10th Annual Conference of Knowledge Forum

Venue: National Institute of Advanced Studies (NIAS), Bangalore 27-28, November, 2015

Urban Transport Policies in India in context to Climate Change: An International Perspective

Dr. Ashish Verma[1] V. Harsha[2] Mehvish Shah[3]

Abstract: Climate change, in the present day scenario, profoundly concerns all the world economies unequivocally, particularly the developing nations. It is certain that climate change impacts would be more pronounced in these nations than in the developed ones due to vulnerable infrastructure and population groups. Transportation sector emissions, one of the main drivers of climate change accounts for 22% of global CO_2 emissions. Transport Greenhouse Gas (GHG) emissions and energy demand will have far reaching implications in developing countries like India, where increasing personal motorization and growing urbanization are the main challenges faced by its metropolitan cities. This paper summarizes an overview of relevant policy instruments in the urban transport sector internationally that have been effective in tackling climate change mitigation & adaptation based on the review of existing literature. The different methodological approaches that have been adopted to develop mitigation and adaptation strategies in the urban transport sector are also discussed. The objective is to identify the scope and application of these methodological choices in Indian scenario. The paper further emphasizes on the case study of Bengaluru city examining the current state of urban transport and state/city level urban transport policies and assessments that have focused on climate change mitigation and adaptation. The review of literature suggests that urban transport and related policy assessments have not been central to the growing concerns of climate change. It is concluded that appropriate and time bound urban transport adaptation strategies must be put to place in order to reduce climate induced risks and deliver multiple social and economic benefits.

Key words: Mitigation, Adaptation, Greenhouse Gas, Climate Change, Urban Transport, India.

[1] *Assistant Professor, Department of Civil Engineering and Centre for Infrastructure, Sustainable Transport, and Urban Planning (CiSTUP), Indian Institute of Science (IISc), Bangalore-560012, India. E-mail: ashishv@civil.iisc.ernet.in (Corresponding author)*

[2] *Research Scholar, Department of Civil Engineering, Indian Institute of Science (IISc), Bangalore-560012, India, E-mail: Vajjarapu06@gmail.com*

[3] *Ex-Senior Research Fellow, Department of Civil Engineering, Indian Institute of Science (IISc), Bangalore-560012, India. E-mail: mehvishshah@outlook.com*

1. Introduction

Growing energy demand and its link to increasing GHG emissions remains a key global concern. As the world awaits a crucial climate change meeting in December 2015, it is most likely foreseen that developing countries, especially fast-growing regions such as those in the BRIC (Brazil, Russia, India and China), will have a major impact on future emission scenario and will play a considerable role in climate negotiations.Climate change is a global challenge and Transport sector is a significant source that contribute towards increasing GHG emissions. In 2011 the transport sector accounted for 19% of global energy use and contributed 22% to the total carbon dioxide (CO_2) emissions in the world (IEA 2014). This contribution is majorly driven by the road transport sector which increased by 64% since 1990 and accounted for about three quarters of transport emissions in 2012(IEA). Transport sector is also responsible for 20 per cent of global emissions of Black Carbon (BC), the second largest contributor to warming of the planet, next to CO_2(TERI, 2014). Climate change is already happening and is manifesting itself globally in the form of extreme weather events, heat waves, and high temperatures. It is expected that these effects will be stronger in developing countries, whose geography and lack of resources make them more vulnerable (IPCC 2007). Also not only does transport sector contribute to climate change but climate change also impacts transportation infrastructure and mobility. A changing climate could have serious consequences on the resiliency and performance of surface transportation systems in response to environmental conditions (Schmidt, 2009).

Urbanization and increasing reliance on personal mode of transport remain a challenge for most of the developing cities particularly in Asia .Growing GDP per capita will continue to drive the demand for mobility and use of personal motorized vehicles. Though per capita urban transportation emissions in developing countries remain many folds lower than developed country cities, it is most certain that developing countries will contribute in increasing emissions proportion to global CO_2 emissions considering the urban growth and vehicular emissions as can be understood by figure 1. There is now a growing international consensus that future targets for CO_2 reductions in the post-2012 Climate Policy Framework will not be achieved unless CO_2 contribution from the transport sector in developing countries is appropriately addressed (ADB, 2009).

India emerging as a strong economy where higher urban densities are resulting in higher levels of private motorization. In light of such trends, rate of growth of GHG emissions would be significant and Holistic Policy framework that decouple economic growth from growth of personal motorization unlike the developed countries like USA are needed to put the country on a sustainable low carbon growth trajectory.

This paper attempts to review policy instruments that have been instrumental in putting urban transport on a low carbon pathway in cities that have set a benchmark in integrated land use transport planning. The initial sections of the paper describe the urban transport scenario in India and transport sector contribution to GHG emissions. The later sections delve into climate change and how it needs to be addressed from urban transport

point of view. Examples of sustainable transport policies from various cities and how they have addressed to the different transport needs along with reducing emissions are discussed. In Indian context, policies that focus on climate change mitigation are listed and discussed.Finally the case study of Bangalore has been taken up, wherein various policy instruments in the urban transport sector that directly or indirectly address GHG mitigation and adaptation are discussed.

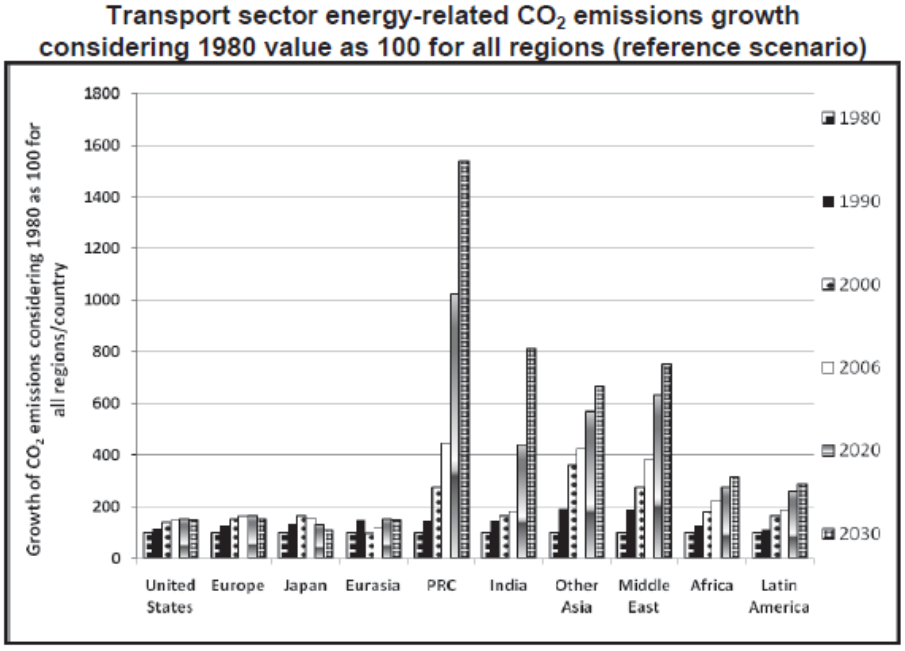

Figure 1: Transport CO_2 emissions

Source: ADB 2009 (adopted from IEA 2008)

2. Urban Transport scenario In India

Burgeoning urban population and area in most of the cities in India is leading towards an increasing travel demand as can be noted in figure 2. Growing per capita income levels and inadequate public transport system have contributed to the increase in demand of personal vehicles. India's most acute Urban transport problems are not because of the number of vehicles but the high concentration of private vehicles in a few selected cities (NTDPC ,2010). About 32 percent of motor vehicles are in metropolitan cities alone, which constitute just around 11 percent of the total population (NTDPC, 2010). The total passenger kilometres are expected to increase from nearly 3,635 billion in 2005 to nearly 19,437 billion by 2030.

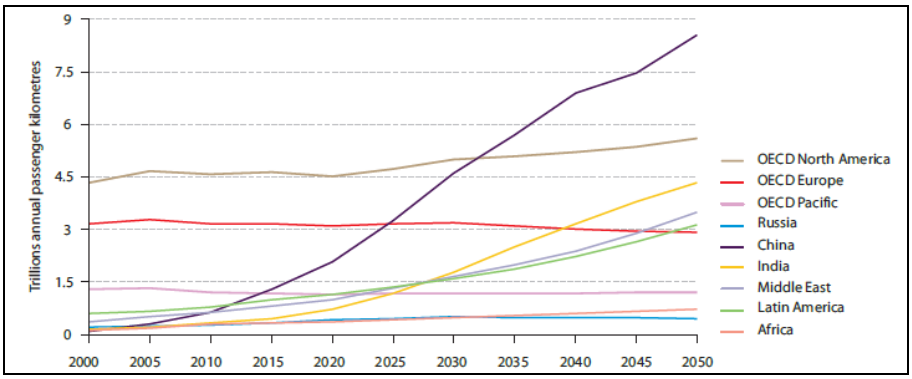

Figure 2: Expected urban private motorized travel (in passenger kilometers)

Source: IEA 2014

(92% on-road transport), resulting in a 5-fold increase in energy demand and carbon emissions in transport by 2020 relative to 2000 under the current trend (Singh, 2006).

2.1 Transport Sector in India – Contribution to GHG emissions

The transport sector, overall, is responsible for about 10% of the total final energy demand, especially dominating the growing demand for oil in India. IEA (2013) estimates that India's transportation energy use would grow at the fastest rate in the world, averaging 5.1% per year, compared with the world average of 1.1% per year. Although, currently, India is one of the lowest per capita emitters of CO_2, at 0.27 metric tons of carbon equivalent, energy sector's carbon intensity is high, and the country's total CO_2 emissions rank among the world's highest (Singh, 2006**).** The transport sector comprising of road transport, aviation, navigation and railways accounted for 142.04 million tons of CO_2 eq emissions, i.e., 7.5% of the total GHG emissions in the country in the year 2007. Of this, road transport alone accounted for 87 percent of the GHG emissions (i.e., 123.57 million tons of CO_2 eq) (ICAMP, 2013) .It accounts for more than half of India's total petroleum consumption and more than 25 percent of the overall energy needs (second only to industry) (MoSPI, 2013). It is also a significant contributor to the emissions generated by the country, accounting for about 13 percent of the emissions from the energy sector.

The vehicle-wise share in overall energy consumption in 2010 in the road transport sector is shown in Figure 3. Under BAU scenario CO_2 emission from road transport in India will increase from 19.80 to 93.25 million metric tons of carbon equivalent in 202-2021(Singh 2006). In 2007, India consumed 595 Mt of energy, and energy-related CO_2 emissions reached 1324 Mt, ranking India the 5thmajor GHG emitter in the world (MOEF, 2010).

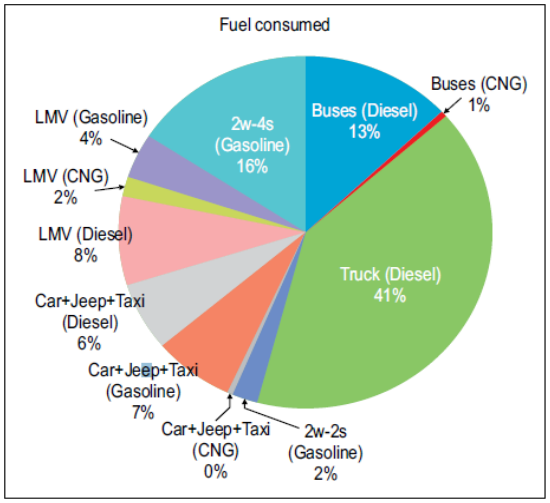

Figure 3: Vehicle-wise share in overall energy consumption in the road transport sector in India (2010)

Source: TERI ICAMP Report 2014

Transport sector as a source of GHG emissions not only drives climate change but also contributes to air pollution and related health impacts. As cities grow bigger, dependence on personalized transport, the energy demand from transport sector and vehicular emissions are bound to increase predominantly. Apart from building climate proof urban systems, developments that increase the vulnerability of cities by ignoring climate change implications must be avoided (GTZ,)

3. Addressing Climate change- Measuring GHG emissions and Impacts

The transition to sustainable transport futures demands an integrated approach to transport policy development and implementation. This includes lowering carbon dioxide (CO_2) emissions in transport, and achieving progress against wider economic, social and local environmental policy objectives (Hickman, 2012). Responding to Climate change not only includes quantifying the transport sector emissions but also to ascertain the possible impacts of climate change on the transportation system. Changes in frequency and magnitude of climate variables are bound to increase the pressing issues of infrastructure damage, floods, urban heat islands and air pollution amongst many other health and ecological impacts. Increased temperatures, rising sea levels and water shortages may lead to changes in behaviour and use of resources. (Walsh et al., 2011).

The foremost step in developing responses to climate change in a specific sector is quantifying the GHG emissions from that sector. In order to assess future impacts of climate change, the degree to which future GHG emissions will effect climate needs to be assessed. The estimation of GHG emissions from transportation sector forms the primary basis in evaluating the impact of motorized transport on climate. Analyzing the potential impact of GHG emissions consists of three key tasks (ADB, 2009):

i. Analyzing and monitoring present transport activity, pollutant emissions, fuel use, and CO_2 emissions.

ii. Projecting future transport activity as outcome of changes in the form of transport Costs, incomes, land uses and many other variables, and projecting resulting fuel use and CO_2 emissions levels.
iii. Evaluating the impact of policies aimed at both transport activities and CO_2 emissions.

The expert group on low carbon suggests an in-depth study for quantification of energy consumption and GHG emissions from the transport sector in India would help examine the impacts that various policies might have on reducing the energy and emissions from the sector. Singh et al (2008) estimated the GHG emissions (CO_2, CH_4, NO_X) and trends in energy consumption road transport sector in India from 1980 to 2000.Ramachandra, Shwetmala (2009) developed a state wise inventory of GHG emissions from India's transport sector for the year 2003-2004. Singh (2006) estimated the level and growth of energy demand, CO_2 emissions from passenger transport in India upto the year 2020-2021.

Measuring and quantifying GHG emissions from the transport sector is a huge challenge in developing countries mostly due to the lack of data. Emissions (G) in the transport sector are dependent on the level of travel activity (A) in passenger km (or ton-km for freight),across all modes; the mode structure (S); the fuel intensity of each mode (I), in litres per passenger-km; and the carbon content of the fuel or emission factor (F), in grams of carbon or pollutant per litre of fuel consumed. This approach known as ASIF framework (Schipper, 2009) shows that actions on total activity (A) and mode share (S) can significantly reduce transportation energy consumption and emissions.

Estimates of vehicle activity data based on vehicle type, fuel intensity data is still in adequate in most of these countries and hampers the measurement of impact of urban transport policies that can limit the growth of CO_2 emissions. Measuring both fuel consumption and distance for each kind of vehicle-fuel combination is important for measuring policy outcomes and impacts (ADB, 2009).

3.1 Approaches

A wide variety of modeling approaches have been employed in the studies for climate change mitigation. There are many studies that use quantitative empirical data and derive conclusions about how climate change might be mitigated in the future from analysing those data using regression or econometric modelling and scenario analysis (Das, Parikh 2004). Most of the research works have estimated future emissions from past trends by developing scenarios about technology development, behavior change, and population growth. Back casting approach (Hickman et al., 2012) has also been used to assess longer-term desirable futures and the different pathways to achieve an emission reduction target from transport sector. Integrated modeling tools like TRANUS and LEAP (Bose 1996) have also been applied to assess the effects of policies on energy consumption and GHG emission from the transport sector.

Most of the studies on climate change mitigation and adaptation have been carried out with the purpose of reducing the Vehicle miles travelled (Schmidt, 2009). There have been

limited studies on economic assessment of adaptation measures. Evaluating how well different practices and technologies will avoid adverse climate change impacts and how the social equity will be addressed needs to be ascertained. For assessing the impacts on urban transport systems, it is also important that a vulnerability assessment of the transportation assets is undertaken. There are quite less instances where susceptibility of the transportation assets to climate change effects is measured or quantified. An impact assessment that allows for an interactive temporal and spatial analysis of explicit climate change impacts for different combinations of scenarios can prove to be an effective tool for evaluation (Kit et al., Hyderabad, 2011).

3.2 Mitigation and Adaptation in Urban Transport - Policies for dealing with Climate change

Effective responses to climate change require policies that consider mitigation and adaptation central to the transportation planning and integrate climate change in the overall policy framework. Strategies/Policies are generally aimed at:

- Reduction in greenhouse gas emissions resulting from movement of goods, services, and people in cities (Mitigation).
- Minimizing the potential impacts on the transportation system from climatic changes such as rising average temperatures, increased intensity of storms, rising sea levels, and increases in overall climatic variability(Adaptation)

Whereas mitigation is a global mandate, adaptation is a local necessity. Mitigation strategies like the Kyoto Protocol have enabled global participation in mitigating climate change. Adapting the urban transport system at city/local level through effective strategies and their prospective evaluation is however the need of the hour.

The Avoid-shift-Improve approach (A-S-I) makes an important contribution towards climate change adaptation strategy. Urban transport mitigation and adaptation strategies and planning need to be broadly considered within the A-S-I framework. The ASIF framework (Schipper, 2009) shows that actions on total activity (A) and mode share (S) can significantly reduce transportation energy consumption and emissions.

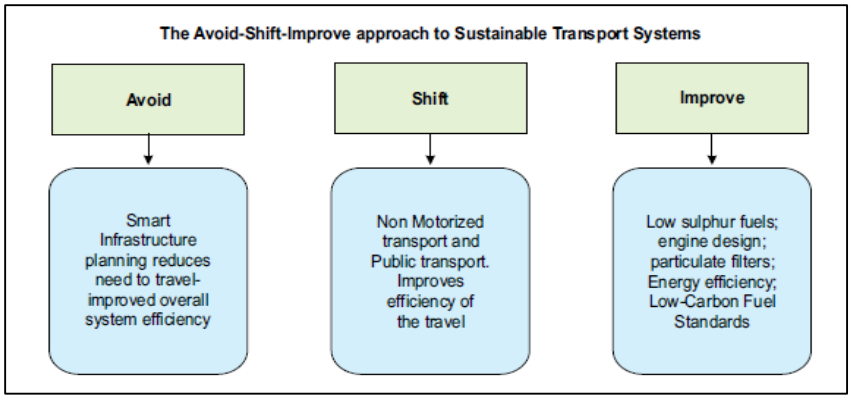

Figure 4: A-S-I framework

Source: ICAMP, TERI

Dhar et.al recommends demand and supply side interventions as described in Figure 5 for reducing transport emissions. The demand side interventions rely on reducing the trips, retaining modal shares of non-motorised transport, and shifting demand from private vehicles to public transport. The supply side strategies essentially rely on policies that affect the technology choices for consumers (e.g., for more efficient cars, cleaner fuels, etc.), as well as decarbonising the electricity.

.

	Demand	Supply
Transport	Transport demand management; speed limits; congestion pricing; fuel tax; public transport subsidy; promotion of non-motorized transportation; road tolls; parking fees; provision of eco-driving schemes.	Investment in mass transit system. Regulation and incentives for improvement of vehicle energy yields or low emission fuels. Facilitate inter-modal linkages application of information technology.
Land use	Land use planning; provision of basic services; property tax regimes to discourage sprawl.	Zoning regulation; town planning schemes; incentives for high density urbanization, regulation to discourage sprawl.

Figure 5: Demand and supply side interventions for low carbon Transport

Source: Climate change and urban transportation systems, Mehrotra et al., 2011

There are many categories of policy instruments that have been used by decision makers in many countries that have fostered sustainable transportation goals. Given the wide array of policy instruments available, myriad forms of combinations are possible and the potential for interaction between different instruments increases (Tanu Priya Uteng). Hickman and Banister (2007) argue that combinations of policies are required to significantly reduce CO_2 emissions, as individual policies are insufficient. The policy instruments are discussed in the following sections.

3.2.1 Planning instruments - City planning that helps reduce or optimize transport and encompass integrated land use and transportation planning .Singapore, Hongkong, Bogota and Curitiba are profound examples of remarkable land use planning. Whether it is the success of Bus Rapid Transit (BRT) in Bogota and Curitiba or mixed development in Singapore, these cities have shown that linking urban transport with land use planning , apart from reducing emissions can deliver multiple benefits in terms of improvement of public

transport and reducing congestion. In a study in China's 35 major cities, it was found that an increase of 1,000 people per km^2 on average is associated with a reduction of CO_2 emissions per household of 0.424 ton from use of taxis and 0.837 ton from the use of buses (ADB, 2012) This may indicate shorter average travel distance and/or much more effective urban public transportation.

3.2.2 Regulatory instruments **-** Regulatory reforms may include mandatory emission norms for vehicles or a complete ban on certain kinds of vehicles.Restrictions to circulation have been widely implemented in towns and cities like Bogota, Sao Paulo, Athens. The short-term benefits are similar to road pricing schemes: reduced congestion and faster average speeds, leading to reduced fuel consumption and lower GHG emissions. The implementation of combined measures such as pedestrian pathways, BRT, car free days in Bogota and Curitiba is estimated to have reduced CO_2 emissions by 318 tons per day from 1997 and decreased rapidly year by year.

In some EU countries, low-emission zones have been introduced in some cities. In these zones, vehicles or classes of vehicles that cannot meet a prescribed standard of emissions are prohibited entry. The Low Emission Zone (LEZ) in London was implemented in February 2008. The main objective of the scheme is to deter the most polluting diesel vehicles from driving inside Greater London. Low Carbon Fuel Standard introduced by the state of California in 2007requires fuel providers to reduce GHG emissions of the fuel they sell. The programme intends to achieve a 10 per cent reduction in the carbon intensity of transport fuels by 2020.

Another way of controlling vehicle use is through restrictions on vehicle ownership. The only example of a direct quantity control of this sort is the Vehicle Quota System (VQS), a policy implemented in Singapore in 1990 and still in place today. Prospective vehicle owners are required to purchase a Certificate of Entitlement (COE), which is a licence that lasts ten years, except for taxis, for which it lasts seven. Traffic management measures include sophisticated traffic signal systems significantly increase the carrying capacities per lane of the affected streets, and thus reduce congestion and increase speed. However, it also makes car use more attractive, so that car use increases. The net GHG emission effect may, therefore, be small, perhaps even negative. In developed countries, traffic management measures have led to 2%–5% emission reductions overall (GTZ, 2013).

3.2.3 Economic instruments**-** Market-based approaches use economic incentives and/or disincentives to pursue a policy goal. The price mechanism serves as a vehicle for policy enforcement. Economic instruments can include emission taxes, congestion charges, or subsidies on the use of cleaner fuels.

The first and most prominent example of active road pricing was introduced in Singapore as congestion pricing for entering the central business district during peak hours .this cordon pricing measure resulted in reducing the private car travel within the zone by 75%.road pricing scheme in London introduced in February 2003, under which vehicles travelling in daytime central London incur a charge of 16$ /day with revenues from the

scheme used to improve public transport. The scheme resulted in an estimated 19% reduction in CO_2 emissions from road traffic and 20% reduction in fuel consumption.

3.2.4 Technology **-** Technological instruments are more effective when applied in conjunction with other policy instruments. These instruments often focus on cleaner fuels and efficient vehicle technologies.

3.2.5 Information - Information instruments include behaviour change campaigns, public information procurement and public acceptance monitoring. These are 'soft measures' sometimes used to complement other instruments. Bogota's car free day promotes bus and bicycle networks. Harmsen, van den Hoed, and Harmelink (2007) study the impact of the Eco-driving program in the Netherlands between 1999 and 2004 and find that, in that period, the program achieved reductions in fuel consumption of between 0.3 and 0.8 percent, equivalent to 0.1– 0.2 million tonnes reduction in CO_2 emissions. VMT (Vehicle Miles Travelled) reductions from car sharing have been found to be even more dramatic in Switzerland, where car owners who sold their vehicles and became mobility car-sharing customers reduced their annual mileage driven by 72%.

3.2.6 Voluntary Agreements**-** voluntary agreements are agreements between a government authority and one or more private parties with the aim of achieving environmental objectives or improving environmental performance beyond compliance to regulated obligations.

GTZ suggests developing countries to focus on short to mid-term measures which are low cost and "win-win," with the highest impact on CO2 mitigation at the same time leading to local economic, social, and environmental improvements.

4. Urban transport Policies in India

India signed the United Nations Framework Convention on Climate Change, and acceded to the Kyoto Protocol in 2002. Despite not having binding mitigation commitments as per the United Nations Framework Convention on Climate Change (UNFCCC), India has communicated its voluntary mitigation goal of reducing the emissions intensity of its Gross Domestic Product (GDP) by 20–25 per cent, over 2005 levels, by 2020. The Government formulated the National Action Plan on Climate Change (2008) that provides for eight missions to help the country adapt to the effects of climate variability and change. The National Mission on Sustainable Habitat which is a component of the National Action Plan for Climate Change emphasizes on Better Urban Planning and Modal Shift to Public Transport in order to reduce GHG emissions from the transport sector.

Numerous Legislative Acts have been enacted so far which have aimed at mitigating climate change and adapting to sustainable transport. Pertinent amongst them are listed as follows:

1. Air (Prevention And Control Of Pollution) Act, 1981

2. Environment (Protection) Act, 1986
3. Motor Vehicles Act, 1988
4. Energy Conservation Act, 2001
5. National Auto Fuel Policy, 2003
6. Jawaharlal Nehru National Urban Renewal Mission (JNNURM), 2005
7. National Urban Transport Policy, 2006
8. National Environment Policy (NEP) 2006
9. Integrated Energy Policy, 2006
10. National Action Plan On Climate Change (NAPCC), 2008
11. National Transport Development Policy Committee, 2010

One of the main short comings of the policy implementation in India is time gap between the framing of the policy and its implementation. For example **Jawaharlal Nehru National Urban Renewal Mission** (JNNURM) was a reform-driven, fast track, planned development program launched in 2005 with an initial mission period of seven years. The time frame was extended by two years in March 2012 due to delays in implementation. Land acquisition etc. The Energy Conservation Act, 2001 provides the much-needed legal framework and institutional arrangement for embarking on an energy efficiency drive. Under the provisions of the Act, **Bureau of Energy Efficiency** has been entrusted to set the fuel efficiency standards (similar to CAFÉ Standards) for passenger cars, to be implemented by MoRTH under Motor Vehicles Act, starting 2017.

National Auto fuel Policy, 2003 adopted a roadmap for progressively tighter fuel quality and vehicle emission standards through 2010.As a result of the implementation of this policy, vehicular emissions of particulate matter (PM_{10}) declined throughout the decade and growth in emissions of oxides of nitrogen (NO_x) slowed, even as the number of vehicles on the road doubled. Fuel conforming to BS (Bharat Stage) III was introduced in 13 major cities across the country from the year 2005 while BS II fuel was made available elsewhere. Whereas BS I fuel has been phased out and from April 2010 BS IV standard fuel has been implemented across the 13 major cities and BS III fuel is made available elsewhere.

National Urban Transport Policy (NUTP) was created to motivate the building of people centric urban transport solutions instead of focusing on improving the conditions for private motor vehicles, Promoting use of public transport, mixed land use and Priority to non-motorized transport are the main features of NUTP.

National Environment policy (NEP) recommended Formulation of a national strategy for urban transport to ensure adequate investment, public and private, in low pollution mass transport systems.

National Transport Development Policy Committee, 2010 recommended Tighter Bharat IV fuel quality standard to be implemented nationwide by the middle of this decade, with a target to reach Bharat VI by 2020 and Establishing a National Automobile Pollution and Fuel Authority (NAPFA) that will be responsible for setting and enforcing vehicle emission and fuel quality standards in India .

With a fragmented Transport Institutional Network in the country, the governance of the sector has been very complex. Although urban transport issues like vehicular emissions feature prominently in Government's policies such as the Ministry of Urban Development's National Urban Transport Policy (NUTP), the National Habitat Mission and the Report of the National Transport Development Policy, yet funding barriers, diffused responsibility between the Centre and the state governments are a constant hurdle in implementation. The government policies, as of now, do little to control personal vehicle ownership. The only dis-incentive for buying cars is the high cost of ownership and higher fuel prices compared to the cities in developed countries. (Verma et al., 2013)

5. Case study of Bangalore- Urban Transport Challenges

Bangalore is the most urbanized district in the state of Karnataka with 90.94% of its population residing in urban areas. With an economic growth rate of 10.3% p.a, it is one of the fastest growing cities in Asia. Bangalore recorded the highest population growth of 106% in the last two decades. Although Bangalore's rapid economic growth has substantially improved the local quality of life, yet challenging issues of urbanization, motorization, congestion & pollution looms over the development of the city. The transportation system in Bengaluru is far behind than what is needed to suffice the increasing urbanization. Personalized modes of transport have grown at a tremendous rate and two wheelers along with the cars almost comprise 90% of the total registered vehicular population in the city. Bangalore's rapid urbanization has given rise to unprecedented growth in motorized vehicles. Higher income levels have made it possible for larger segment of people to own vehicles. Despite the inadequate road space in the city and higher cost of owning a vehicle, the number of passenger cars/personal vehicles has grown up by 106 % in just a span of four years from 2007 till 2011 as shown in Figure 6.

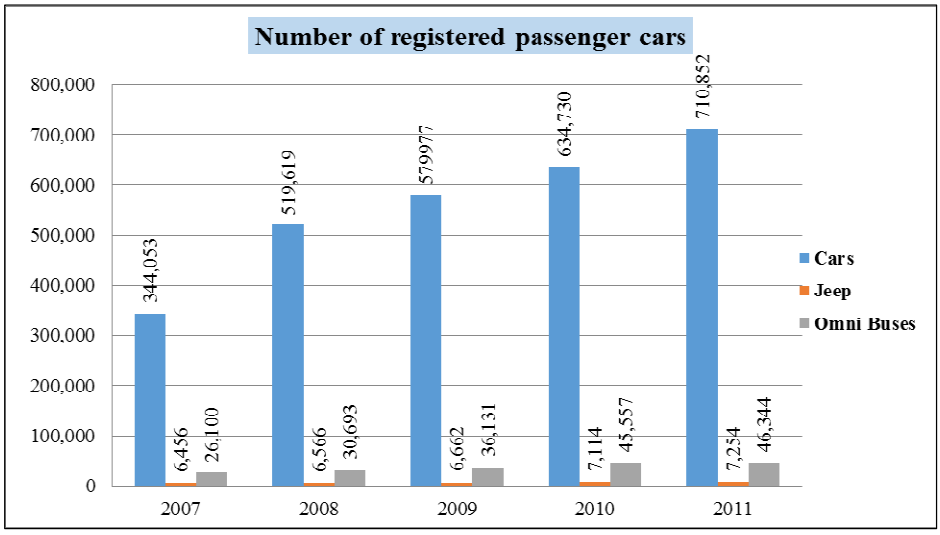

Figure 6: Growth of motorization in Bangalore

Source: Bangalore mobility indicators, 2011

Air pollution also remains a major concern in the city. Deterioration of air quality has been time and again attributed to rapid increase in population and consequent fuel combustion activities. The source apportionment study carried out by CPCB (Central Pollution Control Board) in 2011 in collaboration with Karnataka State Pollution Control Board under the National programme known as National Air Quality Monitoring Programme (NAMP). Table 1 shows the level of pollutants produced by each sector. NAMP attributes much of the air pollution to transport sector as shown below.

Table 1: Sectoral emissions in Bangalore

	PM_{10}	NO_X	SO_2
Transport	22.4	146.36	2.31
Road Dust	10.9	0.00	0.00
Domestic	1.8	2.73	0.68
DG Set	3.6	50.96	3.35
Industry	7.8	17.19	8.21
Hotel	0.1	0.20	0.02
Construction	7.7	0.00	0.00
Total	54.4	217.4	14.6

Source: CPCB 2011

5.1 Climate Change – Response and strategies

Climate change is most likely to aggravate the events like urban flooding. These impacts will be borne directly by the people of the city and also simultaneously hindering development. Given the increasing urban growth, ill planned infrastructure in the city, even a small amount of rain floods the motorways and brings the city to a halt.

In June 2009 Government of Karnataka (GoK) constituted a Coordination Committee to oversee the state's response to climate change. . It assigned the mandate to prepare **the State Action Plan on Climate Change (SAPCC)** to Environmental Management & Policy Research Institute (EMPRI), Bangalore, which submitted its first assessment report in March 2012 The Plan suggests adaptive and mitigation measures to reduce the impact of climate change in Karnataka in different sectors. Though there is no stated mechanism in the draft to ensure evaluation and implementation of plans, the plan identifies the key sectoral issues, actionable points, implementation arrangement, stakeholders, capacity building needs and funding requirements. The plan suggests focus on piloting viable options for a sustainable larger-scale development of bio-fuel as a substitute for fossil fuels like diesel and petrol for use in vehicles.The urban transport sector though is not sufficiently addressed in the plan.

5.1.1 Energy consumption in Transport sector

The CPCB report (2010) mentions transport sector as a major sectoral contributor to PM_{10} and $PM_{2.5}$ concentrations in the city. According to the **Greenhouse Gas Inventory of Karnataka** (Karnataka State Pollution Control Board and Enzen Global Solutions Pvt. Ltd), greenhouse gas emissions as carbon-di-oxide equivalents from the road transport sector in Bangalore City during the period 2005 -06 were around **2.24 million tonnes**. It has been seen that emissions have almost doubled since 1997 (1.01million tonnes CO_2 equivalents) and will be doubled in the next ten years if the same trend continues (Bangalore Mobility Indicators, 2008).

Table 2: Energy consumption and emissions from the transport sector

Fuel type	Annual Consumption (Tonnes)	Energy Content (TJ)	GHG Emissions (Tonnes)		
			CO_2 (Tonnes)	CH_4 (Tonnes)	N_2O (Tonnes)
Gasoline	2,47,577	11,193	7,88,210	224	7
Diesel	4,82,632	20,203	14,60,728	101	12
	Total Emissions		22,48,938	325	19

Source: Bangalore Mobility Indicators 2008

5.1.2 Policy instruments in Urban transport sector

The government policies in the transport sector in Bangalore , it can be said have so far not been instrumental in order to suffice urbanization and rampant vehicular growth.The road supply in terms of road length (metre) per population in the city is 1.20 which is lesser than that of smaller cities like Lucknow (1.83) and Guwahati (2.06). Though the city, also called as the Silicon valley of India is significantly building up its way in terms of economy, but in terms of road infrastructure it is incomparable with the likes of OECD countries like US where the road length (m) per population is 21.39. The cost of bus travel is fairly high in the city than the other metropolitans in the country, making it unaffordable to some sections of the society. Though the travel cost per passenger km in proportion to GDP per capita (0.00055%) is far less than even in the developed cities like London (0.075%), the fact that presently the mode share of PT i.e bus in Bengaluru is 46.9% and that of cars is 7.4% indicates that bus transport is still the attractive mode of transport (Verma et al, 2013). Over the years the government has initiated actions that intended to delimit the vehicular growth.As a means of controlling personal vehicle growth,these policies have directly or indirectly addressed climate change.They are:

- Karnataka State Bio-fuel Policy 2009: Stipulates mandatory bio-fuel use by state departments as a part of a popularization strategy. It also sets 5% as a target for bio-fuel blending in 2012 which as of date was not achieved and 10% by 2017.

- In accordance with the National Bio-fuel Policy prepared by Ministry of New and Renewable Energy (MNRE) that proposed a 20% substitution of diesel by bio-diesel to be achieved in the year 2017, Bangalore Metropolitan Transport Corporation (BMTC) has introduced the usage of bio-fuel in part of its fleet.

- Department of Transport also initiated action to improve air quality in Bangalore. In 2001 it achieved passing of a Government Order prohibiting commercial vehicles older than 15 years. Although it has been 14 years since the order was enacted, on ground implementation has proved to be futile.

- The life time tax imposed on purchase of new vehicles in the state which is anywhere between 10-18% of the cost of vehicle has not been fruitful in containing the rapid vehicular growth.
- As Institutional reforms the state Government created Bangalore Metropolitan Land Transport Authority (BMLTA) & The Department of Urban Land Transport (DULT) to comply with the institutional reforms mandated by the NUTP and JNNURM. DULT has come up with Pedestrian and Parking Policy guidelines for the city, although the implementation is awaited.
- As an informatory instrument, DULT initiated Cycle day in the city as a means to promote non-motorized transport.

6. Conclusion

The foremost challenge that developing countries are facing in present times is of rampant urbanization and increasing transport activity. The linkage between transportation and GHG emissions makes it imperative to devise strategies that limit the emissions and simultaneously make the urban areas resilient to climate change. Through the review of the literature, it is observed that city specific approaches need to be developed to assess climate change and its impacts. Incorporating vulnerability assessment of the urban areas and economic assessment of the adaptation strategies will help overcome the present gaps. This paper has looked at different policy instruments that have been practiced in cities world over to ensure a more sustainable low carbon travel. The review has shown how countries like Singapore through well planned urban transport policies have made travel environment friendly and efficient in terms of energy demand. Through examples it is also observed that though cities enacted urban transport policies to reduce motorization, co-benefits of reduced vehicular emissions, better air quality were also achieved. The review of policy instruments suggest that policy instruments when applied in isolation tend to have a less pronounced effect on motorization. Instead it is imperative for countries or cities to develop a comprehensive package of policy instruments that are acceptable, feasible and are backed by strong political will. As can be seen in the case of Bogota where pro people policies rather than pro car policies resulted in it being considered a precedent for sustainable transport world over. The examples demonstrate that policies that tackle major issues related to

emission reduction should be coherent and integrated in order to reap maximum results. It is though necessary that strategies are selected depending on city specific conditions. Indian transport scenario presents a challenging opportunity to draw lessons and build on from such examples. India has a lot of scope in terms of important policy decisions to significantly alter the growing path of auto mobility. The coming decades will witness huge changes in terms of transport systems, new technologies, demographics etc. and any policy decision taken at this point of time has to ensure the envisaged growth along with proper and constructive investments in the transportation sector. The policies that have been reviewed so far have not been fruitful in limiting the use of personal vehicles nor have encouraged public transport. There has been no comprehensive economic evaluation of the policies in ascertaining their potential to reduce GHG emissions. Also it is observed that the complexity of the Institutional arrangement and governance of the transport sector has by and large been responsible for transport planning not being central to climate change concerns.

The review of policies related to urban transport and climate change in Bangalore city presents a conflicting approach between various stakeholders involved.It is understood that policy decisions have to be made that would encourage the use of public transportation and induce simultaneous reduction in personal vehicle growth. Decisions that include High priority bus lanes, Non Motorized Transport (NMT) infrastructure, congestion pricing, higher on street parking charges, cap on new vehicle registrations can help in mitigating the vast challenges in the present transportation scenario and addressing climate change concerns. For developing countries like India, policies that favour emission reduction yet do not compromise on economic growth and social equity need to be framed ,evaluated and implemented on time to achieve sustainable transport and wider socio-economic benefits.

Acknowledgement:

Authors acknowledge the funding support of Norway Research Council (Project no. ITEN-001) for this work under the CLIMATRANS project. Authors also gratefully acknowledge the inputs of project partners from; Institute of Transport Economics (TOI), Oslo, Indian Institute of Technology Bombay (IITB), School of Planning and Architecture (SPA), Delhi, and The Energy and Resources Institute (TERI), for this work.

References

1. A. Das, and J. Parikh, Transport scenarios in two metropolitan cities in India: Delhi and Mumbai, Energy Conversion and Management, 45 (2004): 2603-2625.
2. ADB (Asian Development Bank) (2009), Transport and Carbon Dioxide Emissions: Forecasts, Options Analysis, and Evaluation. Sustainable Development Working Paper Series.
3. ADB (2012). Urban Transport Strategy to Combat Climate Change in the People's Republic of China.
4. Air quality assessment, emission inventory and source apportionment study for Bangalore city. Final report, New Delhi: The Energy and Resources Institute.186pp. (Project report No.2004EE28)

   Accessed from http://www.cpcb.nic.in/Bangalore.pdf
5. Atteridge, Aaron, et al. "Climate policy in India: what shapes international, national and state policy?" *Ambio* 41.1 (2012): 68-77.
6. *Blind spots in India's new National Action Plan on Climate Change* (2008), InfoChange News & Features, Available at: http://infochangeindia.org/environment/analysis/blind-spots-in-indias-new-national-action-plan-on-climate-change.html
7. Bose (1996), Energy Demand and Environmental Implications in Urban Transport- Case of Delhi, Atmospheric Environment 403–412 (30)
8. Chapman. L., (2007), Transport and climate change: a review, Journal of Transport Geography 354–367(15).
9. Dhar, Subash, Minal Pathak, and P. R. Shukla. *Low carbon city: A guidebook for city planners and practitioners: Promoting low carbon transport in India*. UNEP Risø Centre on Energy, Climate and Sustainable Development. Department of Management Engineering. Technical University of Denmark (DTU), 2013.
10. Environmental Management & Policy Research Institute, The Energy and Resources Institute (TERI), *Karnataka State Action Plan on Climate Change: 1st assessment report* (2012), Department of Ecology and Environment, Available at: http://www.empri.kar.nic.in/Karnataka-SAPCC-EMPRI-TERI-2012-03-22.pdf
11. GTZ (Gesellschaft für Technische Zusammenarbeit) (2004), *Sourcebook, Module 5e: Transport and Climate Change,* available at: www.sutp.org.
12. GTZ Adapting urban transport to Climate Change, *Source book for Policy-makers in Developing Cities Module 5f, 2013: Adapting urban transport to Climate Change.*

13. Hickman, Robin, and David Banister. "Looking over the horizon: transport and reduced CO_2 emissions in the UK by 2030." *Transport Policy* 14.5 (2007): 377-387.

14. Hickman, Robin, et al. "Examining transport futures with scenario analysis and MCA". *Transportation Research Part A: Policy and Practice* 46.3 (2012): 560-575.

15. *IEA (International Energy Agency 2013A tale of renewed cities*. A policy guide on how to transform cities by improving energy efficiency in urban transport systems.

16. IEA (2014) CO_2 emissions from fuel combustion. Highlights.

17. IPCC 1994.Technical Guidelines for Assessing Climate Change Impacts and Adaptations.

18. Jun Li (2011), Decoupling urban transport from GHG emissions in Indian cities- A critical review and perspectives, Energy Policy 3503–3514(39).

19. *Jawaharlal Nehru National Urban Renewal Mission: Overview*, Ministry of Urban Employment and Poverty Alleviation, Ministry of Urban Development, Available at: http://jnnurm.nic.in/wp-content/uploads/2011/01/PMSpeechOverviewE.pdf

20. *Karnataka Climate Change Action Plan: Final Report* (2011), Bangalore Climate Change Initiative – Karnataka (BCCI-K).

21. Kit, Oleksandr, Matthias Lüdeke, and Diana Reckien. "Assessment of climate change-induced vulnerability to floods in Hyderabad, India, using remote sensing data." *Resilient cities*. Springer Netherlands, 2011. 35-44.

22. L.WRIGHT, FULTON (2005), Climate Change Mitigation and Transport in Developing Nations, *Transport Reviews, 691–717(25).*

23. Mehrotra, S., B. Lefevre, R. Zimmerman, H. Gerçek, K. Jacob, S. Srinivasan, 2011b: Climate change and urban transportation systems. *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*, C. Rosenzweig, W. D. Solecki, S. A.Hammer, S. Mehrotra, Eds., Cambridge University Press, Cambridge, UK, 145–177.

24. *National Auto Fuel Policy, 2003, Press Release*, Ministry of Petroleum and Natural Gas, Available at: http://pib.nic.in/archieve/lreleng/lyr2003/roct2003/06102003/r0610200313.html

25. *National Action Plan on Climate Change*, Ministry of Environment, Forest and Climate Change, Available at: http://envfor.nic.in/ccd-napcc

26. *National Action Plan on Climate Change(2008): Press Release*, Press Information bureau, Government of India, Available at: http://www.pib.nic.in/newsite/erelease.aspx?relid=39899

27. *National Environment Policy (2006)*, Ministry of Environment, Forest and Climate Change, Available at: http://envfor.nic.in/sites/default/files/introduction-nep2006e.pdf

28. *Nation Urban transport Policy: A Report*, Ministry of Urban Development, Available at: http://moud.gov.in/sites/upload_files/moud/files/pdf/TransportPolicy.pdf

29. *National Mission on Sustainable Habitat: A Report*, Ministry of Urban Development, Available at: http://moud.gov.in/NMSH.

30. *National Transport Development Policy Committee (NTDPC): Final Report* (2012), Working group on Urban Transport, Ministry of Urban Development.

31. Navroz K. Dubash and Anu Jogesh (2014), *From Margins to Mainstream, State Climate Change Planning in India as a 'Door Opener' to a Sustainable Future: Research Report*, Centre for Policy Research.

32. Ramachandra, T.V., Shwetmala, Emissions from India's transport sector: Statewise synthesis, Atmospheric Environment (2009), doi:10.1016/j.atmosenv.2009.07.015

33. Ramanathan, R., and Jyoti K. Parikh. "Transport sector in India: an analysis in the context of sustainable development." *Transport Policy* 6.1 (1999): 35-45.

34. Schipper, Lee, James Leather, and Herbert Fabian. "Transport and carbon dioxide emissions: forecasts, options analysis, and evaluation." (2009).

35. Singh, Anil, et al. "Trends of greenhouse gas emissions from the road transport sector in India." *Science of the total environment* 390.1 (2008): 124-131.

36. Sharma, S., et al. "India-California Air Pollution Mitigation Program (ICAMP)." (2013).

37. Schmidt, Nicholas, and Michael Meyer. "Incorporating climate change considerations into transportation planning." *Transportation Research Record: Journal of the Transportation Research Board* 2119 (2009): 66-73.

38. Singh (2006), Future mobility in India: Implications for energy demand and CO2 emission, Transport Policy 398–412 (13).

39. Tanu Priya Uteng (2015), *Literature review: Policy instruments in the transport Sector*, Unpublished report, Institute of Transport Economics (TOI).

40. *The Air (Prevention and Control of Pollution) Act*, Air Pollution, Ministry of Environment, Forest and Climate Change, available at: http://envfor.nic.in/division/air-pollution

41. *The Environment Protection Act*, Environment Protection, Ministry of Environment, Forest and Climate Change, Available at: http://envfor.nic.in/division/environment-protection.

42. *The Motor Vehicle Act, 1988*, Ministry of Road Transport and Highways, Available at: http://morth.nic.in/showfile.asp?lid=672

43. *The Energy Conservation Act,* 2001, Ministry Of Law, Justice And Company Affairs, Available At http://Powermin.Nic.In/Acts_Notification/Energy_Conservation_Act/.html

44. *The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth* (2014), Planning Commission, Government of India.

45. Verma A., Velmurugan S., Singh S. K., Gurtoo A., Ramanayya T. V. (2013), "Global Mobility Monitor Network (GMMN) - India Mobility Final Report", Project Report, IISc Bangalore, India.

46. Walsh et al., Assessment of climate change mitigation and adaptation in cities. Proceedings of the Institution of Civil Engineers.Urban Design and Planning 164 June 2011 Issue DP2 Pages 75–84.