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Control and management of greenhouse gas emissions from coastal shipping in India

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REGULATION OF GREENHOUSE GAS EMISSIONS FROM COASTAL SHIPPING IN INDIA

By

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

Mayank R Prasad

May 31st 2013

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ABSTRACT

Title of Research paper: Regulation of Greenhouse Gas Emissions from Coastal Shipping in India

Degree: MSc

Climate change and global warming have been acknowledged as a significant threat to human well being internationally. Increase in concentrations of greenhouse gases (GHG), carbon dioxide in particular, is one of the primary causes of global warming and climate change. GHG emissions from international shipping although relatively small have been on an upward trend since the last two decades. In this regard new regulations adopted by the International Maritime Organization (IMO) have recently come into force and are expected to significantly reduce GHG emissions from ships using technical and operational measures. These regulations however do not apply to coastal ships and ships of less than 400 gross tonnage. Pertinent factors which make emissions from coastal shipping a more potent threat as compared to emissions from international shipping are identified. This paper considers these factors and attempts to builds a case for similar GHG emissions regulations to be enforced on coastal ships in India as well. Freight transport and emissions in Indian and global context are discussed. The Indian coastal shipping fleet is analysed and compared with other transportation modes available in the country for economic and environmental efficiency. Primary research through questionnaires has been conducted to assimilate opinions about climate change, GHG emissions and role of coastal shipping from a wide spectrum of people associated with shipping and environment. Growth forecast of coastal trade and ship tonnage is done to further emphasize the need for GHG emission regulations for coastal vessels in India.

KEYWORDS: Climate Change, Greenhouse gas emissions, Transport, International Shipping, MARPOL, Coastal Shipping (India), Primary research analysis, Growth forecasts

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LIST OF ABBREVIATIONS

BTKM	billion tonne-kilometers
CAGR	compound annual growth rate
CFC	chloro-floro carbon
CH4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
DFRC	dedicated freight rail corridors
EEDI	Energy Efficiency Design Index
GHG	greenhouse gas
GT	Gross Tonnage
Gt	gigatonne (1 thousand metric tonne)
IEA	International Energy Agency
IMF	International Monetary Fund
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ITF	International Transport Forum
MARPOL	International Convention for Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee of the IMO
MOEF	Ministry of Environment and Forests, Government of India
MOR	Ministry of Railways, Government of India
MORTH	Ministry of Road Transport & Highways, Government of India
MOS	Ministry of Shipping, Government of India
MT	metric tonne (1000 kilograms)
N_2O	nitrous oxide
NAPCC	National Action Plan on Climate Change
NASA	National Aeronautics and Space Administration
O_3	ozone

OECD	Organization for Economic Co-operation and Development
PCI	Planning Commission of India
SEEMP	Ship Energy Efficiency Management Plan
Tg	teragram (1 million metric tonne)
UN	United Nations
UNEP	United Nations Environment Program
UNFCC	United Nations Framework Convention on Climate Change
VOC	volatile organic compound
WMO	World Meteorological Organization

Chapter 1: Introduction & Scope

1.1 Research Background

Global climate change and the hazards it presents for the well being of our planet and its inhabitants had been recognized decades ago. The World Meteorological Organization (WMO), a specialized agency of the United Nations (UN), is the UN's authoritative voice on the state and behaviour of the Earth's atmosphere and supports the implementation of a number of environmental conventions and is instrumental in providing advice and assessments to governments on related matters (WMO website). The Kyoto Protocol of 1997 was part of the United Nations Framework Convention on Climate Change (UNFCCC) and was the first major step towards mitigating the threat posed by 'Greenhouse Gases' (GHG). It was a treaty binding thirty seven of the most industrialized nations of the world with one purpose in mind, to stabilize concentration of GHGs in the atmosphere at a level which would not adversely impact the world climatic system.

To fulfill the objectives that the WMO sets, collaboration of national meteorological bodies and other UN agencies is naturally essential for effectiveness at a global scale. One such UN agency is the International Maritime Organization (IMO), which in brief regulates, again by adoption of its conventions at national level, world shipping. Over the past few years a lot of initiatives have been taken by the IMO in the field of environmental protection. The International Convention for the Prevention of Pollution from Ships (MARPOL) of 1973 was developed, adopted and enforced in this regard. Annex VI of MARPOL deals with controlling air pollution from ships. It was adopted in 1997 & entered into force in 2005. Air pollution from ships occurs primarily from the exhaust gases of ships engines most of which burn petroleum based fossil fuels. Other smaller sources are emissions from ships air-conditioning and refrigeration systems, from shipboard incinerators and from cargo related activities of tanker vessels. These regulations were designed for reduction of pollutants like oxides of sulphur and nitrogen, ozone depleting substances and volatile organic compounds (VOCs) but until recently carbon dioxide (CO_2), which

is the main GHG, emission was left out. International shipping is comparatively energy efficient mode of transport constituting only 2.7% of total CO_2 emissions worldwide (IMO website, www.imo.org). But IMO decided to be proactive in view of increasing seaborne trade and in 2011, adopted new measures with a view of reducing GHG emissions. Thus a new Chapter 4 was added to Annex VI of MARPOL which made mandatory Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Plan (SEEMP) for all ships. The regulations entered into force in January 2013 & compliance required some technical modifications and operational changes to building and running of vessels (website of the IMO). The Indian Flag State, which is a party to the MARPOL convention, ratified and adopted the amendments to MARPOL Annex VI in January 2012 for applicable ships under its jurisdiction. Of greater significance as far as greenhouse gas emissions are concerned, is the fact that the latest amendments to Annex VI of MARPOL concerned with EEDI & SEEMP mentioned above have been enforced since January 2013, in line with IMO resolution. These regulations do not apply to vessels of less than 400 gross tonnage (GT) and like a lot of IMO conventions, even vessels on coastal (non international) voyages i.e. vessels plying in waters of her own flag state, are exempted from compliance.

1.2 Research Purpose

The research topic has been chosen in view of growing international concern towards the threat posed by GHGs. The research paper objectives are to:

1.2.1 Identify kinds and types of vessels operating on or near the Indian coast.

1.2.2 Make a comparison between emissions from coastal trade vessels with other modes of transport per ton-mile of cargo carried. Sea transportation is known to be more energy efficient than other modes, which further emphasizes the need for greater control in anticipation of growth of seaborne transport on the coast.

1.2.3 Make a case for technical and operational control for GHG emissions for coastal vessels as well considering that these vessels always operate inside Indian ports or close to Indian coastal waters at all times.

1.3 Literature Review

Environmental protection and Pollution prevention has been a topic of great interest and debate in the maritime field for quite some time now. New stringent regulations regarding this topic have been enforced regularly over the past two decades. Air pollution from ships exhausts was addressed at the beginning of the millennium but included only substances like oxides of sulphur and nitrogen. The rest of the world had been awakening to the phenomenon of climate change brought about by GHG emissions, especially carbon dioxide (CO_2) and had started developing and enforcing International treaties in this regard (The 1997 Kyoto protocol of UNFCCC).

The impact of transportation on climate change is discussed below. But what is the real danger associated with GHGs? As the name suggests they have an ability to trap heat which should normally be radiated by the earth's surface back into space. The hazards associated with this phenomenon are melting of polar ice caps, higher sea levels and air temperatures at most places, erratic and intense weather patterns, increased probability and intensity of droughts, heat waves and hurricanes, etc. Love G et al (2010) have also attempted to study the reverse impact of climate change and extremes on transportation sector. Another dangerous aspect is the human health hazard of GHGs. Ground level Ozone (also a GHG) can cause lung disorders while the thinning down of the Ozone layer in stratosphere means humans are exposed to UV rays of the sun which have the potential for causing skin cancer. (website of the Environmental Protection Agency of USA)

The shipping fraternity was considered to be a small contributor to global GHG emissions contributing 2.7 % of global CO_2. (Air Pollution & Greenhouse Gas

Emissions, IMO website). In 2008, studies done to analyse the transport impacts on atmosphere and climate due to Shipping (Eyring et al, 2009), Aviation (Lee et al, 2008) and Land (Uherek et al, 2008) suggested that oceangoing shipping contributed to 2.7% of all CO_2 emissions in 2000 and growing seaborne trade meant that CO_2 released would only increase from the 780 Tg (Teragram, 1Tg= 1 million metric tonnes) figure then. It was in fact at 3.3% in 2007 (Heitmann et al). IMO estimated that if uncurbed they could reach as much as 12-18% by 2050. Aviation industry had similar figures for CO_2 emission in 2005 (2.5%) but which had come down from 2.7% in 2000. Emissions from land transport, primarily road traffic and to a lesser extent railways and internal waterways are much higher. Road transport emitted about 4300 Tg carbon dioxide in 2000, corresponding to 72% of the CO2 emitted by transport and 17% of the global. But regulations limiting CO_2 emissions from ship are already in force since January 2013 in anticipation of the increase in global trade and seaborne transportation and as part of a universal action against climate change.

Multiple studies and independent representations of shipping routes show that emissions by oceangoing ships can contribute to air quality problems on land making the European commission eager to enforce some sort of legislation. With the economic recession of 2008, shipping markets collapsed. As part of cost cutting measures, shipping companies started using the slow steaming policy to save costly bunker fuel during idle days. In order to maintain their schedule, more vessels were employed on a route, which also served well as the market was highly overcapacity at that time. But another great advantage of this policy turned out to be a reduction in CO_2 emissions as a result. Lindstaad et al (2010) developed a model to calculate costs and emissions from ships as a function of speed. Their results suggested that emissions could be reduced by as much as 19% with negative abatement costs and 28% with zero abatement costs. Psaraftis and Kontovas (2010) also seemed to agree calling reduced emissions as a side benefit to slow steaming. Cariou, (2010) in another study endorsed this view.

The Indian Flag state administration has been an active member of the IMO and is a party to MARPOL convention. Most of the important IMO conventions and amendments are enacted into the legislation, albeit with some bureaucratic delays. Even the latest regulation concerning GHG emissions were made mandatory for ships under its jurisdiction from the International enforcement date of 1st Jan 2013. Government of India has adopted National Action Plan on Climate Change (NAPCC) (2008) to fight against global warming, (Ghosh S). India has also signed the 'Copenhagen Accord' and thus committed to reducing its greenhouse gas emissions by 2020. (Heitman et al, 2010).

Since these regulations are relatively new, *not a lot of literature* is available on them. As Adolf K.Y (2010) in his paper on 'The environmental impacts of pollutants generated by routine shipping in ports' points out that there is a shortage of research work in this field in spite of such consequential risks. His own paper deals with pollution of the water only. As implementation begins, the real picture of the effectiveness of the rules will emerge. IMO has included non-prescriptive performances based measures for new ships (EEDI) and operational measures for existing ships (SEEMP) for augmenting the overall energy efficiency of ships. Studies conducted under authority of IMO over the last few years have indicated that significant reduction of CO_2 from these measures can be attained (IMO website). Psaraftis and Kontovas (2010) have called the new IMO initiative as perhaps the most sweeping piece of legislation. But they also include the following a note of caution saying that whereas the real goal of EEDI is to design ships with better hulls, engines and propellers so as to be more energy efficient, an easy solution might be to reduce design speed, and, as a consequence, installed power. This may have negative ramifications on ship safety. It may also have negative effects on total CO_2 emitted, as an underpowered ship would burn more fuel and hence emit more CO_2 at the same speed, particularly if it tries to maintain speed in bad weather.

Ships also spend a fair amount of time at berth. In 2005, Hulskotte and Van der Gon used onboard surveys to derive a linear expression between fuel consumption (hence

emissions) and ships GT. In the busy European port of Rotterdam, total CO_2 emissions from ships were estimated to be 394000 tonnes (0.394Tg), a 13.5% increase from the year 2000. Lonati et al (2010) conducted a similar study intended to assess the impact on local air quality due to atmospheric emissions from port area activities for a new port project in the Mediterranean Sea. Using a 3-dimensional *Calpuff transport and dispersion* model, the subsequent assessment of the ground level spatial distribution of atmospheric pollutants for both long-term and short-term averaging times was obtained. As per their findings, use of shore power supply by bulk ships at berth could reduce carbon emissions by up to 50%.

Although out of the total CO_2 emissions in India in 2007, shipping transported accounted for only 1%, the increasing trend of coastal shipping means this figure is mounting (Ramachandra et al, 2009). This research paper identifies factors that differentiate coastal shipping from international shipping explores the alternative possibilities available for vessels on the Indian coast to cut down on GHG emissions. The impact of the new rules, the difficulties with their implementation in this nascent stage, the Flag State policy etc will also be noted. As the first set of ships under the new system sets sail the realistic nature of the target figures will be realized.

1.4 Methodology

A combination of primary and secondary research is used in pursuance of objectives set out in Chapter 1.2 comprising:

1.4.1: Desk / Secondary research

- Global outlook about climate change, greenhouse emissions, information on negative impact and hazards of greenhouse emissions through shipping and other industries
- Overview and understanding of rules and regulations regarding GHG emissions for the international shipping industry and the expected benefits

- Understanding of the rules and regulations/or the lack of them in the coastal shipping industry and their impact
- Studying the drivers and restraints for growth of coastal trade in India.

1.4.2 Primary Research.

- For the purpose of primary research, questionnaires were prepared to obtain views and opinions about climate change, greenhouse gas emissions and coastal shipping in India.
- The questionnaires are designed for two categories of respondents, people from the shipping fraternity and people connected to environment related work.
- The questionnaires (attached as appendices 1 & 2) are a combination of objective and subjective questions to gain opinion from broad spectrum of respondents.
- The results of primary and secondary research are analysed to get a broader view of opinion of respondents and to provide a comprehensive base supporting the hypothesis that 'Greenhouse Gas Emission Regulations should be enforced on Coastal Shipping'

1.4.3 Forecasting the growth of Coastal Cargo and Coastal Tonnage.

- A customized Microsoft Excel program model which is based on weighted indexes and arithmetic progression and takes into consideration several qualitative factors which have different impacts over different time periods is used to forecast growth of coastal cargo volume.
- The methodology has been elaborately explained in Appendix 3 to this paper.
- Correlation between coastal cargo volume and coastal tonnage is established using Excel program.
- Growth of coastal shipping tonnage is forecast using both Excel and SPSS programs to reinforce congruency of results.

1.5 Structure of the paper

The paper starts with a general background and introduction to the climate change issue in Chapter 1, which also contains literature review, methodology, framework of the paper and restrictions of the research, along with the difficulties experienced during the research.

The climate change and greenhouse gas emission problem is analysed in the next chapter. The primary contributors, in the present day scenario to climate change, the threats and consequences for the future if no action is taken are reviewed.

Chapter 3 focuses on the contribution of the transportation industry towards greenhouse gas emissions. Initially the chapter starts with international transport as a source of air pollution emissions & the second part focuses on international shipping in particular. The regulation and control measure put in place by theIMO for mitigating this threat are discussed.

The chapter that follows puts environmental protection regulations in the Indian perspective. The measures and commitments at the national level are discussed. It concentrates on the air pollution and GHG emissions in India. The Indian coastal shipping fleet is analysed as per size, type of vessel and age, as these are all factors along with the maintenance standards of the vessels, that have a bearing on the amount of emissions. The chapter also takes a look at other modes of goods transport in India.

Chapter 5 is used to analyse the factors that make emissions from coastal and international shipping different. Comparison between different modes of transport is also done. Qualitative analyses of the responses to the questionnaire have been included. The final part of the chapter includes results of forecasting model used to project growth of coastal shipping in the near future.

The final Chapter 6 is summarizes the paper. The conclusions drawn by the results of the research are mentioned while trying to fulfill the research objectives mentioned in Chapter 1.2.

1.6 Restrictions

Although the potential endangerment caused by climate change had been recognised quite some years ago, the economic cost of 'going green' had always been a cause of reluctance. But as the hazards grew, so did the awareness. The IMO regulations regarding GHG emissions are very recent (entered into force in January 2013) and the IMO can only hope the regulations do help achieve the projected emission control figures.

As mentioned in the literature review, the recency of the regulations to shipping means that not a lot of studies regarding their impact are available in the public domain. Coastal shipping especially, which has been exempted from a lot of international regulations in the past, just like the GHG emission regulations, is a matter of even lesser academic studies in India, although a few studies from an economic point have been undertaken.

There is an acute lack of published data regarding international ships visiting Indian ports and profile of machineries on coastal vessels and even lesser resources / data quantifying their emissions. Correspondence with operators of coastal ships in India had been tried to be established, without much success. Although the economic aspect of enforcing these regulations on coastal vessels has been discussed briefly, they have not been analysed as the theme of the paper essentially is environmental protection. The paper focuses primarily on freight transport and not passenger carriage as coastal trade is essentially used for goods.

As more people awaken to realise and perhaps experience the perils posed by climate change, the matter may finally garner the attention it deserves and more extensive academic studies might provide an elaborate picture of the real situation. A study on the economic impacts on a coastal shipping company, in case the new regulations are made mandatory for them would be an interesting future topic.

Chapter 2: Global Concerns about Climate Change

2.1 Climate Change

Climate change implies a significant long term alteration in weather patterns over a particular region or globally, defined by the WMO in the United Nations Framework Convention on Climate Change (UNFCC) as *"a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods"*. (WMO website)

Although the causes for climate change can be natural, like oceanic circulation, biotic processes, variations in solar radiation received by earth, volcanic eruptions etc, in modern parlance the term climate change has essentially been used to denote changes which are a direct impact of human activity.

Most of the weather related phenomena occurring out of the ordinary, like rising temperatures, freak rainstorms, can be attributed to climate change, namely global warming which is the increase in average global surface temperatures caused essentially by increase of greenhouse gases.

As per the website of National Aeronautics and Space Administration (NASA) of the USA, scientists normally use 'Global Warming' for surface temperature increases, while 'Climate Change' is used to denote not only global warming, but everything else that increasing quantity of greenhouse gases affect.

Greenhouse effect is a process by which certain greenhouse gases (GHGs) in the atmosphere absorb the sun's thermal radiation while it is being reflected back and release this radiation onto the lower levels of atmosphere as is seen in Figure1 below. The greenhouse gases are naturally present in the atmosphere and are essential in keeping the earth warm to a level habitable by humans. So although these gases are essential to our survival, human activity is resulting in increased level of GHG emissions and concentrations in the atmosphere. This is known as anthropogenic greenhouse effect. Global warming and thus climate change are the consequences of higher concentration of GHGs as higher concentrations retain more heat.

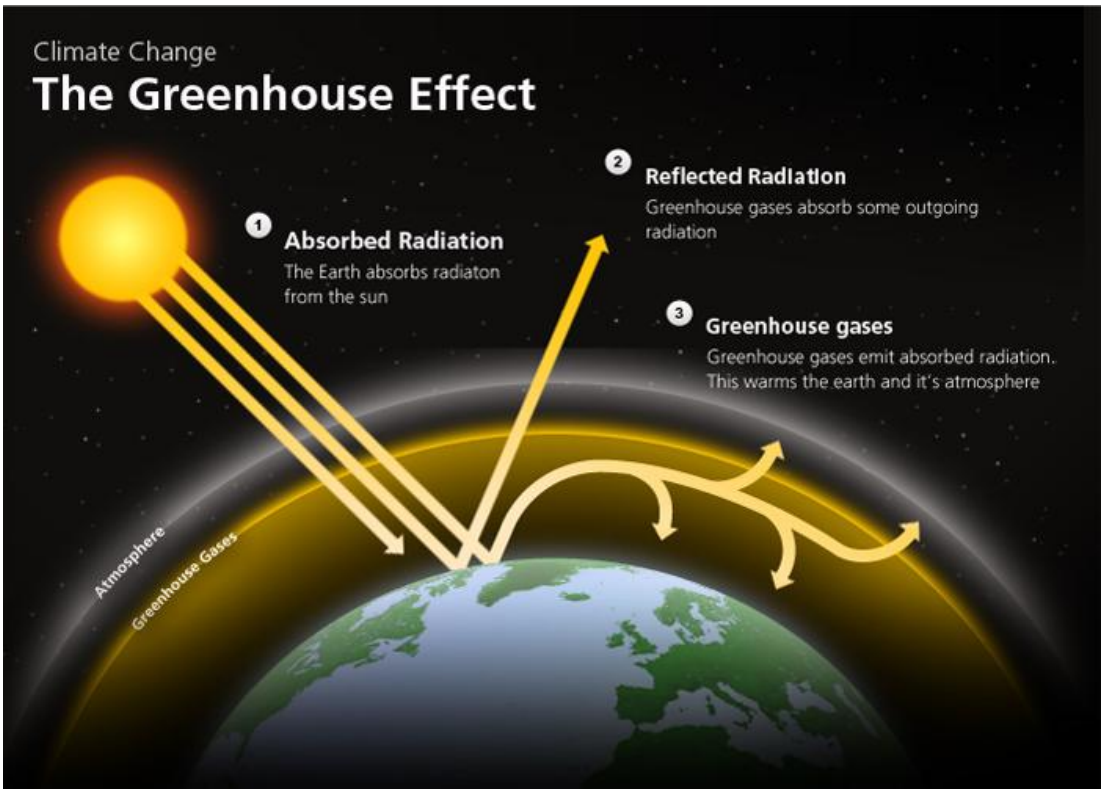

Figure 1: The Greenhouse Effect
Source: http://www.edfenergy.com

The main greenhouse gases are water vapour, carbon dioxide (CO_2), methane (CH_4), ozone (O_3), chloro-floro carbons (CFCs) and nitrous oxide (N_2O). Amongst these gases CO_2 presents the greatest threat, because it is emitted in large amounts by human activities and due to its ability to remain in the atmosphere for a prolonged period of time, maybe even thousands of years.

There have been extensive studies and research in this field since the 1980s and scientists have concluded that global warming has taken place and is expected to continue too. The Intergovernmental Panel on Climate Change (IPCC) of the WMO identifies anthropogenic greenhouse effect as the root cause of global warming, whereby the average temperature of the earth's surface has risen by 0.74 ± 0.18 °C over the last hundred years, and more alarmingly it predicts a rise of almost 1.1 to 6.4 °C in the twenty-first century if the trend continues. The large variation in prediction is because of the uncertainty over future GHG emissions.

2.2 Effects and Threats posed by Climate Change

To the layman a 2 °C rise in temperature may not sound panic worthy but scientists and environmentalists around the world are not sounding a false alarm. Rise in sea levels, change in precipitation levels, melting of polar ice caps and sea ice, expansion of deserts are just a few of the indicative but worrying signs of global warming.

- Impact on Sea level: The warmer temperatures are causing glaciers & ice sheets to melt and the water entering the seas and oceans causing a rise in water levels which have a potential of submerging coastal cities. Studies indicate that globally GDPs would be affected by 1.3% average for a 1metre rise in sea level, with some areas' GDP being affected by as much as 2.09%. (Dasgupta, 2007)
- Impact on weather patterns: Statistics prove that the number of high intensity hurricanes / cyclones has increased over the last few years mainly due to the extra heat energy on the earth's surface. Equally damaging on the other hand have been droughts and heat waves which have become increasingly frequent over the last three decades severely reducing agricultural outputs.
- Impact on Human Health: It is estimated that more than 150,000 people die from climate change related sickness each year (Website of The Washington Post Newspaper, 2010). The severe weather mentioned above has also usually resulted in outbreaks of diseases like dengue fever, malaria and tick-borne encephalitis. Global warming also contributes smog accumulation resulting in higher cases of allergies and asthma.
- Impact on the Ecosystem: There is a legitimate fear worldwide that global warming could drive many species of animals (especially the polar inhabitants) and plants to the brink of extinction owing to their inability to cope with higher temperatures and changing ecosystem. It has also resulted in migration of species in search of habitats that they can survive in.
- Impact on the Social structure: Seawater level rise can cause salinisation of ground water, thereby reducing the availability of fresh water around the world. This in

addition to reduced food production caused by droughts could lead to an escalation in human migration. Belief is that 'environmental degradation, loss of access to resources and resulting human migration could become a source of political and even military conflict' (IPCC website *Impacts, Adaptation and Vulnerability*).

- Economic Impacts: 'By spending $3 trillion per year on climate protection, $12 trillion in annual damages can be avoided. In general climate protection will be more expensive the later it starts' (Ackerman F, 2009). A 2006 study report by Global Development and Environment Institute of Tufts University, estimated that 'if nothing is done to restrain greenhouse gas emissions, annual economic damages could reach US$20 trillion by 2100'. The International Monetary Fund (IMF) had estimated a 3% global GDP loss in case of 3° C rise in temperature.

2.3 Sources of Greenhouse Gases

As shown in figure 2 below, carbon dioxide, methane and nitrous oxide account for about 77%, 14% and 8% of all GHGs respectively. The remaining 1% is comprised of fluorinated gases. Water vapour concentrations are not highly affected by human activity and its decay is rather swift. Concentrations of GHGs especially CO_2 began mounting due to industrialisation process and concurrent de-forestation.

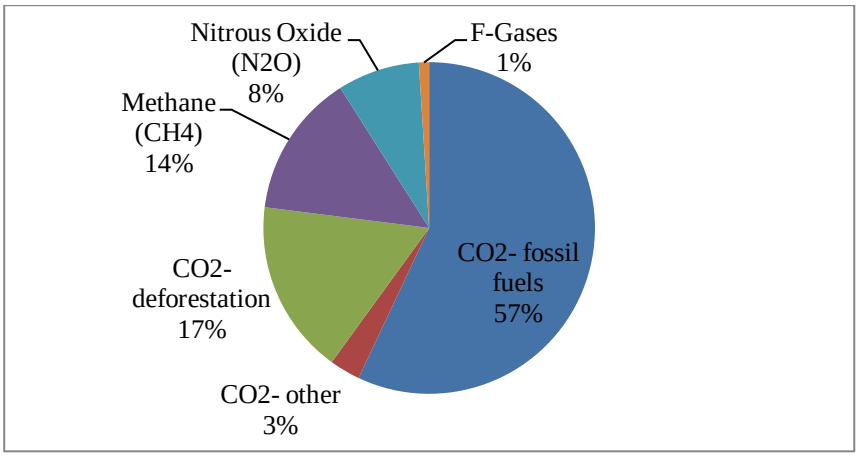

Figure 2: Global proportion of various greenhouse gases
Source: IPCC (2007); *Working Group I - 4th Assessment Report*.

Out of all the anthropogenic GHG emissions, the energy sector has the maximum share.

- Energy Sector: burning of carbon based fossil fuels is the primary source of GHG emissions from the energy sector, which was about 26% of all GHG emissions as per IPCC 2007 report. A United Nations Environment Program (UNEP) report based on 2010 statistics had this figure as 35%. (UNEP, The Emissions Gap Report 2012, pp10). Although efforts are in progress to expand the use of alternative, environment friendly methods of power generation, like wind & solar power, the use of coal and petroleum products remains by far the most common fuel for heat and electricity generation, mainly due to the currently poor cost effectiveness of cleaner energy sources.
- Industries: Emissions from on site manufacturing and processing, but not energy supply, commonly chemical and mineral processes accounted for 18% of GHG emissions in 2010.
- Forestry: Commonly referred to as land use, land use change and forestry (LULUCF). Deforestation takes place not only for construction or land clearance for agriculture but wild natural forest fires are also responsible to an extent. The total contribution of GHG emissions from this sector has already reduced from 17% in 2004 to 11% in 2010. The UNEP Emissions Gap Report 2012, estimates that implementation of national policies for further protection can further reduce CO_2 accumulation by 1.3 Gigatonne (Gt) or 1300Tg.
- Agriculture: The use of agricultural soils and fertilisers, management of livestock manures, burning of bio waste, etc are the activities of the agriculture sector that lead to emission of GHGs. As per the UNEP Emissions Gap Report 2012 this sector, which was responsible for 11% of all GHG emissions in 2010, has the potential to reduce GHG emissions by 1.1-4.3 Gt (1100-4300 Tg) by the year 2020.
- Buildings: In this context, it means energy production for heating of domestic and office spaces and for food preparation in houses. Over the period from 2004-2010, GHG emissions from buildings remain at 8% of total, but the potential to decrease

them by 1.4-2.9 Gt until 2020 exists. This can be achieved by enforcing building construction codes and domestic appliance' standards into national legislation.

- Waste: The largest source of greenhouse gas emissions in this sector are methane (CH_4) from landfill (underground burial of wastes) and nitrous oxide (N_2O).(Environment Protection Agency website). GHG emissions from this sector have increased from 3% to 4% of total emissions and can be reduced by implementing strong sector specific policies by regulatory authorities.
- Transport: The combustion of fossil fuels for transport of people and goods around the world over land, air and sea are the cause of 13% of all GHG emissions worldwide. It is also the sector with the highest projected growth rate of GHG emissions (UNEP Emissions Gap Report 2012, pp31). Air Pollution from transportation, especially shipping, is discussed in detail in the next chapter.

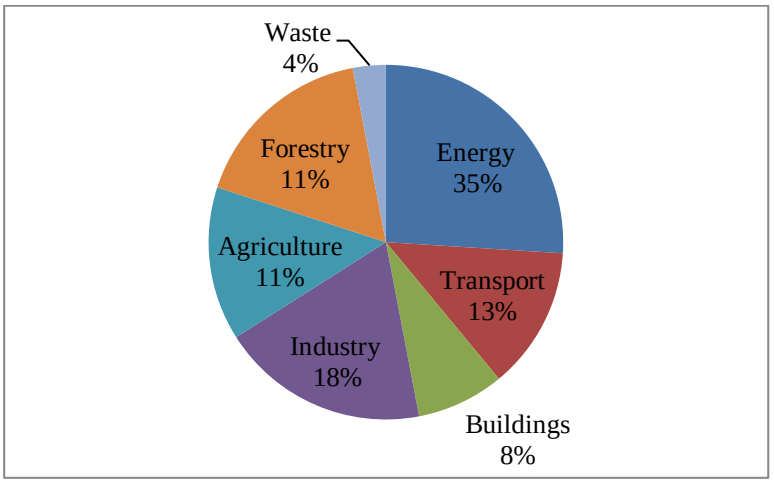

Figure 3: Global GHG emissions – break up by sectors
Source: UNEP (2012); *Emissions Gap Report*

It must be noted that not all climate change effects have been hostile. Increased agricultural productivity in higher latitudes, vegetation near the Sahara desert area, the possibility of using the Northern Sea route etc have all begotten benefits to various communities. Notwithstanding such silver linings, climate change remains a serious threat to our future well being, especially 'as the countries which are most vulnerable, the hot and low lying ones, are expected to be worst affected by climate change and seem to be the most ill equipped to fight against it' (Jones, 2012).

Chapter 3: Role of Transportation and Shipping in Greenhouse Gas Emissions

3.1 Transportation and GHG emission

As mentioned in the last chapter, of all the GHG emissions taking place on earth, 13% can be attributed to transportation. This figure includes transport of people and commodities across all modes, i.e. land (road and rail), sea and air. The main reasons for these emissions are the use of petroleum based substances used as fuels for movement of these transport vessels. Although the transportation sector has the highest projected growth of GHG emission, it has also been recognised as the one with the highest potential to cut emissions with the focus shifting from moving vehicles to moving people and goods (UNEP Emissions Gap Report 2012, pp37).

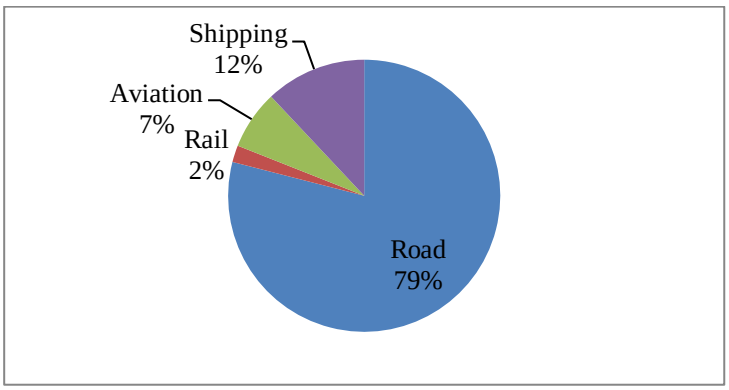

Figure 4: Contribution of different modes in total transport GHG emissions
Source: Buhaug, O. (2009). *Second IMO GHG Study*

Land transport is responsible for 81% of all GHG emissions from the transport sector. The use of alternative engine and/or fuel types like hybrid or battery powered electric engines, fuel cell electric vehicles, internal combustion engine vehicles modified to use gaseous or bio- fuels, etc. would help in improving environmental performance. The continual growth of road freight has also contributed to environmental issues. The movement of freight is a cause of significant congestion on highways. The improved fuel efficiency on road freight transport sector has been offset by burgeoning volumes of transport. For further improvements, traffic policy

decisions, use of technology for optimum routing and driving etc are increasingly being used. To achieve climate mitigation objectives a combination of measures like strongly increasing the vehicles' fuel efficiency, reducing the carbon contents of the fuels, and reducing total transport volumes is necessary (Uherek E, et al, 2008)

Movement of freight by railway is more expensive than roads but ecologically better, producing just 20% of the CO_2 of road transport (Chapman 2007) and the environmental benefits increase with distance.

Transport: Environmental impact of aviation goes beyond emissions' numbers. This is due to the fact that greenhouse gases are being released directly into the upper layers of atmosphere, where the localised effects can be more damaging (Chapman 2007). The release of N_2O also results in formation of another GHG, ozone. Use of aircrafts for freight carriage has been growing steadily and accounts for 10% of all goods transported internationally (by volume). Besides emissions of CO_2 and N_2O, contrails[1] formed from soot particles from aircrafts' engine exhausts increase greenhouse effect. Like roadways improvised fuel efficiency is offset by rapid growth of this sector. In 2004, CO_2 emissions from aircrafts were estimated to be about 700 Tg, where as the global figure stood at 2650 Tg. The International Civil Aviation Authority has adopted a comprehensive policy to reduce GHG emissions by improving annual fuel efficiency by 2% up to year 2050 and stabilizing global CO_2 emissions at 2020 levels by adopting measures like fleet renewal, improvised fuel efficiency, streamlining of operations, testing possibilities for alternate fuels & developing a global CO_2 certification standard for aircrafts.

3.2 International Shipping & GHG Emission Regulations

Sea Transport is not only the most prevalent mode of international freight transport, it is also the most energy efficient and environmental friendly with the least CO_2 emitted per ship tonne nautical mile. Nevertheless, GHG emissions from shipping are significant and at 870 Tg of CO_2 emissions (2.7% of total emissions worldwide,

[1] Contrails are condensation trails formed behind jets by mixture of engine exhaust and water vapor

2007) (IMO website), shipping is still a considerable source of greenhouse gas emissions. Although improvements in machinery and ship designs have resulted in energy efficiency of ships improving by 10% in the period from 1990-2005, this factor was counterpoised by rapidly growing shipping industry driven by trade globalization and larger, more powerful marine engines, serving distant countries over longer routes. Emissions from shipping have been growing steadily (2.4% in 2005). The brisk growth of container ships which operate on strict time schedules catering to just-in-time supply chains and are fitted with the most powerful energy consuming engines is a key factor in rising emissions. (International Transport Forum, ITF, 2008) Container vessels, which represented 4% of all maritime vessels, generated 20% of emissions from international shipping in 2007 (Psaraftis and Kontovas, 2009).

Exhaust gases from marine engines, containing CO_2 and N_2O, are the primary source of GHG emissions from ships. VOCs associated from petroleum cargoes and fluorinated gases used in refrigeration and cooling are minor contributors too. But the chief problem remains CO_2 released in high volumes with engine exhausts. One of the causes for this is the quality of fuel used in ships engines. 86% of marine engines use the very viscous and impure heavy fuel oil (HFO) which is a residual product obtained at the end of crude oil refining thus deemed unfit for use in shore based industries, thence relatively cheap, abundantly available and popular (Love et al, 2010). MARPOL Annex VI has regulated quality standard of shipboard HFO, but these are primarily intended to regulate sulphur and nitrous oxide emissions.

The economic recession of 2008/09 that resulted in slow down of trade and thence had an unintended but positive effect on GHG emissions from shipping. Lack of employment for ships and declining income for shipowners meant that, cost cutting was coming to the fore. Prices of bunker fuel oil which are estimated to be worth 40% of a ship's operating costs were also rising during this time. The concept of slow steaming then developed. The market conditions at that time meant that ships spent a lot of their time idle. Thus rather than proceeding at full speed and then waiting for cargo, ships would travel at speeds below their designed maximum. This

was mainly done as it led to considerable amounts of fuel savings. The relation between speed reduction and fuel consumption on ships is not linear and reducing a vessel's speed by 10% decreases emissions by at least 10–15% *(Psaraftis and Kontovas, 2010, Corbett et al, 2009).* Between the years 2008-2010, slow steaming resulted in about 11% reduction of CO_2 emissions (*Cariou, 2010*).

The global nature of the shipping sector where over two thirds of the world's international maritime fleet is registered in non Annex 1 Kyoto Protocol countries while, conversely, two-thirds of the world's fleet is owned by nationals of Annex 1 countries makes enforcement of new laws a little difficult. As Heitmann et al (2010) have pointed out, environmental effectiveness is dependent on *legal effectiveness and a level of cooperative enforcement is desirable* as methods of evading the regulations will be sought by unscrupulous shipowners. Relocation of head offices or ships' Flag State to more favourable regimes for a variety of financial benefits is commonplace. In order to deliver real CO_2 reductions, action was needed from IMO to target all vessels or all countries and with IMO ratification, its member States which represent almost all of world shipping will enforce the laws in their jurisdictions making evasion very difficult.

The new chapter 4 to MARPOL Annex VI provides a three way strategy to inhibit GHG emissions, technical, operational and market based measures.

The *technical measures* are aimed mainly for new ships which will need to have an Energy Efficiency Design Index (EEDI), depending on ship type and size and will need to maintain energy efficiency , expressed in grams of CO_2 per ship's capacity-mile. New ships will need to adhere to a reference emission level for those types and these levels will be made more stringent over a period of time. The EEDI is a non-prescriptive, performance-based mechanism giving the ship builders the freedom to design ships in the most cost effective manner. It is expected to stimulate innovation and technical development of all the components influencing the fuel efficiency of a ship (IMO website).

The *operational measures* in force are mandatory for existing ships. Ships are required to develop and maintain a Ship Energy Efficiency Management Plan

(SEEMP) which provides methods for making the energy efficiency of ships better in a cost effective manner. Monitoring energy efficiency over time and to track effect of operational changes can be done by using to the voluntary Energy Efficiency Operational Indicator. The IMO circular (MEPC.1/Circ.684) provides guidance on best practices for fuel and energy efficient operation of ships. Some of them are speed and power optimization, better voyage planning in conjunction with weather routeing services, use of just in time concepts, optimizing ship and cargo handling and exploring other methods of energy management.

The IMO believes that these new measures will lead to significant emission reductions, between 9 and 16% by 2020, and between 17 and 25% by 2030. Crist, (2010) estimates that combined technical and operational measures have been estimated to potentially reduce CO_2 emissions by up to 43% per tonne-kilometre by 2020 and by up to 63% per tonne kilometre by 2050. Also very importantly, with deeper investments in more efficient ships and more sophisticated technologies IMO estimates annual fuel cost saving of between 34 to 60 billion $ by 2020.

An expert group was formed by IMO's Marine Environment Protection Committee (MEPC) to evaluate *Market based measures* for reducing shipping emissions. Some of the topics included development of a GHG fund, a Marine Emission Trading System (METS), achieving reductions through Port State arrangements, setting global energy trading systems, using rebate mechanisms etc.

Wang (2010) had studied the economic costs for CO_2 emission reduction from international shipping on developing nations under two different scenarios, first by flag state registration and the other by geographical location of the freight. The conclusion arrived at was that developing countries and economies in transition would pay up to $18 billion and $16 billion, respectively, for CO_2 emission reductions from vessels calling at U.S. ports in the year 2005. Some bigger shipping companies like Maersk, CMA-CGM etc have taken the initiative of reducing carbon footprints in the course their operations.

Chapter 4: Climate Change &Transportation: The Indian Context

4.1 GHG emissions and Climate Change policies in India

India is categorised as one of the non Annex I developing countries under the Kyoto Protocol without binding targets and is party to the UNFCC. India's share of global CO_2 emissions was about 5.4% in 2010 and it ranked third in the world in this regard from 2007 rank of sixth (UNEP, Emissions Gap Report 2012). Increase in population levels and economic growth have increased the demand for energy and thus GHG emissions. GHG emissions in India have increased from 1251.95 Tg of CO_2 eq[2] in 1994 to 1523.77 Tg in 2000 to 1904.7 Tg in 2007 with the energy sector being the biggest contributor (Second National Communication to UNFCC, Ministry of Environment and Forests of Government of India, [MOEF], 2012). The reason for such numbers is the traditional dependence for many years on coal as primary source of fuel (37% in 2010, as per the *International Energy Agency*).

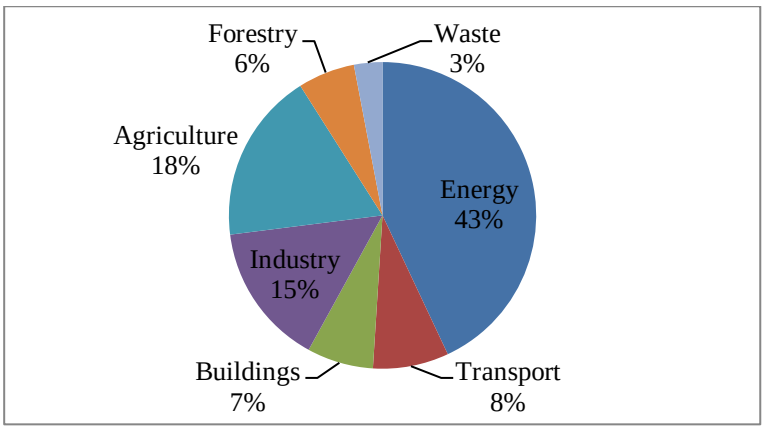

Figure 5: India GHG emissions in 2007 – break up by sectors
Data Source: Ministry of Environment & Forest, Govt of India, (2010). *India: Greenhouse Gas Emissions 2007*

In 2009, the MOEF published a report which assessed and projected India's GHG emissions profile. Independent bodies using different modeling systems predicted

[2] CO_2 eq , Carbon Dioxide Equivalent is used to compare the global warming potential of a GHG relative to that of CO_2 on basis of the warming potential of that GHG.

that total CO_2 eq emissions from India would be between 4300 to 7000 Tg in the year 2031 even in case of sustained economic growth. Although the per capita GHG emission would be below world average and the 2005 level, this represents a fair increase in total emissions. The projections were made on assumptions of investment requirements and regulatory policies being enforced, something which cannot be taken for certain considering the political set-up. Ghosh (2009) referred to a study by Jalil and Mahmud (2009) whereby they concluded that trade has a positive but statistically insignificant impact on CO_2 emissions. But Ghosh empirically established that reduction of carbon emissions would hurt India's economic growth at least in the short-run. An annual report published by the MOEF in 2012 outlined some of the probable adverse effects likely to be faced if global warming is not kept under check as agreed in international Conventions and assessed India as vulnerable to most of the adverse effects mentioned in Chapter 2.2. According to the 4th Assessment report of the IPCC 2007, some of the most severe impacts of climate change will hit India's agriculture and natural resources. With climate change concerns growing, the MOEF has undertaken various initiatives over the past few years to move towards energy efficient technologies and make growth sustainable. The acceptance of the Civil Nuclear deal in 2008 was a landmark moment in this regard, because of the potential of nuclear energy to provide much cleaner efficient energy than traditional fossil fuels. India had committed at the 2010 Copenhagen summit of the UNFCC to reduce emission intensity of GDP by 20 to 25% by 2020 in comparison to the 2005 level. The GOI has considered climate change during recent policies' formation. Furthermore GOI has developed a low carbon economic strategy & National Action Plan for Climate Change (NAPCC).

4.2 Freight Transport & GHG emissions in India

Freight transport in India has been rising steadily as is expected of growing economies. This sector which was dominated by railways in the 1950s & 60s has gradually but surely shifted towards roadways. Figure 6 below show the inter-modal distribution of freight transport in India. The authorities despite having recognised

shipping as the most cost efficient and energy efficient means of transport did precious little over the years to augment the same and its contribution remains dismal. Efforts over the past decade in developing port and shipping related infrastructure and providing incentives for coastal trade have increased.

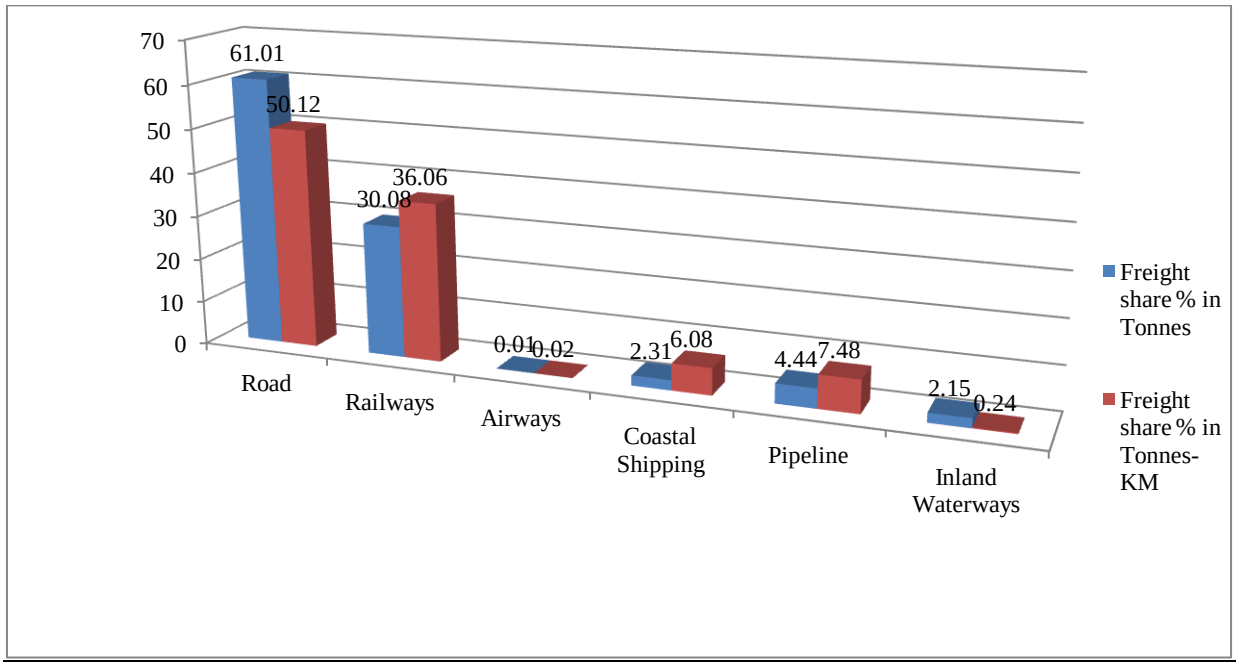

Figure 6: India Modal Shares in Freight Traffic in Transport Sector, 2008
Data Source: Planning Commission of India, (2010). *Total Transport System Study on Traffic Flows & Modal Costs*

Recognising that the transport sector is a major contributor to GHG emissions in India, 142 Tg (7.5%) of CO_2 eq & 139 Tg (8.5%) of CO_2 in 2007 (as per MOEF), the NAPCC specifically consists of a Transport Action Plan which will include Sustainability Indicators and a national level integrated assessment of transport sector emissions and projections of future CO_2 emissions till 2050. Considering the fact that volume of road and air traffic is expected to increase steadily in the coming years, a policy framework towards achieving a sustainable low carbon growth becomes necessary. Use of carbon credit system and incentives for greener transport have been suggested as some of the measures. Mode wise contribution to GHG emission is shown in Figure 7 below.

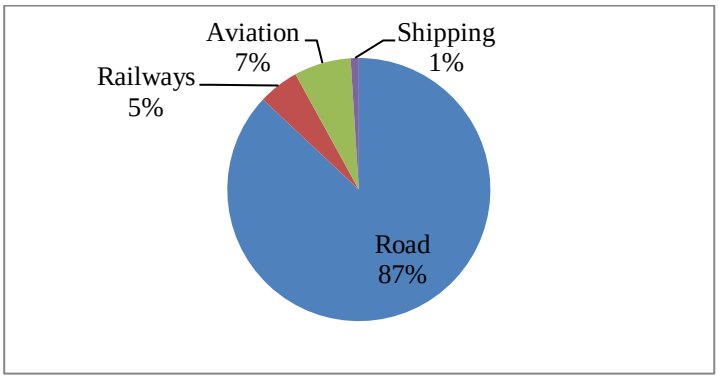

Figure 7 : India GHG emissions from transportation, 2007
Data Source: Ministry of Environment & Forest, Govt of India, (2010). *India: Greenhouse Gas Emissions 2007*

The International Transport Forum *(ITF)* had also published CO_2 emission figures from transport sectors for 2008 shown in the table below. There is a slight difference observed between MOEF & ITF figures. This is primarily because the MOEF has published CO_2 eq figures (all GHGs) for 2007 while ITF has published CO_2 gas emissions for 2008. It may be noted that CO_2 constitutes 97.8% of all GHGs emitted as per the MOEF report.

Table 1: India CO_2 emissions from transportation, 2008

Mode	CO_2 emissions in 2008 (Tg)	% of total Transport CO_2 emissions	% Increase in CO_2 emissions from 1990-2008	Average% change per year
Roadways	121.08	82.7	84%	4.7
Railways	6.88	4.8	(51%)	(2.8)
Aviation	14.06	9.6	166%	9.2
Shipping	4.36	2.9	89%	4.9
Total	*146.39*	*100*	142%	*7.9*

Data Source: International Transport Forum, (2010). *Reducing Transport Greenhouse gas emissions: Trends & data*

4.3 Coastal Shipping in India

India's 7517 kilometer long coastline contains 12 major ports and about 187 non major ports. Shipping contributes about 98% of Indian trade by volume and 68% by value. Together the ports handled 885.44 million tonnes of cargo from April 2010 to March 2011 and 623.05 million tonnes from April to November 2012, with petroleum oil products, containers, and coal and iron ore being the major commodities. Until recently, the importance of coastal shipping, called short sea shipping in the western world had not been duly rated. Out of the government funds allocated to the transport sector until then, shipping was allotted barely 5% and coastal shipping share was even more miniscule (Planning Commission of India, [PCI], 2007). But growing economy and trade meant that coastal trade kept increasing despite the infrastructural and policy road blocks, at the expense of efficiency. The authorities having realised and recognised coastal shipping as an as an area with tremendous potential for effective means of transport both environmentally and economically adopted policies for its growth and development recently.

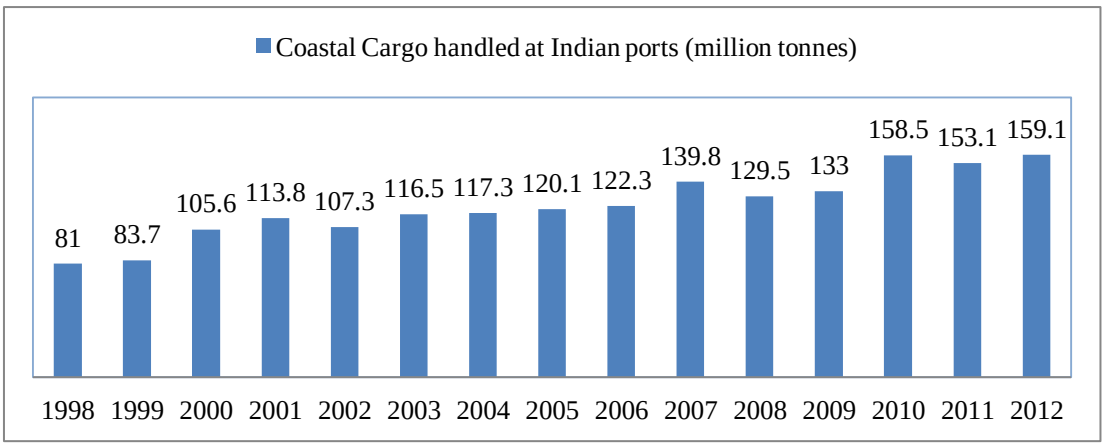

Figure 8: Coastal Cargo Handled at Indian Ports (million tonnes)
Data Source: Ministry of Shipping, Govt of India, (2013). *India Shipping Statistics 2012*

Among the developing countries India is one of the major maritime nations with a total fleet (international and coastal) of over 1,100 ships (over 10.4 million GT). The coastal shipping fleet in India consists of various types of vessels from traditional bulk carriers to dedicated ethylene carriers to specialised vessels for offshore use. As

per the Directorate General of Shipping (DGS), the total fleet of Indian coastal vessels stood at 804 vessels totaling 1.085 million gross tonnage and 1.063 million deadweight at the end of last year. The break up is given in Table 2 below.

Table 2: Indian Coastal Shipping fleet in Dec 2012

Sr. No	Type of vessel	No. of vessels	Total GT	Total Deadweight (DWT)
1	Dry Cargo Liner	85	132908	192716
2	Tug	267	85314	28021
3	Dry Cargo Bulk Carrier	14	225038	345958
4	Product Tanker	13	40437	42811
5	Crude Oil Tanker	2	50080	82246
6	Passenger-cum-cargo	33	89754	27300
7	Passenger	60	22574	1930
8	Ethylene Gas Carriers	4	9193	6781
9	Ro-Ro	1	956	1386
10	Dredger	30	128188	73960
11	Off Shore Supply vessel	112	122780	122460
12	Specialised Off Shore vessel	38	88201	50480
13	Tugs owned by Ports	103	49883	17516
14	Motor Launch	19	3127	0
15	Barge	18	27933	70242
16	Floating Crane	2	4296	0
17	Electric Propulsion	3	4447	0
	TOTAL	804	1085109	1063807

Data Source: Directorate General of Shipping, India. *www.dgshipping.com*

The coastal fleet has been growing at a fair pace over the last two decades as shown in Table 3 & Figure 9 below but finding it difficult to keep pace with the burgeoning trade brought about by the economic growth of the last few years.

Table 3: Growth of Indian Coastal shipping fleet

Year	No. of vessels	Aggregate GT (‘000)
1998	247	654
1999	269	680
2000	312	709
2001	329	731
2002	424	805
2003	429	806
2004	454	808
2005	485	816
2006	526	841
2007	573	893
2008	616	964
2009	662	980
2010	700	1013
2011	750	1048
2012	804	1085

Data Source: Ministry of Shipping, Govt of India, (2013). *India Shipping Statistics 2012*

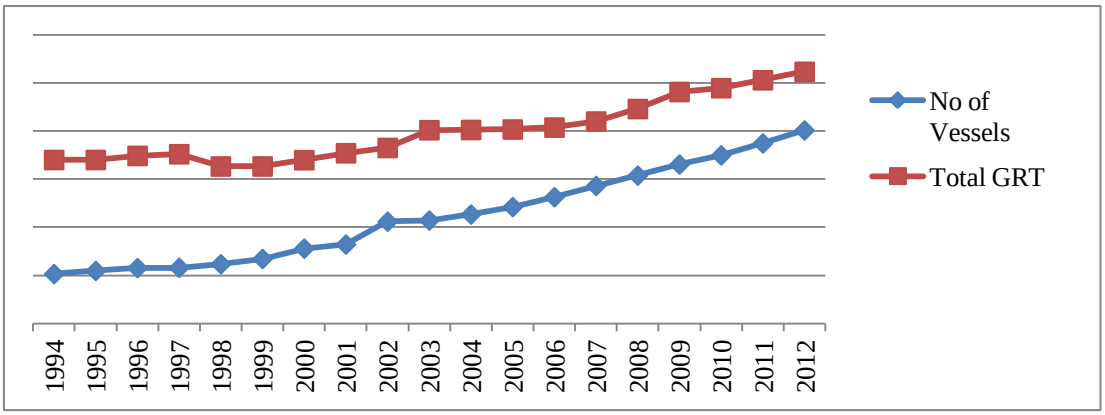

Figure 9: Growth of Indian Coastal shipping fleet
Data Source: Ministry of Shipping, Govt of India, (2013). *India Shipping Statistics 2012*

The average size of the Indian coastal vessel has been decreasing, so although number of Indian vessels is fairly large, India's rank of the global GT share is only 18th. This is partly because off shore activities have increased multi fold during this time and along with that the number of smaller sized support vessels and tugs. But another factor is that the ports have not developed in line with international standards and there are not many deep draft ports in the country to accommodate larger vessels and take advantages of economies of scale.

Table 4: Break-up of Indian coastal shipping fleet by GT size, 2012

Vessel size (GT)	No. of vessels	Proportion (% of total)
Less than 400	396	49.3
400-999	164	20.4
1000-4999	206	25.7
5000-9999	19	2.3
More than 10000	19	2.3
TOTAL	804	100

Data Source: Directorate General of Shipping, India. *www.dgshipping.com*

The average age of the Indian coastal ship is also fairly high. At the end of last year, more than 40% of the coastal fleet was over 20 years of age and average ship age was 17.03 years. Table 5 classifies the coastal fleet as per their age bracket.

Table 5: Age-wise distribution of Indian Coastal shipping fleet, 2012

Age bracket (years)	No. of vessels	Proportion (% of total)
0-5	180	22.4
6-10	89	11.1
11-15	102	12.7
16-20	90	11.2
More than 20	343	42.6
TOTAL	804	100

Data Source: Directorate General of Shipping, India. *www.dgshipping.com*

Ageing vessels have higher maintenance and operating costs, lesser energy efficiency (thus higher emissions). The deteriorating strength of the hull structure also increases the threat of other types of marine pollution. The fact that Indian ship owners continue to buy second hand vessels even at present times when ship prices are very low only exacerbates the problem.

The Maritime Agenda 2010-2020 of the Ministry of Shipping of Government of India (MOS) has outlined substantial investments in the development of shipping and port infrastructures and envisages a fourfold increase in Indian tonnage with 40% of fleet being renewed. It also states that '*Strengthening Indian fleet with cheaper, adequate and easier access to finance is important'*. Some of the proposed measures are concessions from certain dues for coastal vessels, dedicated terminals for coastal cargoes, introduction of tonnage tax regime, proposed setting up of a Coastal Shipping Development Fund, investment for development of non major ports etc.

Coastal shipping carried 2.31 & 6.08 % of all freight transported in India in tonne and tonne-km terms respectively in the one year period ending March 2008 which amounted to 85.7 billion tonne-km (BTKM), increasingly slowly from 63 BTKM in 2002. Indian ports handled roughly 153 million ones of coastal cargo during that period. The coastal cargo consists of 6 commodities viz. Petroleum & petroleum products, coal, iron ore, cement, containers and miscellaneous goods. In 2000, maritime transportation including emissions due to transport in coastal and international waterways emitted 1.03Tg of CO_2 eq., which was 1.0% of the total CO_2 eq. emissions from the transport sector at that time (MOEF, 2012). As per the last available figures of 2008, the maritime transport sector in India had a 2.9 % share of all transport related CO2 emissions (approximately 4.36 Tg, ITF, 2008).

4.4 Other Transport modes in India

Roadways: Due to flexibility and accessibility, roadways in India are the dominant player in the transport sector with a 4.7% GDP share in 2009-10 (website of Ministry

of Road Transport & Highways, Government of India ,[MORTH]). As per the National Highways Authority of India, more than 60% of freight and 80% passenger traffic is carried by the roads. Freight transport vehicles constitute about 44% of motorised road vehicles and their numbers have grown by 35.6% from 2009 to 2011, being roughly 6 million in 2010. They had a 1291 BTKM contribution, 40% of cargoes were industrial and mineral goods. The total length of roads has been increasing too, although comparatively sluggishly at 4.2% average per year over the last five decades. Freight transport by road has been growing recently despite barriers like inter-State en route checks which are not present in any other modes. The economic growth has resulted in a disproportionate increase in road transport of goods and passengers. The poor road infrastructure resulting in slow speeds, higher emissions, delays etc is estimated to cost something in the tune of 550 million $ annually. One of the aspects to be considered is also the fact that due to India's increasing international trade lots of movement of goods is taking place for moving cargo between hinterland centres to and from the gateway airports or seaports. Substantial governmental investment in road infrastructure & logistics development is another factor. Nonetheless it remains a sector with low energy efficiency, higher pollution, slower speeds and little technological advancement.

As per the last available figures of 2008, road transport sector had an 83% share of all transport related CO_2 emissions (approximately 121 Tg as per ITF, 2008). Action has been undertaken in this regard like stricter emissions' standards from new vehicles similar to Euro-I & Euro-II in Europe, the application of Intelligent Transport Systems to reduce congestion, phasing out of old vehicles, compulsory use of more environmental friendly natural gas (CNG) as fuel etc.

Railways: India has one of the largest railway networks in the world with total route length of around 63000 kilometers. India's rail network transported over 1 billion tonnes of freight in 2012 up from 728 million tonnes in 2007. This represents about 30% of all freight traffic. The principal commodities of rail transport have always been coal and iron ore, with almost 50% share. From 480 BTKM in 2007 (MORTH, 2011), goods transported by railways were over 600 BTKM in 2010 as per World

Bank database. But the existing system is bursting at its seams due to severe capacity limitations and inclining people towards road transport. The Ministry of Railways, Government of India, (MOR) is planning dedicated rail freight corridors (DFRC) to fulfill the ever increasing freight transport demand with a modal shift from road transport. The authorities are optimistic that this step will increase energy efficiency markedly & thus reduce GHG emissions as well.

Compared to road transport which emitted 121 Tg of CO_2 eq in 2008, emissions from rail transport stood at 6.9 Tg. More interestingly railway related GHG emissions have decreased by a staggering 51% since 1990. The primary reason for this has been a steady shift from coal powered engines to diesel and electric locomotives. A study conducted by UNEP predicted that if the six proposed DFRCs are operational as per schedule, under certain assumptions, annual CO_2 emissions from rail freight transport could decrease by as much as 70 Tg until 2046. Recent trials have been conducted for development and running of dual-fuel locomotives which would use CNG as primary fuel thereby reducing emissions per tonne-km substantially. Development of engines capable of utilizing biofuels is also underway.

Airways: As per World Bank figures, Indian airports handled over 2 billion ton-km of freight in 2011. The tonne-km figure is a little misleading though as most of the aviation freight traffic is overseas. Most of the domestic aviation traffic is passenger traffic. Although freight traffic handled by civil aviation has grown by 175% between 2000 & 2009, and is expected by the Airports Authority of India to keep growing at about 10-12% for a few more years, the share of aviation in Indian freight transport can still be considered negligible at least as far as volumes are concerned. Parikh et al (2008), projected it to be around 0.02% in 2011. The last available figures for domestic freight traffic indicate 0.29 BTKM in 2008 by aviation used exclusively for transport of high value goods in packaged form. Although the sector has been growing, the contribution is fairly diminutive. In a one year time period ending March 2010, domestic freight carried by air was around 690,000 tonnes. But due to the fact that the sector is energy intensive, GHG emissions gain importance. The civil aviation sector in India emitted 4.1 Tg CO_2 eq in 2000 (MOEF, 2012) &

nearly 14.1 Tg of CO_2 eq in 2008 (ITF), which is around 4% & 9.1% of total emissions respectively. The main reason for this rise was global integration and policy change resulting in the advent of low cost carriers and an 80% increase in passenger traffic between 2000 & 2010. Major airports around the country are also being upgraded to integrate them with cargo freight terminals.

5. Analysis of Indian Coastal Shipping and Transport Emissions

In this chapter comparisons are made between different entities to evaluate GHG emissions and freight transport. Introduction of new rules, especially ones regarding environment are initially always perceived as anti-economic. In order to evaluate the need for such rules, qualitative analyses were done as mentioned in methodology section 1.4.2. For this purpose questionnaires were designed and distributed amongst people from shipping fraternity and people related to environmental issues. The said questionnaires are attached as Appendices 1 & 2 to this paper. The responses have been analysed in section 5.3. Expected future growth of coastal shipping tonnage has been forecast in section 5.4. The methodology used for the forecast model has been elaborately explained in Appendix 3.

5.1 Comparison between different transport modes in India

Freight transport in India is dominated by land transport sector in spite of the presence of such a long coastline and nearly 200 sea ports. Infrastructural constraints are severely felt across all transport sectors in India. But the scale and flexibility of road transport along with its proximity to the end consumer means that it gets a lot more attention than other modes. Infrastructure developed in the road sector is beneficial to passenger transport is another factor that makes it an important issue.

To a lesser extent this is also true of the railway sector as congestion of facilities leads to delays in passenger services. Thus development there is also swift. The shipping sector on the other hand gets no such favours. The goods carried at most times are bulk raw materials, the shippers and consignees involved are normally big corporates and the individual user is far drawn from the daily hassles. But it is up to the administrators who do realise and acknowledge the economic and environmental benefits of shipping transport, but had done little until recently for the promotion of coastal shipping.

Total transport cost is a sum of economic and social costs which are shown in Table 6 for different modes. Economic cost is the financial cost adjusted for taxes and subsidies while the social costs are costs borne neither by the user nor the service provider, for example environmental and accidental costs (PCI, 2010)

Table 6: Cost of Freight Transportation by different modes India, 2008

Mode	Economic Cost (Rs/tkm)[1]	Social Cost (Rs/tkm)
Roadways	1.067[2]	0.202
Railways (Diesel Traction)	0.94	0.051
Railways (Electric Traction)	0.788[3]	0.015
Airways	39.42	0.690
Coastal Shipping	0.315[4]	0.03

Data Source: Planning Commission of India, 2010. *Total Transport System Study on Traffic Flows & Modal Costs*, Data compiled by author

1: Rs=Indian Rupees, 1 Indian Rupee = 0.02 US$ (22-May-2013)

2: Averaged for Distance slab & road Type

3: Averaged for Principal commodities, line type & terrain. Excluding livestock, the costs are reduced to 0.833 & 0.697 respectively.

4: Averaged for the 6 principal commodities carried

Table 7: Modal distribution of Transport in India & resulting Emissions, 2008

Mode	Cargo Handled (million tonnes)	Cargo Handled (BTKM)	CO_2 emissions (gm/tkm)
Roadways	1558.87	706.16	160
Railways	768.72	508.10	29
Airways	0.28	0.29	540 (all aviation)
Coastal Shipping	59.10	85.70	31 (all shipping)

Data Source: Planning Commission of India, 2010. *Total Transport System Study on Traffic Flows & Modal Costs,*

The emission figures given in Table 7 above are slightly misrepresentative. They include international aviation & shipping while rail and roadways are based on domestic figures. The railways in India are composed of electric as well as diesel locomotives with diesel locomotives coming to the fore during the summer season which is a season of frequent power failures. At the time when this data was compiled electric traction share is 77% of total length. But as the electrification process continues and as cleaner fuels are used for power generation of electric lines, these figures should improve. Roadways should also show improved emission levels as the road conditions and engine efficiency improves and use of cleaner fuels increases.

5.2 International & Coastal Shipping

Exhaust gases from main engines and other machinery are the biggest source of CO_2 from ships. These are some of the factors which make emissions from coastal shipping more potent:

- Coastal vessels operate near coasts or in ports at all times. Thus their emissions take place closer to human inhabitations. Compared to that, international ships arrive from overseas spend some of their time while approaching port and staying in port, close to the coasts. Thus most of their emissions take place while in mid ocean.
- Overall maintenance level of coastal vessels is fairly poor due to age of the fleet. Another factor is that coastal vessels due to the nature of their trade are not subject

to port state control inspections, only flag state ones. Thus the absence of possibility of detentions in foreign ports and consequent implications lowers the pressure to maintain standards. They are also subject to less stringent maintenance requirements at times than foreign ships because of their operating area and comply only with the bare minimum standards.

- India has a sizeable coastal fleet and although the average size of vessels is relatively small, a lot of these vessels because of the nature of their work possess very powerful and/or high speed engines resulting in exhaust emissions which are disproportionately stronger for their size.
- The average age of the Indian fleet is fairly high. This means older engines and poorer energy efficiency of machineries. It also means that advantage of technological progress cannot be taken as older machinery does not always provide that flexibility. Also quite often new regulations apply to newer ships and old vessels are exempted.
- Frequency of operations of coastal vessels is quite high because of the proximity of their origin and destination ports. Thus these vessels are constantly maneuvering and operating their engines and other machinery causing emissions.
- Although MARPOL Annex VI has laid down fuel quality norms for merchant vessels and they have been adopted by DGS, control and monitoring of such rules at ground level has proven difficult. There are frequent reports of circumventing of these quality norms which is often beneficial to both parties involved.

Economic growth has meant increased trade for India. Although international trade has visibly grown, coastal trade has been growing steadily as well. In fact increased international trade has contributed to increase in coastal trade because of higher transshipment activities.

Table 8: Number of Cargo Ships sailed at Major Indian ports

Year	Foreign vessels sailed	Coastal vessels sailed	Total vessels sailed
2005	17563	9391	26954
2006	20901	9318	30129
2007	20168	10459	30627
2008	21529	Not Available	Not Available
2009	21117	Not Available	Not Available
2010	22061	Not Available	Not Available

Data Source: Ministry of Shipping, Govt of India, (2013). *India Shipping Statistics 2012*

While Table 8 above shows an overwhelming majority of foreign ship presence, some important considerations are required. The above data is only available for major ports which cater to most of the international ships. Non major ports also have international shipping traffic, but most of their traffic is coastal. Another aspect is that these are statistics for cargo vessels only. A lot of coastal vessels are not cargo carrying vessels but other type of support vessels like tugs, supply boats, survey vessels etc. These are not included in the above table. And as has been mentioned previously, foreign ships in most cases leave the port and sail away far from the coast unlike the coastal vessel which will definitely call at a port within the country and will be travelling close to the coast throughout its voyages.

Insufficient data is available to quantify GHG emissions from these two categories above, but reports published by the ITF have sub classified emissions from maritime sector in India. As per this data, of the 2.33 Tg of CO_2 emissions from the maritime sector in India, domestic shipping accounted for 2.16 Tg while International shipping 0.17 Tg. For 2008, these figures were 3.82 Tg and 0.54 Tg respectively of the total maritime emissions of 4.36 Tg. The MOEFs 'Second National Communication to UNFCC' also attributed 78% of fuel consumed in the maritime sector to domestic transport and thus the corresponding emissions in the year 2000. It must also be borne in mind that international shipping laws for GHG emission control are already in place and even national ships on international trade are following them.

5.3 Analyses of response to Questionnaires

The questionnaires are designed for two sets of respondents. One for the people in shipping fraternity and the other for people working on environment related issues. The questions are formulated to get opinions from a wide spectrum of people, maritime administrators (at DGS), maritime trainers, coastal ships' operators and owners, superintendents and seafarers in the shipping industry, to activists, auditors, officials, research scholars in the environmental industry in line with research objectives set out in Chapter 1.2.3 and to evaluate whether my belief that CO_2 emissions from coastal vessels' should be addressed was in line with their opinion. Further pointed questions are asked to get views on specific problem areas. Respondents were given space and choices for their own opinions. *The said questionnaires are attached as Appendices 1 & 2 to this paper*

Responses to the Shipping Questionnaire

The following is an analysis on basis of responses received from the shipping fraternity. Their opinions have been reported below in the form of pie-charts, graphs and tables. The questions from the questionnaire have been included in parenthesis for ready reference.

1. Effects of climate change have been felt in India for quite a few years now. Floods and droughts, record high and low temperatures are taking place much too often. These are tell-tale signs of a changing climate and a definite cause of worry for most people in India because the knock –on effects cause severe problems like food security, inflation etc. 96% of respondents have through their opinions as shown in figure 10 below have affirmed this.

(Are GHG emissions, of which CO_2 is the main constituent, a cause for concern in India?)

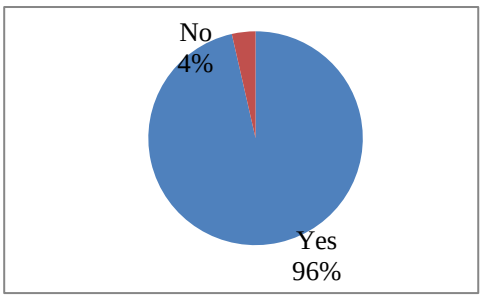

Figure 10: Response to Shipping Questionnaire 1
Source: Author (2013)

2. As mentioned in Chapter 3.2, IMO study has indicated that max cost effectiveness is possible with energy efficient designs conforming to EEDI standards for new vessels and simple operational procedures applicable to existing ships engaged in international trade. These factors combined with fiscal incentives through market based mechanisms will encourage owners to attain greater energy efficiency. Based on the aforementioned facts, there is belief in potential of these regulations to reduce emission levels, as affirmed by 93% of respondents.

(According to IMO the new Air pollution regulations (Chapter 4 of MARPOL Annex VI), will significantly reduce GHG emissions from ships? Do you agree?)

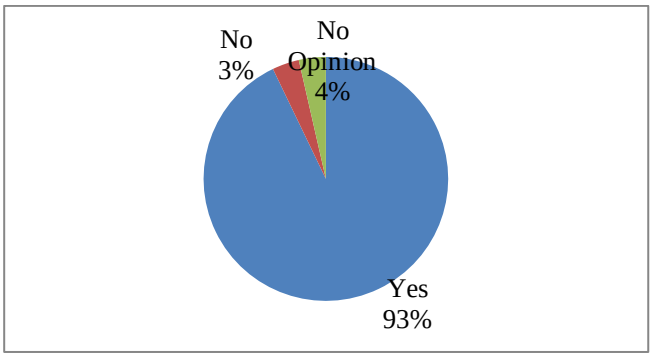

Figure 11: Response to Shipping Questionnaire 2
Source: Author (2013)

3. Enforcing new regulation always has some obstacles. The severity of the barriers changes with passage of time. The people directly affected by the rules will be owners of coastal ships as it will lead to additional expenses. Initial implementation will also cost money as there will costs of surveying, certification and administrative activities. The attitude of the people in general is changing as awareness about climate change is spreading. The impact of these factors is expected to decrease with time. The average age fleet is already 17 years and new technologies are difficult to implement on old ships. Thus as time progresses the hindrance that this factor will cause to enforcement of regulations will increase. This is also something that surfaces from the weighted opinions of the respondents

as summarized in Table 9 below. The opinions suggest that initially the strongest barriers will be opposition of ship owners and indifferent attitude towards climate change. Amongst the *other* factors commonly mentioned by respondents was political willingness to address the issue.

(Please rank your opinion about the Key entry barriers for enforcing legal policy to reduce GHG emission from coastal shipping for the next few years? Ratings indicate severity of the barrier as follows: 1- very low, 2-low, 3- medium, 4- high, 5-very high.)

Table 9: Response to Shipping Questionnaire 3

Factors	0-1 year	1- 3 Years	3-5 years
Opposition from ship owners of coastal ships	Very High	Medium	Medium
Cost of implementation and monitoring new regulations	High	High	Medium
Technical difficulties like age, maintenance standard of vessels	Medium	High	High
Indifferent attitude	Very High	Medium	Low
Other	High	Medium	Low

Source: Author (2013)

4. One of the primary reasons I believe coastal vessels emissions form an environmental threat is the fact that they are operating near the coast at all times unlike ships engaged in international trade which spend most of their time in open seas. Thus, even though total emissions from coastal shipping are lower than international shipping, the fact that these take place near human habitations at all times with direct impacts on human health makes them more cogent. Vast majority of the respondents agree with this.

(Ships involved in international trade spend only a small portion of their time visiting port while the fleet of 800 odd coastal ships operates in port or near the coasts at all times. In your opinion does this make emissions from coastal ships more severe environmental threat?)

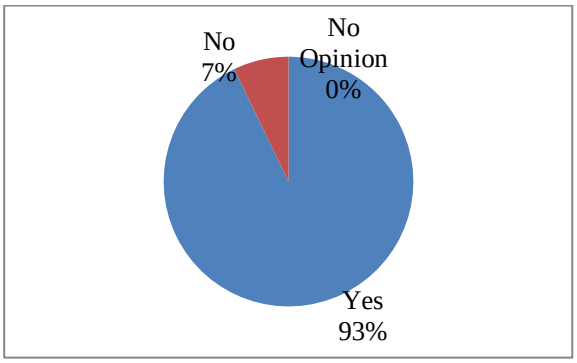

Figure 12: Response to Shipping Questionnaire 4

Source: Author (2013)

5. Opinion on some other emission factors which differentiate coastal and foreign shipping and which have been identified and explained in section 5.2 above was sought by asking the respondents to rate these factors as per the threat levels they posed. 76% of the respondents rated them as severe or most severe, thus supporting my views. As per the weighted responses, the maintenance standards of the average 17 year old fleet make their environmental threat most severe.

   Although comparatively small when compared with other countries like China & USA, 800 coastal ships in India is still a fairly large number and 21% respondents considered that to be the second most important factor in terms of severity of the environmental threat.

(Some factors which differentiate coastal and international shipping are listed below. Kindly rate the factors as per the severity they pose to the environmental threat? [5-MOST severe & 1-LEAST severe])

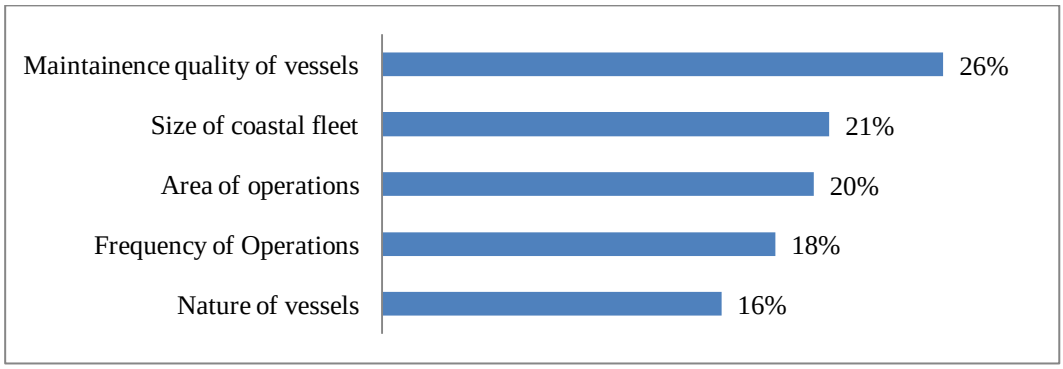

Figure 13: Response to Shipping Questionnaire 5

Source: Author (2013)

6. The IMO requirements for pollution mitigation are based on technical and operational measures aided by market based mechanisms and are expected to yield beneficial results as far as ship emissions are concerned. Some of the measures as described in the IMO GHG study and by few classification societies are not that complex by the shipping industry standards. Their implementation on coastal vessels then will not be any more difficult and should have a positive impact on mitigation of GHG emissions. 86% respondents have felt like this. The prescriptive nature of the requirements also gives shipowners the flexibility to find the most cost effective solutions.

(The new IMO regulations apply neither to coastal ships nor to ships of less than 400 gross tonnage anywhere. In your opinion, will enforcing similar GHG control regulations to these two categories be an effective step in mitigating GHG emissions?)

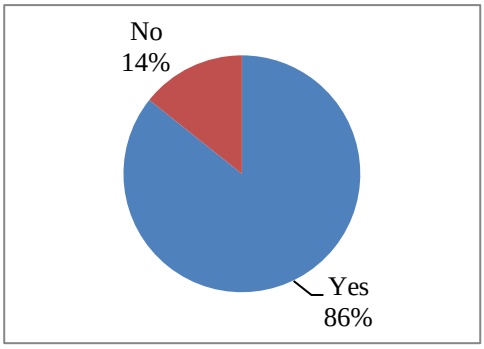

Figure 14: Response to Shipping Questionnaire 6

Source: Author (2013)

7. It is perceived that environmental improvement comes at the sacrifice of some economic benefits. The environmental issues are not high priority for entrepreneurs of developing countries as these small owners operate on marginal profits and in an industry prone to high fluctuation of earnings, they want to save every little cent they can.

   It is noteworthy that the coastal shipping companies which are part of larger business groups though have taken initiatives towards 'greening' their growth.

(What is the attitude of the coastal shipping fraternity towards new regulations, especially environmental regulations? The most common factor in your opinion, select 1)

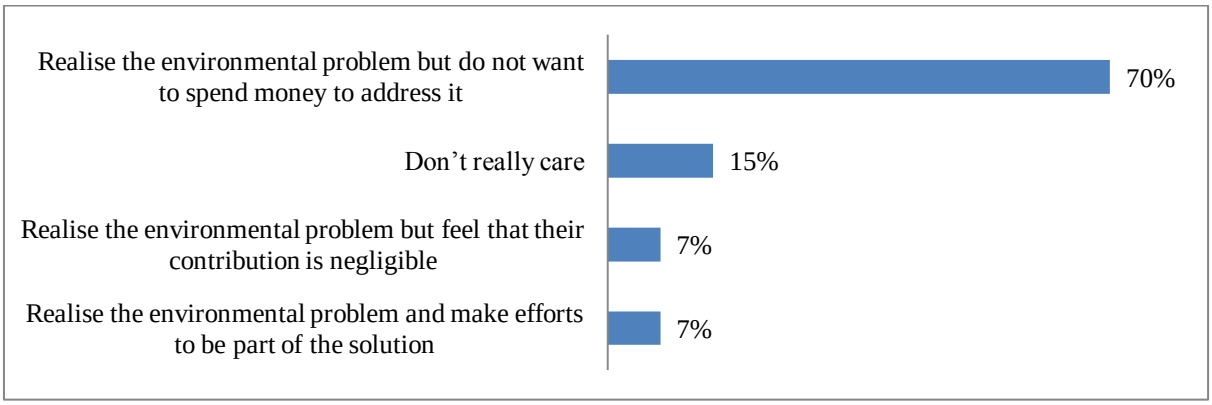

Figure 15: Response to Shipping Questionnaire 7

Source: Author (2013)

8. Some actions taken off late by authorities seem to suggest that there is commitment to tackle the climate change issue. The most popular view though is that such measures will be followed to the extent where they will not hurt economic growth. In the past, DGS has been quite content in enforcing just the basic IMO requirements although in a few notable cases related to safety, it has set more stringent requirements. Opinion of respondents is thus divided on the issue.

(In your opinion, what is the likelihood of GHG emission regulations being enforced on coastal ships?)

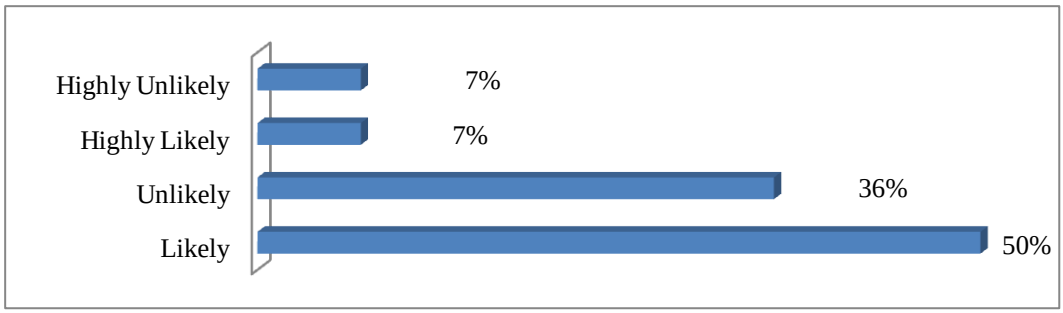

Figure 16: Response to Shipping Questionnaire 8

Source: Author (2013)

9. Long winded procedures burdened with archaic departments and clearance systems means the gap between initiation and actual enforcement of rules is unduly high. In this regard 43% of respondents opined that if at all adopted, the implementation

period for regulations could be between 3-5 years & 36% opined it could be more than 5 years.

(If the rules are indeed applied, likely time frame for their enforcement?)

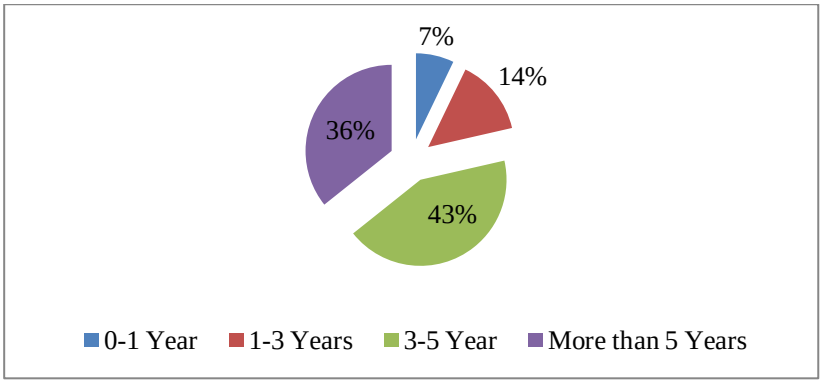

Figure 17: Response to Shipping Questionnaire 9

Source: Author (2013)

Responses to the Environmental Questionnaire

The following is an analysis on basis of responses received from people involved environmental industry and studies, with answers represented similarly in the form of tables, graphs and pie-charts. A few respondents chose not to answer shipping related questions citing insufficient knowledge.

1. A high percentage of respondents are of the opinion that climate change is reason for worry. This is a common feedback between both sets of respondents. One of the reasons cited for the negative answer is India's low emissions per capita as compared to global averages.

(Are GHG emissions, of which CO2 is the main constituent, a cause for concern in India?)

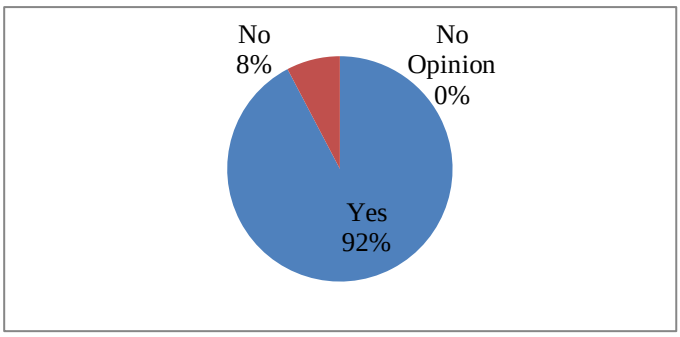

Figure 18: Response to Environmental Questionnaire 1

Source: Author (2013)

2. Considering the consequences suffered due to weather extremes and other phenomena related to climate change, and taking into account the increasing trend, the CO_2 emissions problem seems rather serious. More than half the respondents opine it is very serious.

(How serious is the CO2 emission problem in your opinion?)

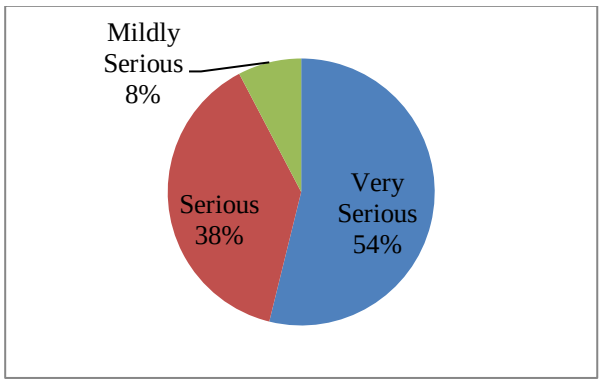

Figure 19: Response to Environmental Questionnaire 2

Source: Author (2013)

3. Weather pattern disruptions have been the most visible effect of climate change and have affected the population on a large scale regularly. 62% of the respondents are of the opinion that it is the one that has been most adversely affected by global warming. Noteworthy responses in the *other* category included the problem of water resources in the North-Eastern region of India and decrease in agricultural products' output as most adverse effect.

(What is the most adverse effect of global warming that has been felt in India?)

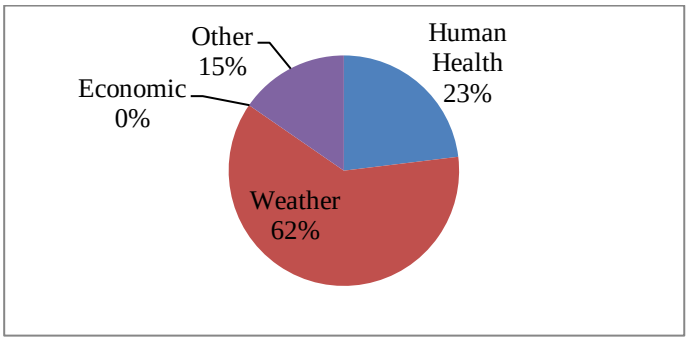

Figure 20: Response to Environmental Questionnaire 3

Source: Author (2013)

4. The phenomenal growth in the automobile sector in urban as well as rural areas with inadequate infrastructure for support has been a major reason for increased CO_2 emissions as briefly mentioned in Chapter 4.3. The problem affects a lot of people on daily basis and the number of vehicles is expected to keep growing far outpacing the infrastructural development. More than half the respondents were of the opinion that the automotive sector was the main source of GHG emissions.

(Which sector is the main contributor of GHGs in India?)

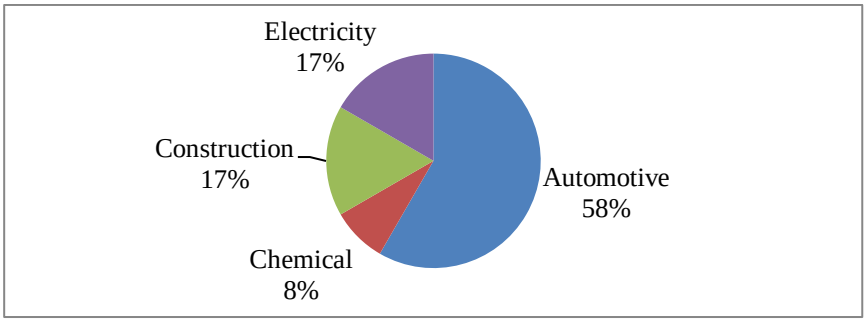

Figure 21: Response to Environmental Questionnaire 4

Source: Author (2013)

5. Since the road transport congestion is more visible than other sectors and impacts the quality of life of many urban dwellers it has also gained maximum attention from authorities. Mandatory conversion of public transport vehicles to CNG, increased investment in mass public transport systems and stricter emission norms

from vehicles are concrete steps aimed at GHG emission reduction which, in the opinion of 42% respondents is more than any other industry.

(Amongst the ones named in Q4 above, in your opinion which industry has taken the most considerable actions to address the problem?)

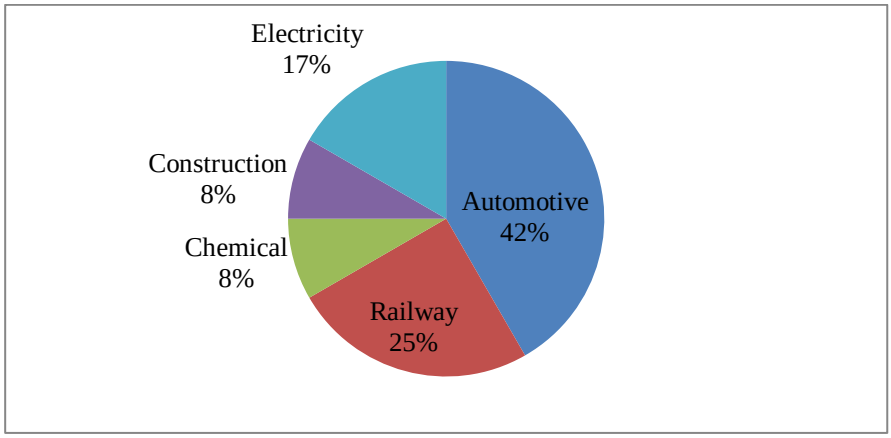

Figure 22: Response to Environmental Questionnaire 5

Source: Author (2013)

6. As the road transport sector is coming under increasing scrutiny and stricter regulations, a lot of old transport vehicles will be unable to ply as new emission norms are enforced, possibly forcing the smaller players out of business. This could result in a modal shift of transport towards coastal shipping although almost half of the respondents were not very sure of this perhaps because of a wide array of uncertain variables involved.

(In view of stricter emission regulations applicable to land transportation, do you think there will be a shift of trade towards coastal shipping?)

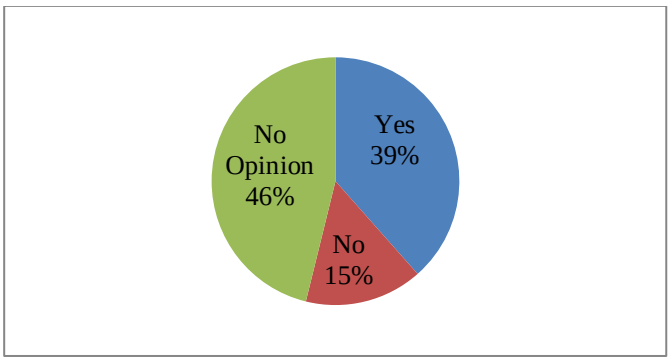

Figure 23: Response to Environmental Questionnaire 6

Source: Author (2013)

7. Majority of the respondents believe that the proximity of their operations adds to the environmental threat posed by coastal vessels, a feedback similar to the responses of the shipping fraternity.

(Ships involved in international trade spend only a small portion of their time visiting port while the fleet of 800 odd coastal ships operates in port or near the coasts at all times. In your opinion does this make emissions from coastal ships more severe environmental threat?)

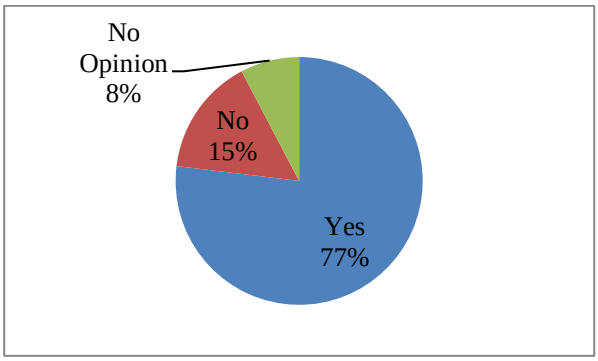

Figure 24: Response to Environmental Questionnaire 7

Source: Author (2013)

8. Severity ratings about factors differentiating coastal and international shipping were sought. The weighted results show that 24% respondents opined that the fleet size, i.e. 800 odd coastal vessels plying in Indian waters as the factor increasing the severity of pollution from coastal ships the most. In order to carry out their functions, certain vessels like tugs etc are installed with powerful machinery having high emission rates and 23% respondents opined that was the factor that increased their environmental threat the most.

(Some factors which differentiate coastal and international shipping are listed below. Kindly rate the factors as per the severity they pose to the environmental threat? [5-MOST severe & 1-LEAST severe])

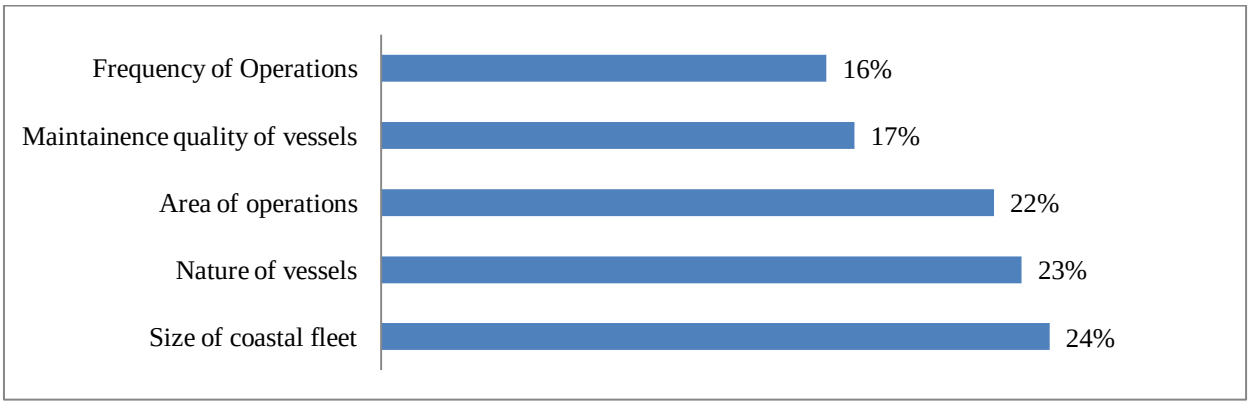

Figure 25: Response to Environmental Questionnaire 8

Source: Author (2013)

9. The land based transport system is the slowest, least cost effective and most environmentally damaging in terms of per TKM basis as seen in Chapter 5.1 but also most popular. But growing trade volumes are likely to make the capacity constraint problems on roadways and railways more acute and delays in the delivery system greater. This could possibly result in a modal shift towards coastal shipping, something 77% of the respondents affirmed to.

(Considering the growing national GDP and increasing freight volumes, do you think there will be an increase in transportation of goods by coastal shipping in view of land transportation capacity constraints?)

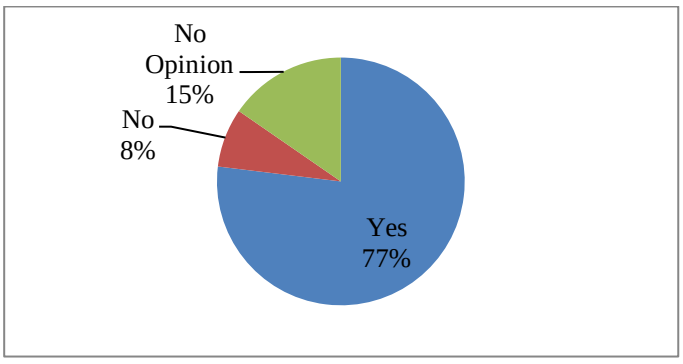

Figure 26: Response to Environmental Questionnaire 9

Source: Author (2013)

10. Environmental issues in the past have taken unusually long to be tackled due to a combination of lack of awareness and their perceived stifling of economic growth.

As awareness is increasing, authorities are taking steps in the right direction but India's procedural systems has caused delays quite often in enforcement of important reforms. 38% of the respondents feel that even if GHG emission regulations are enforced, they could take more than 5 years to come into effect. The resultant cumulative effect of increasing infrastructural deficit and delay in emission mitigation laws will have a high negative impact on the environment.

(If the rules are indeed applied, likely time frame for their enforcement?)

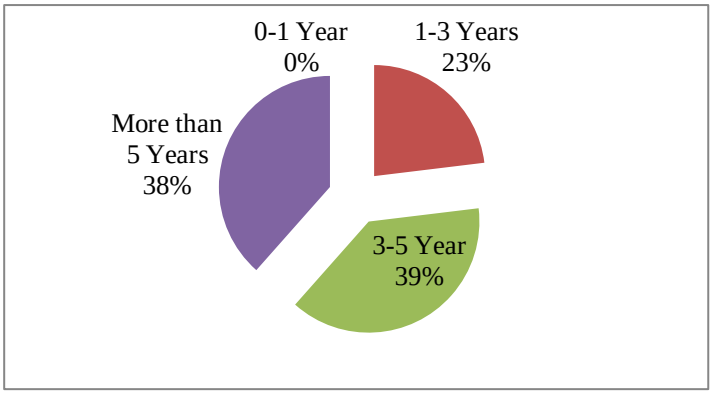

Figure 27: Response to Environmental Questionnaire 10

Source: Author (2013)

11. Table 10 below represents the opinion of the respondents on the severity of the entry barriers over near future time frames. Indifferent attitude & opposition from ship owners have again been rated as very high severity entry barriers, similar to the opinion of respondents from shipping industry.

(Please rank your opinion about the Key entry barriers for enforcing legal policy to reduce GHG emission from coastal shipping for the next few years? Ratings indicate severity of the barrier as follows: 1- very low, 2-low, 3- medium, 4- high, 5-very high)

Table 10: Response to Environmental Questionnaire 11

Factors	0-1 year	1- 3 Years	3-5 years
Opposition from ship owners of coastal ships	Very High	High	Medium
Cost of implementation and monitoring new regulations	High	Medium	Low
Technical difficulties like age, maintenance standard of vessels	High	High	Medium
Indifferent attitude	Very High	Medium	Low
Other			

Source: Author (2013)

Conclusion:

The respondents from both sets seem to concur on the fact that CO_2 / GHG emissions are a cause for concern and should be addressed by authorities. The age and size of the coastal fleet and area of operations of coastal vessels are all factors that enhance their environmental threat. The set up of the procedural systems have resulted in delays of key reforms quite often and a vast majority of the respondents from both sets are of the opinion that rules, even if they are enforced, will take 3-5 years to enforce or more.

It is worth mentioning that if the rules indeed take 3-5 years to come into force, a lot of the vessels in the Indian coastal fleet, which seems set for renewal in next few years, will be exempted from EEDI requirements.

The general consensus is that these rules will have a favourable impact on environment and health. The burden of dealing with new regulations may force smaller coastal operators to shut down and may act as an additional entry barrier for new players. While this has been considered as a likely adverse impact of new regulations, many respondents have expressed this same point to be a favourable impact as it eliminates sub-standard shipping and fly-by-night operators.

Some other adverse impacts that could possible felt are increased freight rates, as the operators will look to recover their increased expenses. This could have a follow on effect of modal shift of freight transport towards railways and roadways.

5.4 Coastal Trade and Tonnage Growth Forecast

In the past few years India has experienced sizeable growth in internal trade. Growing economy has lead to increase in GDP mainly driven by growth in production. The increasing production in turn is driving coastal trade with ships witnessing increasing cargo bookings.

Methodology as mentioned in Chapter 1.4.3 is used. *The methodology is elaborately explained in Appendix 3.*

Based on historical data shown in Figure 8 in chapter 4.3, cargo flow volumes are forecast to determine growth trends in the near future using a customized *Microsoft Excel* model which is based on weighted indexes of several qualitative factors and their impacts over a 5 year period. The results are depicted in Figure 28 below. The figures between the bars are the Compound Annual Growth Rate (CAGR) between those years.

This increased cargo flows is the key driver for increase in tonnage capacity and fleet size. Increase in tonnage capacity and fleet size are bound to lead to higher emission levels.

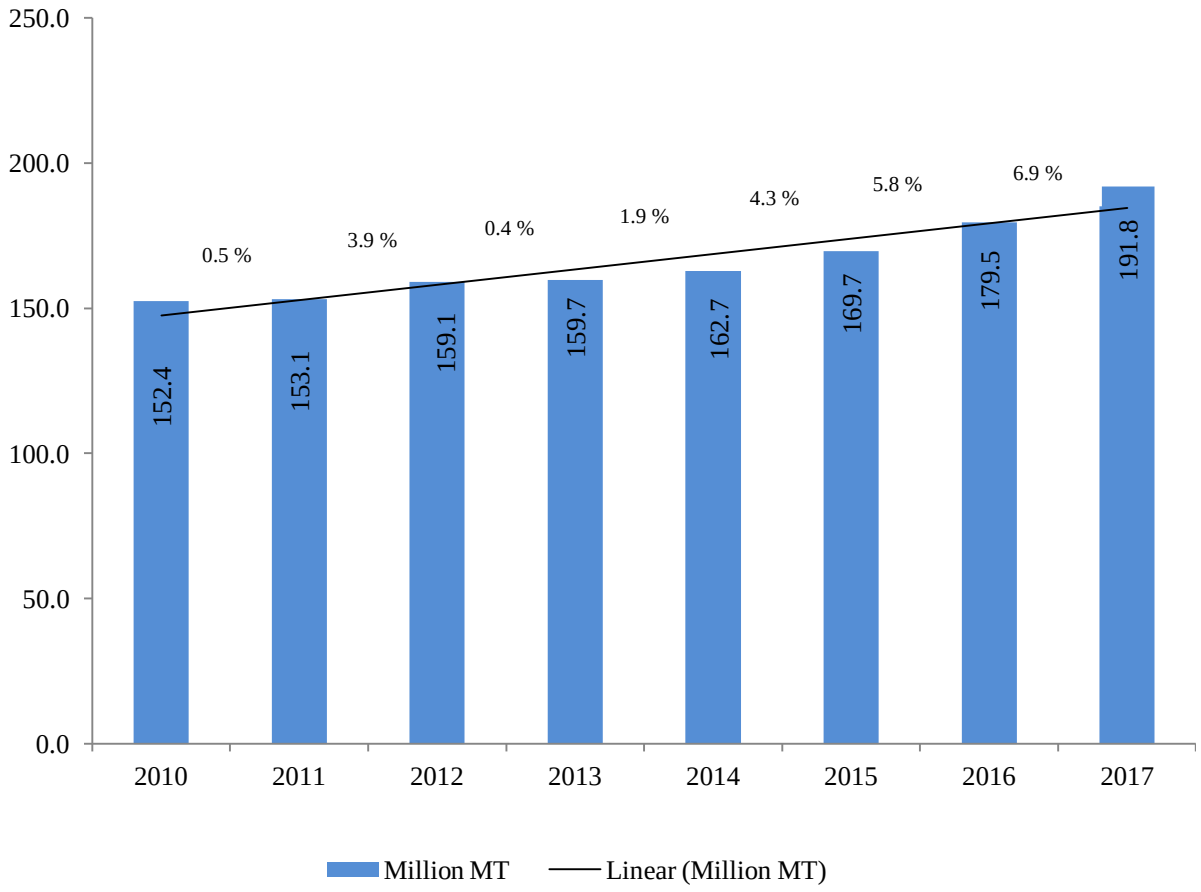

Figure 28: Forecast of coastal cargo volume growth.

Source: Author (2013)

Correlation between cargo handled, number of ships and total tonnage is established using *Excel*. As expected the correlation between number of ships and total tonnage is highly positive and close to 1 for obvious reasons. More important for our purpose, there is a positive trend of correlation between cargo handled and tonnage capacity and between cargo handled and fleet size adding weight to possibility of increased emissions.

Correlation between 'No. of Ships' and 'Tonnage' has not been shown for reason of being too obvious.

Table 11: Correlations result between coastal cargo, number of ships and tonnage.

		Cargo Handled	No of Ships	Tonnage
Cargo Handled	Pearson Correlation	1	.953**	.946**
	Sum of Squares and Cross-products	7486.238	54428.663	4.185E7
	Covariance	534.731	3887.762	2989289.048
	N	15	15	15

Source: Author (2013)

***. Correlation is significant at the 0.01 level (2-tailed).*

Both the correlations are extremely significant. Correlation between cargo handled and tonnage capacity clearly indicates that tonnage is related to the levels of cargo handled. Increase in cargo volumes for transport should thus result in increase of total tonnage.

Based on the above correlation forecasting of the values of tonnage is done to determine growth trends in the near future.

Forecasting of coastal vessels' tonnage:

Using SPSS: By and large, the forecast using time series and regression analysis with the expert modeler in SPSS depicts a linear growth of tonnage. Growth rate depicted by the forecast shows a CAGR of 5.08%. The curve or trend line is a straight fit as shown by the linear regression indicating that tonnage is expected to keep growing in the near future.

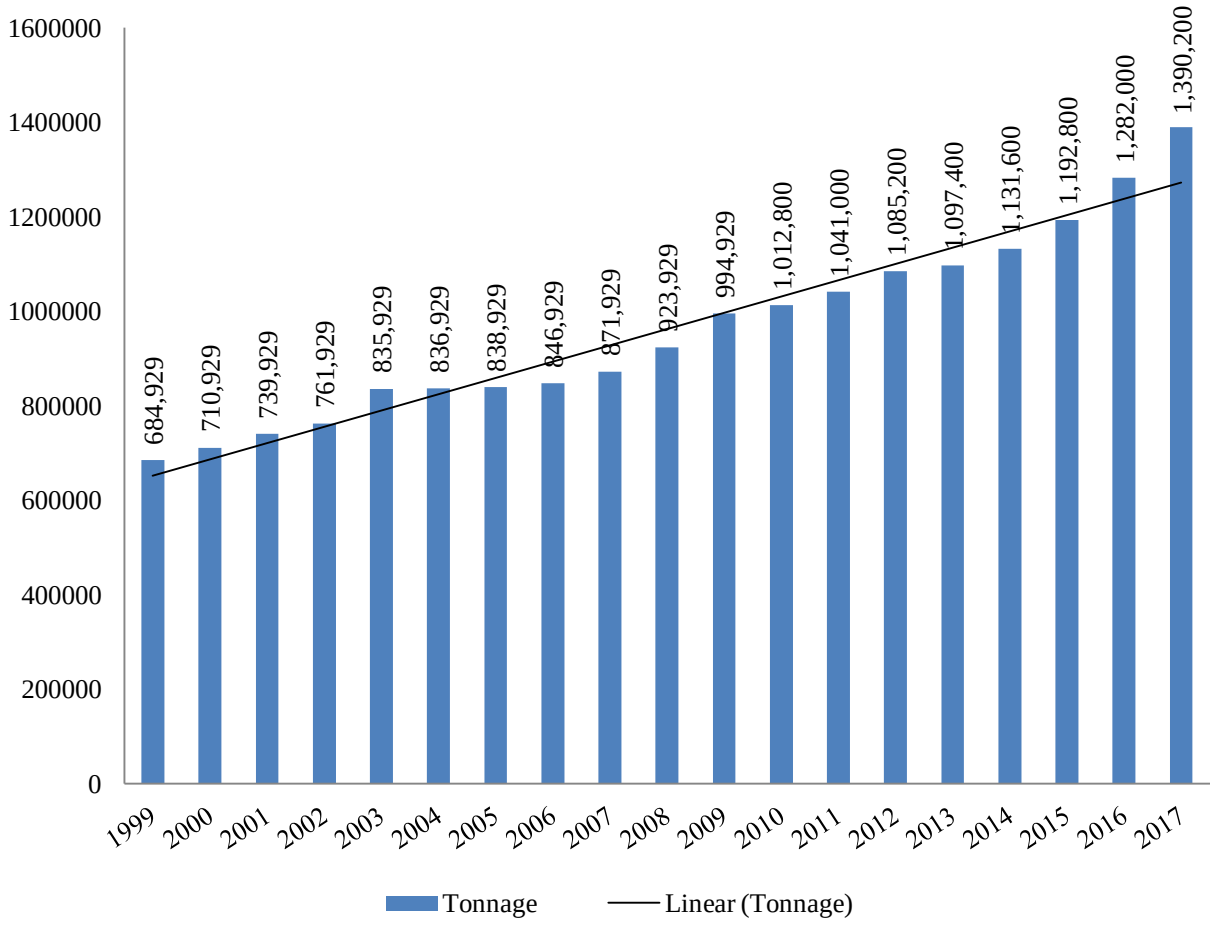

Figure 29: Forecast of coastal cargo tonnage growth using *SPSS*.

Source: Author (2013)

Using Excel: The above forecast is based purely on historical numeric data and to augment it, the customized excel model used for forecast of trade volumes above is also used. The results are depicted in Figure 30 below and show CAGR of 5.23% which is very close to the figure obtained through the regression model.

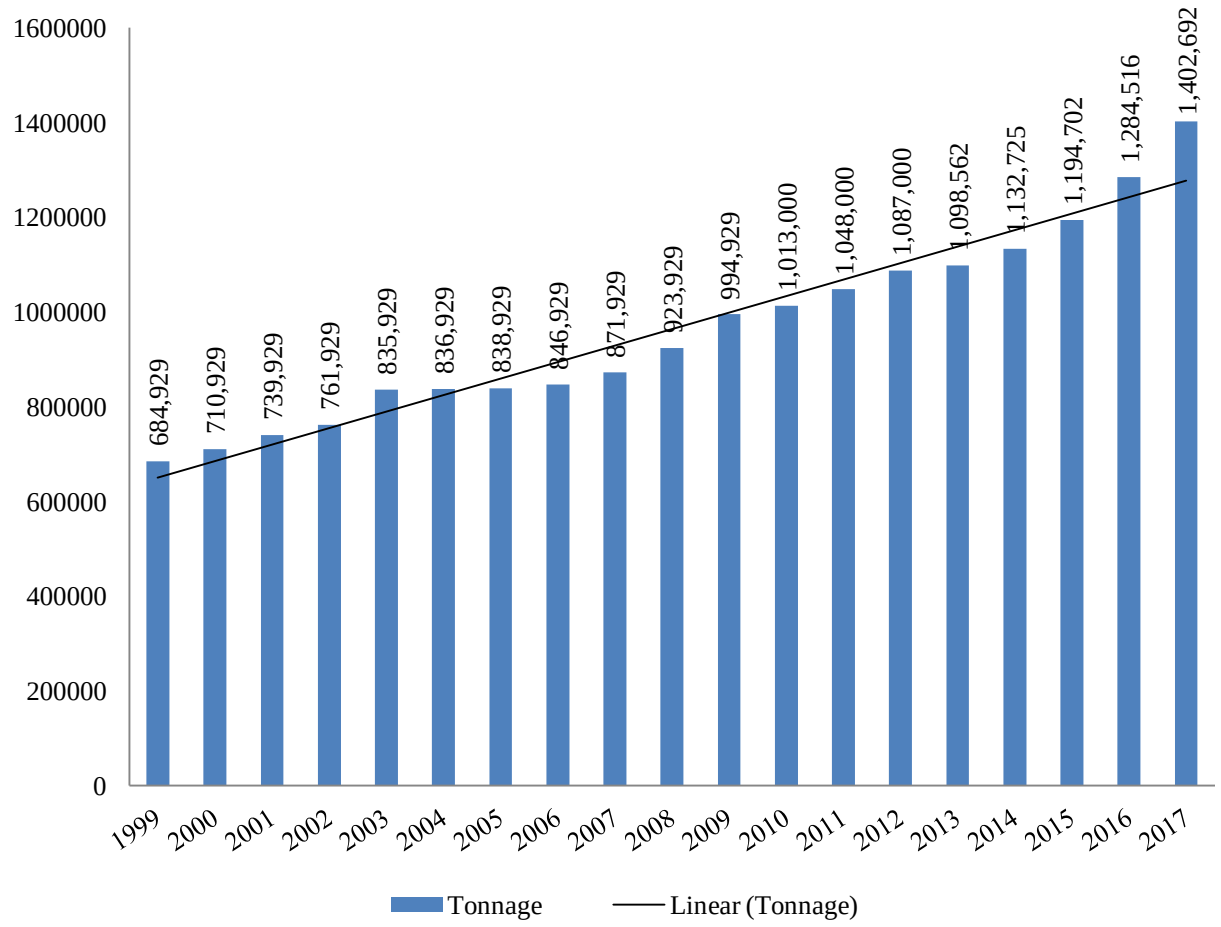

Figure 30: Forecast of coastal cargo tonnage growth using *Excel*.

Source: Author (2013)

Conclusion:

This sector is primarily driven by the trade a country generates. Growth in economy is leading to increasing GDP and production levels which are leading to an overall increase in trade. As the economy, trade and production increase so will the cargo carried and handled at ports. The answers to the questionnaire also affirm this expectation. As the cargo volumes increase, so will the total tonnage. This increase in ships will definitely lead to increase in emission levels. The only way to control these emission levels is for the government and authorities to impose some regulations in a phased manner which will offset the increased emissions.

6. Conclusion and Recommendations

The research paper intends to build a case for controlling GHG emissions from coastal ships as these ships do not fall under the purview of IMO's latest amendments to MARPOL Annex VI addressing the issue. There are factors like areas of operation of coastal ships which are close to human populace and maintenance standards of these vessels which add to the environmental threat posed by emissions from coastal ships.

- An analysis of responses to the questionnaire affirms that a sizeable majority of the people are concerned about greenhouse gas emissions and climate change in India.
- The optimism shown by IMO in the reduction of GHG emissions due to implementation of control measures applicable to ships plying internationally is shared by most respondents.
- The majority of respondents also believe that emissions' mitigation is possible by enforcement of similar rules on coastal vessels.
- Even if emission regulations are at all enforced on coastal vessels, the slow procedural pace in India means that majority of the people are of opinion that the rules will take more than three years to come into force.
- Considering the fact that the technological part of the GHG emission rules are applicable to new ships and that a lot of new ships are expected to be launched in the next few years, these rules can be much more effective if they are enforced faster.
- Opposition from shipowners and their indifferent attitude are two of the strongest obstacles in the way of implementation of such rules. Human resource training to spread awareness and changing the attitudes is an important need.
- IMO has suggested market based incentives to further encourage shipowners to attain energy efficiency. This could additionally serve in shipowners' willingness in accepting the new rules.

- Forecast models used in the paper have shown increase in coastal cargo volume and coastal tonnage in India for the next few years. This concurs with majority of the respondents' opinion as well.
- The increase in trade and in tonnage is bound to cause a rise in emissions, further enhancing the need for quick implementation of the rules.
- Rising fuel prices are gaining a bigger share in total operational costs across all transport modes. This will attract businesses towards coastal shipping.
- The ship operators should be made aware that these rules promote energy efficiency and hence fuel savings and that would be economically beneficial to them in the long run. The cumulative change would include cost savings as well as environmental welfare.

Recommendations:

GHG emission control rules should be enforced on coastal shipping as soon as possible beyond the IMO requirements. The prescriptive nature of the IMO rules ensues flexibility which should make them more acceptable. Technological innovation like retrofits to ships' engines, use of liquefied natural gas as fuel (being followed by North European ferries), use of wind and solar energy to complement fossil fuel based energy, water and air drag reduction systems have all been successfully tested or are being used. Their successful adoption into the coastal shipping fleet should be encouraged. Market based incentives would prove to be very effective since a reduction in profitability is one of the primary concerns whenever new rules come into existence. Training will help to spread awareness, clear misconceptions and educate people on the delicate situation regarding climate change. All this will need commitment from the authorities and they could well start by ensuring a quick adoption and enforcement of the regulations for coastal ships.

Economic implications for coastal shipping companies if the new regulations are imposed and technological innovation for greater energy efficiency are two areas that can prove to be good research topics for the future.

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Appendices

Appendix 1: Research Questionnaire for people from shipping fraternity

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Name (optional):

Company / Organisation: Position:

1. *In your opinion, are greenhouse gas (GHG) emissions, of which CO_2 is the main constituent, a cause for concern in India?*
   ☐Yes ☐No ☐No Opinion

2. *According to IMO the new Air pollution regulations (Chapter 4 of MARPOL Annex VI), will significantly reduce GHG emissions from ships? Do you agree?*
   ☐Yes ☐No ☐No Opinion

3. *Please rank your opinion about the Key entry barriers for enforcing legal policy to reduce GHG emission from coastal shipping for the next few years? Ratings indicate severity of the barrier as follows: 1- very low, 2-low, 3-medium, 4- high, 5-very high. (For e.g., if in your opinion opposition from ship operators will decrease over a period of time, then that row will read 5-4-2 say.)*

BARRIER	0-1 yr	1-3 yrs	3-5 yrs
Opposition from ship owners of coastal ships			
Cost of implementation & monitoring the new regulations			
Technical difficulties like age, maintenance standards of vessels			
Indifferent attitude			
Other (if any), please specify:			

4. *Ships involved in international trade spend only a small portion of their time visiting port while the fleet of 800 odd coastal ships operates in port or near the coasts at all times. In your opinion does this make emissions from coastal ships more severe environmental threat?*

☐Yes ☐No ☐No Opinion

5. *Some factors which differentiate coastal and international shipping are listed below.Kindly rate the factors as per the severity they pose to the environmental threat? (5-MOST severe & 1-LEAST severe)*

Size of coastal fleet (more than 800 vessels of various types)	
Nature of vessels (includes tugs, towing vessels with powerful engines)	
Area of operations (near the coast or in ports almost all the time)	
Frequency of operations (short voyages between Indian Ports or within one port)	
Maintenance quality of vessels (requirements less stringent than for international ships)	

6. *The new IMO regulations apply neither to coastal ships nor to ships of less than 400 gross tonnage anywhere. In your opinion, will enforcing similar GHG control regulations to these two categories be an effective step in mitigating GHG emissions?*

☐Yes ☐No ☐No Opinion

7. *What is the attitude of the coastal shipping fraternity towards new regulations, especially environmental regulations? The most common factor in your opinion, select 1*

☐Realise the environment problem & make efforts to be part of the solution

☐ Realise the environment problem, but feel their contribution is negligent.

☐ Realise the environment problem, but do not want to spend money to address it

☐ They do not really care

☐Another factor

8. *In your opinion, what is the likelihood of GHG emission regulations being enforced on coastal ships?*

☐Highly likely ☐Likely ☐Unlikely ☐Highly unlikely

9. *If the rules are indeed applied, likely time frame for their enforcement?*

☐0-1 yr ☐1-3 yrs ☐3-5 yrs ☐ more than 5 years

10. *If the rules are enforced for coastal shipping, what are the likely overall effects on shipping and trade?*

Favourable:

Adverse:

Any Additional inputs and / or comments will be highly appreciated

THANK YOU FOR YOUR TIME

Appendix 2: Research Questionnaire for people related to environment

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Name (optional):

Company / Organisation: Position:

1. *In your opinion, are greenhouse gas (GHG) emissions, of which CO_2 is the main constituent, a cause for concern in India?*
   ☐Yes ☐No ☐No Opinion

2. *How serious is the CO_2 emission problem in your opinion?*
   ☐Very Serious ☐Serious ☐Mildly Serious ☐Not Important

3. *What is the most adverse effect of global warming that has been felt in India?*
   ☐Human Health ☐Weather patterns ☐Economic ☐Other (please specify:)

4. *Which sector is the main contributor of GHGs in India?*
   ☐Automotive ☐Railway ☐Shipping/Navigation ☐Iron/Steel ☐Mining ☐Chemical ☐Cement / Construction☐ Food & Beverage ☐Other (please specify:)

5. *Amongst the ones named in Q4 above, in your opinion which industry has taken the most considerable actions to address the problem?*
   ☐Automotive ☐Railway ☐Shipping/Navigation ☐Iron/Steel ☐Mining ☐Chemical ☐Cement / Construction☐ Food & Beverage ☐Other (please specify:)

6. *In view of stricter emission regulations applicable to land transportation, do you think there will be a shift of trade towards coastal shipping?*

☐Yes ☐No ☐No Opinion

7. *Ships involved in international trade spend only a small portion of their time visiting port while the fleet of 800 odd coastal ships operates in port or near the coasts at all times. In your opinion does this make emissions from coastal ships more severe environmental threat ?*

☐Yes ☐No ☐No Opinion

8. *Some factors which differentiate coastal and international shipping are listed below.Kindly give your opinion by rating these factors as per the severity they pose to the environmental threat. (5 most severe & 1 least severe)*

Size of coastal fleet (more than 800 vessels of various types)	
Nature of vessels (includes tugs, towing vessels with powerful engines)	
Area of operations (near the coast or in ports almost all the time)	
Frequency of operations (short voyages between Indian Ports or within one port)	
Maintenance quality of vessels (requirements less stringent than for international ships)	

9. *Considering the growing national GDP and increasing freight volumes, do you think there will be an increase in transportation of goods by coastal shipping in view of land transportation capacity constraints ?*

☐Yes ☐No ☐No Opinion

10. *If the GHG emission rules similar to the rules applicable to international shipping are indeed applied to the coastal shipping in your opinion what would be the likely time frame for their enforcement?*

☐0-1 yr ☐1-3 yrs ☐3-5 yrs ☐ more than 5 years

11. *Please rank your opinion about the Key entry barriers for enforcing legal policy to reduce GHG emission from coastal shipping for the next few years? Ratings indicate severity of the barrier as follows: 1- very low, 2-low, 3-medium, 4- high, 5-very high. (For e.g., if in your opposition from ship operators will decrease over a period of time, then that row will read 5-4-2 say.)*

BARRIER	0-1 yr	1-3 yrs	3-5 yrs
Opposition from ship owners of coastal ships			
Cost of implementation & monitoring the new regulations			
Technical difficulties like age, maintenance standards of vessels			
Indifferent attitude			
Other (if any), please specify:			

12. *If the rules are enforced for coastal shipping, what are the likely adverse & favourable effects?*

Favourable:

Adverse:

Any Additional inputs and / or comments will be highly appreciated

THANK YOU FOR YOUR TIME

Appendix 3: Methodology used for forecasting

Methodology for forecasting as mentioned in Chapter 1.4.3 has been used.

1. Based on historical data shown in figure 8 in chapter 4.3, cargo flow volumes are forecast to determine growth trends in the near future using a customized Microsoft Excel model which is based on weighted indexes and arithmetic progression and takes into consideration several qualitative factors which have different impacts over different time periods. These impacts have been considered in three time frames over a 5 year period.
2. To assess the growth in coastal cargo volumes drivers and restraints which will affect coastal shipping over the next five years are accounted for as per their impact level based on my research. All the drivers and restraints are given weightage in the order of importance. Each impact is ranked from 1 to 8, where 1 implies no impact and 8 is the ranking for the highest impact.

   Using the formula for weighted index, a weighted index is created for each driver and each restraint by multiplying the weights (W) by their ranks (r), $\sum W1xr1$.

   These indexes are smoothed over for each driver and each restraint parameter for next 5 years $\{(\sum W1xr1. + W2*r2. + W3*r3. + W3*r3. + W4*r4. + W5*r5)/5\}$. After obtaining the weighted index for the drivers and restraints, they are added together and divided by 2 to obtain an average weighted index. This gives an average percentage for each year which is the growth rate for each consecutive year. The flowchart given in Figure 31 below illustrates the procedure. The drivers, restraints and their impact levels used for coastal cargoes and tonnage have been shown in Table 12 below.

Table 12: Drivers and restraints for coastal cargo volumes

Rank	Driver	Impact (1-2 years)	Impact (2-3 years)	Impact (3-5 years)
1	Increasing trade due to GDP growth	High	High	High
2	Improving port infrastructure	Medium-High	High	High
3	Proposed incentives like subsidies and carbon credit schemes for coastal shipping	Medium	Medium-High	Medium-High
4	High fuel costs making energy efficiency important and causing modal shift of freight transport towards shipping	Low-Medium	Medium	Medium-High
5	Capacity constraints in other transport modes	Medium	Medium-High	High
6	Proposed policy to grant infrastructure status to coastal shipping resulting in tax benefits	Low-Medium	Medium	Medium
Rank	**Restraint**	**Impact (1-2 years)**	**Impact (2-3 years)**	**Impact (3-5 years)**
1	High Tax structure	Medium	Low-Medium	Low
2	Current infrastructure of ports poor	Medium	Low-Medium	Low-Medium
3	Inter modal connectivity inadequate	Medium	Medium	Low-Medium
4	Initial entry barriers for new shipowners high	Medium	Medium	Low-Medium
5	Higher government investment on other transport modes	Medium-High	High	Medium-High
6	Volatile political scenario	Medium-High	Medium-High	Medium

Source: Author (2013)

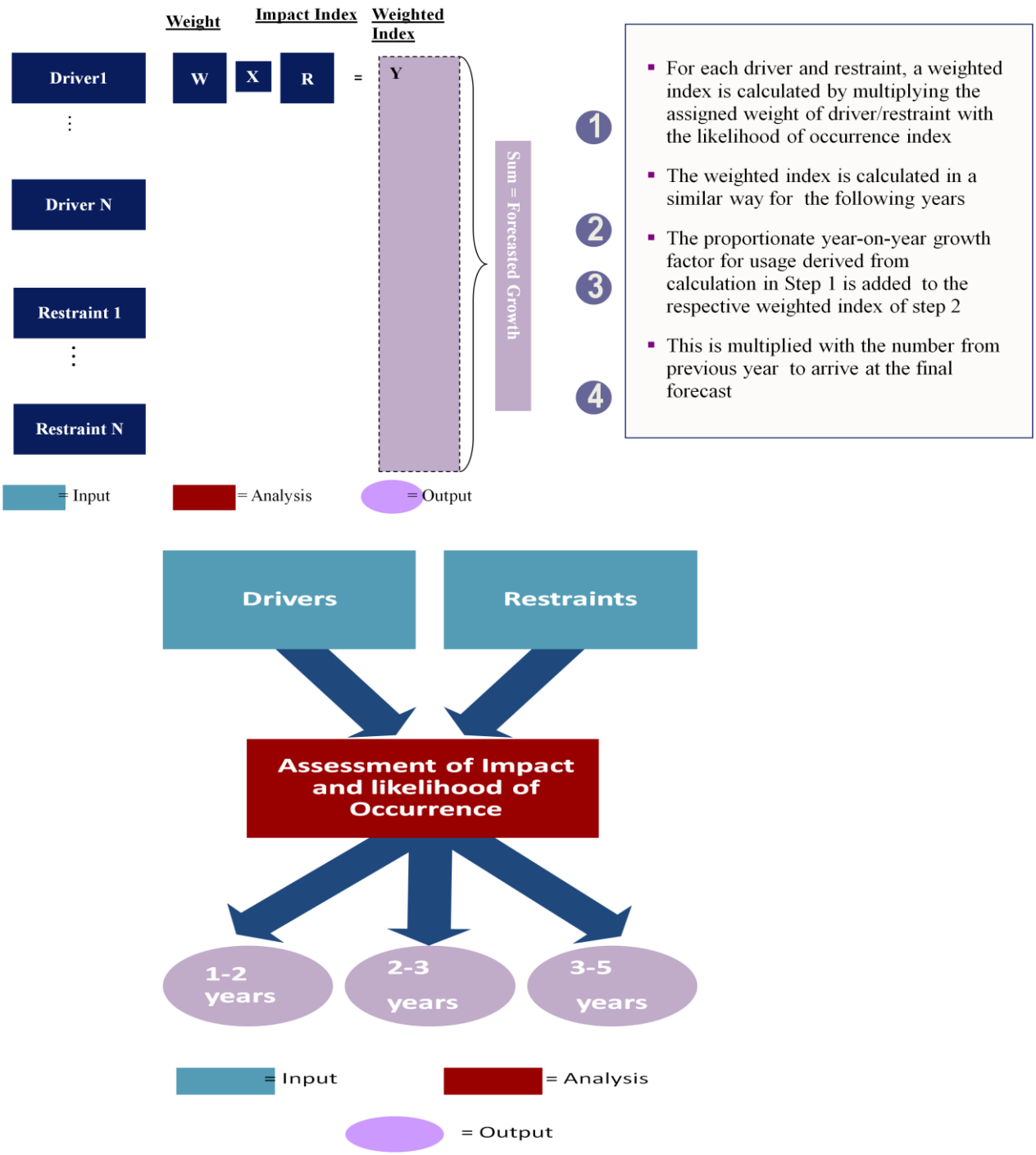

Figure 31: Flowchart illustrating forecasting methodology
Source: Author (2013)

Table 13: Drivers and restraints for coastal tonnage

Rank	Driver	Impact (1-2 years)	Impact (2-3 years)	Impact (3-5 years)
1	Increasing trade due to GDP growth	Medium-High	Medium-High	High
2	Formation of Coastal shipping fund for soft lending to shipowners	Medium-High	Medium-High	High
3	Proposed tax exemptions for coastal vessels built in India	High	Medium-High	Medium-High
4	Government investment in yards, dry docks and repair facilities	Medium	Medium	Medium-High
5	Proposed integration with inland water transport	Low-Medium	Medium	Medium
6	Plans to have dedicated port berths for coastal cargoes	Medium	Low-Medium	Low
Rank	**Restraint**	**Impact (1-2 years)**	**Impact (2-3 years)**	**Impact (3-5 years)**
1	Initial entry barriers for shipowners high	Medium-High	Medium-High	Low-Medium
2	Levy of duties, taxes structures and infrastructural delays leading to low profit margins	Medium	Medium	Low-Medium
3	High operating costs primarily due to high bunker prices	Medium-High	Medium	Low-Medium
4	Poor quality of vessels built in India	Medium	Low-Medium	Medium
5	Higher government investment on other transport modes	High	Medium-High	Medium
6	Volatile political scenario	Medium-High	Medium-High	Medium

Source: Author (2013)

3. With the available historical data shown in Chapter 4.3 (Figure 8 and Table 3), correlation between cargo volumes and number of coastal ships and total tonnage of coastal ships is established using Excel. The results are summarized in Table 11 of Chapter 5.4. Since a strong correlation exists between cargo volumes and coastal tonnage, a future growth in cargo volumes would also imply a growth in tonnage.
4. For forecasting of growth in coastal tonnage, the same excel model used for forecasting growth of cargo volumes is used, after revising the drivers and restraints and impacts to correspond to the subject entity as shown in Table 13.
5. For tonnage forecast, in addition to the excel model, numerical data is analysed using SPSS software as well. This method of forecast is on basis of time series and regression using the expert modeler in 'SPSS' software and includes seasonal variations but largely depicts a linear growth of tonnage. Both results obtained from excel and SPSS results show a CAGR of about 5% for coastal tonnage.
6. This expected growth is bound to cause an increase in emissions thus making the enforcement of regulations more important.