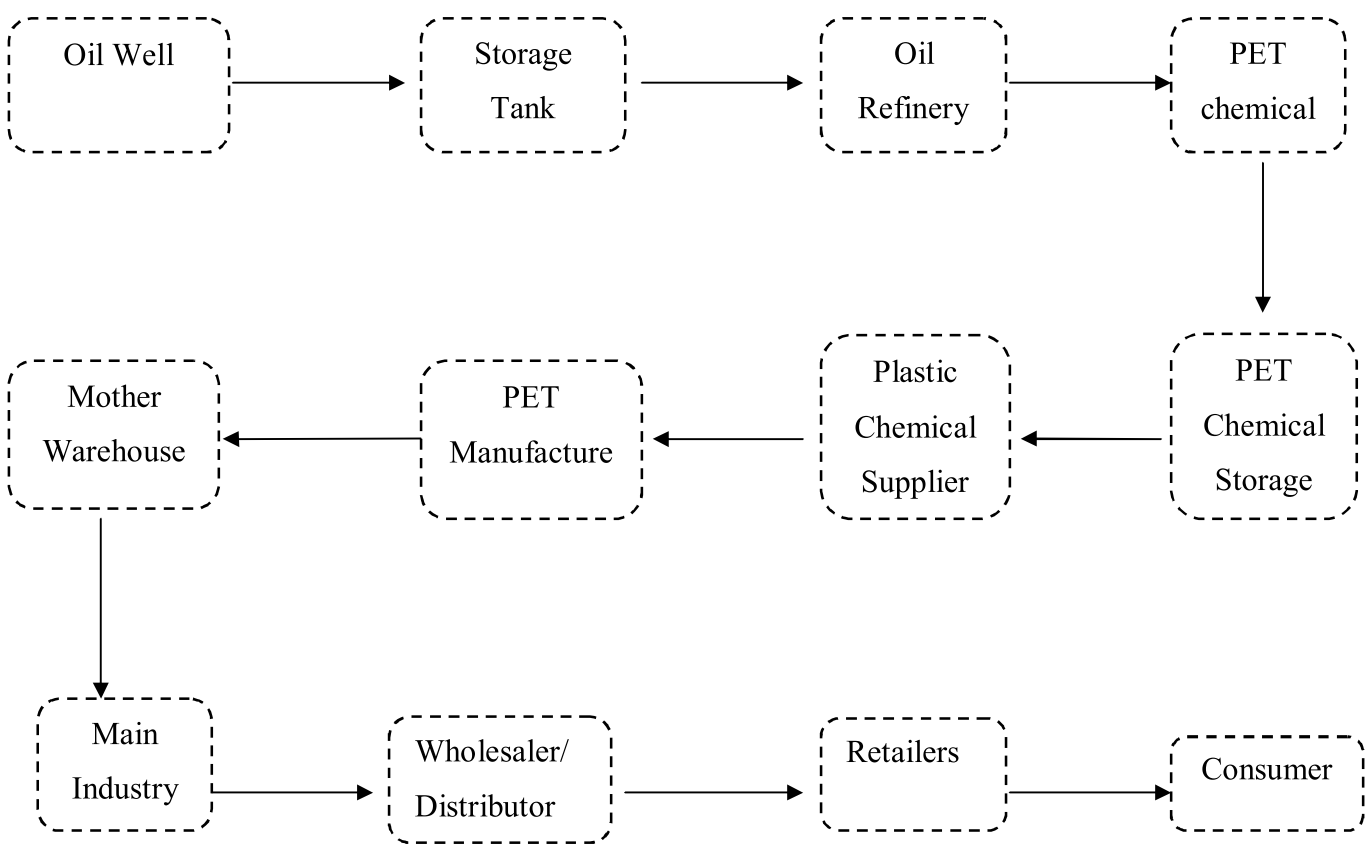
PET BOTTLE SUPPLY CHAIN

Global consumption of polyethylene terephthalate (PET) packaging is forecasted to reach 19.1 million tonnes by 2017, with a 5.2% increase per annum between 2012 and 2017.

This rapid increase in PET bottle consumption has also led to the emergence of various issues. These include environmental pollution, health concerns for scavengers, and low utilization efficiency for reclaimed PET bottles. Even though PET bottles are graded in number one category of recyclable products but are not risk free.

Long periods of use or exposure to sunlight can cause PET bottles to leach toxic carcinogens. In light of growing concerns over environmental protection, resource conservation, and the development of recovery technology, recycling has become a key factor in the supply chain of PET bottles.

Studies have found that for every pound of reclaimed PET flake used, energy use is reduced by 84%, while greenhouse gas emissions are reduced by 71%. Will companies retain ownership of products they sell to Harvest and re-use the materials they contain? Many business enterprises in the 21st century are searching for a preferred policy approach to promote cost effective diversion and recovery of postconsumer solid waste.



Main Industry includes = Pharmaceuticals, Alcoholic Products, Beverages, Industrial chemicals, Drinking water & etc

More than three quarters of the greenhouse gas (GHG) emissions associated with many industry sectors come from their supply chains. For that reason, a growing number of leading companies are engaging their suppliers about managing GHG emissions. Over the past few years, these companies have incorporated systems for reducing GHG emissions into their own business practices and are now seeking ways to drive down emissions beyond their own operations. Some companies are asking suppliers to report emissions data directly to them, whereas others are using third-party reporting programs. In 2008, 34 multinational corporations asked suppliers to report their GHG emissions inventories through the Carbon Disclosure Project's (CDP's) Supply Chain Program. The following year, 56 participating member companies asked their suppliers to report their carbon footprint to the CDP, a not-for profit organization that collects GHG emissions information from corporations on behalf of the financial investor community. In other instances, companies are collaborating with industry peers to develop shared infrastructure for their suppliers to report GHG emissions more efficiently. For example, leading consumer electronics companies developed the Electronic Industry Citizenship Coalition's Carbon Reporting System—a platform for suppliers common to multiple companies. Some companies are making public commitments about measuring and reducing their supply chain GHG emissions. Coca-Cola, for example, received significant attention in early 2010 when the retail chain announced its intent to reduce GHG emissions from its supply chain by 20 million metric tons.' The same year, Procter & Gamble publicly announced the launch of its own questionnaires for collecting emissions data from suppliers.

The federal government is stepping up as well, as it responds to Executive Order 13514 Federal Leadership in Environmental, Energy and Economic Performance issued by President Obama in October 2009. The Executive Order calls for all federal agencies to measure and reduce the GHG emissions associated with their own operations and also seek to reduce the carbon impacts of the products and services that agencies purchase from vendors and contractors. The government is taking the first steps toward engaging key suppliers within its massive supply base by encouraging them to measure and report their GHG emissions, with the view of incorporating emissions management performance into its future procurement decisions. (The term "procurement" is used in this document to indicate an organization that purchases components from suppliers and manages supplier relationships, sometimes also referred to as sourcing, buyers, commodity managers or product managers.)

Why do companies wants to manage the GHG Emission?

Companies are motivated to engage their suppliers on managing their GHG emissions for three primary reasons.

- *Alignment with sustainability commitment:* As companies commit to reduce the carbon footprints of the products and services they provide, they look to their suppliers to align their efforts with the company's sustainability goals. All companies interviewed believe that they can reduce GHG emissions far more by engaging their supply chain. For most of them, supply chain emissions surpass their combined Scope 1 and 2 emissions. Some companies have corporate GHG goals that explicitly include supply chain reductions. For example, Alcatel-Lucent set a goal to reduce its carbon footprint by 50 percent of 2008 levels by 2020, including reductions in its supply chain.

- *Risk mitigation:* Managing supply chain GHG emissions effectively can avoid damage to brand value, exposure to energy price volatility and lack of preparedness for complying with carbon regulations. Companies are keenly aware that the power of a brand is affected by a company's proven reputation for sustainability. Association with less environmentally friendly suppliers can undermine the credibility of firms that are actively seeking to differentiate their brands through environmental leadership. To protect their brands, they seek

- relationships with suppliers that walk the walk alongside them by taking steps to be proactive environmental stewards. Companies also seek to insulate their supply chains from sudden spikes in energy and fuel prices, which may in turn affect the prices and availability of goods and services they procure from suppliers. With this aim in mind, leading companies are beginning to work with suppliers to ensure that they become product efficient.

There is growing consensus that carbon emissions (emissions of carbon dioxide and other greenhouse gases), if left unchecked, will lead to major changes in the earth's climate system. Governments are under growing pressure to enact legislation to curb the amount of these emissions. Firms worldwide, responding to the threat of such legislation or to concerns raised by their own consumers or shareholders, are undertaking initiatives to reduce their carbon footprint. However, these initiatives have focused for the most part on reducing emissions due to the physical processes involved. For example, firms are replacing energy inefficient equipment and facilities, redesigning products and packaging, finding less polluting sources of energy, or instituting energy savings programs.

- While there is clearly value in such efforts, they tend to overlook a potentially significant source of emissions, one that is driven by business practices and operational policies. For example, determining how frequently supply deliveries are made could be as important in mitigating carbon emissions as the energy efficiency of the vehicles used to make these deliveries. In fact, one could argue that many of the popular business practices, such as just-in-time manufacturing and lean production, which favor frequent deliveries with less than truckload shipments, small production runs, and multiple regional warehouses, could have as much of an impact on the carbon footprint of a firm as the energy efficiency of individual units deployed in production or distribution. Similarly, decisions that a firm makes regarding where to locate facilities, from which suppliers to source, and what mode of transportation to use can significantly affect its carbon footprint.

Moreover, a focus on emissions associated with physical processes could overlook important factors that emerge from the interaction among the multiple firms that constitute each supply chain.

Multiple actors taking actions based on their own self-interests, and without coordination with others, are not likely to make decisions that minimize emissions for the entire supply chain. For example, if one firm requires shipments from its suppliers under short notice, then suppliers have little choice but to keep large inventories. For certain products, such as those requiring refrigeration, the associated carbon footprint can be significant.

The need to respond quickly to suppliers may also require staging inventories in multiple locations that are close to the customers, further increasing the carbon footprint. The lack of coordination among multiple firms within the supply chain can also increase the overall carbon footprint.

For example, coordinating production schedules among suppliers to the same customers could allow joint shipments, resulting in fewer emissions per delivery. However, acting on their own, the suppliers may have little incentive to pursue such coordination. Clearly, efforts to reduce the carbon in a supply chain cannot afford to ignore the need to coordinate these efforts across the entire supply chain.

1) Although a lot has been written about the carbon footprint of supply chains in the popular press and in trade magazines, and although numerous websites, nonprofit organizations, trade groups, and government bodies have been dedicated to the issue, the research community in operations and supply chain management has only recently began to pay attention to this area.

2) There is of course significant literature on sustainability and operations in general. However, the concern in that body of literature tends to be more focused on product recycling or reuse or product life cycle assessment. In contrast, there is extensive literature in economics, dating back to at least the 1970s, that incorporates environmental concerns. An important stream from this body of literature examines the impact of different policy instruments. These policy instruments can be classified as being either price-based (e.g., imposing a tax on carbon emissions) or quantity-based (e.g., imposing a cap on emissions and allowing firms to trade emission permits among each other). Numerous variations on these two types of instruments have been studied; see, for example, Another stream in this literature focuses on the design of markets for emissions and the trading of emission permits. Comprehensive reviews of the economics and politics of carbon emissions and climate change can be found. In general, this literature does not deal with operational issues and the corresponding models are not typically used to optimize operational decisions.

Given the potential impact of operational decisions on carbon emissions, there is clearly a need for Operations Management research that incorporates carbon emission concerns that would complement (and benefit) from the body of knowledge in other disciplines. In particular, there is a need for model-based research that extends quantitative models, which typically focus on either minimizing cost or maximizing profit, to include carbon footprint.

These models could then be used to understand how accounting for carbon emissions (either as a constraint or as a decision criterion) might affect operational decisions. They could also be used to inform operations managers on how policies, such as mandatory emission caps, taxes on carbon emissions, and emission cap-and-trade, among others, ought to affect operational decision-making.

Moreover, the models could be used to study how the specifics of these policies (e.g., the scope of carbon emission responsibilities and how these responsibilities are allocated among members of the same supply chain) would affect the costs and emissions of various firms. This project is a step in this direction. My objective in this project is to draw attention to the strong connection between operational decisions across the supply chain of PET and the carbon footprint of these supply chains and the extent to which concerns about carbon emissions can be addressed by adjusting operational decisions and improving collaboration among supply chain partners.

Using relatively simple and widely used models, how carbon emission concerns could be integrated into operational decision-making with regard to procurement, production, and inventory management. How, by associating carbon emission parameters with various decision variables, traditional models can be modified to support decision making that accounts for both cost and carbon footprint. I examine how the values of these parameters as well as the parameters of regulatory emission control policies affect cost and emissions. I use the models to study the extent to which carbon reduction requirements can be addressed by operational adjustments alone, as an alternative to costly investments in carbon-reducing technologies. I also use the models to investigate the impact of collaboration among firms within the same supply chain on their costs and carbon emissions and study the incentives firms might have in seeking such cooperation. Among the contributions of this project is a set of insights, some of which would be difficult to obtain without the support of operational models such as the ones I consider here. A few of these insights are also surprising and point to important factors of which managers and other decision makers should be aware. The following is a highlight of the main insights.

- Although lower emissions are generally associated with higher costs, it is possible (through adjustments in the ordering decisions) to significantly reduce emissions without significantly increasing cost, a result due to the fact that cost tends to be flat around the cost-optimal solution. This also means that relatively modest carbon prices/taxes are sufficient to yield significant reductions in emissions.

- The ability to reduce emission by only adjusting the ordering decision requires that the ratio of the fixed cost to the inventory holding cost parameters is different from the ratio of the fixed emission to the inventory holding emission parameters. This implies that operational adjustments are effective in reducing emissions as long as the emission and cost parameters are not strongly correlated (otherwise, the cost-optimal solution is also emission-optimal).

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- The cost of reducing emissions can be significantly lower if firms within the same supply chain collaborate and carry out their ordering decisions jointly so as to minimize total supply chain cost instead of doing it independently to minimize individual costs.

- Although collaboration always leads to lower total supply chain cost, it may not, depending on the emission regulatory policy, always lead to lower total emissions for either the individual firms or for the entire supply chain. Collaboration may also lead to a significant shift in responsibilities within the supply

CHAPTER 7

CONSEPT OF GREEN SUPPLY CHAIN

Green supply chain management (GSCM) has emerged as a vigorous managerial philosophy to attain cooperate profit and market share objectives by diminishing environmental threats and impacts while improving ecological efficiency of organizations. Green supply chain can be effectively applied to moderate the environmental damages caused by end of life products by considering the interplay of social, economic and environmental aspects with integrated and long-term perspectives. This paper reviews the factors affecting the implementation of green supply chain management for the Indian bottled water industry using Interpretive Structural Modelling (ISM), a multiple criteria decision making method used for structuring complex decision making problems. An important step for using ISM is to identify the prominent drivers that can affect the implementation of green supply chain and their interrelations between each other. The various drivers of green supply chain management are identified based on the literature and an overall examination of the industry taken under study

Introduction:

Global consumption of polyethylene terephthalate (PET) packaging is forecasted to reach 19.1 million tonnes by 2017, with a 5.2% increase per annum between 2012 and 2017. This rapid increase in PET bottle consumption has also led to the emergence of various issues. These include environmental pollution, health concerns for scavengers, and low utilization efficiency for reclaimed PET bottles. Even though PET bottles are graded in number one category of recyclable products but are not risk free. Long periods of use or exposure to sunlight can cause PET bottles to leach toxic carcinogens.

In light of growing concerns over environmental protection, resource conservation, and the development of recovery technology, recycling has become a key factor in the supply chain of PET bottles.

Studies have found that for every pound of reclaimed PET flake used, energy use is reduced by 84%, while greenhouse gas emissions are reduced by 71%. Will companies retain ownership of products they sell to Harvest and re-use the materials they contain? Many business enterprises in the 21st century are searching for a preferred policy approach to promote cost effective diversion and recovery of postconsumer solid waste. Supply Chain management and logistics are not new ideas. From the building of the pyramids to the relief of hunger in Africa, the principles underpinning the effective flow of materials and information to meet the requirements of customers have altered little. Recently, customers' attention to environmental issues, business' adaptation to the competitive market, and an increasingly controlled legislation all play a central role in the way businesses are created and managed in the global market. To meet these requirements, companies increasingly focus on developing sustainability practices and on creating reverse supply chains in order to recapture value and to provide methods of proper disposal. With the increasing social demand of environmental sustainability, companies are recognizing that environmental concerns are the key strategic issue with the potential for a lasting impact on organizational performance. GSCM integrates environmental thinking into supply chain management.

It is important to integrate environmental management practices into the whole supply chain management in order to achieve a greener supply chain and maintain competitive advantage and also increase business profit and market share objectives. Various definition of GSCM exist in the literature. Accordingly, defines GSCM as has ranged from green purchasing to integrated supply chains starting from supplier, to manufacturer, to customer and reverse logistics, which is "closing the loop". GSCM can be defined as "*integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life*". The quality revolution of the 1980s and the supply chain revolution of the 1990s extend the green supply chain literature with the beginning of corporate environmental management, environmentally conscious manufacturing strategy, and supply chain management literature. It has become clear that the best practices call for integration of environmental management with ongoing operations. Green supply-chain management (GSCM) is gaining increasing interest among researchers and practitioners of operations and supply chain management. The past literature also shows that most researchers have studied the GSCM adoption and implementation on developed countries such as Japan, Germany, Portuguese, UK and Taiwan and so on. Still limited studies have examined the GSCM practices in developing countries.

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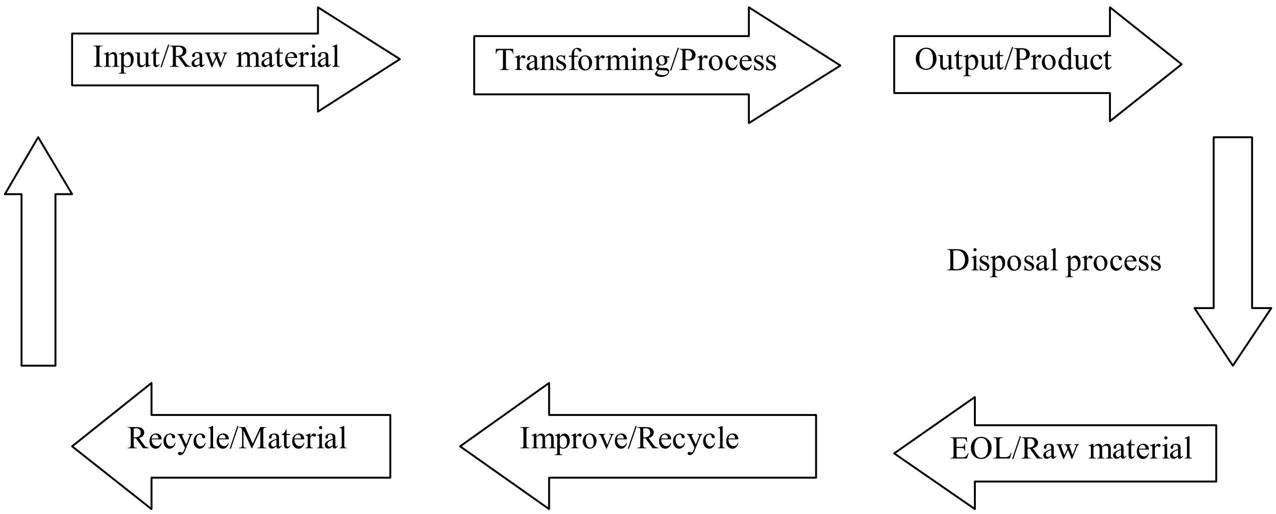
"Green Supply chain is define as the process of using environmentally friendly inputs & transforming these inputs in outputs that can be reclaimed & reused at the end of their life cycle, creating a sustainable supply chain".

Integrating environmental into supply chain management includes:

I. Product design
II. Material sourcing & Selection
III. Manufacturing process
IV. Delivery of final product to the consumer

V. End of life management after use of product



- **Impact of Green Supply Chain:**
- Company can reduce its environmental footprint
- Cost saving – Reducing waste, saving energy, product take back
- Risk management – Industrial accident, consumer boycott, environmental law
- Redefining market – Product into service, product innovation

CHAPTER 8

CONCLUSSION

The key message based on this research is:

Plastic bottles used on the market today enable significant savings of energy and GHG emissions (the production and use phase are most important for savings of energy and GHG emissions). Substitution of PET products by other materials will in most cases increase the consumption of energy and the emission of greenhouse gases. Polymers based on renewable resources are not per se better than conventional plastics based on fossil resources. The range of their GHG balance (due to feedstock selection and waste options) is much greater than the difference with conventional polymers

Green initiatives, in PET Bottle Supply chain, if properly managed, can enable organizations to be responsible corporate citizens and also deliver higher profitability and competitive advantage. With experience in providing end-to-end supply chain solutions aligned with industry trends.

The following steps organizations can adapt while implementing green supply chain initiatives:
Use industry standard frameworks like SCOR to identify potential areas for green initiatives in the manufacturing & supply chain plastic bottles. With Green manufacturing & Supply chain incorporated, the chances of success in any green initiatives increases.

- Align green initiatives with the strategic objectives of the company.
- Adopt GSCM best practices when implementing green initiatives.
- Use technology solutions to facilitate GSCM initiatives with a special focus on the need and importance of end-to-end supply chain analysis and network design.
- Focus efforts to reduce packaging and in-transit damage when shipping.

- Pay special attention to reducing inventory and identifying optimal distribution solutions. Perform lifecycle analysis for plastic bottles to minimize environmental impact.

Limitation of Research:

- The research is basically a descriptive research and done on the basis of secondary data mainly which limits research to not go beyond a certain level as less availability of data, which is basically Deep Web and not accessible.
- Comparatively less experience of researcher is also a limitation for the research.