

A Study of Sustainable Development for Effective Public Transport System

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Abstract:

An effective and efficient road transport system requires regular road maintenance. Road transportation facilitates the movement of people, goods and services in all sectors of the economy, including tourism, mining, trade, health, education and agriculture, among others. A growing concern for public transit is its inability to shift passenger's mode from private to public transport. In order to overcome this problem, a more developed feeder bus network and matched schedules will play important roles. The present research aims to review some of the studies performed on Feeder Bus Network Design and Scheduling Problem (FNDSP) based on three distinctive parts of the FNDSP setup, namely, problem description, problem characteristics, and solution approaches. The problems consist of different Sub problems including data preparation, feeder bus network design, route generation, and feeder bus scheduling. Subsequently, descriptive analysis and classification of previous works are presented to highlight the main characteristics and solution methods. Finally, some of the issues and trends for future research are identified. This research is targeted at dealing with the FNDSP to exhibit strategic and tactical goals and also contributes to the unification of the field which might be a useful complement to the few existing reviews.

Keywords: *Public transit, Urbanization, Bus Network.*

1. Introduction

An important addressing issues of sustainability allows societies to meet their present needs without compromising the environment for future generations. This policy proposal will address the promotion of public transportation systems as a means for sustainable development. A more sustainable approach to transportation will lead to less environmental damage before it occurs rather than as a reaction to the damage that results from vehicle emissions. There are two important aspects of environmental damage: the first is CO₂ emissions that cause climate change and the second is other emissions that contribute to air pollution and subsequent health effects. These two problems are exacerbated by the increasing trend for private vehicles. The trend calls for more vehicles on the road which means more vehicle emissions and thus more deleterious environmental effects. If public transportation is used more frequently, this can serve as a way to reduce the number of vehicles on the road and subsequently reduce emissions.

2. Characteristics of an Efficient Transportation System

Economical: A good transport system should be economical i.e. the cost of transport service should not be high so that the users can carry their products at lowest possible charge. This in turn will help the consumers fetch goods at cheaper and reasonable price.

Delivery of goods: Goods should be delivered at convenient locations so that the receiver of the goods do not face any problem.

Speed: A good transport system should have proper speed in order to carry goods from one place to another in less time. Goods should reach the destination on time except from natural calamities or unavoidable causes.

Availability: Transport service should be available regularly as and when the need arises and it must provide safety of the goods.

Insurance: It should provide for insuring the risks of loss or damage to goods in transit and assure payment of due compensation in case of delay causing loss to the owner of goods.

Arrangements: Goods should be loaded and unloaded promptly and at minimum cost by providing proper arrangements by a good transport system.

Efficiency: A good transport system should be operated by efficient and properly skilled people so that they can handle the problems in emergency, if any

3. Causes and Effects of Transport Development Problems

Since 1951, the development in the transport sector is quite good but there are many hurdles in the path of progress.

1. Faulty Planning of Transport System:

The development of transport system is unbalanced. There is heavy pressure on rail and road transport in certain cities and regions. For balanced development of region, alternative routes should be developed e.g. Metro in Delhi has decreased the pressure on road transport. In metropolitans there is a lack of fast and adequate public transport system. This deficiency leads to explosion of personal transport (own vehicles) which puts extra pressure on roads and cause jams and accidents. On the other hand, hilly and remote areas lack all weather transport facility.

2. Lack of Rail Road Co-ordination:

Rail and Road transport systems are the main means of transportation in a country. These two should work in co-ordination. Generally it is not so e.g. In 1951, the share of road transport in freight traffic and passenger traffic was 11% and 26% respectively. But in present days its share is 60% and 80% respectively. This growth is undesirable from economic and environmental point of view. In a well planned and co-ordinate way, the railways should be engaged for bulky goods and long distances while road transport should be engaged for small goods and short distances.

3. Worn out and Obsolete Assets:

The main problem of our transport system is its worn out and obsolete assets. In all modes of transport there are old and worn out infrastructure. In railways 25% of the route length and 75 to 80% of machinery in railway workshops have to be replaced. Similarly 80% and above of buses plied by State Road Transport Corporations are out-dated and out modeled. These need immediate replacement. They are main cause of accidents and environmental pollution. In air transport nearly one third of the total fleet requires immediate replacement.

4. Improved technology:

Modernisation and use of latest technology in transport system is the need of hour. In rail and road transport system, we are using age old technology so our progress is slow. Our road construction is of substandard and it increases wear and tear of vehicles and over head expenditure. Our engine design, old signalling system, multi-axle vehicles and worn out tracks are the main problem of railway transport.

4. Literature Review

From the overall review of literature related to the transit network planning process, the following observations are made.

Chau, K. W. et al. (1998) studied modernization of a railway line connecting the urban and sub-urban areas will normally result in a shift of the population from urban to suburban areas. This will affect the price gradient of residential prices of two connected stations on the railway line. The results strongly suggest that improvement in public transportation have a negative effect on the price gradient along the railway line. Pina, V. et al (2001) In recent years in the European Union (EU), they have witnessed an externalization process of the provision of local government services, in order to separate the political responsibility and the direct delivery of the service. The reasons that justify this process are focused on the belief that the private sector is more efficient in carrying out economic activities, the pressure to reduce the public deficit and the public debt, the search for management systems that bypass public administration procedures, and the increase of control on local governments in auditing and accountability issues. The objective of this paper is to compare the efficiency of public and private sectors in the provision of urban transportation services. The results allow us to conclude that, in the cities studied, exogenous factors are not relevant and the private management of urban transport service is not more efficient than public management.

Fouracre(2003) conducted survey on urban rail system is an ecologically and economically efficient way of moving large volumes of passengers in big cities. The fact that recent experience has seen a strong and growing demand for metros and LRT suggests that the influence of intangible factors is as strong, if not more so, than the technical evidence. An ideal decision-making process would allow consideration of the intangible benefits of mass transit options, while screening out projects that would cause severe financial hardship.

Thompson, G et al.(2003) in their article 3 and 4 of in this reference suggested that increasingly dispersed travel patterns in contemporary American urban areas raise questions about appropriate policy for fixed-route public transit, particularly rail transit. Some argue that fixed transit routes should be radial, serving only regional central business districts and adjoining inner-city neighborhoods; others argue that fixed routes should be reconfigured as networks to serve many regional destinations. The results of this examination, controlled for population, show that the multidestination approach is more effective, about as efficient, and more equitable than the best of the radial approaches. Martin V. Lawson,(2004) considers a new transport system ULTra (Urban Light Transport) centred on fully automated electric vehicles, meeting the need for urban transport which is both effective and sustainable. In contrast to previous forms of public transport, there is no waiting, no stopping and no transfers within the system. In many circumstances, it can offer better urban transport than available by other means. ULTra is also complementary to existing forms of transport. By providing a network link to major rail or bus stations, it can improve the attraction of existing transport services. The work suggests that novel approaches to transport systems can offer a significant new opportunity for the reduction of energy use and emissions from transport in cities. Becky P. Y et al(2006) studied Rapid urbanization has taken place in China since the Open Policy in 1978. In face of the growing demand for mobility in large cities, new metro systems were developed in large cities like Guangzhou and Shanghai. At present, there are seven cities with 10 metro lines under construction. What are the policy issues and major challenges of developing metro systems in China? This paper systematically reviews the current situation and highlights three major gaps that Chinese cities have to overcome in planning metro systems. They are the technology gap, the financing gap and the affordability gap. A discussion of these gaps in the Chinese context leads us to the conclusion that early planning and careful studies are important in the development of metro systems in China. Vishakha Maskey et al.(2013) studied Automated transportation is an innovative and sustainable concept that works emission-free with fully-automated and driverless vehicles on a network of specially-built, elevated guide ways. These systems are also called Automated People Mover (APM) or Public Rapid Transit (PRT) and are considered to be a solution to many global and environmental problems related to the use of the automobile. These transportation systems claim to be clean, affordable and safe technology, and a smart urban planning solution to move away from America's dependence on foreign oil, the faltering auto industry, and the misuse of urban landscapes. Their findings explore underlying factors regarding commuting, crucial for transportation policies and practices for managing sustainable transportation systems in comparable urban settings.

5.The Statement of Problem

Vehicle emissions have two negative effects on the environment: one is global climate change and the other is air pollution and its negative health repercussions. With the increasingly mobile population in the United States and greater numbers of middle class and wealthy individuals in developing countries who can afford private vehicles, these problems are worsening. Driving one's own car is often considered a benefit of economic success but due to increasingly adverse environmental and health effects related to vehicle emissions, universal car ownership is an issue that can no longer be ignored. Climate change is a result of increasing carbon dioxide, CO₂, emissions. The climate change of concern is increasing global temperatures that are attributed to the "greenhouse" effect. The greenhouse effect results from carbon dioxide, the most important of the greenhouse gases, which acts like a blanket around the earth, keeping surface temperatures at warm levels. Increasing the CO₂ concentration in the earth's atmosphere effectively adds another blanket which warms the Earth's surface even more. As a result of this warming, world temperatures have risen by about 0.5 degrees Celsius in the past century. If the trend of increasing CO₂ emissions continues, scientists project that the global temperature will increase by 3 degrees Celsius in the next century (some US agencies assume an even higher increase of 4-5 degrees Celsius. The results of this temperature increase would also mean a global average increase in sea-level of 0.66 m due to melting of the polar icecaps, causing a loss of some coastal areas. There may also be desertification – the conversion of formerly productive land to desert- in some areas which would contribute to poverty, famine, and food insecurity. It is estimated that approximately 50% of these effects are caused by CO₂. More importantly, about 20% of CO₂ emissions in the US come from motor vehicles. In the developing countries too, increasing modernization has led to an increased presence of motor vehicles which means a large percentage of CO₂ emissions in these countries comes from motor vehicles. In addition to CO₂ emissions and the resulting climate change, other vehicle emissions contribute to air pollution. Vehicles account for most of the carbon monoxide (CO) and a large share of the hydrocarbons (HC), nitrogen oxides (NO_x), and particulates found in the atmosphere in major urban areas. Nitrogen oxide (NO) results when nitrogen in the fuel or in the

combustion of air heats to temperatures above 1,200 degrees Fahrenheit in the presence of oxygen. This reaction occurs in most car engines today. Nitric oxide (NO) is the initial product and oxidizes to nitrogen dioxide (NO₂). Nitrogen oxides also combine with water leading to a component of atmospheric acidification, specifically nitric acid (HNO₃). This leads to “acid” rain. The general term “NO_x” is used to describe this family of emissions . Vehicle emissions constitute the greatest individual source of nitrogen oxides in industrialized countries . Table 1 below shows the contribution of vehicle emissions to pollution in the atmosphere and their resultant effects.

Table 1: Air Pollution from Motor Vehicles

Air Pollutant	Proportion from On-Road Motor Vehicles in US	Effects
Hydrocarbons	48%	Antecedent to ground-level ozone (smog)
Oxides of Nitrogen (NO _x)	43%	Antecedent to ground-level ozone (smog)
Carbon Monoxide (CO)	66%	Contributes to smog production, poisonous in high concentrations
Particulate Matter (PM ₁₀)	10%	Health problems when passing through the throat, nose, and entering lungs

It is clear that much of these air pollutants in the US are due to vehicle emissions. More importantly, these air pollutants have deleterious health effects. Particulate emissions specifically are linked to increased risks of asthma, heart attacks, and reduced lung function).

It is important to note too, that not only has air pollution reached critical levels in the US, but it has in other developing countries as well. In fact, the pollution in these other places may be worse. Table 2 below compares the air pollution in main cities in the US, China, and India.

Table 2: Air Pollution Indicators in Mega-Cities in US, China, and India

City	Population (millions, 2000)	Total Suspended particulates (µg/m ³ , 1995)	Sulfur Dioxide (µg/m ³ , 1998)	Nitrogen Dioxide (µg/m ³ , 1998)
New York	16.6	61	26	79
Los Angeles	13.1	49	9	74
Beijing	10.8	377	90	122
Shanghai	12.9	246	53	73
Guangzhou	3.9	295	57	136
Delhi	11.7	415	24	41
Mumbai	18.0	240	33	39
Calcutta	12.9	375	49	34

For example, China’s and India’s big cities are affected by air pollution problems caused by high levels of total suspended particulates, sulfur dioxide, and nitrogen dioxide. It is exhaust pollution from vehicle emissions that has increasingly become the source of air pollution in these cities. Clearly, there is increasing concern at the local, national, and global levels about the adverse environmental and health effects of air pollution directly attributable to transportation. It is apparent that transportation’s impact on the environment needs.

There are several ways to make transportation more environmentally sustainable. One strategy implemented by car manufacturers in the US involves increasing fuel efficiency through the corporate average fuel economy (CAFE). CAFE standards set an average gas mileage requirement for a car manufacturer’s fleet, rather than for individual cars. The fuel economy of all the cars sold by a manufacturer in any given year must average 27.5 miles/gallon and the fuel economy of all light trucks sold must average 20.7 miles/gallon. However, many opponents to this approach offer that in the absence of higher gasoline prices, improved fuel economy encourages people to drive an extra 10-20% more miles than they otherwise would, thus potentially negating the positive impact of the increased fuel efficiency.

Whether or not the CAFE standards work however is not the issue here. It is more important to focus upon the ongoing problem created by the many high polluting vehicles still on the roads and the trend for increased private vehicles use that that comes with the increasing wealth of the US and developing countries . With affluence, people develop preferences for lifestyles that tend to center around an increased use of personal vehicles even if public transportation systems exist. This lifestyle preference leads to an increase in the negative environmental effects previously discussed .

It is clear then, that climate change and air pollution are issues that need to be addressed in order to move cities and regions towards a more sustainable existence. More public transportation use will mean fewer vehicles on the road, which will mean fewer emissions and less negative effects on climate and health. Society needs to act now to promote public transportation in order to save our environment from further climate change and to avoid the serious health effects of air pollutants.

6. Types of Public Transportation

General public transportation falls into the category of Mass Rapid Transit (MRT), or modes of urban transportation that carry large volumes of passengers quickly. MRT can be further subdivided into two categories: road based and rail based transportation. The categorization of transportation systems can be further broken down into five different types of transportation (including bus, tramway, light rapid transit, metro, and rail, discussed below) that encompass the MRT system .

The first type of public transit involves buses that use dedicated rights of way (ROW), such as bus lanes or bus ways. Effective bus way transit features high passenger capacity, efficient fee collection methods, well-designed bus stops, organized operations, and handicap accessibility. Bus way transit provides good services at a reasonable cost but often falls victim to stigmatization as a negative, unsafe travel modality. People find bus transit to be dirty, slow, noisy, and a generally poor quality ride meant to serve low-income residents without cars.

The second type of MRT system is tramways, which are light, electrically powered cars that travel paths that may be completely or partially shared with other traffic. The third type of MRT system is known as Light Rapid Transit (LRT). It employs a fully segregated travel path and advanced control systems. The trains are light, like modern tramcars, and are often seen as intermediates between metro and bus systems in terms of cost and capacity.

The fourth type of MRT is metros. Metros feature fully segregated and grade-separated tracks and may be underground or elevated. These metros, also known as trains (or subways), are made up of heavy cars and can provide the highest levels of service - in terms of frequency and speed - but are also the most expensive. In addition, metros can carry the greatest numbers of passengers over any other public transportation system. The final type of MRT is suburban rail which transports passengers from suburban to urban areas. This system tends to exist as a larger rail network often separated from road traffic. It functions in the context of a wider network demand and is characterized by higher headways and longer station spacing

7. Existing Public Transportation

United States

The vast majority of people in the US use private transportation mechanisms for commuting. In fact, public transit systems only serve 1% of the transportation demand in this country . Several factors account for this observation. First, many locations nationwide simply lack public transportation systems. Additionally, in the locations where public transportation systems do exist, they may be inadequate and in need of improvements and enhancements.

Furthermore, in many cases, if US citizens can afford private transportation, they choose to use it. In fact, because time has become such a valued commodity in our current society, many people shift towards more convenient methods for commuting to work in order to match their own unique needs. This time factor has the effect of moving people from public transportation and car pooling to private vehicle use.

Private vehicle use is regarded as more convenient and appealing in contrast to the highly stigmatized reputation that public transportation holds in society. Many people view public transit as unreliable, unattractive, unclean, and not worth the wait. Travelers prefer the independence and flexibility of their personal automobile. As evidence of this, a Federal Highway Administration study found that in 1960, 69% of workers nationwide (41 million workers) used private vehicles to commute to work and in 2000, this number had increased to 88% (113 million workers). In addition, the percentage of overall workers who used mass transit dropped from 6.2% to 5.3% from 1980 to 2000..

The cities that do have public transportation systems tend to be those that have highly developed expertise in urban control and management. This is due to the fact that transit mechanisms require a high degree of operational integrity as a prerequisite for their successful implementation and use. Places like Chicago, New York, San Francisco, Philadelphia, Washington, Cleveland, Miami, Buffalo, Baltimore, and Atlanta satisfy these requirements.

New York serves as a good example of public transportation in the US. With 230 miles of track, New York accounts for the bulk of US subway travel. Subways have minimal operating costs and are the most energy-efficient form of public transportation. Compared to bus transportation which requires one driver for about 50 people, one New York subway conductor can transport about 1,400 people.

Chicago serves as another good example of the public transportation in this country. The Chicago Transit Authority (CTA) operates the second largest public transit system in the United States and serves the city of Chicago and its 38 surrounding suburbs. The CTA provides 1.5 million rides on an average weekday. This

includes 560,000 trips to work . In addition to New York and Chicago, other cities, such as Atlanta, have large public transportation systems. In Atlanta, 45% of all trips to work are taken by mass transit . While it is true that public transportation systems do exist in some locations in the US, the systems are by no means adequate. Thus, the public transportation demand is not being met by the current infrastructure.

Developing Countries

The investment needed for the development of public transportation systems varies worldwide depending on location and the existent transportation infrastructure. In fact, the current level of investment in transportation is lower in developing counties than in the rest of the world. The figure below indicates the numbers of rail based systems used in the developing countries compared to other countries

Despite a significant proportion of the world’s population residing in developing countries, especially in China and India, these countries currently have the smallest numbers of urban rail-based systems as shown in the graph. Although a similar graph of bus way transit and suburban rail systems is not available, it is known that suburban rail systems are used in large, developing cities such as Mumbai (Bombay), Madras, Calcutta, and Colombo. However, the trend is that the suburban systems in the developing cities do no meet commuter demands . To be more specific, the current public transportation systems in China and India will be reviewed.

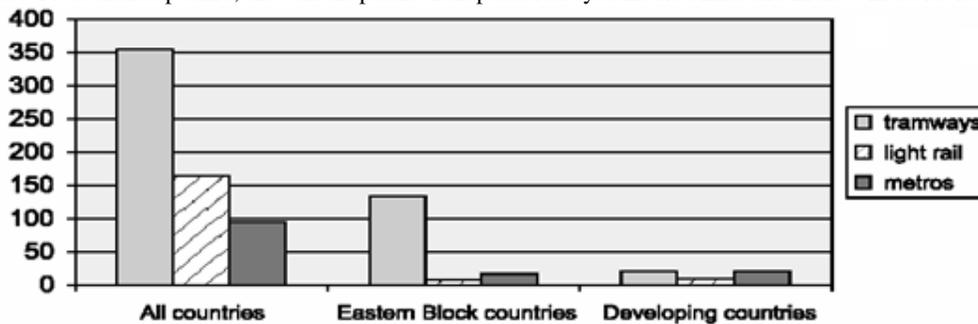


Figure 1 Numbers of urban rail-based systems by location. Source: LRTA (2001).

China

The current transportation system in China has been growing in response to the economic demands and the increased standard of living in that country. There is an increased demand for quality, convenient, and flexible transportation. Further, much like the trend in developing countries, the wealthy and middle class citizens in China prefer private car use . In response to these changing trends, China is building its transportation infrastructure with a high dependency for on-road transportation and extensive use of automobiles. This has led to traffic congestion and environmental problems. In certain locations, like Guangzhou, as of 1998, less than 18% of Guangzhou citizens use public transportation for commuting. The majority of citizens (42%) commute on foot and 22% commute on bicycle.

Despite these compelling statistics, there are some useful public transportation systems in China worth noting. For example, there is an impressive magnetic-levitation rail link in China that uses powerful magnetic fields to elevate trains above tracks. It operates between Shanghai and that port city’s main international airport. This 820 mile rail line is designed for speeds reaching a maximum of 220 miles/hr. Additional work will begin at the end of 2006 aimed at extending the line from Shanghai to Hangzhou.

India

The current transportation system in India displays a similar trend to that of China: the increased living standard has led to an increased demand for quality transportation that is both convenient and flexible in nature . In this regard, wealthy citizens and the middle class prefer private car use. Table 3 below shows the estimated shares of transportation modalities in Delhi stratified by income category.

The table reveals that scooter/motorcycles, walking, and cars each contribute a similar percentage to the total population’s transport modes. However, use of cars and scooter/motorcycles results almost exclusively from high income citizens while walking is the transport mode mainly of low income citizens. Additionally, the data also reveal that the rail system in Delhi is not widespread because only 1% of the total population uses rail. Finally, the bus system seems to be the most effective form of public transit in Delhi; it is the category with the highest percentage of the total population’s use, amounting to 33%. Even among citizens in the high income category, buses are used more than cars - 36% compared to 28%, respectively.

Like Delhi, citizens of Mumbai frequently use their bus system. This, along with the suburban rail system, functions as the most used types of transportation in Mumbai. These two public transportation systems carry about 86% of commuter trips (Larkin, 2006). Walking, biking, private motorized vehicles, auto-rickshaw, and taxis are also used but mainly to access the rail transit stations and bus stops in the city (Rastogi and Rao, 2003).

A successful public transportation system is also in place in Calcutta, India where there exists a 17 km metro. It took 22 years to build and remains state of the art in quality. It is quite impressive, marked by its speed, punctuality, cleanliness, and use of tokens and smart cards at the ticket barriers .

China and India

However, similar to the United States’ lack of public transportation in all locations nationwide, the systems in Shanghai, Delhi, Mumbai, and Calcutta are not matched in other urban locales throughout China and India. Public transportation in these developing countries is certainly non-ubiquitous in nature. The current public transportation systems are not able to meet the increasing demand for commuter transport that comes with China’s and India’s rapid urbanization. This factor, coupled with the increase in the number of wealthy people who can afford private vehicles, has led to an increase in the number of private vehicles in these countries. Table 4 below shows data reflecting this increase in vehicles.

It is clear from the above table that the United States has significant per capita vehicle ownership with more than three quarters owning cars (>750 per 1000 population). The per capita vehicle ownership in the developing countries is significantly smaller. India, for example, falls in the bottom 10 countries with few per capita motor vehicles owed per 1000 people. The only countries (for which data are available) that have less are Pakistan, Cambodia, Uganda, Ethiopia, and Bangladesh (International Band for Reconstruction and Development, 2004). In 1999, only 1.2% and 1% of the population in China and India, respectively, had their own vehicles whereas 78% of the US population had their own vehicles. However, the projected annual growth rate in per capita vehicle ownership over the next decade and a half for China and India is significant at 7.5% and 7.6%, respectively. With public transportation systems requiring remedial efforts in these countries, citizens of high incomes are increasingly turning to the convenience and comfort of private vehicles. Furthermore, since these two countries have a significant proportion of the world’s population, these increases represent a significant number of additional vehicles overall.

The increase in the per capital vehicle ownership in the developing countries is problematic for the global environment. China’s vehicle emissions, for example, have become a major source of urban air pollution world wide. In fact, China is currently the world’s second-leading emitter of carbon dioxide and other greenhouse gases that contribute to global climate change. It is projected to surpass the US and become the world’s top emitter by 2020.

India’s CO2 emissions account for only 2-4% of the world’s total. But in a country rapidly expanding beyond a billion people, there are profound implications for future impact on climate change. Although per capita CO2 emissions are low (below a quarter of the world average), the national growth rate exceeds the global rate, which leads ultimately to an increasing global share . Transportation accounts for 24% of India’s energy use and like China’s transportation system, needs improvements for environmental sustainability.

Table 3: Estimated Shares of Transport Modes in Delhi in 1999

Mode	Low-income (% population)	High-income (% population)	(% Total Population)
Cycles	39	3	24
Buses	31	36	33
Scooter/Motorcycles	3	29	14
Walking	22	2	14
Cars	0	28	12
Rail	1	0	1
3 wheel scootertaxis	1	2	1
Other Vehicles	3	0	1

Table 4: Per Capita Vehicle Ownership (vehicles per 1000 population) (Energy Information Administration, 2001)2

	History (estimates)			Projections				% annual change
	1990	1998	1999	2005	2010	2015	2020	
US	765	775	777	787	792	795	797	0.1
China	5	11	12	18	27	40	50	7.5
India	5	9	10	15	22	33	44	7.6

In some instances, there has already been a push to improve the sustainability of the environment. In India, for example, there have been some advances in the public transportation systems in order to reduce pollution in

certain parts of that country. As a statement of need for these enhancements, Delhi had been one of the most polluted capitals on earth. People have been plagued with asthma and bronchitis. Improvements began in the mid 1990s after a law suit forced Delhi's taxis and buses to use a cleaner-burning compressed natural gas (CNG) as fuel (Perry, 2006). In July 1998, the Indian Supreme Court ruled in favor of this proposal and ordered a ban on leaded fuel, and conversion of all diesel-powered buses to CNG along with the scrapping of old diesel taxis. Delhi's efforts to clean its air has led to stabilization of air pollution. This has attracted international attention from numerous countries including Kenya and Indonesia where there are attempts to mimic what Delhi has accomplished regarding limitations on air pollution (Perry, 2006).

However, more needs to be done to reduce climate change and air pollution. This can be accomplished through changes in public transportation. This report will end with policy recommendations aimed at encouraging the use of and improving the infrastructure for public transportation systems in the US and in the two developing countries, China and India. These policies focus on meeting the population's commuting demands in a more environmentally sustainable way.

8. The Solution: Policy Recommendations

It is clear that vehicle emissions present global climate and air pollution problems. One obvious way to mitigate these effects is to lower the number of cars on the road. Lowering the number of cars on the road could be accomplished through the promotion of public transportation rather than private transportation in the United States and by slowing the growth of private transportation in the developing countries. Policy recommendations will fall into four categories: improving public transportation systems, encouraging the use of public transportation systems, discouraging the use of private transportation systems, and changing urban plans and city designs. All these recommendations can be applied globally to help transportation become more environmentally sustainable. Following outlines the main policy recommendations will follow.

Policy Recommendations

- Allocate more money to build new subway and bus systems and expand or improve old systems
- Encourage citizens to use public transportation systems
 - o subsidize mass transit fees for employees
 - o reward carpooling
 - o educate citizens to dismantle negative stigmas of public transportation
- Discourage citizens from using personal vehicles for travel
 - o increase the price of personal vehicle travel
 - o reduce the number of vehicles allowed in urban areas
- Change urban plans and city designs
 - o build more walking and biking paths and bike racks

9. Conclusion

It is evident that vehicle emissions are problematic to the global environment. CO₂ specifically leads to climate change and other vehicle emissions contribute to air pollution causing negative health effects for the world's inhabitants. A logical way to reduce these negative impacts would be to decrease vehicle emissions; to catch the problem before it worsens. This can be accomplished through lowering the number of vehicles on the road. The increasing trend for private vehicle ownership can be replaced by increased reliance on public transportation. Policy recommendations for reaching this goal involve improving current public transportation systems, encouraging the use of public transportation systems, discouraging the use of private vehicles, and changing urban plans and city designs.

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