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Estimation Of Carbon Foot Print In A Transport Network Of Supply Chain

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Abstract

Logistics is the term widely used to describe storage, transport & handling of products as they move from supply of materials through production system to the final point of sale (or) consumption. Supply chain management (SCM) system is a vital & a global form of a management system that consist of inbound logistics, intermediate processing stage and outbound logistics It is only over the past 50 years that logistics has been regarded as key determinants of business performance, is a major field of academic study. The prime objective of logistics management is maximization of profits. However, due to environmental concern, over the past 10 to 15 years, various industries & firms are trying to reduce environmental impact of the logistics operations. The distribution of goods impairs the local air quality, generates noise & vibration, causes accidents & makes significant contribution to global warming. Green Supply Chain Management is a relatively young but rapidly evolving subject. This paper attempts to find a feasible solution to minimize global warming through reducing CO_2 emission and leading to green supply chain management (GSCM). The paper focuses to promote ecology balance by focusing on air pollution.

Key Words Logistics, Green Supply Chain Management, Environmental Impact, CO_2 emission.

Nomenclature

1. GSCM – Green supply chain management
2. AHP – Analytic hierarchy process

3. F- factory
4. W- ware house
5. C – customer
6. D – distribution centre
7. GHG – greenhouse gas
8. DTDC – desk to desk courier

1.0 Introduction

In present era of global scenario of intense competition and environmental uncertainty flexibility in supply chain has an important role to play for the existence of any supply chain business. (Rituraj Chandraker et. al. 2012). Supply chain management is a process of planning, implementing, and controlling the operations of the supply-chain network catering to the requirements of customers (purchasers) as efficiently as possible (Rajesh kumar2012). GSCM is integrating environmental thinking (Gilbert, 2000) into Supply Chain Management. The waste and emissions caused by the supply chain have become one of the main sources of serious environmental problems including global warming and acid rain. Green supply chain policies are desirable since reactive regulatory, to proactive strategic and competitive advantages (Rajesh kumar et. al.2012). GSCM practices consist of eight major factors (Rituraj chandraker et.all 2013). Organization considers their own strategies measuring GSCM performance based on practices implemented. There are three major aspects related to performance, environmental, economic and operation. In terms of environmental performance, Zhu and Sarkis (2004) distinguished between positive and negative economic impacts.

Environmental Impact

Logistics is responsible for variety of externalities, including

(1) Air Pollution
(2) NoisePollution
(3) Accidents
(4) Vibration
(5) Land Take
(6) Visual Intrusion etc.

As climate change is now considered to be the most serious environmental challenge facing the man-kind, the main focus should be on Greenhouse Gas (GHG) from Freight Transport.

By & large, Logistics Operations include major functions of (1) Transport (2) Warehousing & (3) Waste Management/Reverse Management.The environmental effects of logistics can be distinguished into two: (a) First Order Impact (b) Second Order Impact.

First Order Environmental Impact: Directly associated with freight transport, Warehousing & Materials Handling Operations.

Second Order Environmental Impact: It results indirectly from logistics operations & can take various forms.

Atmospheric Pollution

United Nations Inter-governmental panel on climate change (UNI PCC) lists27 greenhousegases which are grouped into six categories:
CO_2-Carbon Dioxide
MH4- Methane
NOx- Nitrous Oxide
HFC-Hydro fluorocarbons
PFC-Per fluorocarbons
SF6-Sulphur Hexafluoride

Each gas has a different global warming potential (GWP). An emission of huge quantity of greenhouse gases are produced during the usage of electricity, transportation, cooking, burning & consumption of various grades of products & various industrial applications.

Noise Pollution

Road Traffic is the main cause of environmental noise at the local level. The adverse effects of noise disturbance include annoyance, communication difficulties, loss of sleep, loss of productivity, psychological & physiological health issues.
Trucks generate noise from 3 sources:

(i) Propulsion Noise, which dominates at low speed. (Power/Engine)
(ii) Tyre/Road contact noise, main cause of noise at speed (50kmph)
(iii) Aerodynamic noise, which increases as the vehicle accelerates.

Warehousing

Warehouse is more associated today, in terms of storage, flow movement & rapid fulfilment of customers' orders, customization & value added services.
In assessing overall impact of warehousing, consideration need to be given to:

(i) Land occupied
(ii) Direct Energy Used (Heating/cooling warehouse, warehouse lighting).
(iii) Emission Produced
(iv) Water Consumed

2.0 Literature survey

Amy H.I. Lee et. al. (2008) had developed an approach based on the fuzzy analytic hierarchy process (FAHP) and balanced scorecard (BSC) for evaluating an IT department in the manufacturing industry in Taiwan.According to Debmallya Chatterjee et.al. (2010) increased competition amongst the banks and the liberalization of policies had helped many institutions to take up the banking business. PANG Yan et. all. (2011) combined with the supply chain management practice in Hunan Valin Xiangtan Iron and Steel Limited Corporation, through applying the green supply chain management theory, on the basis of demonstrating the connotation of environment-friendly green supply chain and constructs corresponding index evaluation model through applying fuzzy comprehensive appraisal. ÖmürTosunet. all. (2012) in his paper had related between green supply chain management and environmental technologies are presented.Fangzhou Wang *(2012)* using COR model as a framework of green supply chain, established the indicatorsystem of overall performance evaluation on the green supply chain from the finance, operations and environment ofthe supply chain.L.K.Tokeet. all. had attempted to rank, interactions, and weightage of critical success factors (CSF) of the greensupply chain management (GSCM) in Indian manufacturing sector. The AHP was applied for determining relativeimportance and selecting appropriate approach in GSCM practice.P. Muralidharet. all.(2012) had presented a new decision making approach for group multi-criteria evaluation forgreen supply chain management strategies, which combines green procurement, manufacturing, green service to customerand environmental management process with order allocation for dynamic supply chains to cope market variations..

3.0 Objective and scope

The objectives of this study are two-fold ;

- Development of a common, simple, but sufficiently precise method for the calculation of CO_2 emissions from freight transport operations, to determine carbon footprint.
- Assessment and promotion of industry best practices that offers opportunities to reduce transport emissions, primarily focusing on all modes of transportation.

The scope of these calculation guidelines is limited to transport operations. Other logistics activities such as warehousing and handling are not ignored.

4.0 Model Formulation

A simple transportation network is considered as shown in Fig1 below

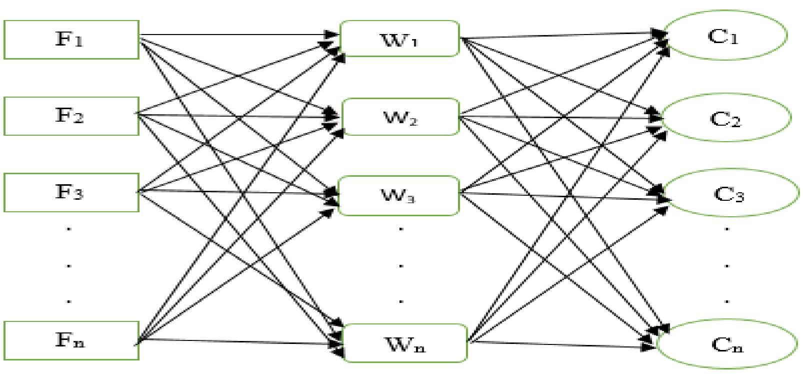

Fig.1 Simple Transportation Network (www.google.com)

Activity-based approach

Since majority of freight transport operations of an industry are outsourced, most shippers have no direct access to energy (or) fuel consumption data. In the absence of such data, shippers can estimate CO_2 emissions of their transport operations by using an activity-based calculation method.

The activity-based method utilizes the following mathematical relation.

$$\text{Total } CO_2 \text{ emission} = \sum_{tf \in TF} \boldsymbol{Eta}^{tf} \sum_{f \in F} \sum_{w \in W} \boldsymbol{Ya}_{fw}^{tf} \, Ma_{fw} \, Sa_{fw}$$

$$+ \sum_{tw \in TW} \boldsymbol{Etb}^{tw} \sum_{w \in W} \sum_{d \in D} \boldsymbol{Yb}_{wd}^{tw} \, Mb_{wd} \, Sb_{wd}$$

$$\text{Tonnes of } CO_2 \text{ emissions} = \frac{\textbf{Total CO2 emission}}{\textbf{1000000}} \text{ (tonnes)}$$

Where,

Eta^{tf} -is the CO_2 released by transport option tf to dispatch a unit product from factory to ware house (CO_2 emission factor)

Ya^{tf}_{fw} –is the number of products dispatched from factory to warehouse.

Ma_{fw} -is the weight of each product dispatched from factory to warehouse.

Sa_{fw} -is the distance between the factory and warehouse.

Etb^{tw} - is the CO_2 released by transport option tw to dispatch a unit product from ware house to distribution centre (CO_2 emission factor).

Yb^{tw}_{wd} – is the number of products dispatched from warehouse to distribution centre.

Mb_{wd} -is the weight of each product dispatched from warehouse to distribution centre.

Sb_{wd} -is the distance between the warehouse and distribution centre.

5.0 Sample Case study analysis

Consider a warehouse (W) at Kolkata and aDistribution centre (D) at Chennai.

The products are to be transported from ware house to Distribution centre as shown in Fig.2

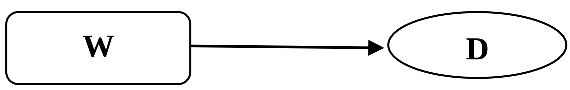

Fig 2. Warehouse & Distribution centre transport.

$$\text{Now, Total } CO_2 \text{ emission} = Etb^{tw} * Yb^{tw}_{wd} * Mb_{wd} * Sb_{wd}$$

$$\text{Tonnes of } CO_2 \text{ emissions} = \frac{\textbf{Total CO2 emission}}{\textbf{1000000}}$$

Where

$Etb^{tw}$is the CO_2 released by transport option tw to dispatch a unit product from Kolkata to Chennai other (CO_2 emission factor)

Yb^{tw}_{wd}-is the quantity of products dispatched from ware house (W) in Kolkata to distribution centre (D) in Chennai.

Mb_{wd}-is the weight of each product dispatched from ware house (W) in Kolkata to distribution centre (D) in Chennai.

Sb_{wd} -is the distance between the ware house (W) in Kolkata to distribution centre (D) in Chennai.

6.0 Modes of transportation – CO_2 emission computation

There are four major modes of transportation viz..Rail, Road, Air freight and Maritime are considered. The CO_2 emissions are calculated in two ways:

- ❖ When constant payload is varying to different modes of transportation.
- ❖ When constant payload is same to different modes of transportation.

In both ways, distance, number of products, CO_2 emission factor is constant only the payload is varied.

6.1 Development of survey questionnaire

Through a thorough and detailed analysis of the literature review, the major sectors that cause the increased GHG emissions in the phase of the supply chain have been identified. The main areas concentrated are transportation, electrical appliances and e-shopping facilities. Thus a survey questionnaire has been developed, to calculate the contribution of these elements to the carbon emissions. A customer based survey questionnaire has been developed in order to check the awareness levels of customers about shopping and e-transactions. Four courier service facilities in the India namely, DTDC, DHL, BLUEDART, GATI are surveyed about the number of items they receive here per day through various means of transportation.

6.2 Data collection

This involves the collection of data based on the survey questionnaire by visiting some of the major retail outlets in India like Vmart , Ritu wears, Pepe Jeans, etc and getting the information from those outlets like their annual revenue, number of employees, number of distribution centers, modes of transportation, no of customers visited & their mode of travel etc as per the questionnaire designed..Data from eight retail outlets have been collected and analyzed. Data was collected from the four major courier services also like average number of items from each means of transport.

Out of various courier companies one courier DTDC is taken as our Case study.

Table 1 : Mean number of items /day through various means of transport for DTDC

DTDC	Number of items transported through varies modes of transportation per day			
	Truck	Train	Air	Ship
1	19	17	1	0
2	18	12	2	0
3	19	8	2	0
4	18	9	1	0
5	16	12	3	2
6	22	11	1	1
7	15	17	0	0
8	17	14	2	0
9	18	15	1	1
10	18	10	0	1
Mean	18	12.5	1.3	0.5

6.3 When payload is varying to different modes of transportation

6.3.1 Rail transport

The average CO_2-emission factor recommended by McKinnon for calculation of CO_2-emission from rail transport operations is 22 gCO_2/ tonne-km. This value is based on an extrapolation of a range of emission factors, taking into account the following factors:

- The average split between diesel and electric haulage.
- The average carbon intensity of the electrical power source.
- The average energy efficiency of the locomotive.
- Assumptions about average train load factors.

The distance between the ware house in Kolkata to distribution centre in Chennai is 1661.1km approximately through rail transport and assume the weight of each product is 10 tonnes.

Transportation volume = number of units * weight of the each product

Table 2Transportation volume vs CO_2 emission – Rail transport

S.No	Number of Units (n)	Transportation volume (tonnes) (n*10)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	17	170	1661.1	22	6,212,514	6.2
2.	12	120	1661.1	22	4,385,304	4.38
3.	8	80	1661.1	22	2,923,536	2.92
4.	9	90	1661.1	22	3,288,978	3.29
5.	12	120	1661.1	22	4,385,304	4.38

6.	11	110	1661.1	22	4,019,862	4.01
7.	17	170	1661.1	22	6,212,514	6.21
8.	14	140	1661.1	22	5,116,188	5.12
9.	15	150	1661.1	22	5,481,630	5.48
10.	10	100	1661.1	22	3,654,420	3.65
					MEAN	4.56

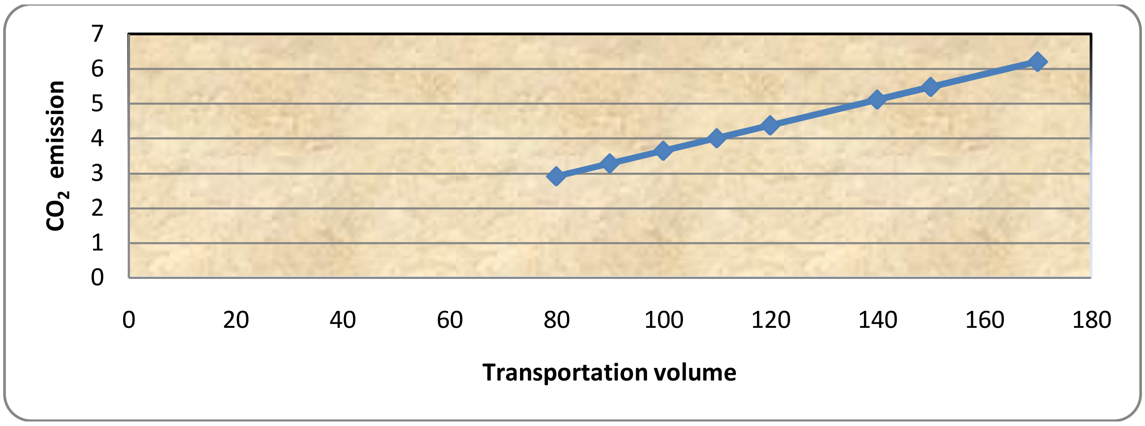

Fig3. Transport quantity vs CO_2emission

6.3.2 Maritime transport

Using published data of average emission factors for barge movements on maritime waterways McKinnon is recommending an average value of 13.5 gCO_2/tonne-km.

The distance between Kolkata and Chennai through waterways is 1650km approximately and assume the weight of each product is 50 tonnes.

Table 3Transportation volume vs CO_2 emission – Maritime transport

S.No	Number of Units (n)	Transportation volume (tonnes) (n*50)	Transport distance (Km)	CO_2Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	0	0	1650	13.5	0	0
2.	0	0	1650	13.5	0	0
3.	0	0	1650	13.5	0	0
4.	0	0	1650	13.5	0	0
5.	2	100	1650	13.5	2,227,500	2.2275
6.	1	50	1650	13.5	1,113,750	1.11
7.	0	0	1650	13.5	0	0
8.	0	0	1650	13.5	0	0
9.	1	50	1650	13.5	1,113,750	1.11
10.	1	50	1650	13.5	1,113,750	1.11
					MEAN	0.55

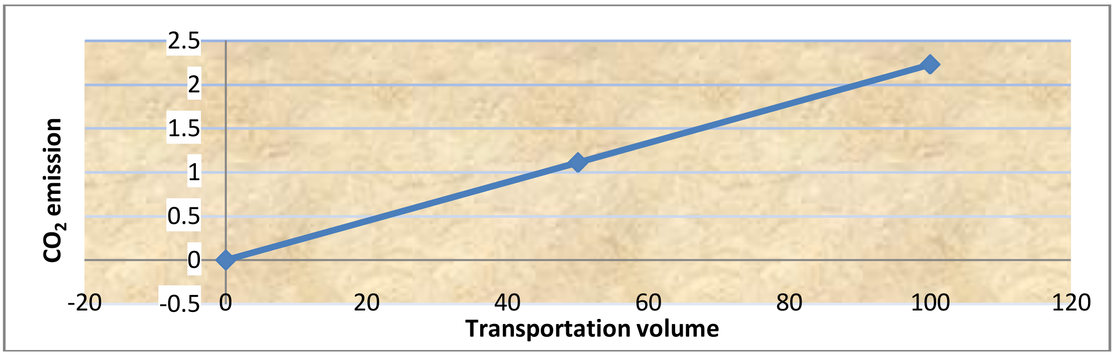

Fig 4. Transport volume vs CO_2 emission

6.3.3Road transport

The average CO_2-emission factor recommended by McKinnon for road transport operations is 62g CO_2/tonne-km. This value is based on an average load factor of 80% of the maximum vehicle payload and 25% of empty running. The distance between the Kolkata and Chennai through road is 1671.7 km approximately andassume the weight of each product is 1 tonne.

Table 4 Transportation volume vs CO_2 emission – Road transport

S.No	Number of Units (n)	Transportation volume (tonnes) (n*1)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	19	19	1671.7	62	1,969,262.6	1.96
2.	18	18	1671.7	62	1,865,617.2	1.86
3.	19	19	1671.7	62	1,969,262.6	1.96
4.	18	18	1671.7	62	1,865,617.2	1.86
5.	16	16	1671.7	62	1,658,326.4	1.65
6.	22	22	1671.7	62	2,280,198.8	2.28
7.	15	15	1671.7	62	1,554,681	1.55
8.	17	17	1671.7	62	1,761,971.8	1.76
9.	18	18	1671.7	62	1,865,617.2	1.86
10.	18	18	1671.7	62	1,865,617.2	1.86
					MEAN	1.86

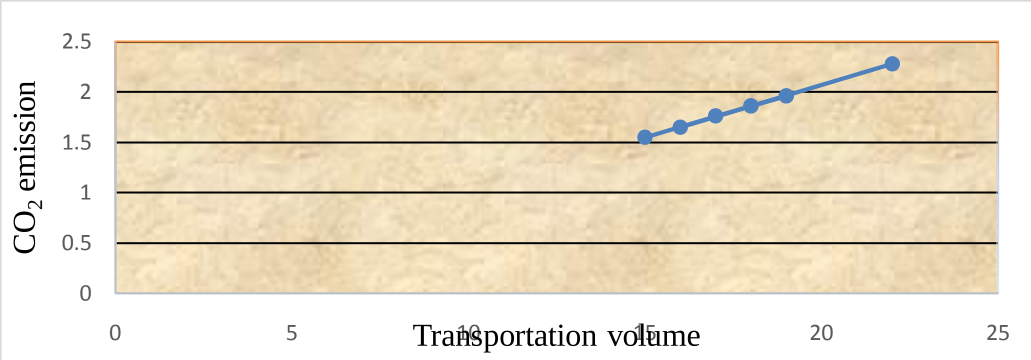

Fig 5. Transport quantity vs CO_2 emission

6.3.4 Air Freight

Published carbon emission factors for airfreight vary widely, reflecting differences in the length of haul and nature of the operation .Two sources, WRI / World Business Council for Sustainable Distribution and NTM, have provided different emission factors for each distance range. As the mean length of haul for airfreight movements in the Cefic survey was 7000 kms, an average of the two long haul emission factors i.e. 602 gCO_2 / tonne-km is proposed by McKinnon. The distance between the Kolkata and Chennai is 1380 km approximately andassume the weight of each product is 5 tonnes.

Table 5Transportation volume vs CO_2 emission – Air Freight

S.No	Number of Units (n)	Transportation volume (tonnes) (n*5)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	1	5	1380	602	4,153,800	4.15
2.	2	10	1380	602	8,307,600	8.3
3.	2	10	1380	602	8,307,600	8.3
4.	1	5	1380	602	4,153,800	4.15
5.	3	15	1380	602	12,461,400	12.46
6.	1	5	1380	602	4,153,800	4.15
7.	0	0	1380	602	0	0
8.	2	10	1380	602	8,307,600	8.3
9.	1	5	1380	602	4,153,800	4.15
10.	0	0	1380	602	0	0
					MEAN	5.4

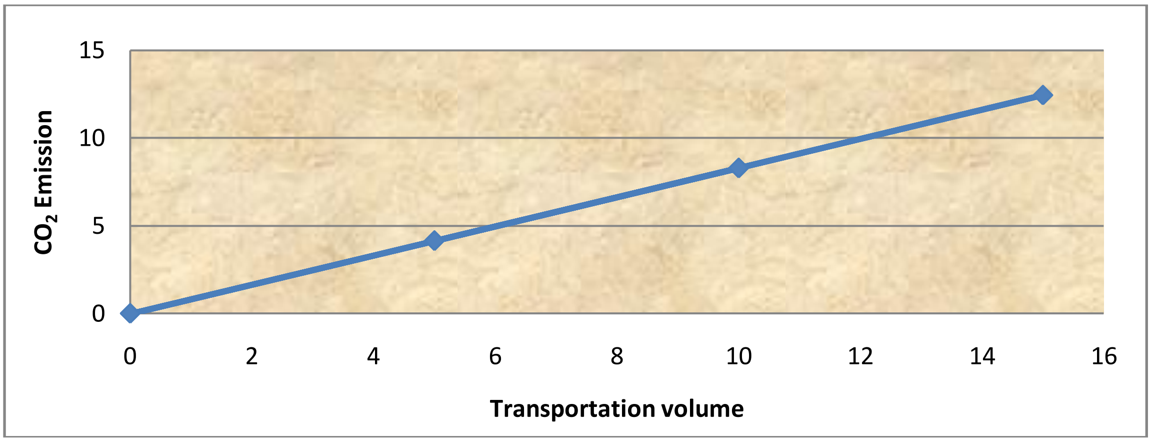

Fig 6 Transport quantity vs CO_2 emission

6.4 When payload is same to different modes of transportation

The weight of each product is same for different modes of transportation and assumeit is equal to 10 tonnes.

6.4.1 Railtransport

The average CO_2 emission factor according to McKinnon is 22 g CO_2 / tonne-km and the distance is 1661.1 km approximately.

Table 6 Transportation volume vs CO_2 emission – Road transport

S.No	Number of Units (n)	Transportation volume (tonnes) (n*10)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	17	170	1661.1	22	6,212,514	6.2
2.	12	120	1661.1	22	4,385,304	4.38
3.	8	80	1661.1	22	2,923,536	2.92
4.	9	90	1661.1	22	3,288,978	3.29
5.	12	120	1661.1	22	4,385,304	4.38
6.	11	110	1661.1	22	4,019,862	4.01
7.	17	170	1661.1	22	6,212,514	6.21
8.	14	140	1661.1	22	5,116,188	5.12
9.	15	150	1661.1	22	5,481,630	5.48
10.	10	100	1661.1	22	3,654,420	3.65
					MEAN	4.56

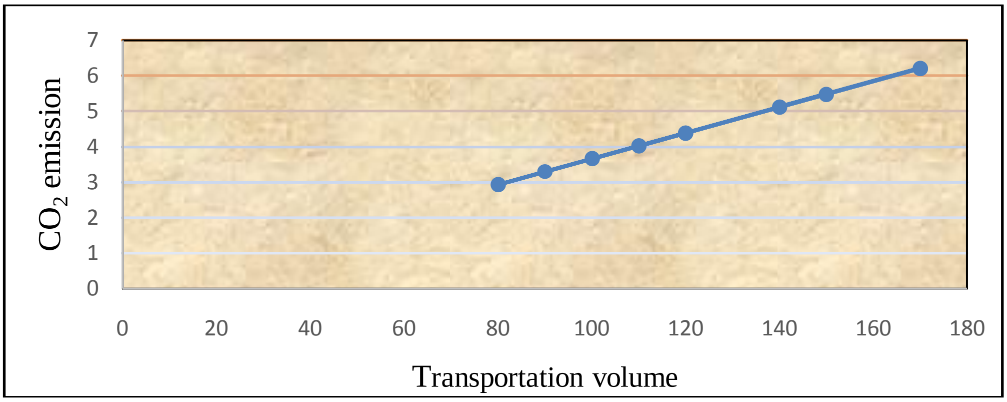

Fig 7 Transport volume vs Co2 emission

6.4.2Maritime transport

The average CO_2 emission factor according to McKinnon is 13.5 gCO_2per tonne-km and the distance is 1650 km approximately.

Table 7 Transportation volume vs CO_2 emission – Maritime transport

S.No	Number of Units (n)	Transportation Volume (tonnes) (n*10)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	0	0	1650	13.5	0	0
2.	0	0	1650	13.5	0	0
3.	0	0	1650	13.5	0	0
4.	0	0	1650	13.5	0	0
5.	2	20	1650	13.5	445,500	0.4455
6.	1	10	1650	13.5	222,750	0.22
7.	0	0	1650	13.5	0	0
8.	0	0	1650	13.5	0	0
9.	1	10	1650	13.5	222,750	0.22
10.	1	10	1650	31	222,750	0.22
					MEAN	0.1105

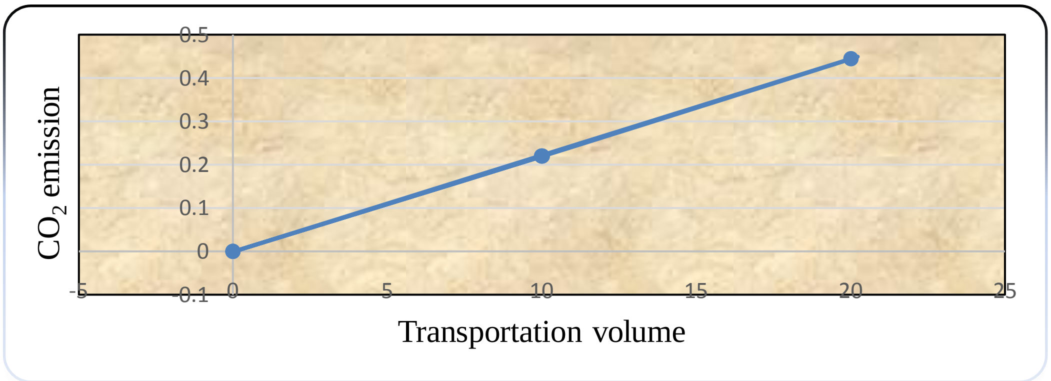

Fig 8. Transport quantity vs Co_2 emission

6.4.3 Road transport

The average CO_2 emission factor according to McKinnon is 62g CO_2 / tonne-km and the distance is 1671.7 km approximately.

Table-8 Transportation volume vs CO_2 emission – Road transport

S.No	Number of Units (n)	Transportation volume (tonnes)(n*10)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	19	190	1671.7	62	19,692,626	19.6
2.	18	180	1671.7	62	18,656,172	18.6
3.	19	190	1671.7	62	19,692,626	19.6
4.	18	180	1671.7	62	18,656,172	18.6
5.	16	160	1671.7	62	16,583,264	16.5
6.	22	220	1671.7	62	22,801,988	22.8
7.	15	150	1671.7	62	15,546,810	15.5
8.	17	170	1671.7	62	17,619,718	17.6
9.	18	180	1671.7	62	18,656,172	18.6
10.	18	180	1671.7	62	18,656,172	18.6
					MEAN	18.6

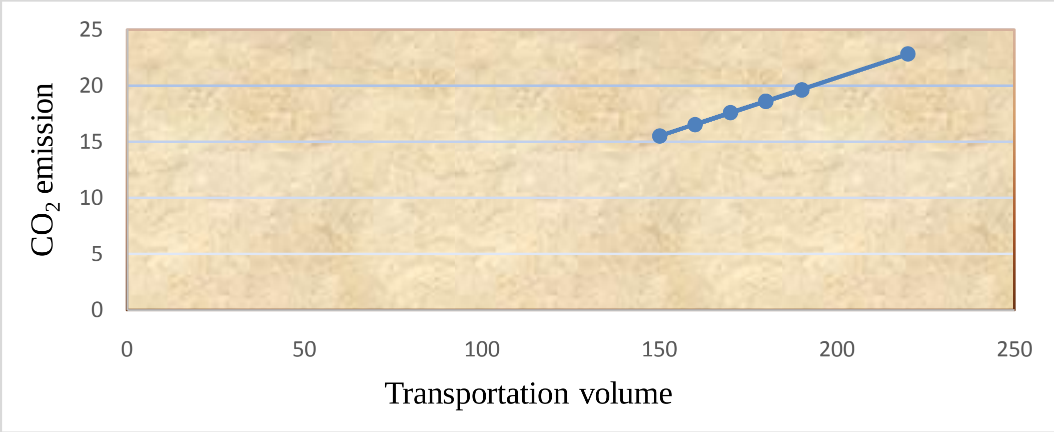

Fig 9 Transport volume vs Co_2 emission

6.4.4 Air Freight

The average CO_2 emission factor according to McKinnon is 602 gCO_2 / tonne-km and the distance is 1380 km approximately.

Table 9 Transportation volume vs CO_2 emission – Air Freight

S.No	Number of Units (n)	Transportation volume (tonnes) (n*10)	Transport distance (Km)	CO_2 Emission Factor	Total CO_2 Emission	CO_2 Emission (tonnes)
1.	1	10	1380	602	8,307,600	8.3
2.	2	20	1380	602	16,615,200	16.6
3.	2	20	1380	602	16,615,200	16.6
4.	1	10	1380	602	8,307,600	8.3
5.	3	30	1380	602	24,922,800	24.9
6.	1	10	1380	602	8,307,600	8.3
7.	0	0	1380	602	0	0
8.	2	20	1380	602	16,615,200	16.6
9.	1	10	1380	602	8,307,600	8.3
10.	0	0	1380	602	0	0
					MEAN	10.8

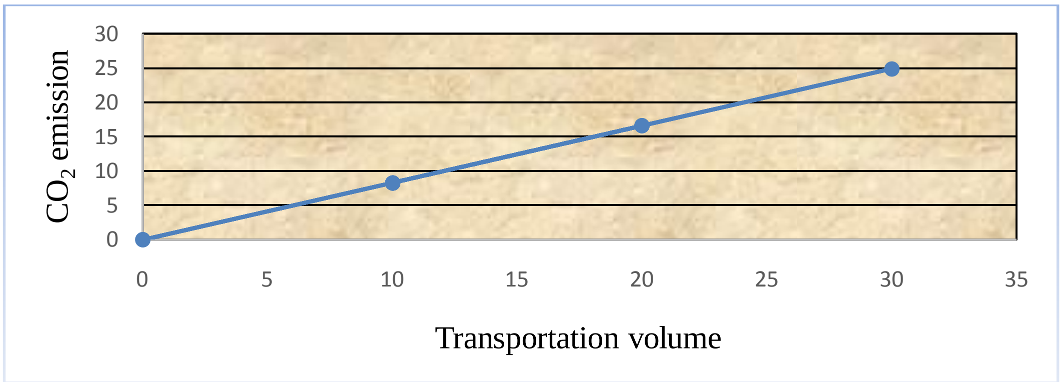

Fig 10. Transport volume vs CO_2 emission

6.5Comparative analysis of CO_2 emission with pay load is varying and constant

Also a comparative analysis is carried out to study the variation in CO_2 emission w.r.to constant when constant payload is same to different modes of transportation and when payload is varying to different modes of transportation. It shown in the Table 9. It is further illustrated by the Fig 11.

Table 10 Comparison CO_2 emission and pay loads

S.No	Modes of transportation	CO_2 Emission (tonnes)	
		Varying load	Constant load
1.	Rail	4.56	4.56
2.	Maritime	0.55	0.1105
3.	Road	1.86	18.6
4.	Air freight	5.4	10.8

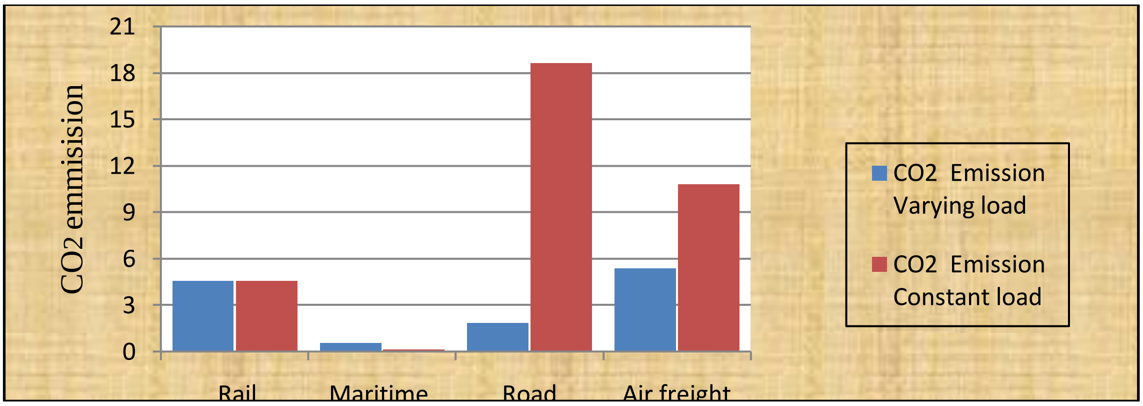

Fig 11 Comparison of CO_2 emission and pay loads

7.0 Implications of CO_2 emission on Environment

In the present era of concern for environment balance, this paper attempts to estimate and compare the co_2 emission with (a) barrels of fossil oil consumed (b) quantity of coal burnt and (c) domestic electric power utilized for one year. It is presented in Table 10. When payload is varying to different modes of transportation and when payload is constant to different modes of transportation in Table 11.

This paper also tries to compensate the adverse effect of CO_2 emission with afforestation to retain environment safety and equilibrium,by checking green-house effect. It is illustrated in the Table 12

(a) Barrels of oil consumed

Carbon dioxide emissions per barrel of crude oil is determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12).The average heat content of crude oil is 5.80 mmbtu per barrel (EPA 2013). The average carbon coefficient of crude oil is 20.31 kg carbon per mmbtu (EPA 2013). The fraction oxidized is 100 percent (IPCC 2006).

Calculation

5.80 mmbtu/barrel × 20.31 kg C/mmbtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg = **0.43 metric tons CO_2/barrel**

(http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results)

(b) Kgs of coal burned

The average heat content of coal consumed in the U.S. in 2013 was 21.48 mmbtu per metric ton (EIA 2014). The average carbon coefficient of coal combusted for electricity generation in 2012 was 26.05 kilograms carbon per mmbtu (EPA 2013). The fraction oxidized is 100 percent (IPCC 2006). Carbon dioxide emissions per pound of coal were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12).

Calculation

21.48 mmbtu/metric ton coal × 26.05 kg C/mmbtu × 44 kg CO_2/12 kg C × 1 metric ton coal / 1,102.3 kgs of coal x 1 metric ton/1,000 kg = 9.31×10^{-4} metric tons CO_2/kgs of coal

(http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results)

(c)Home electricity use

In 2012, 113.93 million homes in the United States consumed 1,375 billion kilowatt-hours of electricity (EIA 2013a). On average, each home consumed 12,069 kWh of delivered electricity (EIA 2013a). The national average carbon dioxide output rate for electricity generated in 2010 was 1,232.4 lbs CO_2 per megawatt-hour (EPA 2014), which translates to about 1,328.0 lbs CO_2per megawatt-hour for delivered electricity, assuming transmission and distribution losses at 7.2% (EIA 2013b). Annual home electricity consumption was multiplied by the carbon dioxide emission rate (per unit of electricity delivered) to determine annual carbon dioxide emissions per home.

Calculation

12,069 kWh per home × 1,232.4 lbs CO_2 per megawatt-hour generated × 1/(1-0.072) MWh delivered/MWh generated × 1 MWh/1,000 kWh × 1 metric ton/2,204.6 lb =7.270 metric tons CO_2/home.

(http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results)

Number of tree seedlings grown for 10 years

A medium growth coniferous tree, planted in an urban setting and allowed to grow for 10 years, sequesters 23.2 lbs of carbon. This estimate is based on the following assumptions:

- The medium growth coniferous trees are raised in a nursery for one year until they become 1 inch in diameter at 4.5 feet above the ground (the size of tree purchased in a 15-gallon container).
- The nursery-grown trees are then planted in a suburban/urban setting; the trees are not densely planted.
- The calculation takes into account "survival factors" developed by U.S. DOE (1998). For example, after 5 years (one year in the nursery and 4 in the urban setting), the probability of survival is 68 percent; after 10 years, the probability declines to 59 percent. For each year, the sequestration rate (in lbs per tree) is multiplied by the survival factor to yield a probability-weighted sequestration rate. These values are summed for the 10-year period, beginning from the time of planting, to derive the estimate of 23.2 lbs of carbon per tree.

Please note the following caveats to these assumptions:

- While most trees take 1 year in a nursery to reach the seedling stage, trees grown under different conditions and trees of certain species may take longer: up to 6 years.
- Average survival rates in urban areas are based on broad assumptions, and the rates will vary significantly depending upon site conditions.
- Carbon sequestration is dependent on growth rate, which varies by location and other conditions.
- This method estimates only direct sequestration of carbon, and does not include the energy savings that result from buildings being shaded by urban tree cover.

To convert to units of metric tons CO_2 per tree, multiply by the ratio of the molecular weight of carbon dioxide to that of carbon (44/12) and the ratio of metric tons per pound (1/2,204.6).

Calculation

23.2 lbs C/tree × (44 units CO_2 ÷ 12 units C) × 1 metric ton ÷ 2,204.6 lbs = 0.039 metric ton CO_2 per urban tree planted

(http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results)

Table11 Implication of CO_2 emission-When payload is varying to different modes of transportation

S.No	Mode of transportation	CO_2 emission (tonnes)	Equal utilization of other utilities			Tree seedlings that should be grown for 10yrs to compensate the bad effects of CO_2 emission
			barrels of oil consumed	Homes electricity use for one year	Kgs of coal burned	
1	Rail	4.56	9.6	0.569	2221.5	106
2	Maritime	0.55	1.2	0.069	268	12.8
3	Road	1.86	3.9	0.232	906	43.3
4	Air freight	5.4	11.4	0.674	2631	126

Table 12Implication of CO_2 emission-when payload is same to different modes of transportation

S.No	Mode of transportation	CO_2 emission (tonnes)	Equal utilization of other utilities			Tree seedlings that should be grown for 10yrs to compensate the bad effects of CO_2 emission
			barrels of oil consumed	Homes electricity use for one year	Kgs of coal burned	
1	Rail	4.56	9.6	0.569	2221.5	106
2	Maritime	0.1105	0.233	0.014	54	2.6
3	Road	18.6	39.2	2.3	9062	433
4	Air freight	10.8	22.8	1.3	2631	251

8.0 Conclusion

From the Table1 and Fig 3, it is concluded that CO_2 emission varies tangentially with transport quantity in Rail transport. It is attributed to the fact that in rail transport the load is distributed to all wagons. The CO_2 emission will be less since the friction will be less between wheels and rails.

From the Table2 and Fig 4, it is illustrated that CO_2 emission varies diagonally with transport quantity in Maritime transport. It is attributed to the fact that in maritime transport the transportation will be on sea water and hence CO_2 will be less.

From the Table 3 and Fig 5, it is evident that CO_2 emission increases, from lower quantity of transportation. It is attributed to the fact that during Road transport, the transportation takes place on road and hence the friction between tyres and roads is high and it results into high CO_2 emission.

From the Table 4 and Fig 6, it is shown that CO_2 emission starts increasing from the lower quantity of transportation during Air freight. It is attributed to the fact that the transportation takes place against gravity. Hence this results into high CO_2 emission.

From the Table 5 and Fig 7, it is concluded that CO_2 emission increases with the constant transport quantity in Rail transport. It is attributed to the fact that in rail transport the load is uniformly distributed to all wagons. The CO_2 emission will be less since the friction will be less between wheels and rails.

From the Table 6 and Fig 8, it is illustrated that CO_2 emission varies diagonally with the same transport quantity in Maritime transport at very lower values of quantity. It is attributed to the fact that in maritime transport the transportation will be on sea water and hence CO_2 will be less.

From the Table 7 and Fig 8, it is evident that CO_2 emission increases steeply when the quantity of transportation is constant. It is attributed to the fact that during Road transport, the transportation takes place on road and hence the friction between tyres and roads is high and it results into high CO_2 emission.

From the Table 8 and Fig 10, it is shown that CO_2 emission starts increasing from the lower quantity of transportation during Air freight. It is attributed to the fact that the transportation takes place against gravity. Hence this results into high CO_2 emission.

From the Table 9 and Fig 11, it is concluded that CO_2 emission is same irrespective of quantity of load transported for Rail transport. But the emission has less difference between constant load and varying load. The emission shows significant difference with varying and constant loads during Road transport and Air freight. It is attributed to the fact that in the Road transport when load is less the emission will be less. In the air freight, the transportation takes place against gravity. Hence when load is less the emission will be less.

From the above conclusion points, it can be found that as the distance increases rapidly, then the emission of CO_2also increases. As we all know that the supply chain starts from the manufacturer to customer through warehouse, distribution centers,store departments etc., This paper considers only one ware house and one distribution centre, for given distance only the CO_2emission was found.but in actual scenario, we have different type of transportation for this the emission also doubles the previous one. So, in order to decrease the emission the aera under the supply should be decrease this mean the distance of transportation should be reduced.In a green supply chain, green purchasing + green manufacturing/materialsmanagement + green distribution / marketing + reverselogistics. In this paper, we mainly concentrated on the co_2emission of a supply chain.

From the Table 10 & Table 11, it is shown that for a given emission of CO_2 , the different types of equivalents like Tree seedlings grown for 10 years, Barrels of oil consumed, Homes electricity use for one year, Pounds of coal burned. These values are estimated.By this data, it can be concluded that forestation diminish the green-house effect.

9.0 Area for further research

The CO_2 emission can be calculated by considering the additional green house gases.

Another area, focus can also be made on noise pollution , warehousing and others to migitate the CO_2 emission.Multi- Echelon supply chain can also be examined.Different CO_2 emission factors can also be considered to compute CO_2 emission.Other Quatification of other green house gases can also be incorporated to estimate adverse of environment.

The green house gases emission can also be estimated by considered by emissions from passenger vehicles, quantity of waste sent to the landfill, waste recycled, gasoline burnt, emission from CFL, propane cylinders used for domestic purposes etc.

10.0 References

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