Leapfrogging towards sustainable mobility:

Enablers of socio-technical transition towards Sustainable Urban Mobility System in developing country cities: The case of Bangalore and Jakarta

Anteneh Getnet Dagnachew

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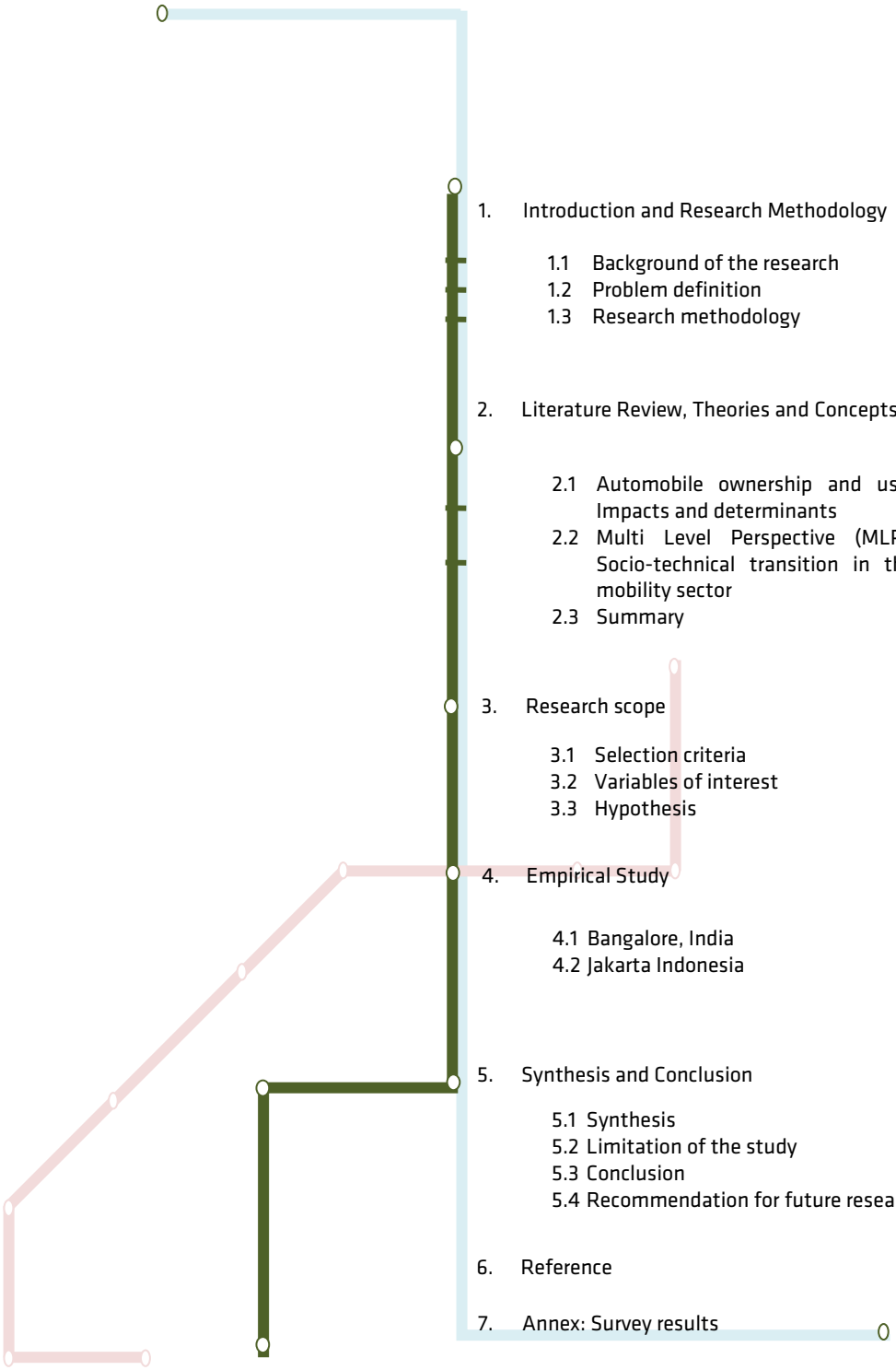

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Acronyms

BBMP	Greater Bangalore City Corporation
BCCI-K	Bangalore Climate Change Initiative – Karnataka
BDA	Bangalore Development Authority
BMRCL	Bangalore Metro Rail Corporation Limited
BMRDA	Bangalore Metropolitan Region Development Authority
BMTC	Bangalore Metropolitan Transport Corporation
BPS	Central Agency on Statistics Indonesia
CBD	Central Business Destrict
CDP	Comprehensive Development Plans
DisHub	Jakarta department of transportation
DV	Dependent Variable
GDP	Gross Domestic Product
GHGs	Greenhouse gases
GNI	Gross National Income
GRP	Gross Regional Product
Gt	Gigga tone
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IV	Independent Variable
IPT	Intermediary Public Transport
Km	Kilometer
MLP	Multi Level Perspective
NMT	Non-Motorized Transport
OECD	Organization for Economic Co-operation and Development
PPP	Purchasing Power Parity
PT	Public Transport
Sq.Km	Square Kilometer
SUMS	Sustainable Urban Mobility Systems
TPB	Theory of Planned Behavior
UN	United Nations
USD	United States Dollar
WEC	World Energy Council

> *"Who controls the food supply controls the people; who controls the energy can control whole continents; who controls money can control the world."*
>
> *Henry Kissinger*

Chapter 1: Introduction and Research Methodology

1.1 Background of the research

The current system of transport suffers from a number of intractable problems that include congestion, noise pollution, accidents, depletion of resources, and local air pollutants. The transport sector is also an important contributor to global greenhouse gases (GHGs) emissions. Hoen et al. (2009)argue that the contributions of the transport sector to global GHG emissions amounted to nearly 20% in 2009. These GHG emissions are causing severe changes of the world climate and are posing a serious threat for the environment and the human health. Moreover, the global transport energy use has shown steady increase in recent decades. From 1971 to 2006 energy consumption of the transport sector rose by between 2.0% and 2.5% annually (IEA, 2009). Road transport consumes approximately 70% of the total global energy use of the transport sector and the road passenger transport accounts for 50% of this energy consumption (Bóhler-Baedeker & Húging, 2012).

Despite the growing energy consumption and the negative environmental impacts, transportation is an important sector and serves as a proxy for global economy. Transportation plays a central role in economic and social development. The goal of the transportation system is to move goods and passengers efficiently, while limiting negative impacts on the environment and society. Because of the rapid urbanization rate in the world, and more significantly in developing countries, urban areas are growing in population and size. As cities grow in size and population, demand for mobility increases. However, cities in developing countries often have the poor quality urban public transport services, therefore, are facing challenges in meeting those demands resulting in an overcrowded infrastructure and alarmingly increasing private vehicle ownership.

In most of the cities in developing countries public transport is heavily subsidized because of its large positive externalities (reduced need for roadways and reduced congestion) but also to ensure access by low-income households. Nevertheless, public transport service in some of these cities is not affordable for the poorest segment of the population. Thus cities face pressure to keep fares very low in order to serve all parts of the population, but in doing so, the quality and comfort of the public transport system will be sacrificed (Faiz, 2011; Sperling & Clausen, 2002). As the result, the middle-class riders react by buying cars as soon as they can afford one. This phenomenon results in diminishing transit revenues, and the quality of the service will be further reduced to keep the fares affordable to the poor. Although the quality of service suffers first, a decrease in quantity of service often follows. Consequently, rapid growth in demand for private vehicles or other motorized transport has swamped transport capacity in most of the cities in developing countries. An article by Wolfgang Köhler (2006, p. 20) shows that in Bangkok 400 additional vehicles (including two-wheelers) are registered every day and Beijing adds 1000 vehicles (including two-wheelers) to the city every day. At the national level, with an economic growth of up to 10 percent per year, the number of newly registered private vehicles in China is rising by 20 percent per year. This inevitably leads to the lock-in in private car ownership. As a result, many of these cities are experiencing stifling traffic congestion, and most are not-able to build enough road infrastructure to keep pace with vehicle demand (Sperling & Salon, 2002).

Cities will be locked into the car-based modes of transport when they adapt themselves to personal vehicle use in terms of ownership, infrastructure provision, training and knowledge, regulations, social practices and cultural acceptance (Geels, et al., 2012). Traditional transport planning aims to improve mobility, especially with respect to the usage of vehicles, but fail to adequately consider the wider or long term impact (Geerlings & Van Meijeren, 2008). The orthodox solutions being provided by decision makers in developing country cities further encourage private vehicle ownership and fuel the 'lock-in' in the dominant car-based transport regime. These measures are similar to patterns of development of several cities in developed countries, which interestingly, are now trying to recover from a car-dominated development era by halting the building of more infrastructures for private vehicles and re-allocating road space for public transport and non-motorized transport (UN, 2011).

Cars in circulation per capita rise once income per capita crosses a certain threshold, shows a study by Ali & Dadush (2012). Their research, which includes a cross-country analysis of more than 60 countries, suggests that the threshold is around 3,400 USD PPP (Ali & Dadush, 2012). According to the same study, during the period 1996-2010, countries with average per capita income between $3,400 and $10,000 have the highest average income elasticity[1] of car ownership at 1.9. The World Bank data shows that currently 45 developing countries, home to a combined 2.2 billion people, lie in the per capita annual income range of 3,400USD to 10,000USD (The World Bank, 2012), meaning that a large share of that population is just on the threshold of affluence. In 2010 alone, the BRIC countries – Brazil, Russia, India, and China – added about 14 million cars

[1] Income elasticity of cars is calculated as the ratio of average car ownership growth and average income per capita growth

to their circulation (Ali & Dadush, 2012). Consequently, transportation energy use in developing countries has been increasing at over 4 percent per year over the past 20 years (Sperling & Salon, 2002). Because virtually all this energy is in the form of petroleum, increases in transportation energy use translate into large GHG emissions increases.

In order to meet the increasing mobility demand for the ever growing urban population without the sever environmental consequences, cities in developing countries will have no better option than to put effort in providing a Sustainable Urban Mobility System (SUMS). SUMS is a multi-modal public transport system that provides access to all groups of people in the city in an environmentally responsible manner, encourages the use of non-motorized transport modes in combination with diverse public transport modes and is affordable to the users of the system.

The objective of this research is to analyze the enablers and the changes needed to leapfrog the transport system in cities in developing countries to a sustainable urban mobility system that addresses the environmental, social and economic pillars of sustainable development in the context of rapid urbanization. The objective is demonstrated by Figure 1 *below.*

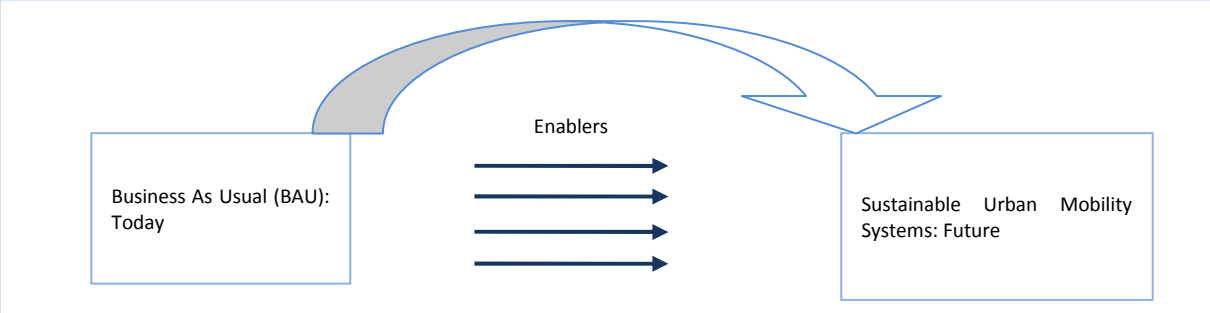


Figure 1: Objective of the research

Enablers for the purpose of this research refer to functions, elements and actions that will facilitate the changes needed (or sometimes to force those changes), as well as eliminate the barriers and brakes in the transition to sustainable mobility.

1.2 Problem definition

1.2.1 Urbanization and Economic development

Urbanization, which is one of the dominant contemporary processes, refers to the process in which an increasing proportion of a society lives in cities resulting primarily through rural urban migration and reclassification of rural areas into urban areas while natural population growth is also a significant contributor (UN-HABITAT, 2006; UN, 2012; UN-DESA, 2011).The world population is set to grow from 7 billion today to 9.3 billion by 2050 (in the medium variant), while the proportion of the global population living in cities is expected to rise from 52% in 2011 to 67% in 2050 (Lerner, 2011; UN Population Division, 2011), in absolute numbers it grows from 3.6 billion in 2011 to 6,3 billion in 2050 (which is more than the total world population was in 2002) (UN, 2012).

This unprecedented rate of urbanization has been a major motor behind development as cities are centers of economic development and innovation. Cities offer more opportunities, better infrastructure and better health care. Cities, when well managed, provide opportunities for economic and social growth. However, cities are also critical elements of unsustainable development because of the high level and ever growing consumption of resources that extend the ecological footprint beyond their geographic boundaries. They become large, more complex, more diverse, hence, difficult to manage. Then, the social and environmental aspects of the process become very important. The most fundamental impact of urbanization due to pressures from population increases is the direct increase in demands for all kinds of infrastructures (UTCE Ltd.- ALMEC Corporation, 2005; Economic and Social Commission for Asia and the Pacific, 2003; Satterthwaite, 2010; Iim, 2005).

> *Soaring personal vehicle use is producing great benefits but also potentially enormous costs.*
>
> (Sperling & Clausen, 2002)

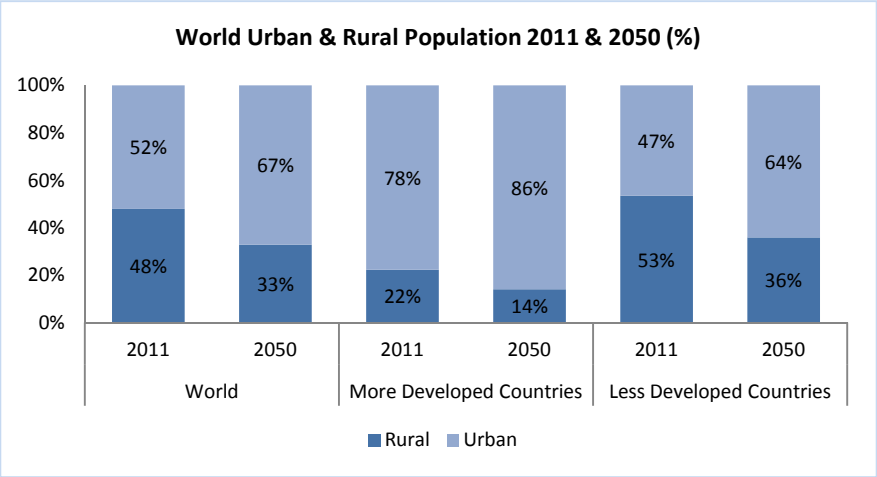


Figure 2: World Urban & Rural Population 2011 & 2050

(UN Population Division, 2011)

According to the World Urbanization Prospect, the expected growth in urban population will mostly be concentrated in urban areas of developing countries whose urban population will nearly double from 2.7 billion in 2011 to 5.1 billion in 2050 (UN, 2012). A report by the International Transport Forum (2012) shows that urbanization rises through 2050, in the OECD (by about 10%) and much more strongly outside of it (about 42%). In 2010, 78% of OECD inhabitants were urbanites, against 45% of non-OECD inhabitants; while in 2050, the respective shares will be 86% and 64%.

The process of urbanization in many developing countries over the past half century seems to have been accompanied by high levels of concentration of the urban population in few very large cities- the so called primacy. At the beginning of the twentieth century, 16 cities in the world contained a million people or more, most of them in developed countries. By 2005, almost 450 cities contain a million people or more, and about seventy percent of these cities are found in developing countries where China and India account for respectively 100 and 40 of these cities (Cohen, 2006; Peng, et al., 2010). New York was the only city with a population of 10 million plus in 1950, in 1975 there were already 5 (3 of which were in developing countries), in 2000 the number of cities with 10 million plus population reached 19 and 15 of them are in developing countries (UN-HABITAT, 2001).

Several recent studies (UN-HABITAT, 2010; Annez & Buckley, 2009) that explored the link between urbanization and economic development in Africa and Asia found positive results that show indeed urbanization is the major factor behind economic growth, contributing to an overall reduction in poverty rates (UN-HABITAT, 2010). In Latin America, economic development and urbanization have also been linked to industrialization and modernization. This link between urbanization and economic development can also be seen when countries are aggregated by income level: high income countries show highest GDP per capita and high level of urbanization while the low-income countries populate the opposite end of the list as shown in Figure 3 below. Annez & Buckley (2009) also say 'no country has ever reached middle-income status without a significant population shift into cities' while strongly arguing that urbanization is necessary to sustain (though not necessarily drive) growth in developing countries. This is also shown in Figure 3 below, where it can be seen that only few countries managed to reach GDP per capita of more than 10,000 USD (2005 values) before reaching an urbanization level of 60%.

Economic development has historically been strongly associated with an increase in the demand for transportation and particularly in the number of road vehicles (Dargay, et al., 2007). Projections in the development of the transport sector show an increase in the number of passenger-kilometer travelled (Schäfer, 2006; International Transport Forum, 2011) putting pressure on the current mobility system. Mobility is an essential element of society and the economy, but the rapidly growing demand for mobility will have a negative impact on society and the economy that includes congestion, air pollution, noise pollution and accidents if not properly addressed. According to Schafer (2006), growth in per capita income and population are the two single most important factors that explain increase in passenger mobility. And the two fundamental variables that influence the demand for personal vehicles in a country are the size and wealth of the population (Sivak & Tsimhoni, 2008). Although there are tremendous diversity in levels of development and vehicle ownership amongst cities in developing countries, the rapid urbanization results in an increasing motorization, and the associated traffic volume and congestion is already resulting in lost productivity and competitiveness, as well as health and other costs related to smog, poor air quality, traffic accidents, noise, and, more recently, climate change (Zielinski, 2006).

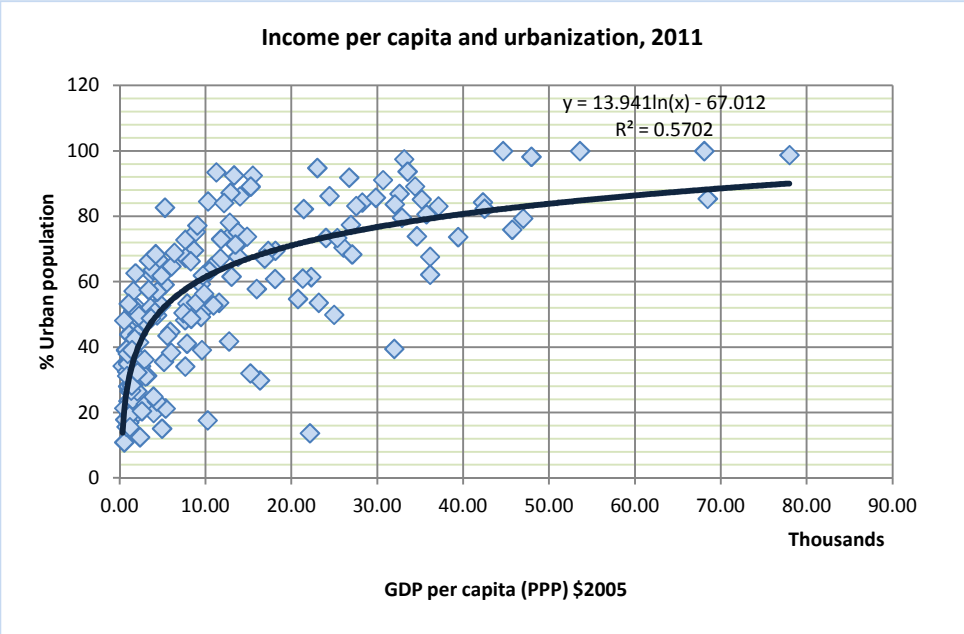


Figure 3: Income per capita and Urbanization, 2011

(The World Bank Data)

1.2.2 Income growth and Car ownership

Driven by the impacts of urbanization, economic development and population growth, the number of passenger cars in the world is increasing. Various studies (Dargay, et al., 2007; Ali & Dadush, 2012; Sivak & Tsimhoni, 2008; Newman, 2000; Dargay & Gately, 1998; Currie & Delbosc, 2009) explored the relation between Per Capita income (one of the most common measures of economic development) and vehicle ownership. This studies show that the relationship between the growth of vehicle ownership and per capita income is highly non-linear where vehicle ownership grows relatively slowly at the lowest levels of per capita income (GDP per capita less than 3,000USD), then twice as fast as Per Capita income at middle-income levels (GDP per capita between 3,000USD and 10,000USD) and as fast as per capita income at higher income levels (GDP per capita between 10,000USD and 20,000USD), before reaching saturation at the highest levels of income. Both Ali & Dadush (2012) and Dargeu, et al. (2007) indicate that the income elasticity of vehicle ownership starts low but increases rapidly over the range of USD 3,000 to USD 10,000, when vehicle ownership increases twice as fast as Per Capita income. Dargeu, et al. (2007) used Gompertz model to project vehicle ownership of countries on the basis of assumptions concerning future trends in income, population and urbanization. The result shows relatively slow growth in vehicle ownership (0.6% annually) for OECD countries (except for Mexico and Turkey) since many of these countries are approaching saturation. Non-OECD countries show a faster rate of growth in vehicle ownership (3.5% annually). According to the study (Dargay, et al., 2007), the most rapid growth is in the non-OECD economies with high rates of income growth, and Per Capita income levels (USD 3,000 to USD 10,000) at which the income elasticity of vehicle ownership is the highest. Currently there are 60 countries within this range of income level, and another 60 below the minimum vehicle ownership threshold.

The 2012 World Energy Outlook (IEA, 2012) projects that the number of passenger cars will double to 1.7 billion by 2035 (from the current 800 million) contributing to the increase in fuel demand from its current 87 million barrels per day to 99 million barrels per day. Unless there is a major shift away from current patterns of energy use, projections from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) foresee a continued growth in world transportation energy use of 2% per year, with energy use and carbon emissions about 80% above 2002 levels by 2030. This is not surprising considering that current transportation activity is mainly driven by internal combustion engines powered by petroleum fuels. The economic and social benefits of motorization are big; it provides individual flexible transportation in urban areas and reduced manual labor and improved market access in rural areas. However, in the longer term, motorization may stifle local development, increase pollution, and create unprecedented safety hazards (Sperling & Clausen, 2002).

This development trend/path leads to a socio-technical system that creates a stable technological lock-in in the car-based transport system. Lock-in, as defined by Tibbs (1998), is the phenomenon by which dominant technologies become established in spite of the existence of technically superior alternatives. For a technological system with an inter-related set of components connected in a network, lock-in is intensified by interactions amongst technologies, infrastructures, manufacturing and consumer behavior. According to Foxon (2002), these positive externalities, which act to reinforce the dominance of the system, arise because both physical and informational networks grow in value to users as they become

larger and more interconnected. In addition, institutions evolve to reinforce the technological system, both in terms of formal rules, such as regulatory structures, and informal constraints, such as codes of behavior.

In the case of the car system, as more and more people own private vehicles and are supported by infrastructure development and the built environment, less and less people will use the public transport system making investments in the sector less attractive (Sperling & Clausen, 2002; Faiz, 2011). Policy makers define the plans and policies on the basis of the current (dominant) technology; the built environment has co-evolved alongside auto mobility, so that amenities and workplaces are often only accessible by car; vehicle manufacturing has developed along 'technological trajectories' which constrains the development of alternative modes; consumer decisions to fulfill emotional-symbolic functions as status, comfort and safety, as well as practical requirements like space and travel cost; socio-cultural norms as quality of life and habitual behavior; all give high value to passenger cars and serve to lock-in the automobile based mobility system (Nykvist & Whitmarsh, 2007).

Michel Best (1982) emphasizes the role of institutions and infrastructure in strengthening the lock-in in the car regime in his article 'The political economy of socially irrational products' by saying:

> *"...If the car, for example, were simply a commodity, then it could be taken or not with a minimum of social consequences. But it is more than a commodity, for it is part of a way of life. Once it has become the dominant mode of transport then housing, family, work, shopping and recreation patterns are designed around it. Not consuming the car is like rejecting a religion into which one was born. It disconnects a person from the social fabric of society. (Best, 1982)"*

These reduce options and choices for movement by non-automobile modes such as pedestrians, cyclists and public transport. It is these social, technological and institutional dependencies that provide positive feedback to private vehicle ownership hence the lock-in and it is to overcome this lock-in that radical change is required in the mobility sector. The good news is that, at present, the passenger car-infrastructure system in most developing countries is far from saturated. However, it also means that it is a critical moment when, if properly addressed, it is possible to leapfrog to a sustainable mobility system and avoid the lock-in in the car-based system.

It is, therefore, no longer a luxury but a necessity to establish an efficient transport system that meets the demand, but consumes as little energy as possible. Several studies (Struben & Sterman, 2008; Leiby & Rubin, 1997; Mediavilla, et al., 2011; Ogden, 2005) addressed the issue of vehicles powered with alternative fuel. However, we think that alternative fuelled cars will only solve the climate related problems in the transport sector or just move the emissions from the streets to the power plant but does not address the problem of lock-in and its associated problems, hence, does not lead to reduction of the number of cars on the roads. Geels (Geels, 2001) explains this by saying, technology, of itself, has no power, does nothing, but only in association with human agency and social structures and organizations, does technology fulfills functions. Besides being environmentally responsible, sustainable transport system should also be economically competitive and socially fair. These mobility objectives could be addressed by the development of an inter-modal mass transit system that is largely energy efficient and well-received by the urban populace.

The study by Newman (2000) where he compared the per capita use of cars in 37 global cities brings good news for sustainability, though, by showing that transport energy and wealth can be decoupled. In the study, Newman (2000) examined the link between mobility and wealth by comparing the per capita ownership of cars in 37 global cities and saw how this compares with their per capita city wealth (Gross Regional Product (GRP)). One of the most significant results of the study was the comparison between the developing Asian cities of Kuala Lumpur, Surabaya, Jakarta, Bangkok, Seoul, Beijing and Manila and the three wealthy Asian cities of Tokyo, Singapore and Hong Kong; where the poorer cities had 108% as much car use but had an average GRP which was only 12% of that in the developed Asian cities. Another comparison shows that New York (the lowest car using US city) had 36% less car use per capita than Houston (the highest car using US city), but was actually 10% higher in GRP. This study indicates that it is possible to transform the transportation system of a city into one that is sustainable without damaging overall economic performance of the city.

Zielinski (2006) argue that the evolution of New Mobility is inspired by emerging innovations and propelled by pressing needs, not the least of which is rapid urbanization. Therefore, the rapid urbanization in developing countries can be seen as a problem but also as an opportunity. It is a problem because it is putting pressure on the existing ill-equipped mobility system, and it is an opportunity because the pressure created by the growing mobility demand can be used to leapfrog these cities from the current state 'no/low-mobility' to 'smart mobility'. In addition, pressures from an increasing awareness of negative side-effects of car use and a desire to achieve sustainability across the entire economic system also give motivation to avoid the lock-into the car-based transport system.

In order to address mobility related issues and avoid the lock-in in the car system, a comprehensive and integrated approach is required that addresses the three pillars of sustainable development: socially inclusive, environmentally friendly and economy promoting mobility system. Transportation that enhances the economic development, environmental stewardship and social equity in a city elevating the broad societal concerns to prominence alongside the goal of moving people and goods is a smart mobility. Sustainable Urban Mobility System (SUMS) refers to a system where various modes of personal travel – walking, bikes, ride-sharing, and mass transit– are co-ordinated to enhance mobility in urban areas (Mitchel & Casalegno, 2005). SUMS is about changing the way the transportation system performs so that negative environmental and social impacts are reduced and options for people and businesses are increased. In SUMS,

there is interdependence between energy systems and mobility infrastructure as real time information, i.e. information from the bus and to pedestrians, from pedestrians to the bus, from the city to the bus and from the city to the passengers, is an important element of such system (Mitchel & Casalegno, 2005; SMART: Global Urban Mobility Solutions, 2010; Trans.21, 2010). Hence, a reliable energy system is the backbone of the Sustainable Urban Mobility System. SUMS is a transport system that incorporates a concern for environmental integrity, social justice, economic vitality, urban resilience and the quality of urban life.

Schiller, et al., (2010, p. 3), as cited by (Moody, 2012, p. 25) provide the following definition of a sustainable transport system that very much suits SUMS:

> *"Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations"*
>
> *"Is affordable, operates efficiently, offers choice of transport mode and supports a vibrant economy"*
>
> *"Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise"*

For the purpose of this research, SUMS refers to an integrated multi-modal transport system in urban areas where various existing forms of transportation are co-ordinated to enhance mobility for all members of society and reduce vehicular traffic in urban areas- all the while accounting for environmental and social concerns. Therefore, it refers to a mixed-mode mobility system that combines trains, trams, buses, metro, walking and bicycle in combination with park-and-ride, kiss-and-ride and/or bike-and-ride facilities.

1.3 Research Methodology

As a result of urbanization, mobility demand in developing country cities will increase. Together with growing income, it will lead to a rapid growth in private vehicle ownership, hence significant increase in the transport energy consumption in developing countries. A transition towards SUMS will help counter this effect and result in lower energy consumption in the transport sector in developing country cities.

Figure 4 shows the conceptual framework of this research. The main objective of the study is to find the enablers of socio-economic transition in the mobility sector to leapfrog from the Business As Usual car-based transport system to the Sustainable Urban Mobility System in order to avoid the lock/in. The basic drivers of car ownership are urbanization and economic development. As high rate of population growth and urbanization lead transport needs to expand, the merging middle-class aspires to the use of private motor vehicles (Bóhler-Baedeker & Húging, 2012), in particular, where public transport service is often inadequate and unsafe. Besides, in developing countries, aspirations towards progress and status often translate into car ownership, even as the risks and costs of securing the energy to fuel these aspirations rise (Zielinski, 2006).

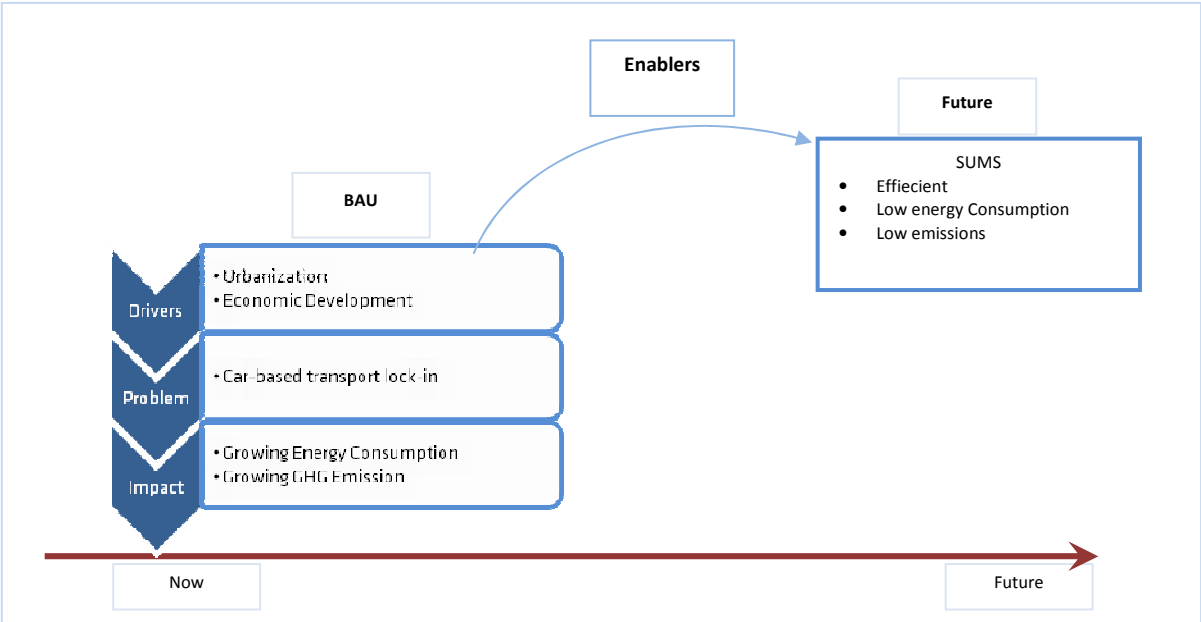
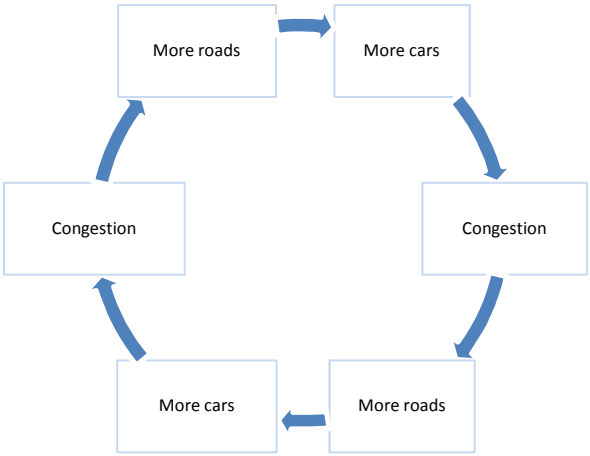


Figure 4: Conceptual framework of the research



Most governments respond to the growing mobility demand by providing more infrastructures to the growing private motor vehicles and designing an automobile dependent built environment and other technological fixes. As a result, the combination of the private motor vehicle and a well developed road system becomes the dominant form of urban transport in cities as shown in Figure 5 below. The figure also shows that traditional solution of constructing new roads and adding lanes to existing once for solving congestion problems in the car-based mobility system leads to more cars on the road.

Figure 5: Vicious Circle of Car-Oriented Transport Development

(UN, 2011)

What we will try to examine is what enables the transformation of the mobility sector in developing country cities to a sustainable urban mobility system. This requires a study of the current trends of the transport sector in terms of geographic, demographic, political, technical and economical aspects of the development process, policies and plans related to transport and energy, norms, and beliefs of stakeholders in developing countries during operation by the year 2050 as will be addressed by the research questions below.

1.3.1 Research Question

As discussed in the sections above, if no intervention is taken, the high rate of urbanization together with the rapid economic development will lead to a rapid increase in private car ownership in cities in developing countries. In this research we will explore the transition process from the current rapidly growing private car ownership regime to SUMS in cities in developing countries to leapfrog the transport sector to a sustainable mobility system. To meet the objective of our research, the following main research question is formulated:

What enables the socio-technical transition processes in the mobility sector (towards a sustainable mobility system) during rapid urbanization and economic development in cities in developing countries?

In order to answer this main research question, we will go through several steps that form the sub-questions. First of all, we need to explore the trends in the mobility sector (private car ownership and public transport infrastructure) in developing countries in order to understand the geopolitical and geotechnical context (spatial development patterns, culture and attitude, economic factors, etc) of the mobility sector and developing country cities. This brings as to our first sub-question:

1. What kind of trend is developing in the transport sector in cities in (selected) developing countries?

Following that, we will explore the possible attractors towards a sustainable mobility system in cities in developing countries by exploring mobility related policies. Geels (2010) describes attractor as the dynamic equilibrium states towards which systems tend. In the case of the mobility system, attractors hold control of other parameters of the system which are constructed and continue to be modified to match the requirements of the persistent regime dynamics and its environment. Thus in the transport system, attractor represent the stable, long term components of the transport system having a long term influence on the nature and extent of flows; such as land use, transport terminals, policies, plans, and visions (Rodrigue, 2013). According to Lorbach (Loorbach, 2007), an attractor

> *...refers to a certain state in which a system sets itself and is hard to get out of. This is the state of dynamic equilibrium, in which minor variations and changes can occur (spontaneous and self-organized) as a response to internal innovations or external pressures, but these variations do not alter the general structure of the system so that it remains in its domain of attraction. (Loorbach, 2007, p. 56)*

This leads to the second sub-question:

2. What attractors exist for the implementation of SUMS in cities in developing countries at present?

Finally, it is important to explore the transport and electricity sectors and the strategies and beliefs of important actors to understand the barriers to implement SUMS in cities in developing country, which brings us to the last sub-question:

3. What barriers exist to implement the system in developing country cities?

1.3.2 Data collection

Data used in this study is collected through:

a. Desk research with literature review, review of organizational record (organizations where data is acquired include International Transport Forum, World Resource Institute, UN-HABITAT, The International Association of Public Transport, Nation Masters, World Bank, IEA Energy Technology Perspectives, Energy statistics IEA, PRIMES, CBS, Cities ACT, Global Transport Intelligence Initiative, ELTIS, European Platform on Mobility Management TEM, Census of India, Bangalore City Municipal Corporations, Bangalore City Bus Transport Corporations, Urban Development Authorities, Bangalore Traffic Police Departments, and other local and national records of the transport and energy sectors in the selected countries and cities),

b. Online surveys that contain 46 questions (of which 11 are on interviewee background) are conducted with land use planners, transport planners and transport operators and residents of the two selected cities: Bangalore and Jakarta. The survey questionnaire has three sections; interviewee background, institutions in the mobility sector (Practices, norms and values), and infrastructure and services in the mobility sector in the two selected cities. After designing the questionnaire, a test sample was send out to contacts in the Netherlands, England, Ethiopia, Nepal, Uganda, Tanzania and Indonesia. Based on the comments from the participants in the sample survey, the questionnaires are updated. The profile of the respondents is given in the table below (for more detailed response data, please see annex 1).

Table 1: Online survey questionnaire respondents profile

	Bangalore	Jakarta		Bangalore	Jakarta
Total number of respondents	52	45	Age		
Planners	10	14	<15	0%	0%
Resident	42	31	15 to 59	94%	100%
Level of education			>59	4%	0%
Primary or below	0%	0%	Do you own a driver's license?		
Middle, Secondary	0%	0%	Yes	90%	80%
Higher Secondary	0%	2%	No	10%	20%
Under Graduate	37%	18%	Do you own a car?		
Post graduate and above	63%	80%	Yes	42%	71%
Gender			No	58%	29%
Male	54%	38%			
Female	46%	62%			

c. Data validation was realized by conducting an in depth interview with a researcher and strategic transport planner who has worked for several years in the transport planning department of the city of Bangalore. We approached Somesh Sharma because he currently resides in the Netherlands and is involved in several ongoing research projects in the city. Somesh Sharma is an urban planner and is currently working in the field of sustainable development and climate change. His main areas of focus are environmental policy, climate change adaptation and mitigation, low-carbon development, and sustainable transportation planning. He has developed travel demand forecasting model, climate change and climate variability assessment model, transport emission estimation model and integrated model for low-carbon and sustainable transport planning.

Chapter 2: Literature Review, Theories and Concepts

> *The world is undergoing the largest wave of urban growth in history; by 2030, five billion of the world's population will reside in cities and 95 percent of that growth will occur in Africa and Asia. This rapid urbanization has resulted in congestion, slow and poor quality mass transit, air pollution, and an urban quality of life degraded by unregulated automobile use. (ITDP, 2010)*

Transport activity is increasing around the world as economies grow. This is especially true in many areas of the developing world where globalization is expanding trade flows, and rising personal incomes are amplifying demand for motorized mobility. Though the car ownership level is still low when compared to cities in developed countries, rapid motorization is creating challenges in cities in developing countries. The challenges faced by cities in developing countries are different from that of cities in developed countries: urbanization is happening much faster and the cost of vehicle ownership is considerably lower.

Although the car-transport system faces persistent problems, discussed in the previous sections, it is obvious that the cracks in the regime are still relatively small. In the last couple of decades, there have been only modest sustainability improvements in the transport sector due to strong lock-in mechanisms, very large and long term investments and deep inertia in the system. The focus of this thesis is to explore enablers of the socio-technical transition in the mobility sector from the current car dominant trend towards a smart mobility system dominated by transit and non-motorized transport. The study will be based on the Multi Level Perspective (MLP) framework that encompasses three functional levels: niche, regime and landscape. The core notion of the MLP framework is that transitions come about through interactions between processes at these three different levels. These interactions are explained by Schot & Geels (2008) as (a) niche innovations build up internal momentum, (b) changes at the landscape level create pressure on the regime; (c) destabilisation of the regime creates windows of opportunity for niche innovations. This will be further elaborated in section 2.2.

This chapter contains reviews of some available literature in the areas of sustainable transport, determinants of transport mode selection and MLP framework and explains concepts and theories in the areas of urbanization, transport and socio-economic transition focusing on enablers and attractors. Factors affecting the transport sector range from global phenomenon (like climate change, oil crisis, economic crisis, economic development, globalization, etc...) to local issues (like urban structure, income, culture, infrastructure, etc...), from component failure (like the prius hybrid components failure, etc...) to technological innovations and development (like the steam engine, internal combustion engine, passenger information systems, smart card, etc...). This chapter analyzes relevant literatures in the field of socio-technical transition studies by focusing on the mobility sector in search of attractors and barriers for transition to sustainable mobility system. In the first section of this chapter we focus on the global phenomenon affecting the transport sector, current trends of development in the transport sector and related factors as urbanization, economic development, policies, spatial patterns and demographic structure of the selected cities. In the second section our focus is on presenting transition theories.

2.1 Automobile ownership and use: Impacts & determinants

A report by the WEC (2011) shows that the global transport sector will face several challenges in the next four decades; the global population will grow to 9.2 billion of which two-third will be living in cities, the number of mega cities will increase from 22 to between 60 and 100, most of the growth in population and in the number of mega cities will happen in developing countries, the number of cars and trucks on the road will be two to three billion, and passenger-kilometer travelled will double.

Though in general, car ownership rises with per capita income within each country, other factors also play significant roles as can be seen with the difference in car ownership of countries at similar per capita income level. It has long been recognized that socio-economic characteristics of individuals, such as gender, age, employment status, income and so on, influence travel choices and patterns. Several literatures address the factors that encourage or discourage personal car ownership and influence mode choice of individuals. These factors include; urbanization, population density, economic development/income, urban structure, travel time, culture and attitude, regulations and policies, institution and governance, level of transit service quality and fare, access to alternative modes. Geels (2001) presents the socio-technical configuration of personal transportation, as shown in Figure 6 below, that represent the various factors that build up the car regime and the barriers that need to be addressed to reverse car ownership trends. The following section discusses factors affecting the mode choice and the travel behavior of individuals.

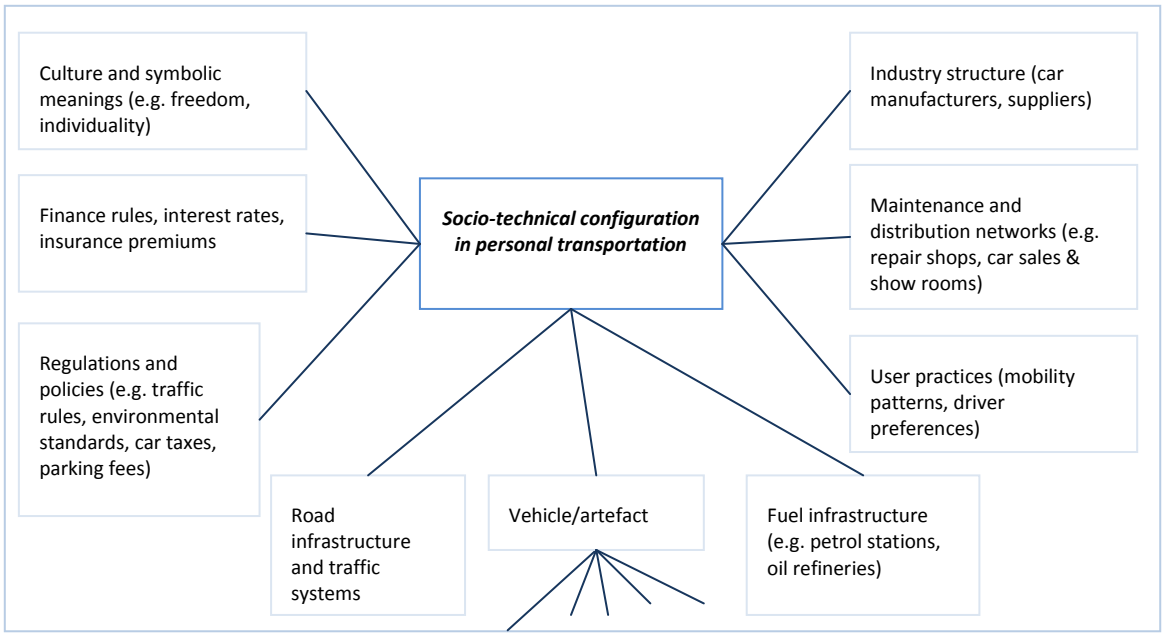


Figure 6: Elements from the socio-technical configuration in personal transportation

Adapted from (Geels, 2001)

2.1.1 Climate change and sustainable development

In this sub-section we will look at climate change and sustainable development challenges to understand the trends in the transport sector and attractors towards sustainable transport system at a global level. Reducing CO_2 emissions is a growing challenge for the transport sector. In 2010, transport energy use amounted to 26% of total world energy use (2,200 million tons of oil equivalent) and the sector was responsible for about 22.3% (6,755.8 million tons) of world CO_2 emissions from fuel combustion (IEA, 2012). Between 1990 and 2006, global transport energy use grew at an average of about 1.8% a year for OECD countries, and about 2.8% for non-OECD countries (IEA, 2009). Looking at the recent trend, between 2000 and 2006, average growth of the energy use by the transport sector was about 1.2% for OECD countries and about 4.3% for non-OECD countries (IEA, 2012). The recent high growth in energy consumption of the transport sector in developing countries is the result of the rapid urbanization, population growth and economic development and is expected to keep increasing.

Motorization is the largest consumer of the world's petroleum supplies, making it central to international concerns over energy security and political stability in volatile regions. The study by Sperling & Clausen (2002) shows that, in most of the developing world, cars use about six times as much energy as buses per passenger-kilometer. And it is an increasingly greater source of greenhouse gas (GHG) emissions contributing to climate change. Emissions from transport, and especially motor vehicles, add considerably to the levels of greenhouse gases in the atmosphere. Worldwide, GHGs are rising faster in transportation than in any other sector, and fastest of all in developing countries (Sperling & Clausen, 2002).

Traditionally, industrialized countries have emitted the large majority of anthropogenic greenhouse gases (GHGs), however, current trends show a world where established economies have large - but declining - carbon emissions, while the new economic giants are growing rapidly. The IEA statistics (IEA, 2012) show that, in 2010, the global CO_2 emission was 44.4% higher than the 1990 level. Transport is a significant contributor to overall GHG emissions accounting for 13% of overall GHG emission and 22% of the total CO_2 emission (ITF, 2009; IEA, 2012). In 2010, the emission from the transport sector was 47% higher than the 1990 level (IEA, 2012). This same report also shows that emissions from the road transport were up by 51.1% in 2010 than the 1990 level (IEA, 2012). The IEA (IEA, 2012) projects that global CO_2 emissions from fossil fuel combustion will increase 45% from 28 Gt in 2006 to 40 Gt in 2030 while 97% of the increase occur in non-OECD countries. Yet, global transport emissions account for one-fifth of the overall increase and are projected to grow by 38% over the same period while 98% of the growth occurring in non-OECD countries (IEA, 2012).

Different motorized transportation modes, automobile, transit, or two-wheelers, have different carbon emissions. In cities with concentrated and distinct urban employment centers, mass transit is generally the most efficient urban transport system, with rail-based systems including subways or elevated rail systems usually outperforming bus systems, in terms of minimizing greenhouse gas emissions per passenger mile (Mehrotra, et al., 2011). According to the IPCC (2007, p. 329), "the world automobile fleet has grown with exceptional rapidity – between 1950 and 1997, the fleet increased from about 50 million vehicle s to 580 million vehicles, five times faster than the growth in population." The report by the Urban ITS Expert Group (2013) indicates that, in Europe, a 1% of modal shift from cars to bikes and public transport accounts for 24 000 tons of CO_2/year.

These trends in CO_2 emissions from fuel combustion illustrate the need for all countries to shape a more sustainable energy future in order to limit the effect of anthropogenic enhanced global warming. The changing climate and the associated effects, like warmer temperature, rising sea levels and more frequent and severe extreme weather events, as well as depletion of natural resources, are increasing pressure on the transport sector. International agreements to reduce global warming to 2°C above pre-industrial level (Kyoto protocol), Copenhagen Accord, other mitigation commitments and voluntary actions will have a significant pressure on the development of the transport sector in the future.

So, we see that the landscape is changing as climate change and sustainable development policies are putting significant pressure on the transport sector. Challenging climate change and achieving the desired future will require more than just technological improvement; a bigger change in the whole system towards sustainability is of crucial importance to sustain the development path.

2.1.2 Urbanization, economic development and population growth

In this sub-section we will address demographic change and economic growth to understand the barriers and opportunities of the current system for the progress towards sustainable transport system. Development increases transport demand, while availability of transport stimulates even more development by allowing trade and economic specialization. As economies grow there will be an increase in demand for passenger and goods transport, similarly, an efficient and well functioning transport system provides economic and social opportunities and benefits that result in positive multipliers effects such as better accessibility to markets, employment and additional investments contributing to the growth of the economy. A country's profound social and economic changes can be simply understood by concentrating on just a single key economic variable, income per capita (or GDP per capita). Obviously, increasing income makes owning and maintaining a car feasible and also increase the opportunity cost of travel time, making faster modes more attractive.

Comparing the IRF's data (IRF, 2006) on passenger cars per 1,000 people with the World Bank's data (The World Bank, 2012) on Per Capita income, we can see that rising incomes are associated with increasing car ownership. The relationship between per capita income and car ownership, discussed in more detail in chapter one, is demonstrated by Figure 7 and Figure 8 below.

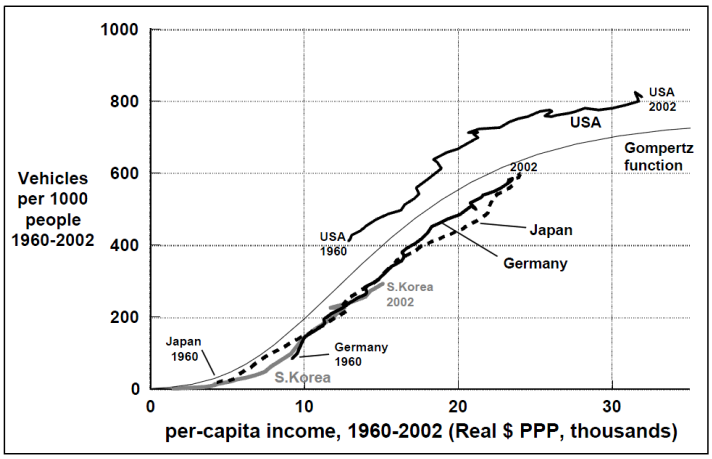


Figure 7: Vehicle Ownership and Per Capita Income for USA, Germany, Japan, and South Korea, with an Illustrative Gompertz Function, 1960-2002

(Dargay, et al., 2007, p. 6, appears in original as figure 1)

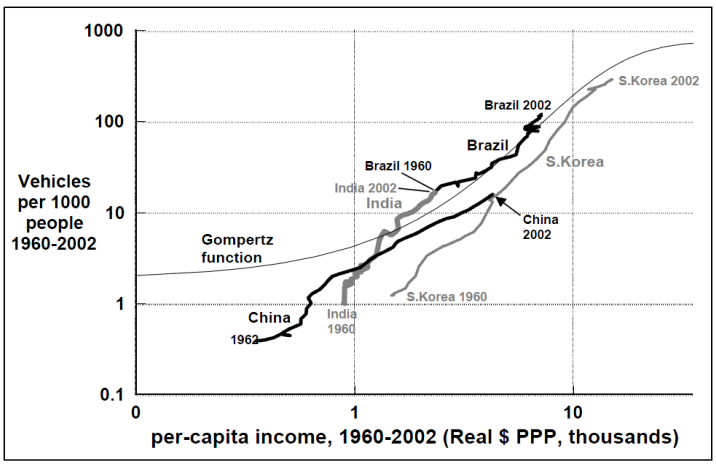


Figure 8: Vehicle Ownership and Per Capita Income for South Korea, Brazil, China, and India, with the Same Illustrative Gompertz Function, 1960-2002

(Dargay, et al., 2007, p. 6, appears in original as figure 2)

The results of a similar study, conducted by IMF (2008), confirm that as more and more households reach income levels that allow them to afford a car, ownership should rise by half billion cars in China and one-third billion

cars in India between now and 2050. As indicated in this research, the relationship between income per capita and car ownership is non-linear where ownership rates are low in the lowest income nations but increase rapidly as per capita incomes grow past the minimum threshold that the study estimated to be around US$5,000 (higher than the US$3,000 given by Dargey, et al., (2007). Several countries are at this level of per capita income and more will follow soon.

According to a report by PWC (2013), by 2050, China, India, Brazil, Russia Mexico and Indonesia will be amongst the top ten largest economies while ranked based on GDP in PPP terms together with the US, Japan, Germany and France. Of course, the emerging economies are expected to grow faster than the established OECD economies. GDP is growing fastest in China by 10.3 per cent per year, India by 9.7 per cent, and Brazil by 7.5 per cent per year, in 2010 (UNEP, 2012; The World Bank, 2013).

Similarly, the urbanization rate is very fast in most developing countries. According to The World Urbanization Prospect (UN, 2012), the Chinese urban population more than doubled from 1990 to 2012; from 302 million to 712 million. This rapid urbanization and rapid expansion of urban built-up area together with the improvement of citizens' standard of living have contributed to the increase in the number of daily trips in most of urban China. Similar trend is happening in majority of developing countries be it in Africa, Asia or Latin America. On the one hand, increasing urbanization opens up the possibility for public transport and can reduce the demand for long distance travel. On the other hand, insufficient public transport opportunities combined with high individual mobility demand will lead to rapid growth in Car ownership fuelling the lock-in.

Growth in mobility demand resulting from urbanization (UN, 2012) *and economic development (Dargay, et al., 2007; IMF, 2008) can be an opportunity to steer the transport system towards sustainable mobility. As income starts to grow fast, many people will soon be able to afford a personal vehicle that could stretch the infrastructure to its limits and beyond and that provides food for thought for most governments. However, higher income will also make high quality public transport affordable for the majority of the population and an opportunity to shape the system towards the desired future for all.*

2.1.3 Urban structure

This sub-section covers the role of urban structure in personal vehicle ownership and the efficiency of the public transport system in cities in order to understand the barriers and opportunities for a sustainable transit system. Urbanization has raised a debate about whether the urban form characteristics affect travel behaviors and the mode choice of individuals. As a result, the search for sustainable urban transport policies has contributed to increasing attention being paid to land use and urban form and how this might help to reduce the need to travel and affect mode choice. The term urban form and land use refers to sidewalks, population density, employment density, parking fees & availability, average commute time, housing density, retail, commercial, service, industrial, employment density, average parcel size, and other pedestrian environment factors. The fact is that, with every change in land use of an area, which could be in terms of intensity and/or type of use, there is a corresponding change in the flow of people and goods to and from the site. Similarly, with every change in flows of people, vehicles and goods along routes adjacent to a site, there is a corresponding change in accessibility to the site and its attractiveness to the present use, or for some other potential use.

While trying to accommodate the rapidly growing urban population; cities have been going through various changes in spatial forms that, mostly, occur at the edges of the city. The location of major-socio-economic activities has also been frequently varying for the last few decades. It is the theory of urban economics that predicts that the length of a trip and its mode choice of different trips for a household depend on the structure of the city which is a function of the population distribution, the employment distribution, its size and its road and transit network (Bento, et al., 2005). Considering the simplest urban model, the mono-centric model, where all employment is concentrated in the CBD and the frequency of work trips is fixed, the commute distance for a household is proportional to its location with respect to the CBD. However, the modification of the mono-centric model allows firms to locate anywhere in the metropolitan area that affected the commute distance by affecting the households' residential and job location choices.

Therefore, the spatial structure of cities has a serious impact not only on the functioning of the labor and consumer market but also on mode choice and sustainability of the transport system. However, cities are growing at different rates and have diverse spatial planning issues according to their unique conditions such as the stage of development, the history of urbanization and policies, and the role in the global society (Murayama, et al., 2006). As indicated by Bertaud (2003), the spatial structure of cities is linked with transit use and motorization, air pollution due to transport, and poverty. Literatures, for example (Adolphson & Snickars, 2003), describe different urban forms as the single nuclear city, the multi nuclear city, the edge city, the corridor city and the dispersed city and their impact on travel and the environment. According to Bertaud (2002)the spatial structure of cities varies from being dominantly mono-centric to being dominantly polycentric. The worlds' large cities transformed from mono-centric structure to polycentric structures as they grow in city size and/or population (ibid). Bertaud (2003) argues that mono-centric cities are favorable to transit provision while the polycentric structure encourages personal automobile ownership. Another aspect is that travel distance will be longer in long and narrow cities than in circular cities with radial networks (Bento, et al., 2005).

The interactions between policy, regulation, physical resources, and private decisions determine urban spatial development, which in turn influences mode choice and frequency of travel. Some aspects of urban structure are highlighted to be important in influencing car ownership by several urban structure-transport relations studies. These variables are summarized as the three D's: Density, Diversity (Land use diversity) and Design (street network design).

Density: Population density refers to the intensity of use of land and it is an important factor affecting mode choice and travel behavior of individuals. Studies , for example (Borrego, et al., 2006), show that high density residential developments result in less dependence on the auto and higher rates of commuting to work by walking or public transportation. While low density and spread-out developments make walking and cycling unattractive due to long distances between trip origins and destinations. In densely populated areas, car travel tends to be slower and less attractive due to traffic congestion, limited parking availability and high parking costs, while it makes public transport provision economical due to the economies of scale. The study by Newman and Kenworthy (1989) clarified that the low density areas under 30 persons/ha generate automobile dependence due to a combination of factors including greater distances to travel and little option to walk or use public transport. On the other hand, though it depends on the type of public transport, for those areas where densities are over 30 persons/ha, the public transport and non-motorized modes are strong travel options. Based on several case studies, the UK department for Transport, Local Government and the Regions gives a benchmark of average densities 100 person/ha and 240 persons/ha for buses and trams respectively (DTLR, 2001). Lo, et al., (2008) analyzed the relationship between urban density and the financial viability of mass transit rail carriers in Hong Kong and concluded that a minimum threshold of 315 people/ha is essential for operating an efficient rail transit system. Newman and Kenworthy (1989) also show that people are willing to walk for an average of 700-800 meter to access public transport. Hess & Oog (2002) conclude in their study 'Traditional neighborhoods and automobile ownership' that:

> *...Households located in dense, mixed land use areas may be able to access many activities by walking or biking to nearby locations, and thus they exhibit a lesser need for autos. Households in areas well-served by transit similarly may be able to access many destinations and services using transit... As a result, the households located in high density areas own fewer cars than those in the low density areas (Hess & Ong, 2002, p. 19).*

Therefore, in general, higher urban densities allow for better public transport services, in terms of coverage, frequency and service quality, which are essential for initiating a positive cycle of attracting more passengers to leave cars and use transit services.

Diversity: Land use diversity refers to the overall mix of land uses (residential, commercial, institutional, recreational, etc). Mixed land uses provide more transport options. A more accessible land use pattern means that less mobility (physical travel) is needed to reach goods, services and activities. Increased land use mix tends to reduce the distances that residents must travel to reach amenities by locating origins and destinations close to each other and allows more use of walking, cycling and transit services. Spears, et al., (2010)conclude that the elasticity of vehicle travel with respect to land use mix is -0.02 to -0.11, which means that each one percent increase in land use mix results in an average vehicle miles travelled decrease in a range from 0.02 to 0.11 percent. Similarly, Ewing & Cervero (2010) found that land use mix reduces vehicle travel and significantly increases walking. On the other hand, increasing transportation accessibility through transit-oriented development (TOD) has the potential to increase the share of trips made by public transport, in addition to influencing car ownership levels. Also, clustering different uses such as shopping, offices and retailing would help to encourage more trips done by walking and public transportation. Such development certainly could decline the level of car ownership and car use. Cervero (1996) found a significant amount of elasticity between built environments and commuting choices in 11 large U.S. Metropolitan areas. The neighborhoods with mixed land uses tended to reduce vehicle ownership rates and were associated with shorter commutes, controlling for socio-economic characteristics. Kockelman (1996) analyzed the travel data in the San Francisco region based on 1990 San Francisco Bay Area Travel Surveys and found that land use balance (entropy) and mix (dissimilarity) do appear to matter; affecting vehicle mile travelled and walk/bike probabilities substantially. Land use diversity is measured by the land use entropy index given by (Manaugh & Kreider, 2013) as:

$\frac{-\sum(A_{ij} ln A_{ij})}{ln N_j}$ Where, A_{ij} is percentage of land use type i in year j and N_j is the number of land uses types in year j

Entropy scores equal one when land use is maximally mixed or heterogeneous and zero when land use is maximally homogeneous.

Design: street network design can also affect travel behavior in several ways. Increased connectivity can reduce vehicle travel by reducing travel distances between destinations and by improving walking and cycling conditions, particularly where paths provide shortcuts. One of the conclusions of the 'New Jersey Long Range Transportation Plan 2030' is that interconnected streets create shorter and more direct transit trips and bring the service closer to riders (DMJM MARRIS/AECOM, 2007). This is because curved streets and multiple cul-de-sacs[2] are often difficult to access with a transit vehicle because of the limited number of access points into the neighborhood, thus, they are inhospitable to the provision of transit service. Furthermore, these streets result in an indirect travel path through the neighborhood leading to longer distances to get from one point to another compared to a trip on a linear street. Grid street system in neighborhoods provides straight and more direct trips resulting in shorter travel time, while at the same time, allowing more effective penetration of residential neighborhoods, thus offering possibility for transit systems to get closer to where people live (DMJM MARRIS/AECOM, 2007). Song & Knaap (2004) give four indicators for measuring connectivity of a neighborhood:

[2] dead-end street with only one inlet/outlet

a. Internal connectivity (IC): This measure shows the ration of the number of street intersections with the total number of node points in a neighborhood.

b. Block perimeter (BP): This measures the average perimeter of the blocks in the neighborhood.

c. Block-Housing ratio (BHR): This measures takes the ration of the number blocks with the total number of housing units in the neighborhood.

The above two measures are taken to show that sprawl gives less connectivity within the neighborhoods relating the internal connectivity with the block perimeter and the number of blocks. However, the two measures could give us opposing results since larger perimeter means less internal connectivity as well as less number of blocks (which indicates higher internal connectivity).

d. Length of cul-de-sac (LC): This measures the average length of the cul-de-sac streets within the neighborhood.

The urban structure of a city, with special attention to the 3 Ds, does influence the mode choice and travel behavior of residents (Borrego, et al., 2006; Newman & Kenworthy, 1989; Hess & Ong, 2002; Ewing & Cervero, 2010; Kockelman, 1996; DMJM MARRIS/AECOM, 2007; Song & Knaap, 2004). *A compact city will allow economical provision of quality public transport service while a sprawled development will lead to dependence on private automobile. Cities should be designed to allow people of all levels of income to have freedom to travel about the city without relying on car ownership, which requires a development of dense city with land use diversity and a Sustainable Urban Mobility System (multi-modal public transport system).*

2.1.4 Culture and attitude

Anable (2005) used the theory of planned behavior (TPB) to predict mode choice to leisure trips to a tourism destination. He tried to meaningfully group travellers in a psychological sense and compared them to empirical observations of travel behavior. The basic concept of the theory is that if alternative behaviors exist, a choice is made amongst them based on the relative strengths of the intentions to perform the behaviors (Bamberga, et al., 2011). According to Curtis & Perkins (2006) the TPB assumes that behavior is guided by behavioral beliefs, normative beliefs and control beliefs. *Behavioral believes* refers to the likely outcomes of behavior and the evaluations of these outcomes that produce favorable or unfavorable attitude towards the behavior, *normative believes* refer to the expectations of others and motivation to comply with these expectations that result in perceived social pressure or social norm, and *control beliefs* refer to the presence of factors that may facilitate or impede performance that give rise to perceived behavioral control.

In addition to these believes covered in TPB, Anable (2005) included additional factors to explain the complex travel behavior: moral norm, environmental attitudes, worldview and knowledge, efficacy, identity and habit. The cluster analysis of the study identified six relatively stable groups, four car-owning and two non-car-owning, presented in the table below. The four car-owning segments display significant differences in the extent to which they exhibit psychological attachment to the car, feel responsible for the environmental effects of their car use and perceive behavioral control over using alternatives to the car. The two non-car-owning segments are also differentiated by these variables while 'actual control' factors in the form of age and income have a significant role in the profile of these groups.

Table 2: Segment profiles

(Anable, 2005, p. 72, Appears in original as Table 3)

Segments	***Characteristics***
Malcontented Motorists	· High moral responsibility to reduce car use · Above average willingness to sacrifice for the environment · Feelings of guilt when the car is used unnecessarily · Fairly high participation in pro-environmental behaviors, though less than the 'Aspiring Environmentalists' and 'Car-less Crusaders' · They need persuasion that reducing their own car use will make much difference, as they believe other people will not reduce theirs (efficacy) · Frustrated with congestion but on balance enjoy car travel- · Express a desire to use alternative modes but they perceive far higher difficulties than all the other groups except the 'Die Hard Driver's, who do not claim to want to reduce car use anyway *This suggests that although they could be willing to reduce car use for altruistic motives and to avoid congestion, they are held back by weak perceptions of behavioral control*
Complacent Car Addicts	· Do not see many problems with using car use, nor the point of reducing it · Not attempting to limit car use for environmental or any other reasons · Low participation in other pro-environmental behaviors · Below average levels of education · Their rejection of alternative modes is less likely than the 'Die Hard Drivers' to stem from a particular love of

Segments	***Characteristics***
	car travel (or a strong dislike of alternatives) - instead, stems from complacency and indifference. · Distinguished from 'Malcontented Motorists' and 'Die Hard Drivers' on perceived behavioral control as they less constraints in terms of time, information acquisition and carrying luggage—accordingly, they are less likely to believe that their lifestyle cannot be adjusted to living without the car. *This suggests the obstacles to using alternatives to the car are less related to perceived behavioral control than a lack of awareness of the environmental implications of behavior and a moral imperative to change*
Die Hard Drivers	· Lowest desire to reduce car use · Highest psychological car dependency · Claim to be more concerned about the negative effects of car use and value nature more for its own sake · But unwilling to sacrifice for the sake of the environment · Feel strongly about an individual's right to use a car · Particularly enjoy car travel and believe that all their car use is necessary · Perceive the highest number of obstacles preventing the use of alternatives, particularly time constraints *This suggests a strong resilience to reducing car use as moral and social norms; attitudes and perceived behavioral control are not in favor of forming intentions to change.*
Aspiring Environmentalists	· Feel the most responsible for environmental problems · Pro-environmental behavior is seen as important and worthwhile · The negative effects of car use enter into the decision making process · Do not enjoy travelling by car · Youngest of all the segments · Although just under half still admit they would find it difficult to give up the car altogether, this is significantly less than the previous 3 groups · The majority (though less than the previous 3 groups) still judge public transport to be problematic · Compared to the 'Car-less Crusaders' it is clear that they feel more restricted by time constraints and other obstacles *This suggests a practical approach to car use. Both moral norms and attitudes contribute to a high propensity to use alternatives. perceived constraints limit choice, but these may be less 'perceived' and more 'real' than other groups*
Car-less Crusaders	· Statistically this group match 'Aspiring Environmentalists' on most measures to do with the environment although they have more romantic views towards the value of nature · Significantly stronger perception of behavioral control than all the other groups · Some indication that individuals in this group are slightly more influenced by personal and social norms *The analysis suggests that this group's tendency to favor alternative modes may be due to a high sense of environmental awareness and concern and fewer perceptions of the difficulties with these modes.*
Reluctant Riders	· Not particularly motivated by environmental issues · Despite moderately high concern for the negative effects of car use, they are more reluctant to sacrifice for the sake of the environment · Participate in fewer 'Green' activities than groups 'Malcontented Motorists', 'Aspiring Environmentalists' and 'Car-less Crusaders' · Less content with the use of alternatives that the other non-car owner group · Although time constraints are not a particular problem, a high number perceive many problems with using public transport—they are the same as 'Complacent Car Addicts', though less than 'Malcontented Motorists' and 'Aspiring Environmentalists' in this respect *This suggests that this group use alternatives less voluntarily than* 'Car-less Crusaders*' as they are not motivated by altruistic motives and perceive many constraints with their use. Their older age profile and lower income point to 'actual' constraints on behavior*

Anable (2005) concludes that the choice of travel mode is largely a reasoned decision related particularly to attitudes and perceived barriers to behavior. The Two segments, the 'Die Hard Drivers' and the 'Complacent Car Addicts', exhibit very high car dependence and low intention to use alternative modes while the two non-car-owning segments, show the opposite trends. What Anable (2005) found most interesting from the point of view of mobility management and influencing current trends are the 'Malcontented Motorists' who exhibit very high car ownership and use but also demonstrate a relatively high intention to change.

As a general rule, argues Anable (2005), stronger intentions to use an alternative mode for day trip travel are related to: more favorable attitudes towards alternative modes, less psychological attachment to the car, stronger moral norms and greater perceived control. Therefore, measures that encourage those who already use alternative modes a little already to use them a little more or to encourage those who express a willingness to reduce car travel to begin to experiment with

alternative modes are more efficient than measures that encourage those people who do not currently use alternatives at all and have no intention of using them.

In summary, travel behavior of individuals is affected by culture and attitude (Anable, 2005)*. The car is not only very attractive for its functional characteristics, such as speed, flexibility and convenience, but also other motives, such as feelings of sensation, power, superiority, and pleasure. The important factors that influence car ownership and use, from the perspective of culture and attitude, include environmental attitudes or ecological norms and values, feelings of responsibility, perceived effectiveness of a transport mode, personal norms, social value orientation and trust in the co-operative behavior of others.*

2.1.5 Regulations and policies

Car ownership and use can be affected at a number of points of influence over individuals and organization and their choices, such as where, how and whether to travel, and which services to provide. A variety of policies have been proposed to address the points of influence in order to decrease automobile ownership and use and guide society towards a sustainable future. Some policy instruments that seek to influence car ownership and use can either directly tackled the automobile itself by restricting sales and ownership as has been the case in Singapore (Eggermond, et al., 2012) or by de-marketing the car as a status symbol and convenient accessory of modern life (Wright & Egan, 2000).

Schuitema, et al., (2007) makes a distinction between push and pull policy measures. *Push measures* are aimed at directly reducing the attractiveness of car use, for example an increase in the costs of car use by increasing fuel taxes. *Pull measures,* on the other hand, are aimed at increasing the attractiveness of alternative transportation modes, and, consequently, at making car use relatively less attractive, for example by decreasing costs for public transport. Hong Kong and Singapore managed to limit car ownership at 77 and 117 passenger cars per 1000 people respectively by implementing various measures to increase the cost of car ownership (The World Bank, 2013). Regulatory, physical and fiscal measures to control car ownership and use include; control and charging of parking spaces, permit schemes that allow access only for designated users or drivers with certain license plate numbers, bus only and high occupancy vehicle lanes, fuel price increases, and road pricing. The result of the study by Schuitema, et al., (2007) on Dutch residents shows that lowering public transport fares (a pull measure) mainly reduced (a small number of) longer car trips. While, an increase in fuel prices (a push measure) mainly resulted in a reduction of short car trips, which were often replaced by trips made by foot or bicycle.

To conclude, a combination of pull and push policy measures are required to increase the effectiveness of policies and overcome any deficiencies in controlling car ownership and use in urban area (Schuitema, et al., 2007; Eggermond, et al., 2012; Wright & Egan, 2000)*s. These measures should also be supported with public transport improvements to attract people from cars, thus reinforcing the benefits of controls on car ownership and use.*

2.1.6 Transit service quality and fare

In order to stimulate transit service use or modal shifts from private automobile to transit services, high service quality of public transport system that is competitive in meeting travelling needs of the user is very important. Transit service quality may be considered as a function of rider comfort, cleanliness and appearance, safety and security, pedestrian environment, amenities, headway, hours of service, parking spaces, reliability, service coverage, transfer and cost (Litman, 2013). A list of transit service quality attributes is given in table 3 below. Generally, according to Ho & Yamamoto (2011), people living in areas with better public transport services tend to use public transport more compared to those living in areas with poorer quality public transport.

Eriksson (2011) carried a study to investigate the determinants that enable car users' to switch to public transport when driving to work. In one of his empirical studies, he conducted a survey with employees of companies located in the centers of a medium-size Swedish city and asked what improvements to public transport services they believe would make them use the services. 76% of the respondents said that shorter travel times, increased service frequencies, and lower fares were the most important reasons for increasing public transport use. According to the study, the longer the distance to work and/or bus stops, the more the participants desired increased frequencies and shorter travel times, but less frequently lower fares (Eriksson, 2011). In his another empirical study, Eriksson (2011) conducted a web-based experimental simulation where 75 university students who commute by car participated. The main result of the study shows that shorter travel times and better access to bus stops led to a higher frequency of bus use. Thus, improvements to public transport services (travel time and accessibility) increase bus use during work commutes, specially, when car use costs are high.

Low quality alternatives for the private car can be barriers to reduction in car use (Ho & Yamamoto, 2011)*. It is clear that reliability, frequency, travel time, and fare level, comfort and cleanliness, as well as security are all important factors in the users' evaluations of the quality of public transport services. However, studies* (Eriksson, 2011; Ho & Yamamoto, 2011) *show that one of the most important service quality attributes is travel time from origin to destination that is affected by average speed of the vehicles, the frequency of service and accessibility of stations. Improving the service quality of the public transport system can be the most practical and central 'pull' measure to reduce car ownership and use.*

Table 3: Transit service quality attributes

(Litman, 2013, p. 11)

Attributes	
·	Availability: when and where transit service is available
·	Coverage: the portion of a geographic area, or the portion of common destinations in a community, located within reasonable distance of transit service
·	Frequency: how many trips are made each hour or day
·	Travel speed: absolute and relative to automobile travel
·	Reliability: how frequently service follows published schedules
·	Integration (ease of transferring within the transit system and with other travel modes).
·	Price structure and payment options
·	comfort and security, including riding on, walking to, and waiting for transit user
·	Accessibility (ease of reaching transit stations and stops, particularly by walking)
·	Universal design (ability to accommodate diverse users including people with disabilities, baggage, inability to understand local languages, etc.)
·	Affordability (user costs relative to their income and other travel options)
·	Information (ease of obtaining information about transit services)
·	Aesthetics (appearance of transit vehicles, stations, waiting areas and documents)
·	Amenity (extra features and services that enhance user comfort and enjoyment)

2.2 Multi Level Perspective (MLP): Socio-technical transition in the mobility sector

"You cannot solve a problem with the same state of mind that created it".

Albert Einstein

Transition in the mobility sector requires more than just innovation and technological fixes; it requires a broader structural change in technology, as well as in institutions. The many problems mentioned in the previous sections are too complex to address within existing institutions. In order to transcend our current way of thinking and escape the lock-in, according to Loorbach (2007), structural changes are needed at the level of our societal systems: transitions. Loorbach (2007) defined transition as:

> *Transitions are transformation processes in which existing structures, institutions, culture and practices are broken down and new ones are established (Loorbach, 2007, p. 17).*

Transportation in urban areas is highly complex because of the modes involved, the multitude of origins and destinations, the amount and variety of traffic, the number and variety of actors involved, and the number and variety of institutions involved. From a complex systems theory point of view, argues Rotmans, transitions could be considered as system transformations from slow equilibrium dynamics to quick development and instability, reverting to relative stability (Rotmans, 1994). This way transitions are generally recognized as fundamental changes to a more sustainable configuration of a socio-technical regime.This concern was also shared by Geels, et al., (2012):

> *The way forward therefore involves not only technological solutions, but also the development of fresh perspectives that offer novel ways of understanding how society as a whole can make transport transitions that encompass more radical change in mobility behavior, spatial planning, traffic management and infrastructure. (Geels, et al., 2012, p. 4)*

Transitions involve several factors, several actors and different levels and can only be understood in terms of co-evolutionary processes amongst markets, infrastructure networks, institutions, technologies, policies, and cultures which link up these actors, factors and levels. According to Elzen (2003), transition displays the following attributes:

> *Multi-actor: They will involve a wide range of actors, including firms, consumers, NGOs, knowledge producers and governments;*
>
> *Multi-factor: They are not caused by a change in a single factor but are the result of the interplay of many factors that influence each other. They are a combination of technical, regulatory, societal, and behavioral change.*
>
> *Multi-level: They imply change at various levels: at the micro-level of individual actions, at the meso-level of structuring paradigms and rules (regimes or systems) and at the macro-level comprising wider societal and cultural characteristics and trends such as individualisation and globalization (Elzen, 2003, p. 7)*

The dynamics of the transition process can be explained by the multi-phase concept. Transitions are not linear processes that result in a system change over four consecutive phases (Loorbach, 2007). These phases are represented by an S-shaped-curve shown in Figure 9 below. The nature and speed of change differ in each of the transition stages (Loorbach, 2007):

- A Pre-development phase, where there is very little visible change on the status quo but there is a lot of experimentation
- A take-off phase, where the process of change gets under way and the state of the system begins to shift.
- An acceleration phase, where structural changes take place in a visible way through an accumulation of socio-cultural, economic, ecological and institutional changes that react to each other; during this phase, there are collective learning processes, diffusion and embedding processes.
- A stabilization phase, where the speed of societal change decreases and a new dynamic equilibrium is reached.

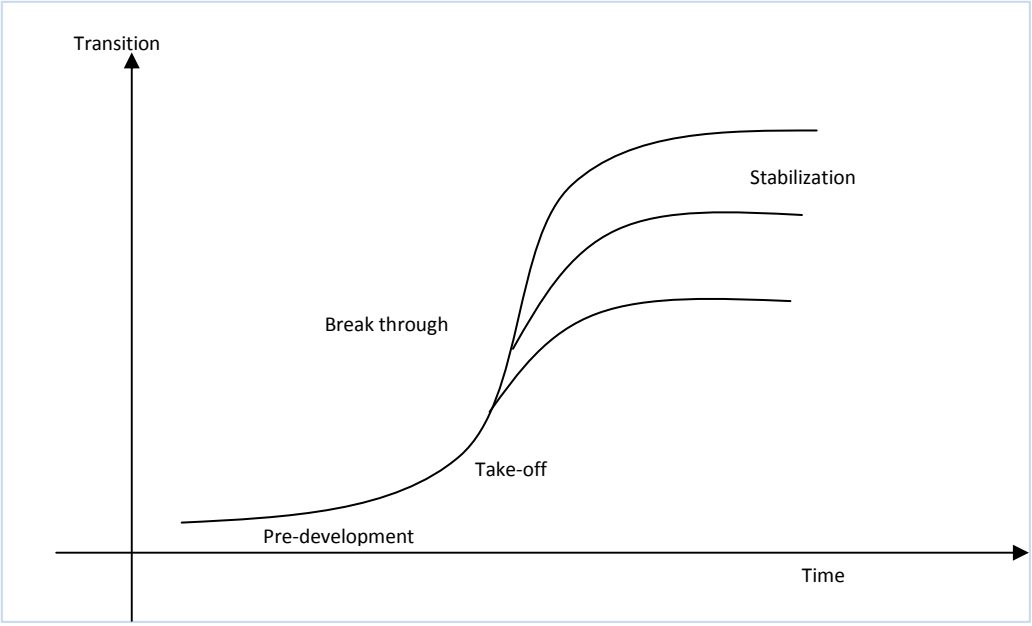


Figure 9: Four phases of transition

(Van der Brugge, et al., 2005, p. 166, appears in original as Figure 2)

The different phases in transitions shown in the figure above are caused by multiple changes at different levels ranging from global phenomenon to individual preferences and involve interactions between technology and society. It has already been studied that social processes shape development and use of technology; while on the other hand, technology open up possibilities for new social practices (Smith & Stirling, 2008; Russell & Williams, 2002).

Frantzeskaki (2011) identifies three paradigms in the theoretical approaches and frameworks to socio-technological transitions. These are; Technological determinism (technology drives societal change), Institutional determinism (institutional change precedes and conditions technological change), and Social determinism (societal needs and demands drive technological change) (Frantzeskaki, 2011, p. 134). According to the *technological determinism* theory, technology is an autonomous force that changes society, and argues that technology provides explanations for many changes that can be observed in society (ibid). Though, technology has important effects on our daily lives, as can be seen, for example, the internet revolutionizing the economy and society, the theory ignores the complex social network that supports the technology. *Institutional determinism* puts changes in institutions at the forefront of technological innovation and consequent technological changes (Frantzeskaki, 2011). According to this theory, technological change is assumed to be primarily motivated by a desire to conform to institutional pressures and stresses that institutional innovation is more important than technical innovation. *Social determinism*, on the other hand, is the converse of technological determinism and argues that society is an autonomous force that changes technology. According to the theory, society provides explanations for many changes that can be observed in technology ignoring some of significant technical aspects of the complex socio-technical system (ibid).

Recent technology innovation and transition studies use the concept of co–evolution to analyze socio–technical transformation and transition processes (Geels, et al., 2012; Geels, 2001; Hekkert, et al., 2006; Geerlings, et al., 2012). Most of these studies emphasize the crucial role of the interaction between various levels of actors, factors and institutions in the socio-technical system. This way, the different forces that are considered critical in the three deterministic paradigms are brought together in an inter-related inter-disciplinary dynamics. Geels (2007) argues that, the innovation process is an interactive, co–evolutionary Multi-level process, involving technological artefacts, individual actors, organizations, sectoral institutions, and finally, socio–technical regimes. The name of the theory/framework, multi-level perspective (MLP), refers to the distinction that the perspective makes between several scale levels.

Similarly, in this study we will employ the Multi-level Perspective (MLP) framework on technological transitions to explain what leads to the lock-in and which type of niche-regime interactions are in place in the form of drivers and barriers that may result in a lock-in in the car regime or contribute to the transition of the mobility system from the current state of low-mobility to a sustainable mobility system in the future. MLP's analytic understanding of the processes of transition is premised on three levels: (1) the *micro-level* contains niches referring to protected spaces that are pockets of innovation where individual actors, technologies and local practices are acting on, (2) operating at the *meso-level* are the socio-technical regimes that refer to social norms, interests, rules and belief systems built around the dominant system and (3) *macro-level* covers the socio-technical landscape that form a broad external environment which is beyond the direct influence of regime and niche but is determined by slow changes in society. The framework of the theory is shown in Figure 10 below.

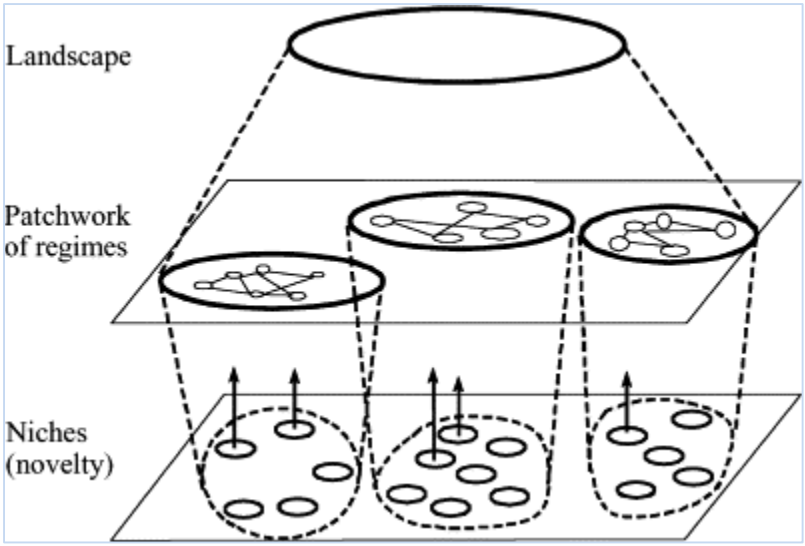


Figure 10: Multi Level perspective (MLP) Framework

(Geels, 2001, p. 8, appears in original as Figure 3)

Landscape connotes the broader 'conditions', 'environment', and 'pressures' for influencing transitions to new socio-technological system which is beyond the direct influence of regime and niche (Sarangi & Mishra, 2011). It consist of heterogeneous, slow changing factors such as cultural and normative values, broad political coalitions, long term economic developments, macro-economic trends, land use, environmental problems, population growth, emigration etc. For example, cars are culturally valued rather than simply functionally important. In most cultures, especially where the ownership level is low, cars are the most powerful and pervasive status symbol, a way of displaying success in society. So people own cars partly out of desire for identity and social status that form part of the landscape in the car system.

The socio-technical landscapes are often shaped by shocks and surprises like war, economic crisis, sudden rise in oil prices, climatic eruptions etc. Geels & Schot (2007) define landscape as follows;

> *"The socio-technical landscape is a broad context that sustains action and makes more actions easier than others. These external landscape developments do not mechanically impact niches and regimes, but need to be perceived and translated by actors to exert influence") (Geels & Schot, 2007, p. 404).*

The **regimes** are at the meso-level and denote an existing socio-technical system that is embedded in society; they are the infrastructures, the policies, rules and regulation, and social norms that are in place. According to Foxon et al., (2010), the regime 'reflects the prevailing set of routines or practices that 'actors' and institutions use and that create and reinforce a particular technological system; these practices include: "engineering practices; production process technologies; product characteristics, skills and procedures embedded in institutions and infrastructures' (Foxon, et al., 2010, p. 3). Institutions are the general rules that structure social interaction; formal and informal. Marletto (2011) defines a regime as a structured agency with three inter-related dimensions; technology, institution and market. These three structural dimensions can be considered as sub-regimes which are linked by a co-evolutionary process, because each of the dimensions has its internal dynamics and a relative autonomy (Marletto, 2011). The car system is currently the dominant mobility system in most cities which encompasses personal automobile, fuel, service stations, streets and other infrastructure, traffic rules and regulations and preferences like flexibility and freedom. The system also involves diverse and powerful actors like car manufacturers and other related industries, oil companies, various ministries, car owners, associations, etc (Marletto, 2011).

At the micro-level are **niches** where innovations occur; these are spaces protected from normal market selection and provide a relatively risk-free incubation space (Geels, 2002). The protected environment enables actors to develop and apply an innovation without immediate or direct pressure from existing regimes. Niches can also be defined as a new and relatively instable set of rules and institutions for innovative practices (Raven, et al., 2010). This new technology/system competes with the dominant technology/system of the existing regime and can eventually replace it. Niches are usually a positive phenomenon as counterpart for the regime representing radical change, improvement and better future. Niches in the transport system, amongst others, include alternative fuel technology, green propulsion technology for cars, intelligent transport systems (ITS), car-sharing, public transport and inter-modal travel (Geels & Kemp, 2010). Table 2 below briefly summarizes the main characteristics of and differences between the three levels of the MLP. The table is adapted from (Pierick & Mil, 2009, p. 59, appears in original as Figure 3.4) and modified based on our literature review on transition in socio-technical regimes.

Table 4: Sociological characteristics of niche, regime and landscape level

(Pierick & Mil, 2009; Geels, 2001)

	Niches	**Regime**	**Landscape**
Rules	fluid, broad, diffuse, in the making	Specific, negotiable, can be adjusted based on new insights	Deeply embedded structural trends, widely supported norms, values, cultural beliefs, symbols
Stability of rules	Hardly stable, unstable	Dynamic, stable, well articulated	Very stable, broadly embedded
Linkage & alignment	'loose coupling', Small, precarious networks	'strong coupling', large social networks	Deeply embedded, very strong
Co-ordination	Barely	Strong	Deeply embedded, very strong
Possibility for change	Optimal	Possible, requires a lot of effort	Very difficult, changes are (short term) exogenous, regime & niche actors have no or hardly any influence

The interconnectedness of the three levels creates a nested character where regimes are embedded within landscapes, and niches within regimes. According to MLP, breakthroughs in the niche innovations is basically guided by the landscapes changes which create pressure on the existing regimes and offer windows of opportunity for innovations occurring at the niche to break through and enter into the regime. Pressure might come from several directions; a change in the cultural values, ideologies, political co-coalitions, etc (Sarangi & Mishra, 2011). Some internal (technical) problems in the existing regime can also contribute in creating opportunities for novelties, and, often negative externalities also create pressure on the regime. Changing user preferences often results in tensions within the regime technology/system when established technologies have difficulties in meeting them. The landscape pressure will give chance for the niches to lobby for support and acknowledgment which, if successful, will put pressure on policy makers to design policies to the advantage of the new technology (or system, depending on the demarcation). These new technologies (or system, depending on the demarcation) created in the niche will then be eventually used in the regime or even replace it. However, this process requires (a) the creation of niches and (b) creating linkages to overcome the existing regime and its path dependencies by smartly connecting the dynamics at all three levels.

To conclude, the MLP distinguishes three inter-related analytical levels - the landscape, regime and niche levels- each with its own internal dynamics (Geels, 2001). The theory is the result of an attempt to gain more insight into large scale socio-technological transition and how and why these happen. According to the theory, incumbent socio-technical systems are often stabilized by existing infrastructure, institutions, and actors, for example, culture, utilities, favorable legislation, etc (Foxon, 2002; Marletto, 2011). The transformation to a sustainable mobility system is thus likely to involve not only technological changes, but also changes in user practices, regulations, industrial networks, infrastructure and cultural meaning. The transition happens as the interaction process at the regime and landscape levels create a 'window of opportunity' for new technologies/mobility systems to break out of niches (Sarangi & Mishra, 2011). This will result in changes or modifications of regulation, infrastructure, symbolic meaning, and social networks in the car regime.

2.3 Summary

From the previous two sections, an analytic framework that determines the variables of interest and survey instrument is developed as shown in figure 11 below. The high rate of population growth, unprecedented rate of urbanization and rapid economic development has negative consequences on the climate. As a result, the landscape of the transport system will be affected through pressure from climate change as will be translated in to sustainable development agendas at global, national and local levels which will then, amongst others, be included in transport and land use policies of national and local governments. The system will also be altered as the result of local phenomenon like population growth, urbanization, economic development, urban structure change, infrastructure development, and institutional change. Figure 11 below summarizes the factors in the mobility sector that are strengthening the car regime as discussed in the literature review.

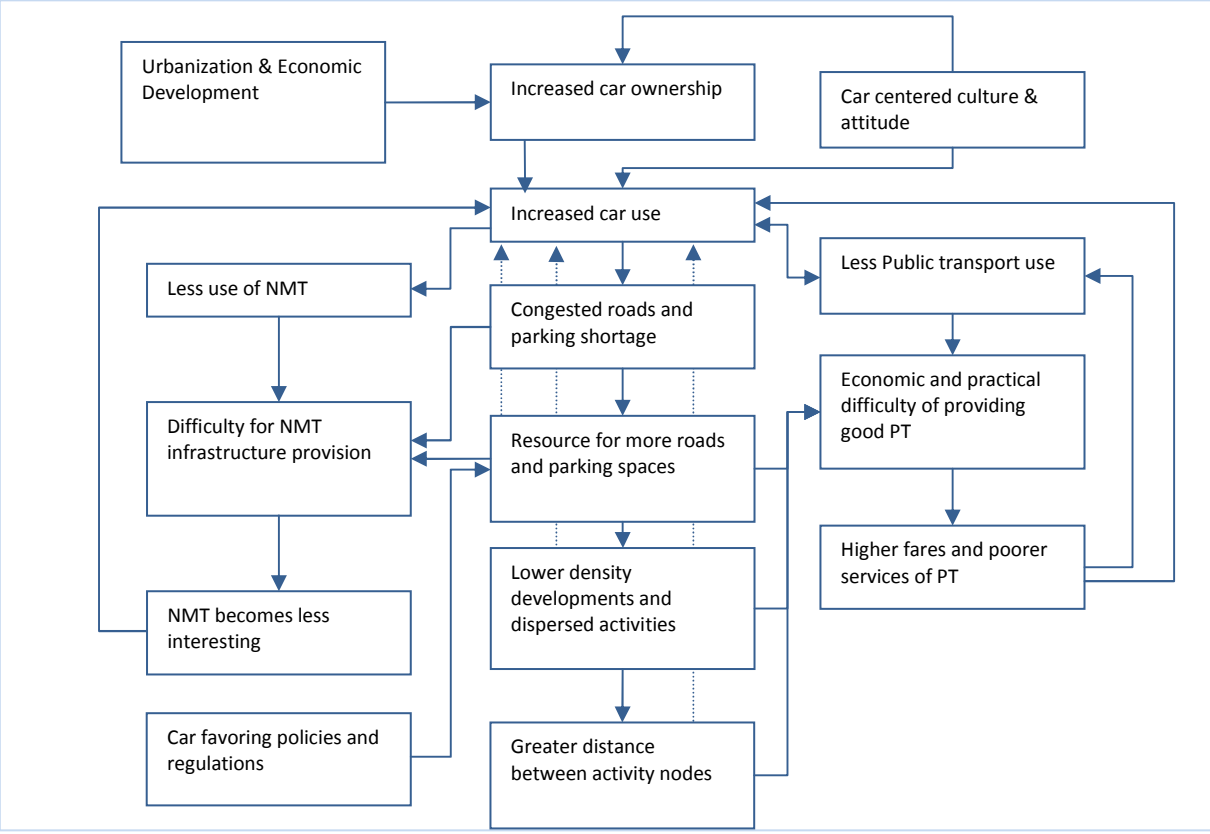


Figure 11: Factors in the vicious circle of the car regime

Most of the factors identified in the literature as determinants of the (current) mobility system are similar to the once indicated by Geels (2001) as elements of the socio-technical configuration in personal transportation in figure 6. Depending on the magnitude and direction of the cumulative change in the mobility system, a city will either develop to be automobile dependent or provide sustainable urban mobility solutions that include high quality multi-modal transit system and non-motorized transport options. This interaction is demonstrated in figure 12 below.

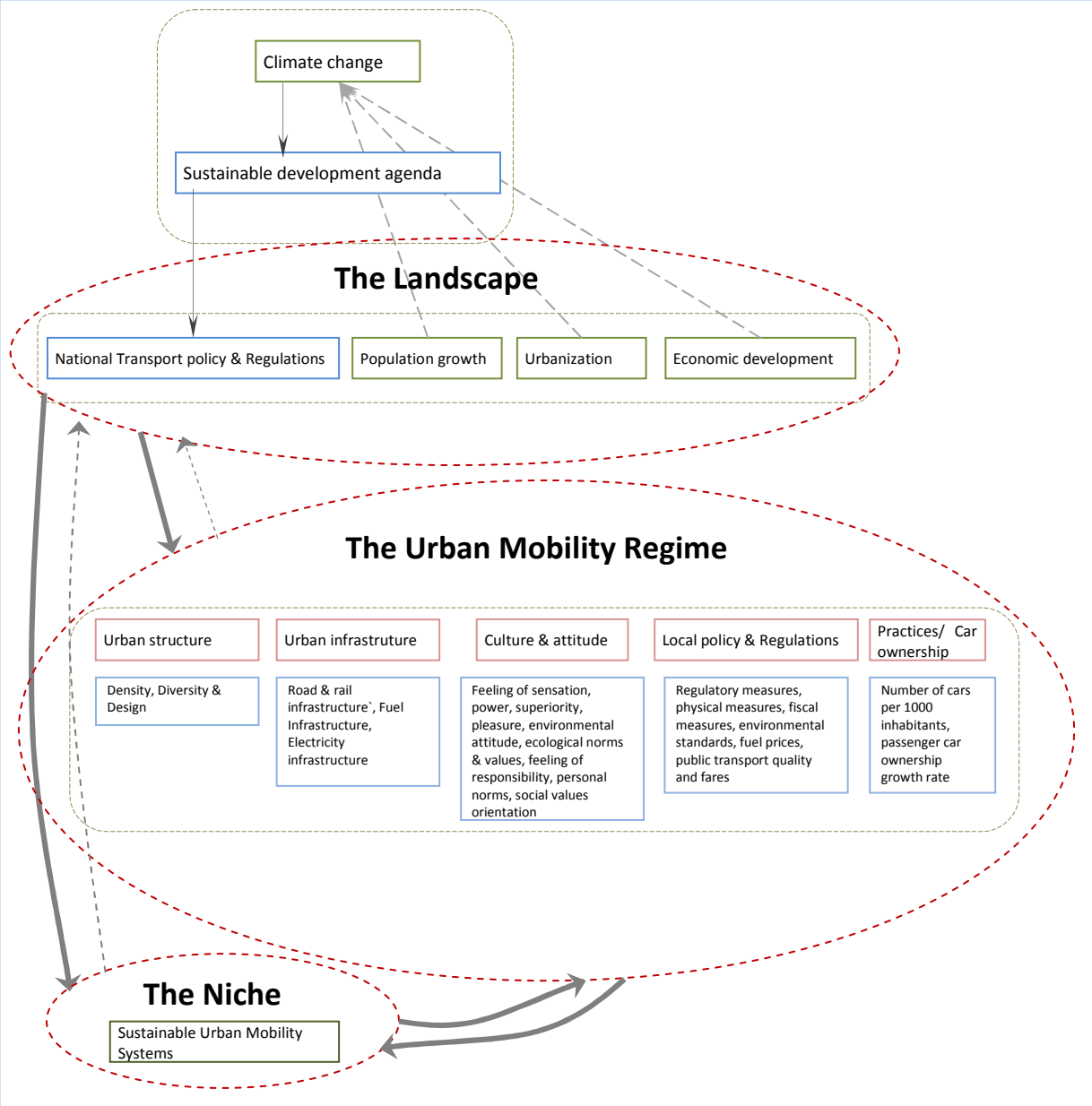


Figure 12: Analytical framework of the research

Chapter 3: Research scope

Many societies are built around the car. The sunk investments and the scale of the required investment for alternative options create path dependence and lead to the lock-in in the car system. The car regime has continued to develop and strengthen over the years despite the call for sustainable transport modes as the existence of lock-in phenomena together with the ability of the actors involved to resist to change. In order to reverse this situation, we need to address elements that made the regime very stable and elements that made alternative options less attractive. In chapter 2 we have looked at the factors affecting the transport mode choice and travel behavior of individuals as well as the MLP theory for socio-technical transition. In general, we can understand that there are some regular patterns in the growth of personal mobility in several cities worldwide. These patterns comprise of some essential factors that can be categorized in to the three levels addressed by the MLP theory as shown in the table below. It is these factors that represent the set of strengths and weaknesses of the existing regime that need to be addressed to change the course, as well as barriers and opportunities for transition to sustainable mobility.

Table 5: MLP and the mobility sector

Landscape	Climate change, the need for sustainable development, population growth, urbanization, economic growth, culture, attitude
Regime	Urban structure (density, diversity, design), regulations and policies, institutions, Infrastructure
Niches	Sustainable Urban Mobility Systems (SUMS)

So far we have seen that most cities went through the process of rapid car ownership with income growth. However, it is possible to learn lessons from the very few successful cities that manage to leapfrog from low-mobility to sustainable mobility systems while going through a rapid urbanization and income growth and avoid the path to car dependence. Singapore is one of the most successful cities to control car ownership at a very low level with respect to the income per capita of residents. The GNI per capita PPP of Singapore amounts to USD 59,380 in 2011 (current USD) which makes it one of the most wealthy countries in (Southeast) Asia. As of 2010, the car ownership stands at 117 passenger cars per 1000 people. While San Marino with GNI per capita PPP of USD 36,200 has car ownership of 1139 passenger cars per 1000 people, the United States has car ownership of 627 passenger cars per 1000 people with GNI per capita PPP of USD 48,820, Italy with GNI per capita PPP of USD 32,400 has 602 passenger cars per 1000 people (The World Bank, 2013). The success of Singapore is the result of policies and regulations discouraging car ownership together with policies that facilitate efficient public transport system. According to Eggermond, et al., (2012), a set of policies has been devised to decrease the attractiveness of purchasing a car by increasing the up-front costs. These policies include vehicle growth cap at 3% under the Vehicle Quota System (VQS), a registration fee of flat rate for all cars, an Additional Registration Fee (ARF) of 100% the open market value (OMV) of the vehicle, an excise duty of 20% of the OMV and a 7% Goods and Services Tax. In addition, the prospective car owner has to bid for a Certificate of Entitlement (COE) under the VQS with a validity of 10 years and pay for an annual road tax based on the engine capacity. Furthermore, car use is discouraged by toll fees through Electronic Road Pricing (ERP) (Eggermond, et al., 2012). In addition to these measures to reduce vehicle ownership, the government is also committed to enhance the capacity of the public transport system that consists of a heavy rail system (mass rapid transit or MRT), a light rail system (light rapid transit or LRT), public buses and taxis. Measures to enhance the capacity of the public transport system include; large investments in the Mass Rapid Transit (MRT) to increase the rail network to improve accessibility, improvements in the bus services by providing higher capacity buses and additional bus trips, buses get greater priority on the road, close Co-operation with bus operators to increase the bus fleet, and improve connectivity of the network (NCCS, 2012).

Key Levers to Manage Private Transport Demand

Vehicle Ownership: The Vehicle Quota System (VQS) was implemented in May 1990 to control the vehicle population by limiting the maximum number of new vehicles registered in Singapore each year. Those wanting to register a new vehicle would need to bid for a Certificate of Entitlement (COE), which entitles the person to own and use the vehicle for 10 years. The COE quota is calculated based on the vehicle population that is assessed to be sustainable in the long term. Under the VQS, Singapore limited its annual vehicle growth rate to 3% between 1990 and 2008, and progressively reduced this rate to 1.5% (2009 to 2011), 1% (2012) and 0.5% (2013 onwards).

Vehicle Usage: Whilst VQS manages vehicle population, the Electronic Road Pricing (ERP) manages usage by levying a charge on vehicles using congested portions of roads, thereby encouraging motorists to either use alternative routes, travel at a different time, or switch to public transport. In addition, a fuel excise duty of S$0.41 to S$0.44 per liter of petrol is levied, depending on the fuel grade.

Box 1: Key Levers to Manage Private Transport Demand in Singapore

(NCCS, 2012)

Though, it was in the 1970s that Singapore started to practice imposing heavy taxes on car ownership, the VQS was implemented in 1990 (see Box 1) when the GDP per capita was 12,874 USD (UNSD, 2013). The GDP per capita was a bit higher than the range estimated by various studies as the threshold income level where car ownership grows fastest (discussed in chapter 1). However, since in the 1990's the cost of car ownership was higher than that of now, we can conclude that it was a critical period in the transport sector in Singapore.

Therefore, the factors that determine mode choice and travel patterns discussed in chapter 2 together with the research objective provide us with the selection criteria for the focus country as well as the focus cities.

3.1 Selection criteria

As already discuss in the problem definition, the risk of car lock-in is significant in countries with high rate of urbanization, high level of economic growth and GDP per capita income between 3000 USD and 10,000 USD. Our selection criteria for the countries of focus are:

a. The country is an Emerging Market as classified by the International Monetary Fund
b. The country has a GDP per capita PPP of between USD 3000 and USD 10,000
c. The country has a rapid economic growth (GDP growth rate greater than the Global average, i.e. 3.9% in 2011 (IMF, 2013))
d. The country has a rapidly growing middle-class
e. The country has urbanization level lower than the global average (i.e. 52%) and rate of urbanization higher than the global average (i.e. 1.9%) (UN Population Division, 2011)

We identified six countries, as the first step for the selection of countries for the study. The rationale behind this filtering is to capture countries that are representative of the future of most developing countries between now and 2050, hence, countries with rapid economic development and high urbanization rate. Five of these countries are the group of emerging economies known as BRICS; Brazil, Russian Federation, India, China and South Africa. The other country is Indonesia, which is the third most populous developing country next to only China and India. Indonesia is classified as an Emerging Market and it is one of the two developing countries in the list of the 15 largest economies in the world that do not belong to BRICS. The other one is Mexico, but since Mexico's GDP per capita is 15,177 USD, it is not included in the comparison.

Table 6: Evaluation of selected group of countries for the study

Criteria			***Observations***					
			Brazil	***Russia***	***India***	***China***	***South Africa***	***Indonesia***
Variables	Economic classification		Developing	Developing	Developing	Developing	Developing	Developing
	Population (in millions)		194	143	1,210	1,354	52	238
	Urbanization level		84.6	73.8	31.3	50.6	62.0	50.7
	Urbanization rate		1.80	-0.20	2.40	2.70	1.40	3.30
	GDP per capita PPP terms		11,640	21,246	3,627	8,400	10,960	4,636
	GDP growth rate		1.30	3.60	5.40	7.80	2.60	6.00
	Size of the Middle-class (% of total population)		40.00	30.00	10.00	30.00	19.8	10.00
	The size of the middle-class[3] in 2050		60.00	60.00	50.00	50.00	N/A	50.00
	Other factors	Transport data availability and accessibility	Available	Limited	Available	Available	Available	Available
		Language		Limited information in English		Limited information in English		

Data sources (unless specified otherwise, all the data are from 2011):

[3] The World Bank (2013) defines the middle-class as: lower middle income, $1,026 - $4,035; upper middle income, $4,036 - $12,475

Brazil: (SECOM, 2010; Future Challenges, 2012; Ward & Neumann, 2012; IRF, 2009; The World Bank, 2013; UNSD, 2013)

Russia: (Bloomberg, 2012; Ward & Neumann, 2012; IRF, 2009; The World Bank, 2013; UNSD, 2013)

India, China, South Africa & Indonesia: (Ward & Neumann, 2012; IRF, 2009; PWC, 2013; The World Bank, 2013; UNSD, 2013)

	Urbanization level (10%)	**Urbanization rate (20%)**	**GDP per capita PPP terms (10%)**	**GDP growth rate (20%)**	**Size of the Middle-class (% of total population)(10%)**	**The size of the middle-class in 2050 (10%)**	**Other factors (Data availability, language, contact), etc (20%)**	**Aggregate**	**Rank**
Brazil	0.000	0.114	0.055	0.000	0.100	0.100	0.067	0.435	4
Russia	0.020	0.000	0.000	0.071	0.067	0.100	0.000	0.258	6
India	0.100	0.149	0.100	0.126	0.000	0.083	0.200	0.758	2
China	0.064	0.166	0.073	0.200	0.067	0.083	0.067	0.719	3
South Africa	0.042	0.091	0.058	0.040	0.033	0.000	0.133	0.398	5
Indonesia	0.064	0.200	0.094	0.145	0.000	0.083	0.200	0.786	1

Normalized X = (X - Min(x)) / (Max(x) - Min(x)) for Urbanization rate, GDP per capita, GDP growth rate, the size of the middle-class in 2050, other factors that include transport data availability, language barriers and ease of establishing contact.

Normalized X= (Max(x)-X)/ (Max(x)-Min(x)) for Urbanization level, and current size of the middle-class

Note: Min(x) and Max(x) are, respectively, the lowest and highest values for any given indicator and the weight of the indicator is given in brackets.

The focus of this study is limited to India and Indonesia due to time constraints and the significant effort required to collect, compile, and verify the quality of the required data. India is selected because, as part of the BRICS economy, the rate of the economic growth in India is representative of the future trend of development in other developing countries. Similarly, Indonesia, the third populous country in the developing world, is increasingly central to global production and consumption with a high economic growth rate. The selection of India (in South Asia with more than 80% of the population following Hinduism) and Indonesia (South-east Asia with more than 87% of the population being Muslim) will also provide diversity due to the different cultural values between the two countries. South Africa (GDP of USD 11,100 PPP), Brazil (GDP of USD 11,900 PPP) and Russia (GDP of USD 17,000 PPP) are not included because their per capita income level is higher than the range where car ownership grows fastest as identified by the study. China, on the other hand, is not included because of language barriers for interviews and lack of entry contacts which we used as screening criteria.

In 2011, only 31.3% of India's population lived in urban areas. But with the current annual urbanization rate of 2.4%, which is the highest in BRICS countries, it is expected to grow to 55.2% in 2050 (UN Population Division, 2011). A report by McKinsey Global Institute (2007) shows that India will become the world 5th largest consumer market by 2025, just behind the USA, Japan, China and UK, as the middle-class swell from the current 50 million to 583 million. The rapid growth in population combined with high growth in GDP per capita of 6.9% (in 2011) resulted in the growth of the consumer market (The World Bank, 2013).

Similarly, Indonesia's experienced rapid urban population growth in the past few decades where the urban population grew from 12% in 1950 to 50.7% in 2011 and will further grow to 79.6% in 2050 (UN Population Division, 2011). The population of Indonesia will also grow by 46% to 313 million in 2050 from the current 214 million. This population growth is accompanied by the growth of the middle-class that will account for 50% of the total population in 2050 from the current skimpy 10%. These, together with annual GDP growth of 6.5%, make Indonesia an interesting case for this study.

The focus needs to be further narrowed to a city or cities in the selected countries for in depth study of enablers of transition to sustainable mode in the mobility sector. The selection criteria for the focus city are:

a. The city plays an important role in the economic development of the country (measured as the proportion of the contribution to the national GDP and level of economic growth)
b. The Car ownership in the city is not saturated (the minimum saturation level estimated by Dargay, et al., (2007) is 508 cars per 1000 people)
c. The city has a rapid growing population (urban population growth rate faster than the average national growth rate, i.e. 2.5% (The World Bank, 2013) for both India and Indonesia in 2011)

India: in India, there are several cities that are very populous and contribute significantly to the economic development of the nation. The first step is to narrow the number of candidate cities to a manageable number, in this case four. For this

purpose, we identified the top four Indian cities in the Global City Competitiveness Index 2012 which ranks the competitiveness of 120 of the world's major cities and applied the previously developed criteria to select our focus city for the in depth study. The index is an aggregate measure of Economic strength, Institutional effectiveness, Financial Maturity, Physical capital, Human capital, Environment and natural hazards, Global appeal and Social and cultural character of the city (Economist Intelligence Unit, 2012). This index is very close to our designed criteria because the economic importance of the city is addressed by economic strength and financial maturity, while the population aspect is addressed by the physical and human capital measures in the index. Moreover, the index addresses environmental and social and cultural aspects of the city. The four Indian cities that made it to the index are: Delhi, Mumbai, Ahmedabad, and Bangalore. We first decided to narrow the selection to the top three Indian cities in the Global City Competitiveness Index 2012, but later included the fourth as advised by an Indian researcher who said that Bangalore might be an interesting case amid its rapidly growing population and fast growth in passenger car ownership.

Table 7: The Global City Competitiveness Index 2012 Indonesian Cities

(World Economic Forum, 2012)

Criteria	Delhi	Mumbai	Ahmedabad	Bangalore
Economic strength	42.4	42.4	45.3	45.9
Institutional effectiveness	52	52	52	50.1
Financial Maturity	33.3	50	16.7	33.3
Physical capital	64.3	58	53.6	47.3
Human capital	64.8	60.4	57.3	57.9
Environment and natural hazards	58.3	50	66.7	87.5
Global appeal	12	8	1.4	1.7
Social and cultural character	50.8	58.3	28.3	40.8
Overall score	46.7	46.6	41.9	44.6

After the preliminary selection of the four Indian cities, we applied the selection criteria mention previously. Mumbai is the most populous city in India, closely followed by Delhi. Bangalore has roughly two-third of the population of Mumbai, while Ahmedabad is home for almost half the population of Delhi. Bangalore has the highest rate of population growth amongst all four cities, followed by Ahmedabad in second place and Delhi in third, while the lowest population growth rate is in Mumbai. The largest share of the GDP of the country comes from Delhi, which is the largest city in terms of land area, contributing 14% of the national GDP and has the highest car ownership level in the country. The attributes of the cities is shown in the table 7 below.

Table 8: Evaluation of selected Indian cities

	Delhi	Mumbai	Ahmedabad	Bangalore
Population	16,314,838	18,414,288	6,352,254	8,499,399
GDP PPP Billion USD (2012)	211.3	125	64	83
Contribution to the national GDP % (City GDP to National GDP ratio 2012)	14.04	8.30	3.45	4.58
Economic growth rate in 2011 (% per year)	9.9	8.5	10.1	10.3
Car ownership level in the city (cars per 1000 people)	117	24	55	103
Urban population growth rate (% per year)	1.9	1.4	4.1	4.9

Source: (Das, et al., 2010; Pai, 2007; Census of India, 2011; Government of Karnataka transport department, 2011; Asian Enterprise, 2010; Government of NCT of Delhi, 2012; Census Organization of India, 2011)

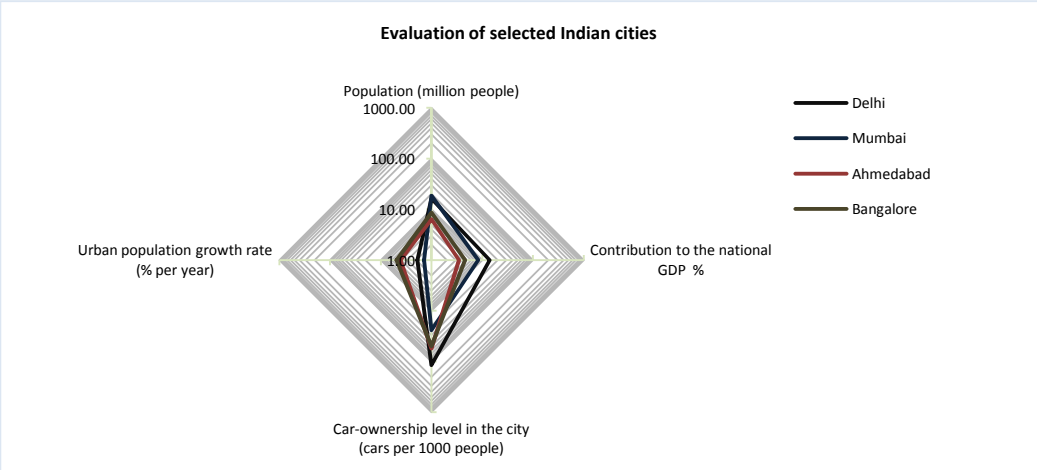


Figure 13: Evaluation of selected Indian cities (in log scale)

According to the Government of Karnataka transport department (Bangalore is the capital of the state of Karnataka), the number of passenger cars in Bangalore grew from 180000 in 2000 to 710000 in 2010 with an average annual growth rate of 13% following the rapid population growth resulting from the expansion of the IT and other associated industries in the city (the city is also known as 'Silicon Valley of India'). The relatively high population growth of Bangalore means that the city adds more population every year than any other city in India. Population growth in Delhi and Mumbai is lower than the average population growth rate of India. The economy of Bangalore is also the fastest growing city economy in India with annual growth rate of 10.3% followed by Ahmadabad with 10.1%. The fast population growth in Bangalore, accompanied by the high economic growth rate, is putting pressure on the urban mobility infrastructure in the city. Data is well developed and accessible in the city that is also known as 'silicon valley of India'. This makes Bangalore a very interesting city for our study. The result of the comparison is shown in table 8 below.

Table 9: Result of the Indian cities comparison

	Contribution to the national GDP % (City GDP to National GDP ratio 2012) (25%)	Car ownership level in the city (cars per 1000 people) (25%)	Urban population growth rate (% per year) (25%)	Other factors (Data availability, ease of establishing contact, etc) (25%)	Aggregate	Rank
Delhi	0.250	0.250	0.036	0.000	0.536	2
Mumbai	0.114	0.000	0.000	0.000	0.114	4
Ahmedabad	0.000	0.083	0.193	0.150	0.426	3
Bangalore	0.027	0.070	0.250	0.250	0.597	1

Normalized X = (X - Min(x)) / (Max(x) - Min(x))

Note: Min(x) and Max(x) are, respectively, the lowest and highest values for any given indicator and the weight of the indicator is given in brackets.

Indonesia: Similarly, the first step is to narrow the number of candidate cities to a manageable number. For this purpose, we identified the three Indonesian cities that are included in the Global City Competitiveness Index 2012 and applied the previously developed criteria to select our focus city for the in depth study. Data from The Global City Competitiveness Index 2012 also puts Jakarta far ahead of Surabaya and Bandung in overall competitiveness (Economist Intelligence Unit, 2012).In Indonesia, unlike India, Jakarta is by far the largest city in the country with a population of 9.6 million people, while Surabaya, the second largest city, has a population of 2.7 million and Bandung has a population of nearly 2.4 million. These data show the primacy of Jakarta as the biggest city in terms of economic development and population size.

All the three cities selected have an urban population growth rate lower than the country's average. This is because, in the past two decades, most of the urban population growth in Indonesia happened in small cities that in 1990, almost all, had population under 100,000 people, and in 2010 most of these cities still had population under 1 million people. To mention a few, cities with an average annual population growth higher than 25% are Cikarang (56%), Batam (51%), Tambun (38%), Cileunyi (28%) and Rancaekek (27%). The population of these cities together equals only 25% of the population of Jakarta

and the five cities together add less population per year than Jakarta does. Therefore, we decided to focus on the cities selected by the index.

Table 10: The Global City Competitiveness Index 2012 Indonesian Cities

(World Economic Forum, 2012)

Criteria	Jakarta	Surabaya	Bandung
Economic strength	38.3	28	29.6
Institutional effectiveness	51.4	51.4	51.3
Financial Maturity	33.3	16.7	16.7
Physical capital	61.6	55.4	47.3
Human capital	59	55.5	54.7
Environment and natural hazards	79.2	58.3	41.7
Global appeal	5.7	0.6	2.5
Social and cultural character	40.8	25.8	25.8
Overall score	44.1	35.9	34.8

After the preliminary selection of the three Indonesian cities, we applied the selection criteria we developed. Jakarta, as mentioned earlier, is by far the most populous city in Indonesia, followed by Surabaya which has roughly one-third the population of Jakarta and closely followed by Bandung. Not surprisingly, the largest share of the GDP of the country comes from Jakarta which has more than twice the GDP of Surabaya. The attributes of the cities is shown in the table 10 below.

Table 11: Evaluation of selected Indonesian cities

	Jakarta (jakarta province)	Surabaya (East Java Province)	Bandung (West Java Province
Population	9,607,787	2,765,487	2,394,873
GRP[4] per capita (Million Rupiahs)	982,540,043.96	498,614,636.36	861,006,347.79
Contribution of the city to the national GDP in %	16.32	7.00	2.00
Economic growth rate in 2011 (% per year)	6.7	6.7	n/a
Car ownership level in the city (cars per 1000 people)	207	80/135	53
Annual urban population growth rate in %[5]	1.45	0.37	2.05
Availability and accessibility of transport data	Excellent	Good	Good

Source: (Mayors' Task Force On Climate Change, Disaster Risk & The Urban Poor, 2011; Susilo, et al., 2007; Nippon Koei Co., Ltd., 2007; Samad, 2012; Government of Jakarta, 2012; Government of Bandung, 2012; Government of Surabaya, 2012)

Amongst the three cities selected in Indonesia, Jakarta score high in all criteria. The city has 3.5 times more population than the second most populous city, contributes the largest to the national GDP, and has the highest joint economic growth rate with Surabaya. Though it has the second highest population growth rate of the three cities, in absolute numbers Jakarta adds over 120,000 people per year to the city's population compared to fewer than 50,000 for Bandung and about 10,000 for Surabaya. Furthermore, transport and socio-economic data is easily accessible in Jakarta than any of the other cities. Therefore, in the case of Indonesia, we decided to study Jakarta further. The result of the comparison is shown in table 11 below.

[4] Raw data was only available for the regions and not the cities.

[5] Refers to the growth rate of the province, data at city level was not available

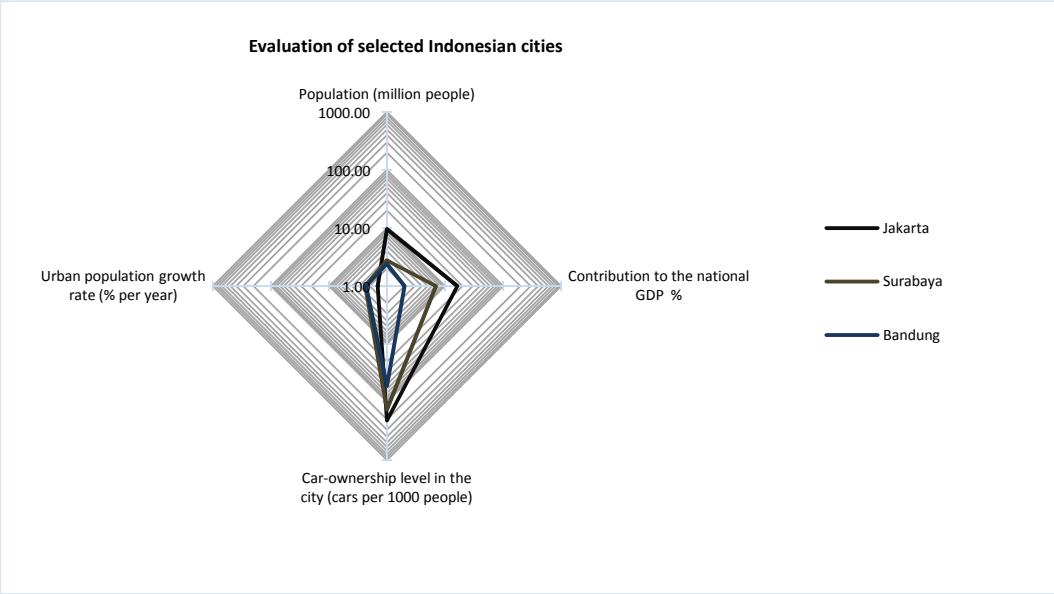


Figure 14: Evaluation of selected Indonesian cities (in log scale)

Table 12: Result of the comparison of the Indonesian cities

	Contribution to the national GDP % (City GDP to National GDP ratio 2012) (25%)	Car ownership level in the city (cars per 1000 people) (25%)	Urban population growth rate (% per year) (25%)	Other factors (Data availability, ease of establishing contact) (25%)	Aggregate	Rank
Jakarta	0.250	0.250	0.000	0.250	0.750	1
Surabaya	0.087	0.133	0.250	0.000	0.470	2
Bandung	0.000	0.000	0.231	0.000	0.231	3

Normalized X = (X - Min(x)) / (Max(x) - Min(x))

Note: Min(x) and Max(x) are, respectively, the lowest and highest values for any given indicator and the weight of the indicator is given in brackets.

3.2 Variables of interest

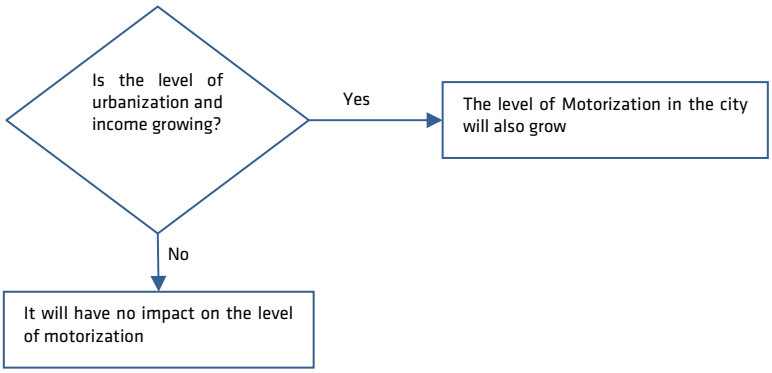
As mentioned earlier, urbanization and income are the two most important factors driving car ownership. In this study we will explore the enablers for transition towards a sustainable mobility system in cities in developing countries in time of rapid urbanization and economic growth. As given by the MLP theory, it is the interaction between the three levels of the system (landscape, regime, & niches) that will lead to a change of the regime. Below are selected variables of interest for the purpose of this study that will address the interaction across demographic, economic, institutional and technical variables in the transition towards a more sustainable mobility system SUMS. The independent variables are marked IV and the dependent variables are marked DV.

- Number of Urban population as measured in million people (IV),
- Rate of urban population growth as measure in percentage per year (IV),
- Income or wealth as measured in GDP per capita PPP (IV),
- Local economic growth as measured in percentage per year (IV),
- Growth of Motor Vehicle ownership as measured in motor vehicle per 1000 people (DV),
- Institutions; norms (Feeling of sensation, power, superiority, pleasure, environmental attitude, ecological norms & values, feeling of responsibility, personal norms, social values orientation), transport policies and regulations (regulatory measures, physical measures, fiscal measures, environmental standards, fuel prices, public transport quality and fares) (IV),
- Urban Structure (Density, Diversity & Design) (IV),
- Public transport services quality (accessibility, reliability, information availability, safety, frequency, etc...) (IV)
- Public transport ridership level measure in passenger-km (DV)

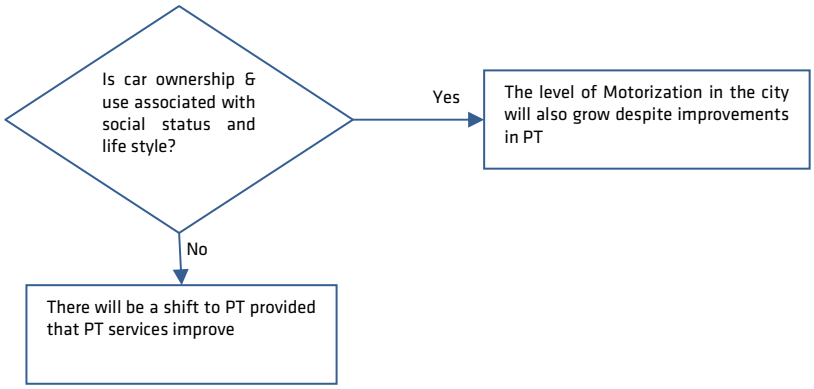
3.3 Hypotheses

Based on the literature review in chapter 2, we will test a set of hypothesis in Bangalore and Jakarta. The specific hypotheses to be tested by this study are:

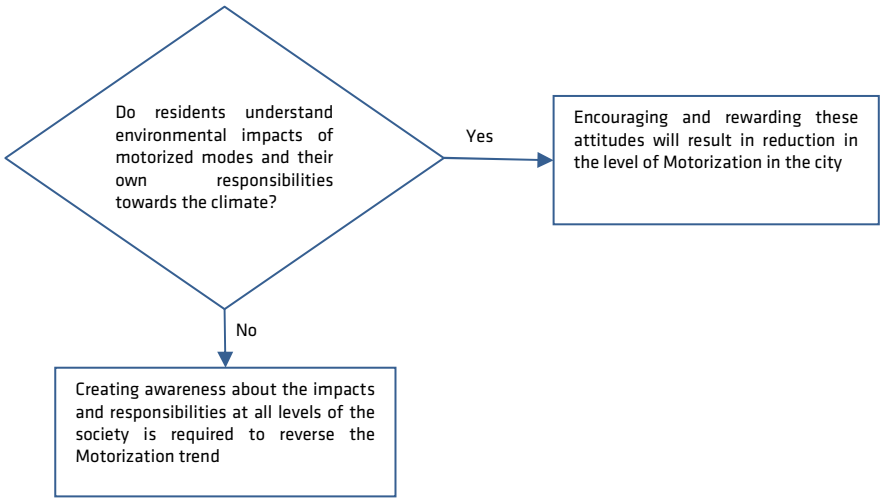
Urbanization-Income-Motorization hypothesis: Accompanied by a high level of urbanization, if the per capita GDP of Bangalore and Jakarta increases (above 3000 USD), then the motorization level in the cities will also increase.



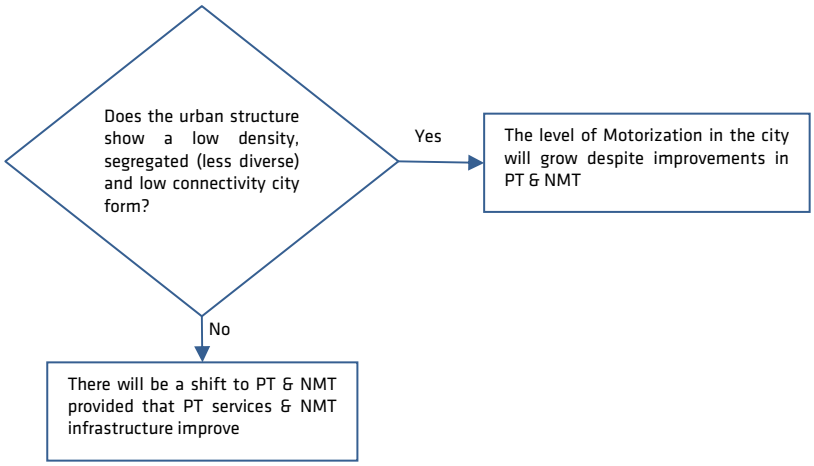
The social value hypothesis: If people in Bangalore and Jakarta associate vehicle ownership with social status and life style values, then improvements in public transport services will not affect the car ownership and use in the cities.



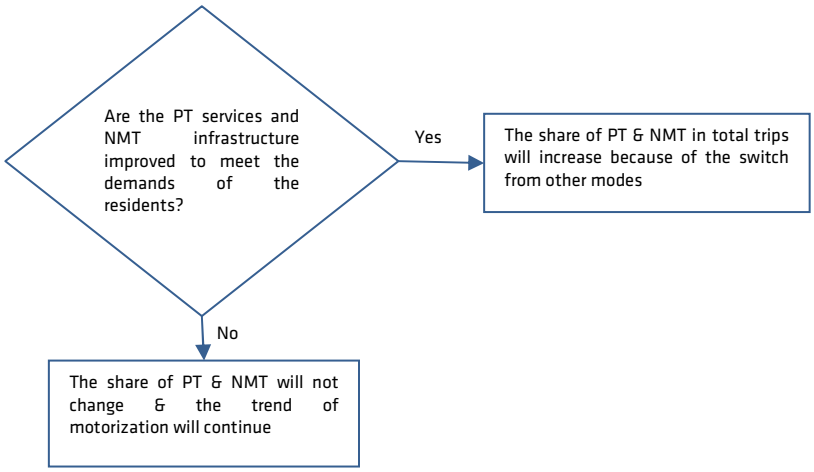
The green norms hypothesis: If more environmentally responsible attitudes (environmental attitude, ecological norms & values, feeling of responsibility) are encouraged by governments, then ownership and use of personal cars in Bangalore and Jakarta will reduce.



The urban structure hypothesis: Segregated/sprawled urban structures (density, design and diversity) in Bangalore and Jakarta leads to growing motorization.



Public transport service quality hypothesis: If the quality of the public transport systems in Bangalore and Jakarta improve accompanied by NMT infrastructure, then PT ridership and the mode switch from other motorized modes of mobility will increase.



The research, as already mention in chapter 2, is based on online surveys with selected transport planners and operators and secondary data collected through various agencies and research groups. Components (modes of transportation) of SUMS to be analyzed in this research include Bus, Metro, Tram, Light Rail Vehicles, and Train. These modes of transport are selected to insure accessibility and comfort for all parts of the population. Our study will focus in the following elements to identify enablers for the socio-technical transition towards SUMS:

1. Trends in the transport sector: The geographical and geopolitical context (infrastructure investments and priorities) of the current mobility systems in India and Indonesia will be revised in order to identify the opportunities for transition to SUMS.
2. Attractors: Infrastructure, visions, regulations and policies in favor of SUMS will be summarized. Sustainable development targets, environmental movements, demographic changes and behavioral transitions will also help identify possible attractors towards sustainable mobility systems.
3. Barriers: Current and future socio-economical (GDP, literacy rate and levels of employment), institutional (decentralization, fiscal and decision power of local governments, leadership, capacity) and technological (availability, quality and cost of technology) barriers and opportunities in the transition towards sustainable mobility will be evaluated.

Table 13: Variables of interest and indicators

Research Questions		Type of Variable	Variable	Indicator	Units of measurement	Data source	Hypothesis
Main	**Sub**						
What enables the socio-technical transition processes in the mobility sector (towards a sustainable mobility system) during rapid urbanization and economic development in cities in developing countries?	1. What kind of trend is developing in the transport sector in cities in (selected) developing countries?	Independent variable	Urbanization	Number of Urban population	million people	Organizational records (census data)	Urbanization-Income-Motorization hypothesis
				Rate of urban population growth	percentage per year	Organizational records (census data)	
		Independent variable	Economic Development	Income or wealth	GDP per capita PPP	Organizational records (Local Government)	Urbanization-Income-Motorization hypothesis
				Local economic growth	percentage per year	Organizational records (Local Government)	
		Dependent Variable	Growth of car Ownership & Use	Number of cars in the city	Cars per 1000 people	Organizational records (Local Government)	Urbanization-Income-Motorization hypothesis, The green norms hypothesis
				VMT growth in the city	Vehicle Km	Organizational records (Local Government)	
	2. What attractors exist for the implementation of SUMS in cities in developing countries at present? 3. What barriers exist to implement the system in developing country cities?						
		Independent variable	Norms	Feeling of sensation, power, superiority, pleasure, environmental attitude, ecological norms & values, feeling of responsibility, personal norms, social values orientation	n/a	Residents' survey questionnaire-questions 1-8 & 11-16 Planners' survey questionnaire-question 1-16	The social value hypothesis, The green norms hypothesis
		Independent variable	Urban Structure	Density	People/hectare	Organizational records (Local Government)	The urban structure hypothesis
				Diversity	Index (0 to 1)	Calculate from Organizational records (Local Government)	
				Design	Ration, Km	Calculate from Organizational records (Local Government)	
		Independent variable	Quality of public transport services	accessibility, reliability, information availability, safety, frequency	n/a	Residents' survey questionnaire Planners' survey questionnaire	Public transport service quality hypothesis
		Dependent Variable	Public transport ridership level	Annual number of passengers	Passenger-km	Organizational records (Local Government)	The social value hypothesis, The urban structure hypothesis, Public transport service quality hypothesis

Chapter 4: Empirical Study

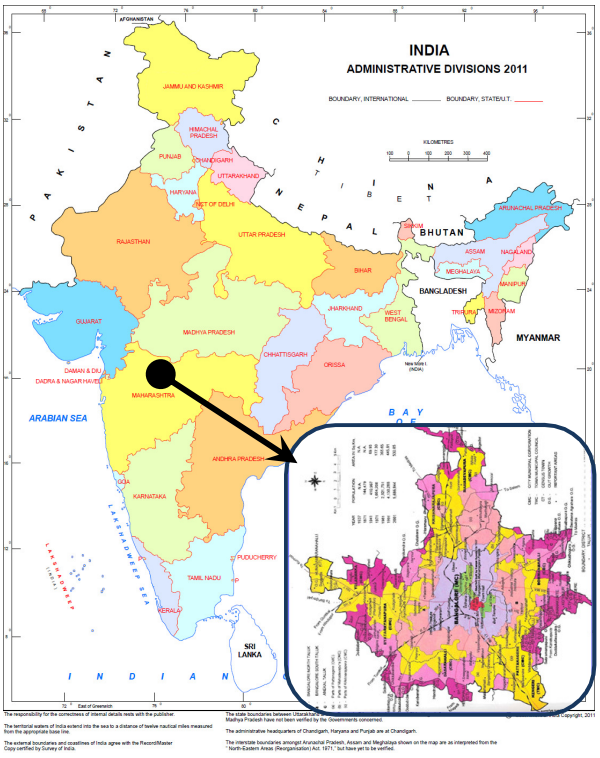
In this chapter we will explore the trends and dynamics, the barriers and opportunities, and the strengths and weaknesses of transport system seeking to find enablers to leapfrog to a sustainable mobility system in Bangalore and Jakarta. The core of the chapter is the result of the empirical data collected through online surveys and documents reviews.

4.1 Bangalore, India

Introduction

Home to a population of 8,749,944 in 2011, Greater Bangalore City Corporation (Bruhat Bengalooru Mahanagara Palike-BBMP), the principal administrative, cultural, commercial, industrial, and knowledge Capital city of the state of Karnataka, is the third most populous city and the fifth most populous urban agglomeration in India. The city is located at 12°59' north latitude and 77°57' east longitude. Situated at an altitude of 920 m above mean sea level, Bangalore has a pleasant climate with mean annual total rainfall of about 880 mm and about 60 rainy days a year over the last 10 years. The summer temperature ranges from 18 °C to 38 °C, while the winter temperature ranges from 12 °C to 25 °C (Sudhira, et al., 2007, p. 382). BBMP is an administrative unit consisting of Bangalore Mahanagara Palike (BMP), seven city municipal councils (Byatarayanapura; K R Pura; Mahadevapura; Bommanahalli; Yelahanka; Dasarahalli; and Rajarajeswarinagara), one town municipal council (Kengeri) and 110 villages. The 'Greater Bangalore' concept, officially proposed in September 2006, is implemented in January 2007 with four main objectives: 1) improvement and co-ordination of infrastructure development; 2) upgrading of the quality of urban civic services; 3) strengthening the administrative capacity for enforcing various rules and regulations; and 4) optimizing expenditure on establishment (Sastry, 2008). BBMP is part of the Bangalore Metropolitan Region (BMR) in the state of Karnataka.

Dittrich (2007) distinguished four phases in the economic history of the Bangalore. The first phase, during the 1950s and 1960s, was dominated by the Government of India's initiatives in locating large institutions and public sector heavy industries. These had a major impact in the development of the city that includes housing schemes, and transport systems that provided numerous subcontracting opportunities for small and medium enterprises in the city. The second phase, beginning in the late 1960s and running through the 1970s, witnessed the rapid growth of state government bureaucracy and state-run businesses. The third phase began during the early 1980s, when Bangalore experienced the effects of preliminary liberalization launched by Prime Minister R. Gandhi and private enterprises became growth engines. The fourth phase, starting in the late 1980s, brought increasing and more varied relationships with multinational corporations.



Since the 1980s, Bangalore has enjoyed the reputation of being one of the fastest growing cities in Asia. The name Bangalore is synonymous with the IT industry revolution in the country, hence, the nickname 'the silicon valley of India' and 'Silicon Valley of Asia'. In the past decades, the city has turned into a major commercial, industrial, and cultural hub in South India and contains some of the top colleges, research institutes, Industries, aerospace, software companies, telecommunications, defense organizations, etc in the country (Sudhira, et al., 2007). The industrial boom in Bangalore over the last two decades has seen its population grow from 4.13 million in 1991 to about 8.75 million in 2011 and the size of the city expanded from 226 sq. km. to 1000 sq. km. in the same period (Merugu, et al., 2009; Bangalore City Traffic Police, 2013). This rapid growth was not without consequences. Apart from creating a ripple effect in the local economy, there has also been great pressure on infrastructure and resources in the city, like water supply, energy, public transportation, land, etc. The city administration has recognized the challenges to meet the infrastructure and service needs of the residents of Bangalore (JNNURM, 2009).

Figure 15: India administrative division 2011

In the next chapters, Bangalore refers to the Greater Bangalore City Corporation or BBMP.

Climate change and sustainable development

In the global climate change debate, the issue of great importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to projected climate change. India's nearly 700 million rural population directly depend on agriculture, forests and fisheries, water, biodiversity, mangroves, coastal zones and grasslands for their subsistence and livelihoods (BCCI-K, 2011). The state of Karnataka is the second most vulnerable state in the country to climate change, only next to Rajasthan. In line with national policies, the state of Karnataka has also recognized the impact of climate change on the livelihood of the people and the global population. Therefore, several initiatives were formed and studies are conducted to assess the vulnerability of the state and design adaptation and mitigation mechanisms.

The Bangalore Climate Change Initiative – Karnataka (BCCI-K) was formally launched in Bangalore in 2010 (BCCI-K, 2011). This initiative works with the government of Karnataka for the development of low-carbon green growth for the state. The first project undertaken by BCCI-K titled 'Karnataka Climate Change Action Plan' was submitted to the government of Karnataka in 2011. The plan depicts that the annual total emissions of the state of Karnataka is 80.24 million tons of CO_2 equivalent which accounts for 4% of the national emissions. The transport sector takes a share of 10.4% of the emissions accounting for 8.35 million tons of CO_2e (BCCI-K, 2011).

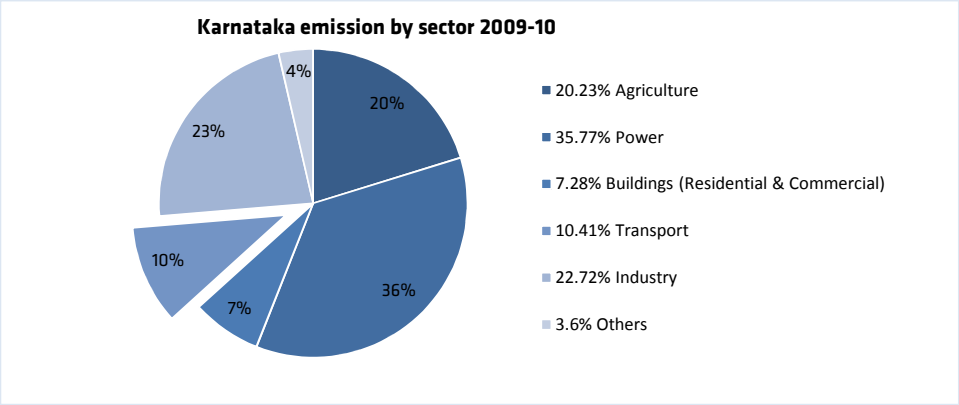


Figure 16: Karnataka emission by sector- 2009-10[6]

(BCCI-K, 2011)

The plan assesses the rainfall and temperature variability in the state in the past three decades and provides projection for the future of the state of Karnataka. The projections show a warming of 1.8 to 2.2 °C and a significant variation in rainfall for most parts of the state (BCCI-K, 2011). One of the main concerns of the report is that the increasing concentration of people in urban areas of the state may cause heat stress, urban flooding, and urban drought causing immense pressures on the urban infrastructure. The document also shows that the highest potential of emission reduction lies in the power sector and the transport sector. Amongst the measures recommended to help reduce emissions in Karnataka along with improving the overall infrastructure of the state are; increasing the share of public transportation in the cities (increased buses and metro services), making bicycle lanes available in all the cities where possible, defining a (new) efficiency standard for the vehicle fleet and transition towards Electric/Hybrid transportation system (BCCI-K, 2011).

The climate is also increasingly becoming an important issue for residents of Bangalore in their day to day activities. 82% of the respondents in the city agree that the personal car has more impact on the environment than public transport and 85% said their choice of transport mode is primarily influenced by their concern for the environment. However, the most important factor in dictating the mode choice of respondents is the convenience of the transport mode as 65% strongly agree and 23% agree on the importance of the factor. It is followed by journey time taken (60% strongly agree & 25% agree), reliability (60% strongly agree & 25% agree), health benefits (42% strongly agree & 29% agree), safety (58% strongly agree & 19% agree) and cost (31% strongly agree & 21% agree).

Climate change is recognized as a major challenge in India at the national and local levels. Together with BCCI-K, the governments of the state of Karnataka and the city of Bangalore try to incorporate sustainable development concerns in the development of the transport sector in the city and the state. Residents also associate local pollution with declining quality of life in the city.

Demography and Economy

Census data since the end of the 19th century shows that Bangalore has always been the biggest city in the state of Karnataka and consistently retained its urban primacy status for more than a century. According to the latest census (Census of India, 2011), the urban agglomeration had an overall population of 8.75 million, accounting for 37% of the state's urban population, within an area of 1000 sq. km. Thousands of new apartments are under construction on the

[6] The data for emissions from the transport sector and buildings are from 2007-2008

outskirts of Bangalore to accommodate the city's growing population. Though the city has a literacy ratio of 86%, which is higher than the country's average literacy rate of 63%, only 44% of the city population is formally employed.

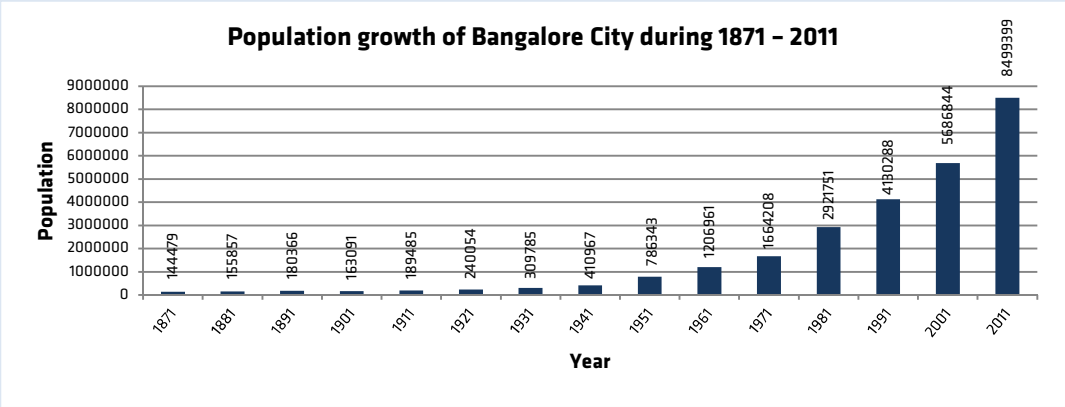


Figure 17: Population growth of Bangalore City during 1871 – 2011

(Sudhira, 2008, p. 52, appears in original as Figure 3-4)

The Electric Park, the first Software Technology Park (STP) in India, was then established in Bangalore in 1976 and since then Bangalore became the heart of India's IT industry having about 30 % of all IT workforces in the country. The thriving economy of the city has resulted in a per capita income of Rs. 99,420, which is more than twice the state average per capita income of Rs. 47,911 in 2011-2012, and a personal disposable income greater than the Indian city average (Sudhira, et al., 2007; Kulkarni, 2013). Investments in other industries, infrastructure and services, have also significantly contributed to a growth and diversity of the economy. The city also contains 60% of the Biotechnology companies in the country and it is home to numerous institutes of higher learning and research, which is evident from the establishment of premier centers like Indian Institute of Science (IISc), Indian Institute of Management (IIM), Institute for Social and Economic Change (ISEC), Indian Institute of Information Technology (IIIT), National Institute of Advanced Studies (NIAS), Tata Institute for Fundamental Research (TIFR), Jawaharlal Nehru Centers for Advanced Scientific Research (JNCASR), Indian Space Research Organization (ISRO), National Aerospace Laboratories (NAL), Central Power Research Institute (CPRI), Central Manufacturing Technology Institute (CMTI), various research centers of Defense Research and Development Organization (DRDO), and several professional engineering and medical colleges at undergraduate and graduate levels (Sudhira, et al., 2007). In its 2001 Human Development Report, the United Nations has ranked Bangalore fourth in the list of "Technology Hubs of the World" along with Austin (USA), San Francisco (USA), and Taipei (Taiwan) (UNDP, 2001).

Between 1980 and 1993, the economy of India and Bangalore grew at an annual average of 6.55% and 6.86% respectively. But what was more interesting is that, between 1993 and 2004, while the average annual growth of the Indian economy was 7.93% per annum, the economy of Bangalore grew at 20.76% per annum (Louie, 2011). The credit to this astonishing growth is largely given to the improvement in labor productivity in the city and the shift from primary economic activities (i.e. agriculture, fishing, mining & quarrying, and forestry) to mainly tertiary economic activities (i.e. wholesale and retail trade, hotels and restaurants, transport, storage and communication, finance, insurance and real estate, community, social and personal services, and government services) (Louie, 2011). For 2010-2011, the GDP growth rate of Bangalore was 8.6% and slows down to 6.9% in 2011-2012 (BMTC, 2013).

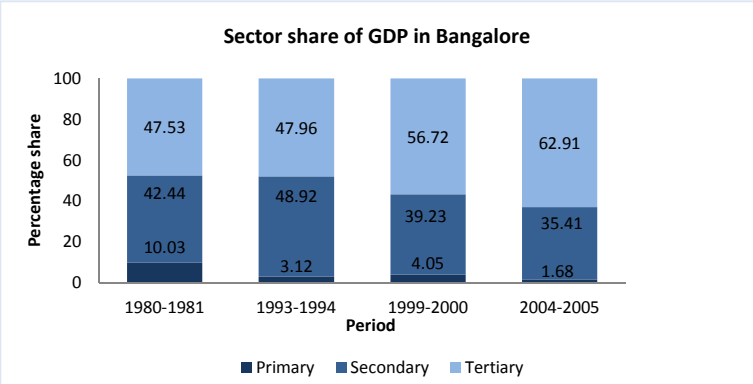


Figure 18: Sector share of GDP in Bangalore

(Louie, 2011)

Key:

- *Primary (Natural)- agriculture, fishing, mining & quarrying, and forestry*
- *Secondary (Industry)- electricity, gas & water, construction and manufacturing*
- *Tertiary (Services)- wholesale and retail trade, hotels and restaurants, transport, storage and communication, finance, insurance and real estate, community, social and personal services, government services*

In 2012, Bangalore had a GDP PPP of 69 Billion USD and contributes 30% to the GSDP of the State of Karnataka (Istrate & Nadeau, 2012; pwc, 2009). It has proven to be very difficult to find a historical data series of GDP growth in Bangalore that contributes 30% to the GSDP. According to most economic reports of the state of Karnataka, most of the historic growth in the GDP of the state happened in the secondary (8.4%) and tertiary (10.21) sectors and less so in the primary sector.

Since the highest contribution to the state GDP comes from Bangalore and that 98.32% of the GDP of Bangalore is from the secondary and tertiary sectors, we can use the GDP growth rate of the state of Karnataka as a proxy for Bangalore. In the past two decades, the GDP per capita of the State of Karnataka increased by over 600% growing from RS.9027 in 1994 to Rs.48000 in 2012 (Istrate & Nadeau, 2012).

Table 14: Annual growth of GDP of the state of Karnataka by sector (1994-2004)

(Planning Commission- Government of India, 2007)

	Karnataka annual growth of GDP by sector										
	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	Average
Primary	-0.31	2.24	4.87	-2.27	10.87	9.18	11.93	-14.24	-6.36	-4.98	1.09
Secondary	8.70	6.73	9.39	14.09	18.42	-4.55	3.92	10.42	9.35	6.90	8.34
Teriary	9.20	9.81	11.97	9.34	10.24	9.66	12.63	9.28	9.05	10.88	10.21

In the last few decades, there has been a rapid population growth in Bangalore that followed the economic boom in the city. In the past two decades alone the city's population has doubled and the GDP per capita PPP has tripled. Both urbanization and economic development have slow down in 2011-2012 but remain above the country's average.

Mobility infrastructure, culture & attitude

The urban transport system in Bangalore is essentially road based. The total road length in BBMP is 4500 km including ten state and/or national roads, most of them radial, and an outer ring road that carries mainly the long distance through traffic (Bangalore City Traffic Police, 2013). A study by the World Bank (2005) shows that 35% of the road network in the city is in a poor condition and traffic accidents in the city are very high. As the city grew in size and population, in the past two decades, the total annual trip in the city has increased from 14.11 billion passenger-kilometer (bpkm) in 1990/91 to 54.07 bpkm in 2010/11, which is an average annual growth of 4% (Wilbur Smith Associates, 2008). This rapid growth in mobility in Bangalore has been characterized by rapid growth of motorization (mainly two-wheelers), narrow roads, severe congestion problems, inadequate infrastructure for non-motorized modes, deteriorating air quality, and increasing number of road accidents (JNNURM, 2009). As of 2012 Bangalore city is estimated to have vehicle population of about 4.2 million, and 1000 new vehicles are being added to the streets every day (Bangalore City Traffic Police, 2013). This gives a vehicle to population ration of 480 vehicles per 1000 persons, which is as high as most cities in developed countries. However, the vehicle structure in Bangalore is different than cities in developed countries as 69% of the vehicles (i.e. 2.9 million) are two-wheelers and only 21% (i.e. 0.9 million) are passenger cars. Thus excluding the two-wheelers, the passenger cars-to-population ratio in the city is 103 cars per 1000 persons in 2011 (Government of Karnataka transport department, 2011). This is far lower than most cities in emerging economies, but it is second only to Delhi with the highest vehicle to population ration in Indian cities. This has led to increased congestion in road networks across the city and frequent traffic jams. With a growth of 4.7% a year, the number of motor vehicles is projected to reach 9.5 million by 2030 (Harish, 2012).

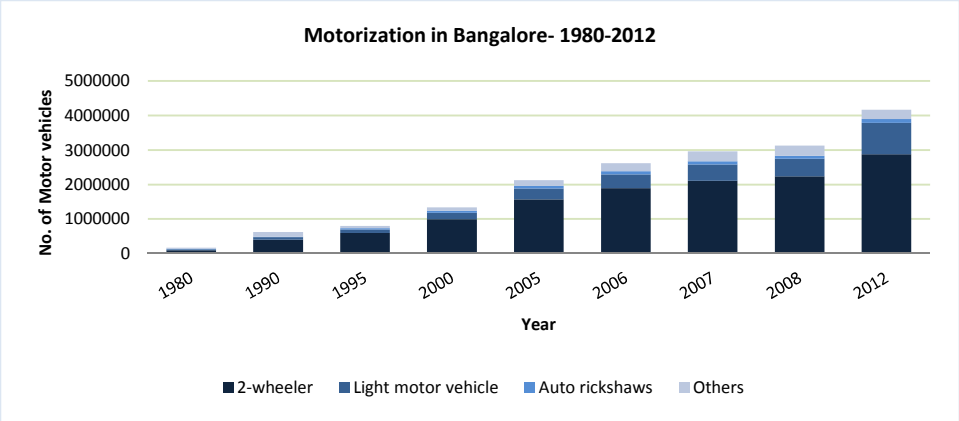


Figure 19: Vehicle population in Bangalore (1980-2012)

(Bangalore City Traffic Police, 2013)

Though only 42% of the respondents in Bangalore own a car, 69% agree that owning a car is important. From the respondents who agree that owning a car is important, 83% think it is very useful for heavy luggage, family trips or when someone is sick, 44% say it is the fastest travel mode available in the city, a staggering 64% agree that the public transport services in the city are not good, 6% think it is socially obliged and 22% argue that it confirms their status in the society. But none of the respondents associated owning a car with personal rights. The first three reasons are directly or

indirectly related to the quality of the public transport services in the city which indicates where the main problem for the rapid motorization trend lies.

Despite the growing motorization, like most cities in developing countries, public transportation forms one of the key functionalities for mobility in urban Bangalore. The Bangalore Metropolitan Transport Corporation (BMTC) is the sole public bus transport provider for Bangalore, serving urban and sub-urban areas. In the city of 3.8 million working population, BMTC operates with 6476 vehicles and provides 80760 trips every day of the year. This gives as about 0.76 buses per 100o0 population. The number of buses required per 1,000 population will depend on the public transport mode share, the presence or otherwise of rail or other public transport modes, the capacity of the buses, etc. With many variables the minimum requirement varies considerably from city to city, but will typically lie between 0.5 and 1.2 per 1,000 populations (Urban Bus Toolkit, 2006).

The bus system carries 4.8 million passengers per day, with 41 depots (and another 8 under construction) and 50 bus stations in the city (BMTC, 2013). However, the public transport of the city has not been able to keep pace of the rapid growing demand for mobility. Most big companies in the city are still forced to hire fleets of taxis and buses to ferry their workers to and from home, due to the inadequacy of this public transport system.

An interesting result is that 79% of all respondents (those who say owning a car is important and those who say it is not important) agree that personal cars are bad for the environment and that it is difficult to drive in the city because of the congestion and the bad infrastructure in the city. 72% of all respondents think owning a car in Bangalore is still expensive which gives the upper hand to the public transport services to hold the lion's share of the trips made in the city provided that service quality improves.

Table 15: Growth of the bus fleet in Bangalore

Year	1997	2000	2008	2009	2010	2011
Bus fleet size (Nos)	1921	2149	5071	5792	6113	6476

Another important aspect of transport in Bangalore is the Intermediary Public Transport (IPT), which refers to the intermediary facility falling in between traditional public transport and the personalized automobile. IPT in India is synonymous with "auto rickshaw" because of the dominance of three wheelers in the system. In Bangalore, 3% of all the trips in 2012 were done with 1.12 million auto rickshaws.

The study by the Ministry of Urban Development in Indian cities shows that, cars, two-wheelers and auto rickshaws together account for 78% of the vehicle composition in Bangalore at peak hours, despite the lion's share of the trips being made by foot or public transport (Wilbur Smith Associates, 2008). As shown in the figure below the modal split of daily trips made in Bangalore is still dominated by public transport services, walking and biking rather than motorcycles and cars. While the combination of walking, cycling and public transport account for 68.5% of all daily trips made in the city, cars account for a mere 4.6% and two-wheelers for 21.4% (Bangalore City Traffic Police, 2013).

The survey results show a different result where 42% of the work/school trips, 42% of shopping trips, 23% of leisure trips and 37% of friend/family visits are done with motorbikes. Cars account for 50% of trips for friends/family visit, 42% of leisure trips and 27% of shopping trips. This could be the result of a specific profile of respondents where 75% have annual income more than 3000 USD.

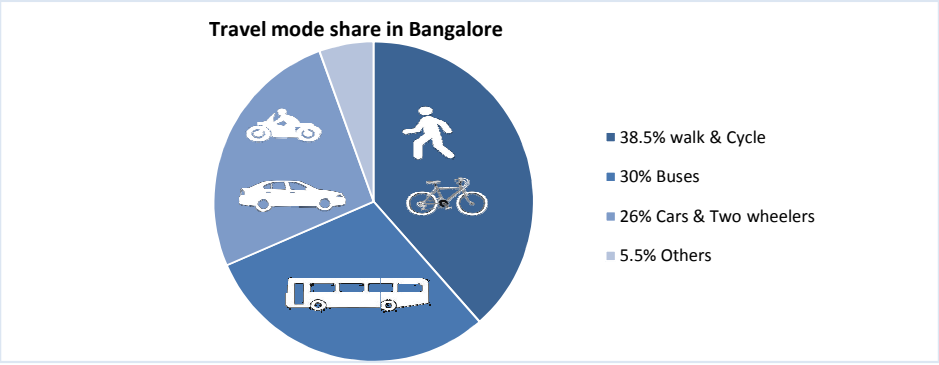


Figure 20: Travel mode share in Bangalore in 2012

Bangalore Metro Rail Corporation Limited (BMRCL), a joint venture of Government of India and Government of Karnataka is a special purpose body entrusted with the responsibility of implementation of Bangalore Metro Rail Project known as 'Namma Metro'. The project has an 18.10 km long East-West corridor and a 24.20 km long North-South corridor (to be extended in phase B by 10.1 and 18.3 km respectively) containing 23 elevated stations, 7 Underground stations and 2 Surface stations. The project is expected to be completed in December 2014. On completion of the whole metro project, Namma metro will cover 114.4km connecting the city center with major destination at the fringes in four corridors. For the Namma Metro service, air conditioned electrically tractioned high tech coaches are used and escalators are provided in elevated stations to allow access to the disabled and elderly residents.

Trains run from 6 am in the morning till 10 pm in the night at a frequency of 15 minutes from 6 am to 8 am in the morning and 8 pm to 10 pm in night and with frequency of 10 minutes from 8 am to 8 pm. The transit time from the start to end of each corridor is estimated to take on the average 30 minutes. The BMRCL's website also shows that the entire system is operated with an integrated network of telecommunications, fare control, fire detection, fire fighting system as well as on-site and off-site emergency management systems (BMRCL, 2011).

Figure 21: Route map of the first phase of Namma Metro

The public transport will not be a choice for many as personal cars and 2-wheelers are becoming affordable. This, according to the respondents, is because of the inability of the public transport system in Bangalore to meet the demand of the growing middle-class. When asked about the characteristics of the transit services in the city, all of them say they are not accessible for the not-able, only 10% say they are frequent enough, only 20% say they are reliable, 10% say they have good integration between modes, only 10% feel secure, 10% say it is easy with luggage and 10% thought it is easy to obtain transit information. The perception about the public transport services cannot be any worse.

There are two forms of tickets that are used to perform payment for metro services in Bangalore: tokens and Contactless smart cards (this includes Namma metro travel card, Combo card, Varshik (stored value tickets), Sanchar (Trip tickets), Metro-Bus Ticket (MBT) and Group tickets). The public transport fares are not a concern for the respondents as only 29% say they are expensive and only 6% of the respondents say that the payment system is complicated or not easy.

Fare rules:

- Tickets are not required for children below 3 feet (just under 1 meter). No age criteria are considered.
- The Automatic Gates admit one person at a time. Hence every passenger needs to carry one token or smart card.
- Minimum Fare will be charged for entering into a station.
- Penalty for ticketless travel or lost ticket is INR 50 (an equivalent of 0.7 Euro) apart from maximum token fare.
- Mismatch: The Automatic Gates record entry/exit details in token/Smart card. Every entry at these gates must be followed by proper exit through the gates on same day. Skipping of any entry or exit is termed as MISMATCH. The penalty for mismatch is INR 10 (an equivalent of 0.15 Euro).
- Overstay Rule: A passenger holding a valid ticket can exit from same station within 20 minutes and from other stations within 120 minutes. For overstaying in paid area of Namma Metro beyond these limits, penalty of INR 10 (an equivalent of 0.15 Euro) per hour is charged subject to a maximum of INR 50 (an equivalent of 0.7 Euro).

(BMRCL, 2011)

Though there are nearly half a million bicycles in Bangalore, they account only for 4.5% of the total trips in the city (Bangalore City Traffic Police, 2013). The survey also shows that there is almost no trip made by bicycle and only a mere 31% of the shopping trips were made by walking. This is because the large number of bicycle ownership does not translate into trips on roads for several reasons. There are several factors that could explain the low share of bicycle trips in Bangalore. The first one is lack of bicycle infrastructure in the city. None of the 4500 km long road infrastructure in the city has designated bicycle path, which makes them cyclists nightmares. The competition for road space with over 4 million motor vehicles pushes many cyclists to abandon their bikes in favor of the automobile. The second factor is the scale and speed of urban Sprawl in the city. Bangalore has transformed from compact city of 226 sq. km in 1991, to a conurbation of 1000 sq. km. This sprawl has stretched the average trip length in the city from 7.1 km in 2001 to 10.57 km in 2007, shifting the composition of travel mode share in favor of motorized transport. Another very obvious factor is the increase in number of traffic accidents to non-motorized transport mode users. Thought the number of traffic accidents has fallen in the last decade, from the total of 5502 accidents, 755 people died in 2012 out of which an estimated 49% are pedestrians and cyclists (Bangalore City Traffic Police, 2013). Beyond fatalities, the risks of riding a bicycle in Bangalore can be seen from the fact that there are more than 14000 traffic violations occur every day (Bangalore City Traffic Police, 2013). 20% of these violations are booked for dangerous driving, over speeding, drunk driving, jumping traffic signal, lane discipline, defective dead light, and using mobile Phone while driving. The last factor is the social stigma attached to cycles. In Indian society, as disposable incomes grew and two-wheelers and four wheelers become cheaper, cyclists are viewed with contempt while shifting to a motorbike, a moped or a car become a wealth statement. This again has shifted the balance

of the modal share in favor of motorized vehicles. Despite this, 61% of the respondents in Bangalore believe that separate bicycle lanes are one of the most effective ways to encourage sustainable transport use in the city.

When we look at the road infrastructure, though only 49% is paved, India has approximately 4.1 million km of road length, making it the third largest road networks in the world, only next two United States and China (Ministry of Road Transport and Highways, 2012). In terms of road density (km of road per 100 sq.km of land area), India's score of 125 is better than both United States and China, almost twice that of the United States (66) and more than 3 times that of China (39). The road density in Bangalore is superior to the average of the nation, 450km of road per 100 sq.km of the city area but inferior to Delhi's 1922 km for every 100 sq.km of area. As of 2012, the road density when measured in terms of the average road length in km per 1000 population, Bangalore has only 0.5km, which is low even in the Indian standard of national road density 3.2km and urban road density of 0.91 km (for comparison purposes, Singapore has 0.66 km per 1000 people). Besides, most of these roads are narrow and have very poor quality. They are already over-burdened and sag under the weight of 4.2 million vehicles, including cars, trucks, motorcycles and 3-wheelers, as well as more traditional forms of transport. The traffic police report shows that the average volume to capacity ratio of roads in Bangalore is 2.5 (ranging from 3.6 in Nrupatunga Road to 1.5 in Sankey Road) and travel speed in the city has dropped to 15 km/h during the peak hours in the last decade, despite introducing several measures to ease the persistent congestion (Bangalore City Traffic Police, 2013). The pressure to maintain adequate car mobility continues to result in significant investment in urban road infrastructure in Bangalore and the local government seems committed to it.

What adds to the traffic pressure in Bangalore, according to the Bangalore Development Authority, is that there is very little scope for expansion of roads and the need to use existing roads for smooth movement of vehicles is even more pronounced. Thus the administration takes it mandatory to ensure better parking facilities. As a result, the BDA and BBMA are working on several road improvement and expansion projects like flyovers, underpasses, grade separators, junctions, elevated roads and road widening projects. However, increasing provision of roads and more parking spaces is associated with the hallmarks of automobile dependent cities. More roads lead to sprawl developments and longer travel distances for all trips, especially to and from work. Public transport services are less competitive to such developments, which leads to lower provision and use of public transport service.

The transport trends in the past years show a growing motorization in Bangalore. 94.5% of all journeys are made by motorized modes, out of which 30% are made by public transport. This trend generally shows the monopoly of the motorized personal transport mode in the city. As the result of lack of NMT infrastructure and quality transit services, former pedestrians, cyclists and PT riders turn into motorists at a dramatic rate as the personal transport modes become affordable. The trend doesn't show a sign of decline, despite a significant improvement in the public transport services, as government policies are focused in improving the infrastructure for motorized transport modes and neglect the NMT.

Land use and urban structure

BBMP is now the key 'urban local body' (ULB) responsible for the city and outlying areas. Planning in the form of land use zoning and regulation are vested within the authorities of Bangalore Development Authority (BDA), a parastatal agency of BBMP. Land use plans are formalized through the Comprehensive Development Plans (CDP) prepared for every 10 years. The last CDP prepared in 1995 for the period up to 2011, was revised in 2005-06 for the period up to 2015 (Bangalore Development Authority, 2007). Key aspects of these CDPs are that they indicate the amount and location of land use allocated for various uses (like residential, commercial, industrial, etc.) as well as restricting development in specific areas demarcated as Green Belt and Valley Zones. Five concentric zones are distinguished in Bangalore Metropolitan Area in the revised CDP (JNNURM, 2009, p. 14). These are:

1. Zone one - The core area consists of the traditional business areas, the administrative centers, and the central business district. Basic infrastructure (acceptable road system and water conveyance), in the core areas is reasonably good – particularly in the south and west part of the city, from the industrial zone of Peenya to Koramangala. This space also has a large distribution of mixed housing/commercial activities.
2. Zone two – The peri-central area has older, planned residential areas, surrounding the core area. This area also has reasonably good infrastructure, though its development is more uneven than the core area.
3. Zone three – This covers the recent extensions of the city flanking both sides of the Outer Ring Road, portions of which are lacking infrastructure facilities, and is termed as a shadow area.
4. Zone four – This is the new layouts that have developed in the peripheries of the city, with some vacant lots and agricultural lands. During the past few years of rapid growth, legal and illegal layouts have come up in the periphery of the city, particularly developed in the south and west. These areas are not systematically developed, though there are some opulent and up-market enclaves that have come up along Hosur Road, Whitefield, and Yelahanka. The rural world that surrounds these agglomerations is in a state of transition and speculation. This is also revealed by the "extensive building of houses/layouts" in the green belt. Both BDA and BMRDA are planning to release large lots of systematically developed land, with appropriate infrastructure, to address the need for developed urban spaces.
5. Zone five– The green belt and agricultural area in the city's outskirts including small villages. This area is also seeing creeping urbanization.

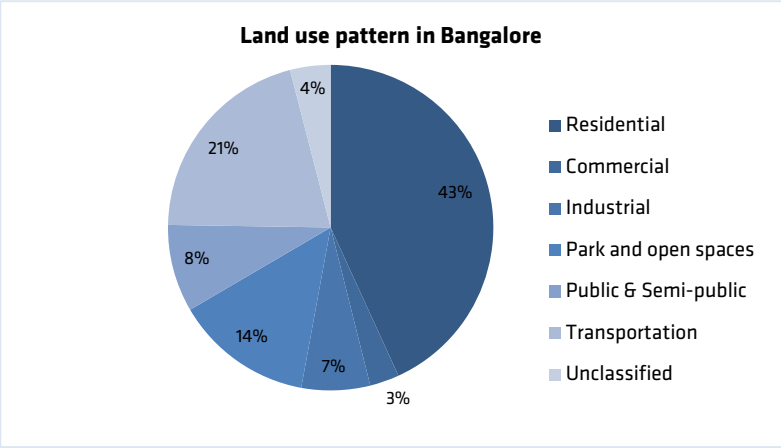


Figure 22: Land use patterns in Bangalore, 2009

(JNNURM, 2009, p. 15, appears in original as table 3)

Year	Motorization level	Land area sq.km
1971	n/a	171
1995	797000	260
2005	2130000	558
2006	2621000	560
2007	2960000	602
2008	3126000	710
2009	3407333	860
2010	3659833	930
2011	3912333	1000

Table 16: Expansion of Bangalore city land area

Source, Various

The city spatial structure follows the concentric model, growing at the fringes more than in the inner areas and structured by ring roads and radial roads. In the past few decades, the city has spread in all directions along major radial roads. While most of the development along these radial roads is generally industrial, the intermediary area between these roads is occupied by residential settlements. The average population density in the city is 8750 people per sq.km which is more than 27 times dense than the state average of 319 people per sq.km. However, this number could be significantly higher for the density of the residential areas only (up to 30000 people per sq.km) and for the inner parts of the city (up to 19100 people per sq.km) (JNNURM, 2009) and significantly lower in the fringe areas where the population density is under 100 people per sq.km.

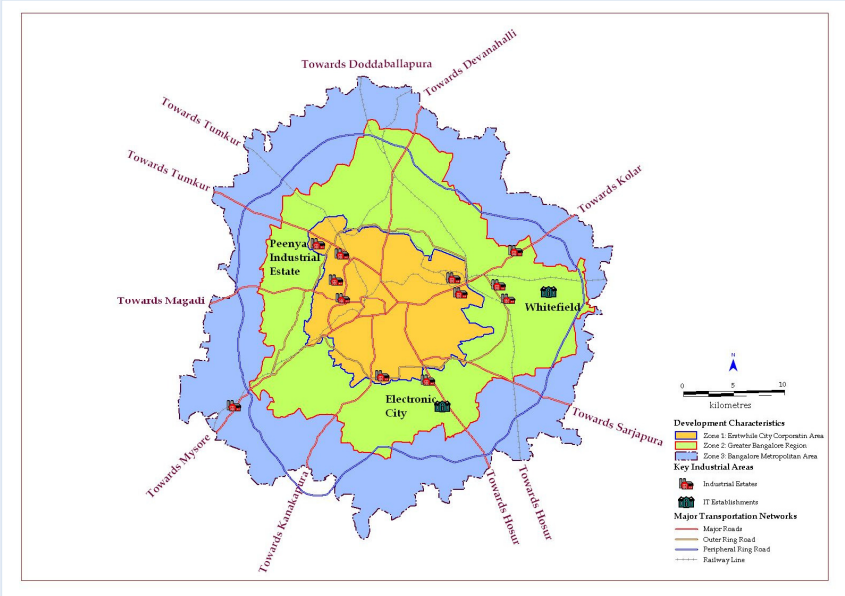


Figure 23: Development Characteristic over Bangalore

(Sudhira, et al., 2007)

The urban structure of Bangalore follows the concentric zone model going from the densely populated CDB to the sprawled suburbs at the fringes of the city. The population density in the city varies by location from as high as 19000 people/sq.km to as low as 3000 people/sq.km, the average being 8750 people/sq.km. CDPs are prepared for 10 year and determine the land use pattern of the city for the period.

Institutions, regulations and policy

Bangalore has the most diverse institutional framework for transport in India. There are several organizations involved in land use planning and transport planning in the city at different levels of mandates. These include:

1. The Bruhat Bengaluru Mahanagara Palike (BBMP) is the administrative body responsible for the civic and infrastructural assets of the Greater Bangalore metropolitan area. The BBMP represents the third level of government, after the Central government and State Government and is responsible for orderly development of the city. Its roles and responsibilities in the transport and land use sectors include zoning and building regulations, parks and greenery, maintenance and development of roads, pedestrian facilities & other non-motorized transport facilities.
2. The Bangalore Development Authority (BDA) is a governmental organization and the principal planning authority for Bangalore city. BDA, as a regulatory body, is required to prepare in the prescribed manner a Comprehensive Development Plan (CDP) of the city. It also oversees planning and development of infrastructure, provision of development-related sites and services, and the housing needs of underprivileged citizens in Bangalore. No other authority or person may undertake development within the Bangalore Metropolitan Region without the permission of the BDA.
3. Bangalore Metropolitan Region Development Authority (BMRDA) is an autonomous body created by the Government of Karnataka under the BMRDA Act 1985 for the purpose of planning, coordinating and supervising the proper and orderly development of the areas within the Bangalore Metropolitan Region (BMR) covering 8000 sq.km which comprises Bangalore urban district, Bangalore rural district and Ramanagara district excluding parts that are under the jurisdiction of the BDA.
4. The Directorate of Urban Land Transport (DULT) is created recognizing the capacity limitation of the existing institutions to address the mobility chaos in the city. DULT is functioning under the Urban Development Department of Government of Karnataka and is in general responsible for overseeing all the urban land transport initiatives in Urban/ Local Planning Areas of Karnataka. A Bangalore Metropolitan Land Transport Authority (BMLTA) has been constituted for the Bangalore Metropolitan Region (BMR) that reviews all transport projects (excluding Railways) in the BMR and will function as an umbrella organization to co-ordinate planning and implementation of urban transport programs and project.
5. Regional Transport Office (RTO) is an Indian government bureau which is responsible for the registration of vehicles and the issue of Driver's Licenses in India.
6. Bangalore Metropolitan Transport Corporation (BMTC) and Bangalore Metro Rail Corporation Ltd. (BMRC) are organizations responsible for the provision of road based urban public transport system and Rail-based urban public transport system respectively.

Table 17: Organizations involved in Land use planning and transport in Bangalore

Organizations	Functional areas (scope of work)
Greater Bangalore City Corporation [Bruhat Bangalore Mahanagara Palike (BBMP)]	Urban local body responsible for overall delivery of services – roads and road maintenance including asphalting, pavements and street lighting; solid waste management, education and health in all wards, storm water drains, construction of few Ring roads, flyovers and grade separators
Bangalore Development Authority (BDA)	Land use zoning, planning and regulation within Bangalore Metropolitan Area
Bangalore Metropolitan Region Development Authority (BMRDA)	Planning, coordinating and supervising the proper and orderly development of the areas within the Bangalore Metropolitan Region, which comprises Bangalore urban district and parts of Bangalore rural district. BDA's boundary is a subset of BMRDA's boundary
Bangalore Metropolitan Transport Corporation (BMTC)	Public transport system – bus-based
Bangalore Metro Rail Corporation Ltd. (BMRC)	Public transport system – rail-based (Proposed)
Directorate of Urban Land Transport (DULT)/ Metropolitan Land Transport Authority (BMLTA)	Overseeing all the urban land transport initiatives in Urban/ Local Planning Areas
Regional Transport Office (RTO)	Motor vehicle tax; Issue of licenses to vehicles

Just as there are several organization involved in the development, there are also several policy plans guiding and regulating the development of the Bangalore, amongst which;

Bangalore City Development Plan: The main policy document guiding the development of Bangalore, together with the Master plan of the city, is the Comprehensive Development Plan prepared in 2006 and revised in 2009 by the BDA. The vision statement in the document, which was developed by continuous consultation with the public, reads:

> *Bangalore has evolved as a cosmopolitan and livable City, with a global presence. To retain its pre-eminent position as a City of the future, the City shall enable and empower its citizens with:*
>
> - *Growth opportunities to promote innovation and economic prosperity;*
> - *A clean and green environment;*
> - *High quality infrastructure for transport and communication;*
> - *Wide-ranging services aimed at improving the quality of life for all;*
> - *Conservation of its heritage and diverse culture; and*
> - *Responsive and efficient governance*
>
> *(JNNURM, 2009, p. 45)*

This statement demonstrates a range of reflection on sustainable development and commitment for sustainable development in the city. This vision statement is followed by 10 mission statements, amongst which, the need for developing a sustainable urban transport system is explicitly addressed by mission number 3, which reads

> *Putting in place appropriate, comfortable, integrated, multi-modal public transport system for the region, based on efficiency and affordability*
>
> *(JNNURM, 2009, p. 45)*

Overall, the document addresses all aspects of sustainable development as mentioned in the mission statements that read, amongst others; building the economy of the city, ensuring environmental sustainability of land use, equitable growth and social equity. This document, however, does not (explicitly) address the need for NMT in the city and its role in sustainable society.

Bangalore Comprehensive Traffic and Transportation Plan: Every metropolitan region in India is required to develop a comprehensive integrated transport plan, with a strong emphasis on enhancing public transport. In line with that, based on a projected traffic demand up to 2025, Bangalore has prepared a Comprehensive Traffic and Transportation Plan that suggests an integrated multi-modal mass transport system on various corridors. The focus of the plan is very much on public transport (Metro System, Monorail/LRT System, Bus Rapid Transport (BRT) System, and Commuter Rail Services) and to certain extent NMT.

Policy Paper for Pedestrian Movement in the Bangalore Metropolitan Region: This is another policy paper prepared by Ides Consulting Pvt. Ltd in 2008 as requested by DULT. This policy paper is devised with intent of creating a framework for regulating and co-coordinating programs as well as actions by various stakeholders such that there is increased comfort, convenience and safety to the pedestrians and their movement. But the implementation of this document has always been in question since it has no power over the previously prepared Master Plan, CDP or CTTP. The Master Plan for BDA and the CDP contain hardly any clause for the provision of Pedestrian facilities and the CDA (revised in 2009) makes no mention of this document or its content. The main concern of the document is that there are only few roads with pedestrian facilities but they are not accessible to the disabled and the elderly. Besides, these facilities are already being encroached by two-wheelers and street vendors (Ides Consulting Pvt. Ltd., 2008).

There are several policy plans guiding and regulating the development of the city of Bangalore. These policy plans are also implemented and enforced by several state and local legal bodies that have stake in the development of the city. The multiplicity of organizations and documents creates confusion, conflict and overlapping of mandates. And the array of independent legislations and inherent conflict in the roles and responsibilities of stakeholders involved in the transport sector management impede in the process of planning and implementation of major schemes aimed at development.

Summary and conclusion

The mobility landscape

The contribution of the state to the changing climate and its impact on livelihood of residents is already recognized by the state of Karnataka and the local government of Bangalore. This has been well documented in the 'Karnataka Climate

Change Action Plan' prepared by BCCI-K. However, to everyone's surprise, this has not yet been followed by regulatory frameworks and policy interventions.

In the last few decades, Bangalore city grew in area and population resulting in longer trips and an increase in the mobility demand in the city that is matched only by a rapid growth in motorization. This change is the result of developments in the landscape of the mobility system that include a rapid increase in population (resulting from natural growth, migration and expansion of the city boundary) and fast growing personal income. The figure below shows correlation between urbanization, economic growth and motorization in Bangalore.

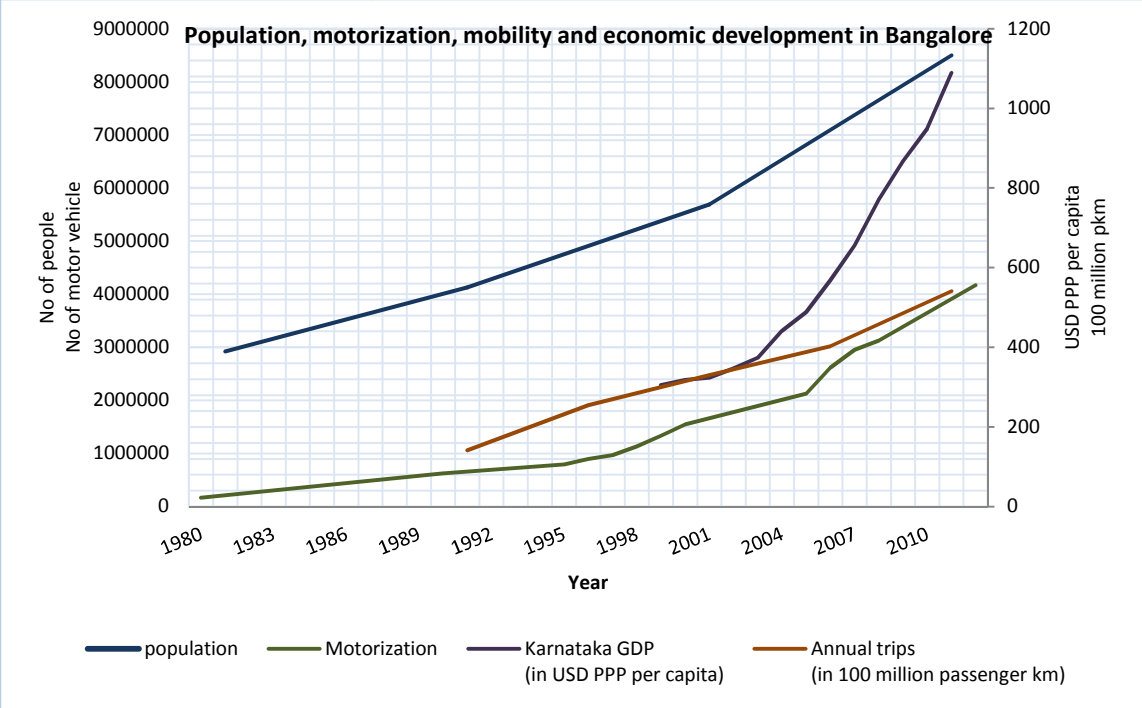


Figure 24: Trends in the population, motorization, mobility and economy of Bangalore

On the other hand, climate change and local air pollution are becoming increasingly important issues for the residents of Bangalore. This shows that and values are changing with widespread awareness of problems associated with transport and concern about environmental issues including pollution and climate change. The large majority of the respondents in the city agree that the personal car has more impact on the environment than public transport and their choice of transport mode is primarily influenced by their concern for the environment. The choice of the transport mode, according to the respondents, is highly dictated by the transit service quality that the transport fares.

The mobility regime

The population density in the core areas of Bangalore makes it very attractive for provision of public transport services with firm financial base. However, recent sprawled and segregated development at the fringes of the city makes the provision of infrastructure costly, hence, unattractive for service providers. The apartment complexes and commercial centers being developed in the periphery act as trip generators as well as trip attractors. As the city grow in size, population and affluence level, the demand for mobility and the average length of trips also grow. This trend has resulted in a rapid increase in the number of motorized vehicles in the city.

Though the vehicular composition in the city is dominated by two-wheelers and passenger cars, the large bulk of the daily trips still happen by public transport services. This trend, however, is changing in the last decade as the level of affluence in the city grew. This trend of motorization is further fuelled by provision of infrastructure (i.e. roads and parking spaces) for motorized transport modes in the expense of Non-Motorized Transport (NMT) modes. The share of the bicycle in daily trips is virtually non-existence. In relation to infrastructure, the built environment has co-evolved alongside personal motorized transport; more residential developments are happening at the fringes of the city and trip lengths are increasing. This makes NMT unattractive option and when the public transport is not catching up with the trends, it leaves the two-wheelers and passenger cars being the only choices available with no competition. The problem also lies in the intermediate transport option, that is limited to auto rickshaws which are usually in a bad condition, uncomfortable and dangerous.

The current public transport infrastructure is ill-equipped and incapacitated to meet the growing mobility demand, thus Bangalore city is swamped with two-wheelers and passenger cars in the past few years. 83 percent of the respondents who own cars or motorbikes agree that the public transport system is not their favorite because it is too crowded, unreliable and insecure. When asked what might encourage them to choose for sustainable modes of transport, 100% and 88% of

the respondents answered several improvements in the transit services and in the NMT infrastructure in the city, respectively. This will be the negative feedback to the current mobility regime in the city dominated by two-wheelers and passenger cars and the focus of the government should be on improving the infrastructure for public transport services and NMT modes to satisfy the desires of the residents of Bangalore for sustainable mobility. Safety for pedestrians and cyclists and reliable information service for public transport are amongst the concerns of the respondents. Push measures like less parking spaces and higher parking fees are also mentioned by the respondents to encourage the use of transit services. However, 63% think that parking spaces are already scarce and 75% doubt if they will have any impact on commuters' behavior since the change in attitude might not be as strong as the traditional values of freedom, affluence, and the high social status given to personal mobility.

The land use plan of Bangalore also supports the dominance of the personal car in the mobility regime. 88% of the transport and land use planners amongst the respondents believe that the land use of the city is segregated and the current plan does not support transit-oriented development. They also believe that the integration of the land use and transport policies and density targets to support transit should be priority in the future plans of the city.

On the other hand, the institutional framework of urban transportation in Bangalore city is constantly evolving in response to the growing challenges in the rapidly growing metropolitan region. As previously mentioned, overall institutional structure of the mobility sector is provided by several agencies operating at various levels of government. The multiplicity of organizations in the sector creates confusion, conflict and overlapping of mandates. And the array of independent legislations and inherent conflict in the roles and responsibilities of stakeholders involved in the transport sector management impede in the process of planning and implementation of major schemes aimed at development (RITES Ltd, 2007). Efforts to improve the urban transport system in the city remain scattered and redundant and remain bound to the dominant regime of the personal transport. There is also a problem of multiple planning documents used by these institutions; for example the City Development Plan (CDP) and Master Plan up to 2015 prepared by BDA, and the Comprehensive Traffic and Transportation Plan (CTTP) up to 2025 prepared by DULT/BMLTA do not seem integrated.

The main objective of the CTTP being to address the projected demand for mobility, it pays almost no attention to the environmental benefits or the impact of the current trend of transport system on the environment. Throughout the 34 page document, the word environment is mentioned only six times. NMT is mentioned in few paragraphs in the CTTP but receives less attention in the implementation as most resources are devoted to improving the infrastructure for the motorized transport modes. Besides, the policy paper clearly puts that it is the integration between Bus, Metro, and railway that is vital for the future, excluding NMT as part of the mobility system (RITES Ltd, 2007, p. 25). NMT is also totally neglected in the master plan of the city. In the Revised Plan for Bangalore 2015, there is not even a single measure of NMT infrastructure requirements in the entire 70 page document. Thus it is the policy, infrastructure, and institutions working together to sustain the unsustainable mode transport in the city.

The Niche: SUMS

The public transport services in the city are provided by buses and projects are underway for Metro services. The bus services in the city are crowded, unreliable, infrequent and in bad condition, hence, unattractive. As the result, most middle-class residents of Bangalore switch to two-wheelers or personal cars, even if that means high travel time budget. What makes it even worth is that the limited infrastructure capacity in the city does not allow for provision of right of way and priority for public transport services. The transit fares are well affordable by the residents of the city but the payment system is still complicated and does not allow the integration of payment services between several transit providers.

There are several issues that make the public transport unattractive for the better off, according to the result of the survey. Most respondents agree that transit services are not accessible for the not-able, not frequent enough, unreliable, bad integration between modes, do not feel secure, not easy with luggage and difficult to obtain transit information. The feeling towards NMT infrastructure is no better either. All respondents unanimously agree that Bangalore is not bicycle or pedestrian friendly.

The longer journey distance that followed the sprawling of the city stretched the capacity of the bus service provider to its limits and the vision of providing a seamless public transport service stayed a dream. The auto rickshaws tried to fill the gap left by the public transport services serving as an Intermediate Public Transport (IPT) services. But they are disorganized, profit only oriented, reckless and dangerous. For the majority, they are nothing more than nuisance. The lack of bike paths and sidewalks (or the encroachment of it by two-wheelers and street vendors) made NMT an option for the urban poor only.

Cultural, institutional and behavioral changes support the use of Sustainable Urban Mobility Systems through an increased use of public transport systems in combination with NMT. From the survey, 67% of respondents associated car ownership with social norm and culture, fuelling the lock-in. Therefore, measures that will address this aspect explicitly, might offer windows of opportunity by renegotiating the societal norm that may lead to sustainable modal shift either without or with targeted policy interventions.

One of the major problems in improving the efficiency of the public transport system to make it competitive with the motorized personal transport is lack of dedicated lanes for buses, high occupancy vehicles, pedestrians or cyclists and other transit priority measures. According to the planners in the survey, traffic signal priority is the only transit priority measure to encourage the use of public transport in Bangalore.

4.2 Jakarta, Indonesia

Introduction

Located on the northwest coast of Java, Jakarta, the capital and largest city of Indonesia, is the economic, cultural and political centers of the fourth most populous country in the world. After the independence in 1945, the population of Jakarta rapidly grew from less than 1 million, to 4.7 million in 1971. As of 2011, with a population of 10,187,595, Jakarta is the most populous city in Indonesia and in the whole of Southeast Asia. It was in 1966 that the government of Indonesia declared a special status for Jakarta: special metropolitan district with a status and administration similar to that of a province. Thereafter, Jakarta was referred as DKI Jakarta, short for Daerah Khusus Ibukota Jakarta Raya or Special Capital Area of Greater Jakarta (cSUR, 2008).

A dramatic rise in urban migration over the past twenty years is the primary cause of Jakarta's rapidly growing population (BPS, 2012). The official metropolitan area, known as JABODETABEK (a name formed by combining the initial syllables of Jakarta, Bogor, Depok, Tangerang and Bekasi), is the second largest metropolitan area in the world and is home for 28 million people (Demographia, 2013). Jakarta has an area of 664 sq. km. which is grouped into five Municipalities and one district administrative area: Central Jakarta (47.9 sq km), North Jakarta (142.2 sq km), West Jakarta (126.15 sq km), South Jakarta (145.73 sq km), East Jakarta (187.73 sq km), and the Thousand Islands administrative district (11.81 sq km). These are further divided to 44 sub-districts and 267 villages (BPS, 2012).

City of Jakarta is a lowland area with an average altitude of +7 meter above sea level. The city lies between 6° 12° South latitude and 106° 48° East longitudes. In general, Jakarta is subject to a hot climate with maximum air temperatures ranging between 32.7°C and 34°C during day, and 23.8°C and 25.4°C at night. Between 2002 and 2006, rainfall averaged 237.96 mm ranging between 122.0 mm in 2002 and 267.4 mm in 2005 (Government of Jakarta, 2012).

In a country of 240 million people, Jakarta is a major population center and the heart of the country's economy. During the 1970s to 1980s, as Indonesia was industrializing, Jakarta became one of the centers for manufacturing, especially electronics, automotive and consumer goods. After the 1997 economic crisis which hit the city (and the country & the region) very hard, Jakarta established itself more as a city of service; home to domestic and foreign financial institutions, multinational company headquarters and other businesses. Currently, it contributes 16 percent of the national GDP and in the last two decade has received 66 percent of Indonesia's total foreign direct investments and 45 percent of domestic investments (Government of Jakarta, 2012; Febrina, 2009; BPS, 2012).

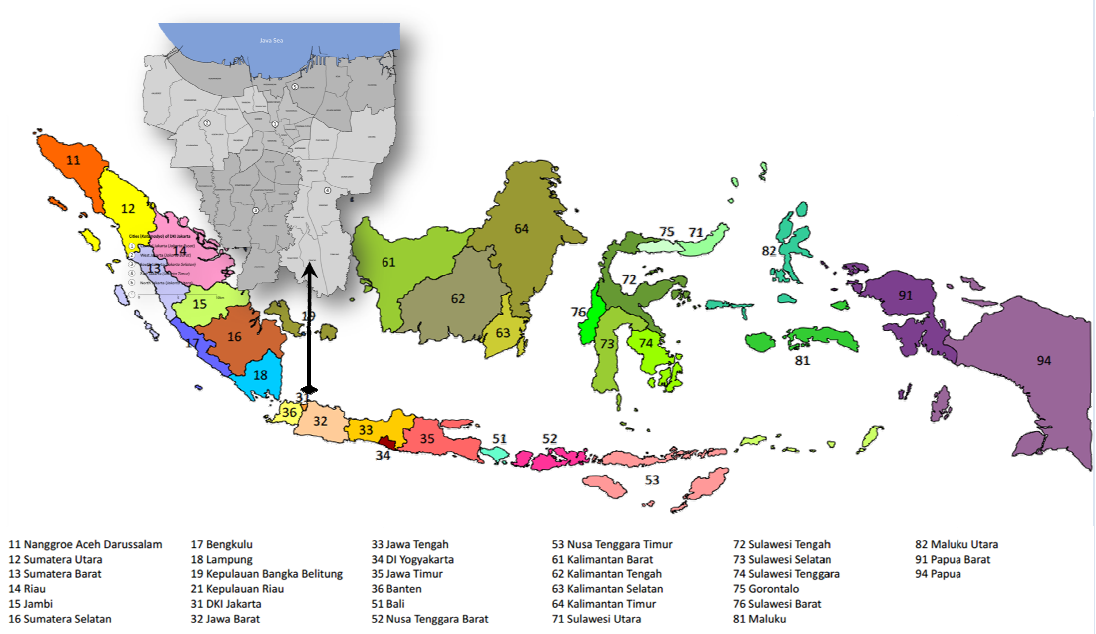


Figure 25: Map of Indonesia

(DisHub, 2009)

Climate change and sustainable development

In Indonesia, climate change is recognized as one of the challenges for development and a national priority. The Government of Indonesia issued Law no. 17/2007 on National Long Term Development Plan (RPJPN) for years 2005-2025, which on it also tries to integrate climate change mitigation and adaptation into all aspects of development planning. In addition, it was announced that the country is committed to a voluntary 26 percent reduction below the Business As Usual (BAU) Scenario by the year 2020 unilaterally, and a further 15 percent reduction with international support (Dalkmann, 2010). Transport is one of the major sources of greenhouse gas (GHG) emissions in Indonesia. In 2005, the transport sector in Indonesia contributed 20.7% of the total CO_2 emissions in the country and the road transport represents around 90% of these emissions (Frazila, et al., 2010). At the local level, the contribution of the transport sector to the total provincial GHG emission is more than twice as high as the national level. The figure below shows that transport contributes 45% of the total GHG emission in DKI Jakarta, followed by the Energy sector with 41%. The national and local governments have set up several plans and institutions to address the issue of climate change and the challenges to sustainable development.

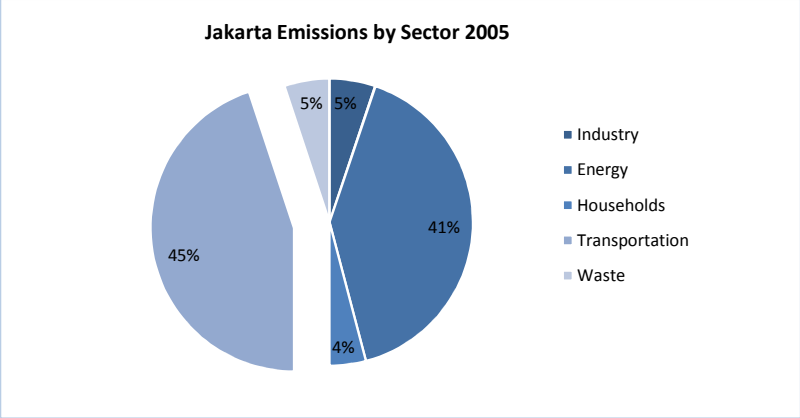


Figure 26: Jakarta's estimated GHG emissions in 2005

(Anggraini, et al., 2011)

At the national level, various institutions are involved in the formulation and implementation of actions related to reduction and mitigation of emissions (Dalkmann, 2010);

1. A National Action Plan (NAP) on climate change published in 2007, setting out the key strategies for taking action on mitigation and adaptation.
2. A National Council on Climate Change (NCCC, or DNPI) is established, aimed at facilitating communication and collaboration with stakeholders involved in issues of climate change mitigation and adaptation.
3. Sectoral roadmaps are formulated in all key sectors by the National Development Planning Agency (BAPPENAS)
4. The Indonesia Climate Change Trust Fund (ICCTF) is created to support domestic mitigation and adaptation activities and co-ordinate international donor contributions
5. Climate change, low-carbon growth and energy security emphasized in the mid-term development plan (RPJM), and energy efficiency and cleaner transport is expected to feature prominently
6. A Green Paper on Economic and Fiscal Policy Options for Climate Change Mitigation is published by Ministry of Finance in 2009, including proposals to impose a carbon tax/levy on fossil fuel use, coupled with access to international carbon markets facilitated through a "no-lose" target.

In line with this policies and initiatives at the national level, the local government of Jakarta has also set a target of 30% reduction of emissions compared to the BAU scenario by 2030 in the Jakarta region. In response to this target several Travel Demand Management (TDM) measures like Bus Rapid Transit (BRT), Mass Rapid Transit (MRT), 3-in-1, etc are (being) designed and (being) implemented in the city.

Like in India, climate change is recognized as a major challenge in Indonesia's development at the national and local levels. In correspondence with national plans and strategies, the local government of Jakarta has developed plans to reduce GHG emissions and the transport sector is an important part of the strategy.

Demography and Economy

Metropolitan Jakarta, also known as JABODETABEK, is currently the world's second largest urban agglomerations with a combined population of 21 million, accounting for nearly 10% of Indonesia's population and 20% of its GDP (BPS, 2012). Its core area DKI Jakarta has a land area of 664sq.km (covers 3% of the country) and a population of 10,187,595 in 2011. The population of Jakarta shows an increase of 25% in the last two decades growing from 8.2 million in 1990 but the land area shows little change growing by only 10sq.km since 1980. The average literacy rate in Jakarta is 98.8, and in 2011, only 10.8% of the population was unemployed (BPS, 2012).

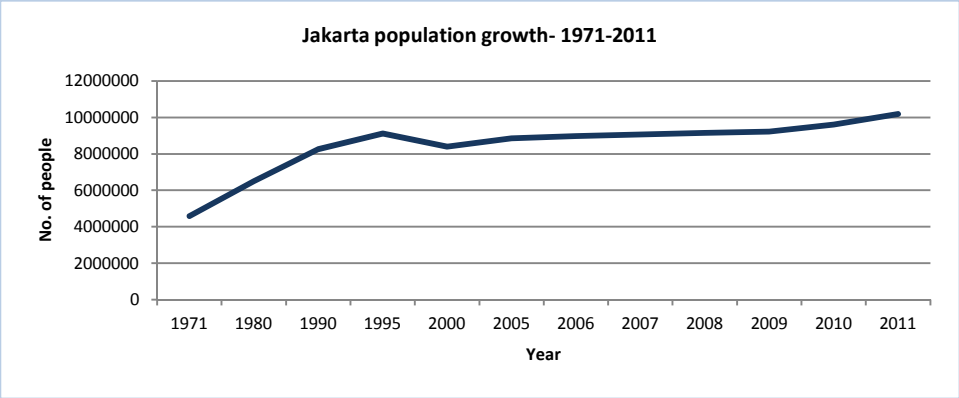


Figure 27: Population growth in Jakarta- 1971-2011

Jakarta has been playing a significant role in the national economic development since the mid 1970s. In 2011, the GDP per capita of Jakarta was Rp. 96,444,749.12, which is an equivalent of USD 10,600 which makes it the country's richest city with GDP per capita similar to that of Turkey and three times higher than Indonesia's national GDP per capita of USD 3,495.

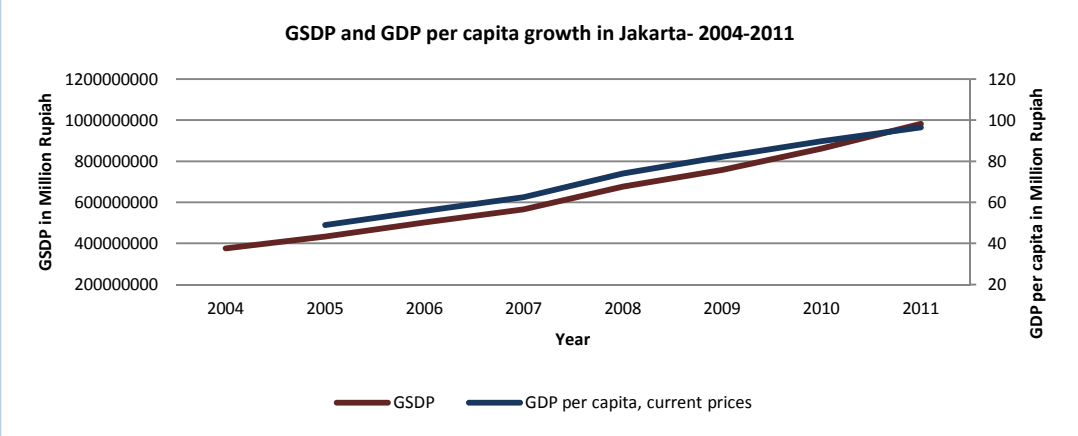


Figure 28: GDP growth in Jakarta- 2004-2011

Mobility infrastructure, culture & attitude

The main transport mode used by residents of JABODETABEK is the rail transport. In 2006, 123 million people used the rail transport services, which was a 6% increase from 2005. 84.9 percent of these trips happened between Bodetabek and Jakarta, while only 8.9% and 6.2% were inside Jakarta and outside Jakarta, respectively (BPS, 2007). In Jakarta city, however, road transport is the dominant mode for people to go around the city. Indonesia has a total road length of 396, 362 km 55% of which is paved. Jakarta has 7,650 km of total road length with 540 km of pedestrian way (BPS, 2012). The road infrastructure covers 8.1% of the total land area of DKI Jakarta (MPA Master Plan Study Team & JICA, 2012). According to the department of transportation (DisHub) Jakarta has a significant road deficiency that resulted in the congestion. The solution proposed by DisHub is either to increase the road ratio up to 12% by building 5,950 km new roads or reduce/restrain traffic by 32.6% (DisHub, 2009 as cited in (Wentzel, 2010)).

The travel demand in the city in 2012, according to a report by the local government of DKI Jakarta, has reached 21.9 million trips daily (an increase from 16,703,167 in 2010) of which 70% are made by motorized transport modes (Government of Jakarta, 2012). The number of commuters from Bodetabek to Jakarta has shown an increase of 50% between 2002 and 2010 (Ministry of Economic Affairs & JICA, 2012). 82% of survey respondents in Jakarta posses a driving license and 71% own cars, out of which 33% have two cars in the households and 8% has more than three cars in the household. Decades of rapid economic growth has resulted in a rapid increase in mobility demand, which, together with the poor public

transport services, has led to a dramatic increase in motor vehicle ownership and usage, particularly two-wheelers. This is further exacerbated by fuel subsidies and car-oriented infrastructure development.

78 percent of the respondents in Jakarta say it is important two own a car; where 88% say it might be important when carrying heavy luggage, for family trips or when someone is sick, 69% say it is because it is the fastest transport mode available in the city and a staggering 90% say that it is because the public transport services are not good. Surprisingly, only 39% did not agree that the car confirms their social status and 49% disagreed it is socially obliged to own and drive a car. The biggest difference from Bangalore is that, in Jakarta only 15% of the respondents disagree that it is their right to use a car (remember that nobody agreed on this statement in Bangalore). So, in Jakarta, even if the poor public transport quality plays a role, social factors play a significant role in driving the motorization process in the city. A concerning element of the survey response in Jakarta is that only 15% of respondents agree that owning a car is bad for the environment and only 34% say that owning a car is expensive. However, the second factor could be a result of the respondents' profile where 78% earn more than 3000USD annually.

In 2010, Jakarta had 11.6 million motor vehicles out of which 11 million are private vehicles. With an average annual growth of 11%, the city adds 1,172 motor vehicles to the streets every day (Indonesia Infrastructure Initiative, 2013). The modal share of the trips shows that 98% of the vehicles are private vehicles and serve only 44% of all trips while 2% of the vehicles are public transport vehicles and serve 56% of the trips. This has resulted in chronic congestion (particularly in the peak hours), local air pollution, high levels of noise pollution, and a significant reduction in road safety (particularly for pedestrians and cyclists). The National Planning Board (BAPPENAS) and the Regional Planning Board (BAPPEDA) are the bodies responsible for decision on railroad and toll road development at the national and regional level respectively.

Figure 29: Growth of motor vehicles in Jakarta- 2005-2010

The Bus Rapid Transit (BRT) system in the city (Transjakarta) is one not-able example of the effort of the local government to combat the trend of motorization. The initial corridor of the BRT network was conceptualized in 2002 and rapidly made operational within two years. By the year 2010, there were already 10 corridors run by 5 different private operators under the co-ordination of the public agency Transjakarta. According to Dalkmann, (2010) Transjakarta was the first successfully implemented BRT system in Asia. The BRT system has significantly reduced the travel time across the city, as well as an estimated emission reduction of more than 37,000 tones CO_2e per year across its 10-corridor network (Dalkmann, 2010). The BRT network covers a total of 172km with 170 shelters and serves 82.4 million passengers annually (Dalkmann, 2010). Public transport buses in Jakarta can be categorized to large buses (50 seated passengers) and medium-sized buses (25 seated passengers) and small buses (<25 seats). In DKI Jakarta, there are 2967 large buses (562 operated under Transjakarta), 4944 medium buses, and 14183 small buses (Government of Jakarta, 2012) that roughly gives over 2.3 buses per 1000 inhabitants. Though this classification was meant to feed each other, most of the buses run in the same route resulting in redundancy in some routes and shortage on the others. The gap between the private automobile and public transport is filled with taxis (mostly affordable by the upper middle-class), three wheelers and with motor cycle and bicycle taxis in the suburbs of Jakarta. Recently, Transportation and Traffic Department of the Government of Jakarta has signed an agreement with GMV for advanced fleet management and passenger information system of the BRT (GMV, 2013). This will improve the BRT service in one of the numerous cities in the world by providing GPRS based fleet management system and a complete passenger information system.

The city of Jakarta is also implementing a Mass Rapid Transit (MRT) which is a combination of subways and trains. The project is still under development and during completion it will cover 14.5 km with 12 stations (Government of Jakarta, 2011). The projected capacity of the MRT system is between 200,000 and 300,000 passengers daily with a speed of 27 km/h and waiting time between trains of 5.5 minutes (Government of Jakarta, 2011). Another important aspect of the MRT is that several key stations will be integrated with other mass transport modes, such as the buses, the Greater Jakarta railway, the monorail, and the waterway systems. However, the project implementation has not yet started and does not seem to start any time soon because of misunderstandings amongst stakeholders about the financing and fare structure of the project. It is also facing opposition from resident who believe that part of the project will disrupt their livelihood (Indonesia Infrastructure Initiative, 2013).

Figure 30: Map of the Jakarta BRT corridors

(Wentzel, 2010, p. 33, appears in original as Figure 3.10)

The existing fare system in Jakarta utilizes a flat fare for large and medium bus, and distance based fare for small bus. The fares range from Rp. 1200 on regular city buses to Rp. 3500 in the air conditioned BRT buses. There is no integrated fare system in the city, so basically every passenger has to pay each time he or she steps in to a bus or a taxi (Alvinsyah & Zulkati, 2005). All respondents think that the fair for train and metro are affordable and 94% agree that purchasing tickets is not difficult.

The government of Jakarta does little if not non to promote and facilitate NMT in the city. The first and only dedicated bicycle lane stretching 1.5 kilometers from Ayodia Park to Blok M in South Jakarta was inaugurated by the Jakarta administration in 2011. However, it was encroached by private cars, public minivans and three-wheeled right after the inauguration process (This Big City, 2011). 71% and 86% of the survey respondents agree that it is not easy to walk and to cycle in the city, respectively. This is obviously because hardly any NMT infrastructures exist in the city but also without strict law enforcement, the dedicated bike lane will not be an effective way to reduce Jakarta's traffic woes and will only be a failed initiative. Not surprisingly, 89% of respondents in Jakarta believe that bicycle lanes are one of the most effective ways to encourage sustainable transport modes in the city.

Despite the efforts to improve the public transport system to curb the trend of growing motorization, the government of Jakarta did not manage to stop the private vehicle from being the dominant mode of road transport. The JUTPI report by the Ministry of Economic Affairs & JICA (2012)shows that, while the share of public transport and NMT is falling, the share of two-wheelers in trips in JABODETABEK is growing rapidly. This is the result of the failure of the government to meet the demand for a higher quality and quantity of public transport options that come with the rapid population and income growth in the region. This trend is shown in the figure below. In 2002, the public transport share (38%) alone was higher than the share of the 2-wheelers and the passenger cars combined (33%). In less than a decade, that trend has been reversed and 2010, the share of the 2-wheelers and passenger cars (50%) was higher than the share of the public transport and NMT combined (47%) (Ministry of Economic Affairs & JICA, 2012).

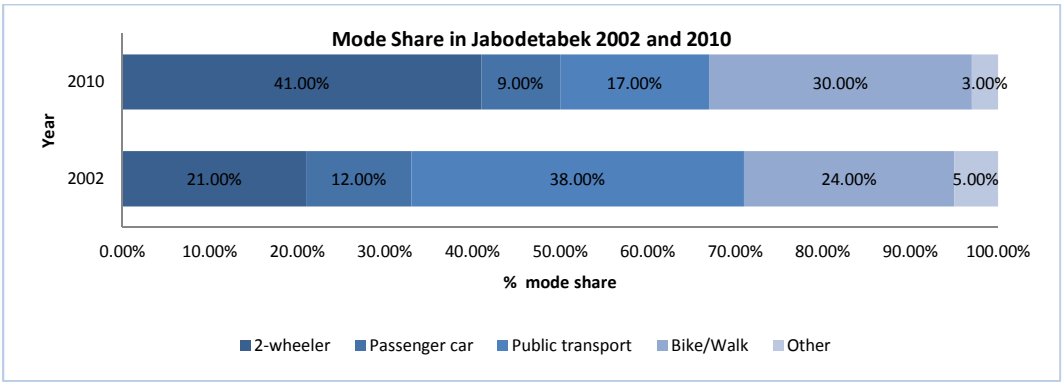


Figure 31: Travel mode share in JABODETABEK

(Ministry of Economic Affairs; JICA, 2012, p. 38, appears in original as Figure 12)

The mode share from the susrvey shows a different picture. 47% respondents use cars for work/school trips, 16% use motorbikes, while the rest use a combination of walk and public transport services. Leisure trips are almost entirely performed by using the car (76%) while the rest 24% are long trips made by a combination of taxi and train services. The majority of the shopping trips (64%) is also made by car, and the remaining 36% with taxi, bus, motorbike, train and walking. Similar trend is shown for trips for friends/family visit; 78% done by car and the rest with taxi, bus, train and motorbikes. Again, not surprisingly, a tiny fraction (2%) of the leisure trips are made in combination with a bike.

85% of the repondents agreed that the lack of information about transit services and safety concerns often prevents them from using the services, and home-station-work distances and service frequency are mention 86% and 89% of the time, respectively. Journey time, fare and weather are also amongst the factors frequently mentioned by the respondents, but comfort and quality are barely mentioned. 69% of the respondents believe that the public transport services are not accessible for the dissabled, 85% think they are not frequent enough at pick hours, 64% do not think they are reliable, and 88% agree that the integration between modes is poor. What gives the public transport a bad image is that 87% of the respondents say they have experienced harasment, robbery or assault while traveling with public transport and they feel

insecure while taking transit. Other important factors that reduce attractiveness of public transport services in Jakarta, according to the interviewees, are difficulty in finding appropriate public transport options (78%), difficulty of using the services while carrying luggage (65%) and difficulty of obtaining service information (66%). Only 32 percent of the respondents say parking spaces are scarce in the city and 86% think they might switch modes if parking prices increase.

The trend of motorization in Jakarta is similar to that of Bangalore's. 76% of all journeys in the city are made by motorized modes that are dominated by two-wheelers. The rapid improvements in the BRT system in the city did not stop the car monopoly in the city. The lack of NMT infrastructure gives no options for most but to turn into motorists at as soon as the personal transport modes become affordable. Most government policies in Jakarta are targeted to improve the motorized transport modes and give little or no attention to NMT.

Land use and urban structure

Jakarta's first development plan after the country's independence was drafted in 1953. This was revised and ratified in 1985 into a long term Jakarta Spatial Structure Plan 1985-2005 as a lot of practice on the ground violated designated zones stipulated in master plan (Government of Jakarta, 2012). Currently, Jakarta's 2010 Spatial Plan is linked to the Master Plan for the bigger metropolitan area- JABODETABEK. These master plans addressed the issue of transport planning in the city and in the neighboring areas.

Though the 2005 master plan show a multi-nuclei urban structure, the land use of the city is quite segregated (Mercy Corps, 2008). The central area is administrative and political center, while the south is the heart of the commercial sector, west Jakarta has large concentration of small scale industries, East Jakarta is home for middle and low-income families, and North Jakarta holds the old city. While trying to accommodate Jakarta's growing urban population and demand for land, most of the rural agricultural land has been converted for urban use. Most of the residents of Bodetabek work in DKI Jakarta, the city that contributes 71% of the GRDP of JABODETABEK (MPA Master Plan Study Team & JICA, 2012). And like most urban areas, the residential area covers around 50 % of the land area of Jakarta city and 70% of houses in the city have been developed informally on land and layouts outside official planning and development control (Theis, et al., 2003). These are the factors that contribute to an increase in the mobility demand and length of average trips in the metropolitan.

It was in the 1970s till 1990s that a lot of peri-urban areas of Jakarta were converted to large scale housing projects, particularly for high and medium income families (Hakim & Parolin, 2009). The uncontrolled development of residential building in the city fringes has resulted in longer trip in the last couple of decades. A study by Susilo, et al., (2007) shows that the average trip for all activities has shown a large increase between 1985 and 2000. According to the study, work trips increased from 6.7 km in 1985 to 9.6 km in 2000, while school trips increased from 2.7 km to 5.5 km, and shopping trips from 2.6 km to 4.8 km (Susilo, et al., 2007). It was not until 1974 that a separate transport study was conducted in Jakarta. Since then there has been several studies on the transport challenges of Jakarta city. But almost all of them, according to (Dewi, 2011), focus on improving the motorized transport system. As mentioned earlier, the recommendations of the local government for improvement of the transport sector are centered on the needs to increase the capacity of the city's roads and on providing a high capacity transit system based on increasing travel demands.

Today, Jakarta City has a population density of 14,476 persons per square kilometer, an increase from 12,355 persons per sq.km in 2008. This number significantly varies in different locations of the city with the highest being in central Jakarta (18590 person per sq.km) and the lowest in the islands (2233 persons per sq.km). Febrina (2009) argues that planning in Jakarta is more a reflection of what has already happened on the ground and it is reactive, the reality guiding the planning, rather than being proactive. The most crucial problem with Jakarta's urban planning, argues Febrina (2009), is perhaps the fact that plans are not enforced on the ground and later on revised to suit the reality.

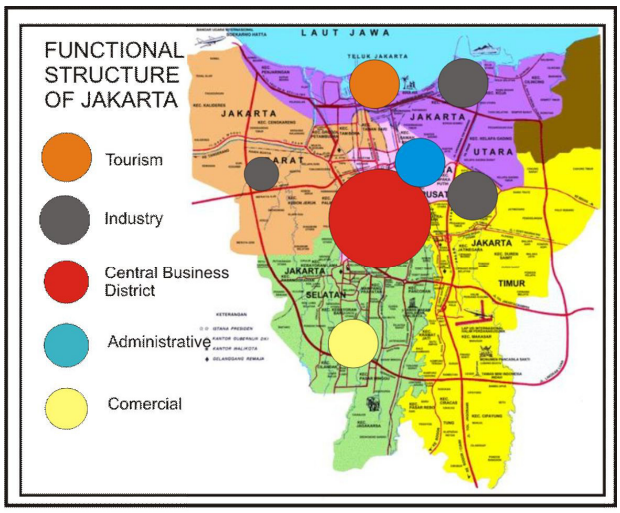


Figure 32: Function concentration in Jakarta

(Rizkiya, 2011)

The master plan of the city shows a multi-nuclei urban structure. However, on the ground Jakarta's land use is segregated and the city is dominated by informality and illegal settlements. The city administration seems to take the easy way out by modifying the master plan to match the situation rather than enforcing planning regulations. The average population density in the city is 145people/hectare with a huge variation in different locations that range from 186people/hectare to 22people/hectare.

Institutions, regulations and policy

The land use development and transport infrastructure in Jakarta is guided by several policy plans from National and Local level. The National Medium Term Development Plan (RPJMN) serves as the guideline for the national, regional and municipal governments in implementing the National Long term Development Plan (RPJPN), which has more power. The current version of RPJMN (2010-2014) is the second phase version of the implementation plan of RPJPN (2005-2025). The National Spatial Plan (RTRWN) 2008 is prepared to cover a 20-year period, and is reviewed every five years. The National Spatial Planning Co-ordination Board is responsible for preparing the plan and is chaired by the Coordinating Minister for the Economy. The plan includes guidelines for effective and efficient planning processes towards the objectives of the plan. There is also a strategic development framework that seeks to achieve security, economic viability, and sustainability in the use of land in Indonesia. The Regional Spatial Plan for JABODETABEK emphasizes the unity of the metropolitan area, the optimal use of its space, the co-ordination of the spatial plans of the local governments, the sharing of basic data on spatial use and roadmaps with a view to the future use of spaces, the designation of special economic zones, and the social welfare aspects of spatial plans.

When it comes the transport planning, besides the development of BRT and MRT as a response to the stifling congestion, the government of Jakarta has designed and implemented several programs in the city.

- The 3-in-1 policy is a traffic restraint strategy applied on several arterial roads in the centers of Jakarta from 6.30 a.m. to 10.00 a.m. and 4.30 p.m. to 7.00 p.m. on week days that grants access to part of the central business district (during peak hours) to cars only containing more than 3 people. The measure has so far been very difficult to enforce as drivers pick up children from the streets to accompany them to the restricted areas in an attempt to avoid fines. Moreover, there is a significant increase in traffic volume on parallel roads that worsens the congestion in the city (Wentzel, 2010; Dewi, 2011).
- Electronic road pricing (ERP) – which charges drivers "at the point of use", thereby creating incentives to rationalize the usage of their vehicles. Bus way lanes will be sterilized. There are four routes that are expected to have a big impact. Subsequently, a 20 percent increase in the number of passengers in the sterilized lanes is expected.
- Parking restraint – which is generally found in the form of increased parking charges, physical restrictions in the number of parking space available, or both. By controlling the availability and affordability of parking, road users are encouraged to rationalize their vehicle use and consider alternatives to driving their private vehicles into the city centers (such as public transport).
- Further improvements in public transport (particularly BRT) to encourage a shift to forms of transport that are more efficient and result in lower greenhouse gas emissions per passenger-kilometer

Additional programs to reduce the environmental impact of the transport sector in Jakarta include:

- There will be a study for a cheaper gas prices. In addition, gas re-fuelling spots will be added. DKI Jakarta Governor should arrange to arrange for public transport vehicles to use gas.
- Public transport using an inefficient small fleet will be restructured.
- The possibility of incentive provision for fleet rejuvenation will be assessed. Small bus companies are encouraged to switch to a large bus fleet.
- JABODETABEK train fleets will be expended. Passengers are targeted to reach 3 million people per day.
- A JABODETABEK transportation authority will be established, with the Governor of DKI Jakarta acts as its coordinator.
- The inner-circle railway project will be integrated with the mass transportation system.
- Make arrangements to ensure an optimal number of vehicles, using all available instruments.
- To support the train, park-and-ride facilities will be built to reduce vehicle use. By the order of the Minister of Home Affairs land areas are reserved for the provision of parking space.

Several vertical and horizontal government institutions are involved in inner city urban development in Jakarta. The main agencies of national and local governments involved in the management of urban area development and transport in the city are shown in the table below.

Table 18: Agencies involved in urban development in Jakarta

(Theis, et al., 2003, pp. 3-3)

Level	***Organization***	***Responsibility***
National level	National Development Planning Board (BAPPENAS)	This agency is responsible in coordinating the cross-sector development in national strategic areas. The co-ordination is administered through the National Spatial Planning Co-ordination Board (BKTRN) which consists of the related central government departments and institutions.
	Department of Home Affairs	This department could directly and indirectly (through the local government) administer the co-ordination in urban development. One of the tasks is issuing the management right (hak pengelolaan) of an area.
	Department of Settlement and Territorial Development	The role of this department is administering directly or indirectly through the local offices spatial planning, management, urban development policy and the related infrastructure.
	Department of Transportation	This department has responsibilities for transportation management in the area including the public transportation provision.
	National Board of Land Affairs	This agency administers the UU No.5/1960 Land Act and Presidential Decree 26/1988 that make provisions for land use planning and issuing Business Utilization Right (Hak Guna Usaha). This comprises the Utilization of Building Right (Hak Guna Bangunan) for Indonesian citizens and the Utilization Right (Hak Guna Pakai) for foreigners residing in Indonesia.
	The State Ministry of Public Works	This department has responsibility in coordinating the general Public Works affairs in Indonesia. The role is indirectly to co-ordinate the spatial planning, management, urban development policy and the related infrastructure in support to the role of Department of Settlement and Territorial Development.
	Department of Industry	This department directly or indirectly administers the industrial affairs of industrial development in urban areas.
Local level	DKI Jakarta planning department (BAPEDDA)	BAPEDDA is responsible for coordinating land use and transportation planning, to ensure that the transport plan is consistent with the objectives of the regional land use plan. BAPPEDA is also responsible for the co-ordination of various implementing agencies in Jakarta. It administers the UU 24/1992 statutory Act of Spatial Planning and the drawing up of development plans and policy in accordance with the provincial and the Kotamadya's master plans (RTRWP and RTRWK). This includes the related environmental management plans (AMDAL), administered by the Local Environmental Impact Agency (Bapedalda) in the respective municipalities.
	The Regional Environment Agency (BPLHD)	The agency is responsible for the implementation of environmental policy in the Jakarta capital region. In relation to transport, it is responsible for setting emission standards policies for vehicles. More recently, in the context of the mitigation targets set by the Governor, the Agency is seen as a key player in the MRV of mitigation actions. In this regard, the Agency is currently investigating ways of setting a baseline at the Jakarta regional level, and consequently aiming to provide a roadmap of mitigation actions to meet the aforementioned target.
	The department of Trade, Industry and Transportation	The agency provides overall directional guidance in the transport sector, e.g. in the form of formulating a Transport Master plan.
	The Regional Transportation Agency (DISHUB)	It is tasked with the implementation of transport related policies in the Jakarta capital region. There is currently no environmental responsibility within DISHUB but its priority lies in tackling the stifling congestion in the city.
	Transjakarta	The BRT operator is a specialist agency under DISHUB tasked with the operation of the BRT system. It is responsible for the day to day running of the BRT system, including procurement issues, management of staff etc.

Because of the economic and political importance of the city, several national institutions have interest in the assets and the development process. The complex involvement of horizontal and vertical organization in urban development issues of the city create confusion, conflict and overlapping of mandates and hinder the decision process of the local government. The multiplicity of organizations resulted in conflicting decisions in land use planning and redundancy of activities.

Summary and conclusion

The mobility landscape

Similar to the Bangalore, the impacts of climate change and the challenge to sustainable development are recognized in Jakarta at national and local levels. Indonesia is committed to a significant reduction in GHG emission in all sectors of the economy. The transport sector, being one of the contributors of GHG emissions, is considered one of the main sectors to meet the reduction targets. This is reflected in several policies and plans at the local and national level; most of them focusing on improving the public transport services, restricting car use in some locations or shift in the fuel used for motorized transport.

The population of Jakarta grew fastest between 1970 and 1995. Since then, it has shown a steady slow growth. The land area of Jakarta has not shown any growth for the last few decades, as well. However, it was the rapid growth in population of the neighboring cities together with the increasing interaction with Jakarta that has resulted in longer work/school trips and an increase in the mobility demand in the region that is matched only by a rapid growth in motorization. This change is the result of developments in the landscape of the mobility system that include a rapid increase in population of the JABODETABEK metro area, the increasing economic activities in the region and fast growing personal income. The figure below shows correlation between urbanization, economic growth and motorization in JABODETABEK.

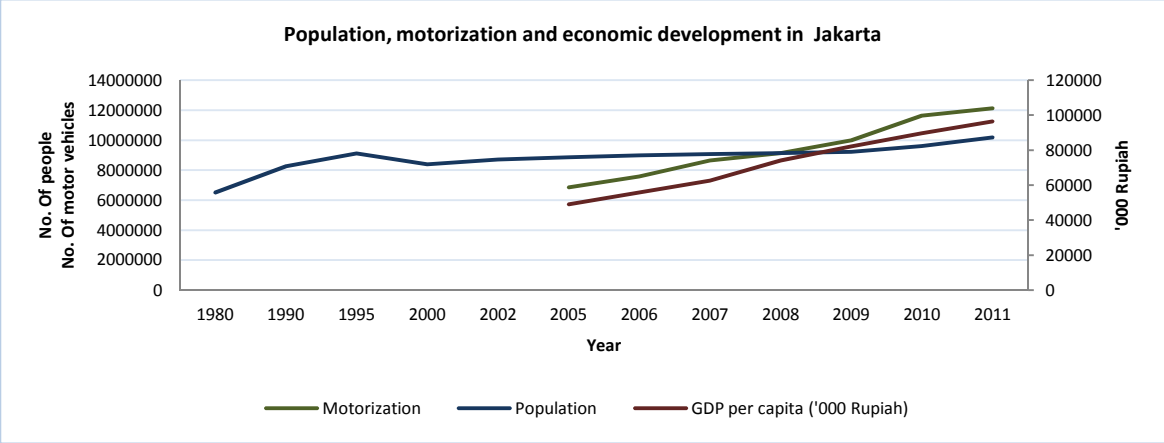


Figure 33: in the population, motorization, mobility and economy of Bangalore

In Jakarta city, climate change and local air pollution are becoming increasingly important issues for the residents. This shows that, similar to Bangalore, values are changing with widespread awareness of problems associated with transport and concern about environmental issues including pollution and climate change. From the survey, 88 percent of the respondents agree that passenger cars and two-wheelers have impact on the climate. 95% agree that the personal car has more impact on the environment than public transport and all of them said their choice of transport mode is primarily influenced by their concern for the environment. However, safety, reliability, journey time and convenience also have equal importance which made the public transport services less attractive.

The mobility regime

Like many cities in countries with rapid economic development, mobility in Jakarta is dominated by passenger cars. Te number of motorized vehicles, especially two-wheelers, has increased drastically in the last few years, creating terrible traffic jams in all parts of the city. The government introduced several measures to reduce the stifling congestion by expanding the road network, improving the public transport services and discouraging cars in very few locations. However, the improvement of the public transport services did not meet the growing mobility demand in the city and the metro area, that left the residents of JABODETABEK not many options but to depend on personal travel modes. The few restrictions were also ill-enforced and were not supported by adequate public transport infrastructure allowing people to exploit the loop holes in the system. Most of these policies made it even more difficult for people to move from private vehicles to mass transit because of the very poor inter-modal integration; i.e both for integration of routes and integration of fares. Besides, all these measures are focused on improving the infrastructure for motorized transport only.

Though Jakarta is densely populated, the land use is quite segregated and commuters come to the city from the surrounding cities. Most of the developments in the fringe areas are built informally and does not comply with regulations.

The master plan of the city still lacks long term development goal and is once again ineffective in practice as seen over and over again. The economic importance of the city made it the focus several national government offices that hinder the decision process of the local government. The multiplicity of organizations resulted in conflicting decisions in land use planning and redundancy of activities.

Despite the rapid improvements in the BRT system, the transit infrastructure in Jakarta is still long way from meeting the growing mobility demand. For 94 percent of the respondents who own cars or motorbikes, the public transport system in the city is too crowded, unreliable and insecure.

The need for a change in the land use and transport sector was also addressed in the document "Master Plan for Establishing Metropolitan Priority Area for Investment And Industry in JABODETABEK Area in The Republic Of Indonesia''. Amongst the four needs identified in the plan, the two that directly or indirectly address these topics are:

1. Switch to multi-core urban structure: Enhancing the sub-centers is considered to be an urgent need for Jakarta Metropolis, so that the satellite cities of Jakarta Metropolis should be enlarged and more activated.
2. Need to adapt to a low-carbon society: The risk of global warming is conceived widely throughout the world. As Indonesia is an island nation, the possible effects of global warming may be serious in the future. Thus there is a need to shift to a low-carbon society.

To achieve these needs, detailed programs and indicators are designed. The programs include densification in the suburb neighborhoods and increasing the share of the transit services in daily trip in JABODETABEK area. Successful implementation of high quality public transport will require a focus on mobility management rather than on relieving congestion, and that requires consensus between stakeholders and creating synergy.

The Niches: SUMS

The current Jakarta transit service leaves a lot to be desired. The public transport services in the city are provided by BRT service, buses, taxis and other intermediate transport options. However, the system is crowded and, as mentioned earlier, there is poor integration between the different transport modes.

At the moment, the TransJakarta Bus way is the heart of Jakarta's mass transit system carrying over 225000 passengers every day. The system is overcrowded far beyond its capacity, not reliable and is unsafe. This BRT system is supplemented by small and medium local buses that are also overcrowded and are in a bad condition and 3-wheelers that are uncomfortable and dangerous. In a city that is hot and humid, a crowded bus system is a bad image for the transit services.

Monorail system and Mass Rapid Transit (MRT) are the other transit service in Jakarta that are either planned or under construction. The construction of MRT is well accepted in Jakarta. According to the plan, the MRT will carry 1.9 million passengers every day when completed. The high carrying capacity of the system will make it suitable for the city of 10 million people. But only if it can be well integrated with the other transit systems and improved NMT infrastructure.

Even stronger than the case of Bangalore, the transport mode choices of respondents in Jakarta are highly influenced by cultural, institutional and behavioral values. From the survey, 65% of respondents associated car ownership with social norm and culture. Therefore, measures that will address this aspect explicitly, might offer windows of opportunity by renegotiating the societal norm that may lead to sustainable modal shift either without or with targeted policy interventions. Another important element in this challenge is that 83% of the respondents have indicated that they might leave the car if parking fees increase. However, the biggest challenge in Jakarta's transport services remains enforcement of regulations; for both land use and transport services.

Chapter 5: Synthesis and Conclusion

From the two cases, Bangalore and Jakarta, we can see that the personal car is the dominant system in the mobility sector. The landscape in the transport sector is changing as the result of economic, social and spatial developments. In both Bangalore and Jakarta, economic development, urbanization and social factors affected the total volume of trips, the average length of trips and the choice of the travel modes. In the past couple of decades, urban development in both cities was predominantly guided by the need for housing to accommodate the fast growing population and with no consideration to the infrastructure demand and environmental impact of such development trends. Activities in both Bangalore and Jakarta are segregated, most of the residential developments being at the fringes of the city. In the past four decades, Bangalore and Jakarta added 8 million and 6 million people to the city, respectively. And within the past decade, the GDP per capita PPP more than doubled in both cities. This had a serious consequence in the urban infrastructure of the cities and the transport service is no exception.

Besides the high rate of urbanization and economic growth, the increasing importance of the climate in development policies in India and Indonesia is positively impacting the mobility landscape. The transport sector is identified as the main sector to achieve reduction targets by both governments. The measures in the Bangalore transport sector include increasing the share of the public transport services in the daily trips in the cities, new efficiency standards for vehicles, switch to more sustainable fuels, and improving the NMT infrastructure (though very limited). Jakarta has designed several programs in the transport sector as a response to climate change and sustainable development challenges like BRT (Trans Jakarta), Car free day, Vehicles emissions control, Traffic restriction zone, Blue Bajaj program (run on compressed natural gas instead of diesel), Mass rapid transit, Electronic road pricing, Light rail transport, and Monorail transport.

It is obvious that public transport is not a free good, which is not-able to play in a pure free market. Thus the intervention of and taking sides by the local and national governments to improve the service quality and quantity is imperative. It is pointless restraining the use of the automobile while there is no acceptable alternative mode. That will only make drivers find a way around the traffic restraint schemes rather than consider changing their mode as seen in both Bangalore and Jakarta. Besides, there is not even one measure that stimulates and facilitates NMT in Jakarta. Expanding public transport networks and infrastructure is a good start but alone does not make a city transit friendly. All the improvements in the public transport will be useless in reducing car use unless it is integrated with NMT modes that require significant infrastructure improvements.

Both cities, Bangalore and Jakarta, have prioritized infrastructure expansion in order to alleviate congestion and improve the transit services in the city. Though these decisions are justified, it is also important to make use of the moment to develop the NMT infrastructure in the city. At the moment, 94.5% and 76% of all journeys in Bangalore and Jakarta, respectively, are still motorized and the concern is barely addressed in policy documents in both case study cities. Law enforcement is also another issue when it comes to existing NMT infrastructures that are being encroached by two-wheelers and used as parking plots by other motorized modes. A safe and accessible NMT infrastructure provides alternative to the dangerous and unfavorable intermediate transport modes in the cities. That will give a feeling of safety and encourage people to use the infrastructure for the right purposes.

Urbanization-Income-Motorization hypothesis: Accompanied by a high level of urbanization, if the per capita GDP of Bangalore and Jakarta increases (above 3000 USD), then the motorization level in the cities will also increase.

In both cities, population and GDP growth show a significant correlation with the trends of motorization in the cities. The square of the correlation coefficient for population growth and motorization is 0.99 and 0.97 for Bangalore and Jakarta, respectively that shows a near perfect correlation. For correlation of GDP per capita PPP growth and motorization, the R-square value is 0.99 and 0.85 for Bangalore and Jakarta, respectively. Therefore, we can conclude that, there is a significant correlation between motorization, population growth and economic development in both Bangalore and Jakarta. Thus the Urbanization-Income-Motorization hypothesis is proved true in both cities.

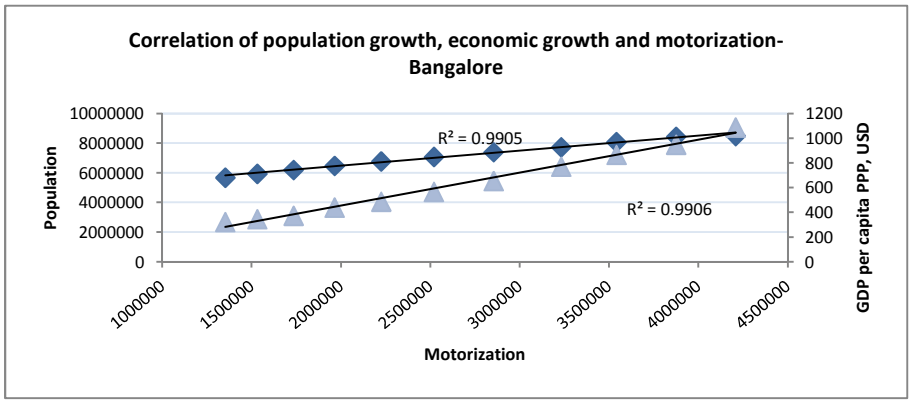


Figure 34: Correlation of population growth and economic growth with Motorization in Bangalore

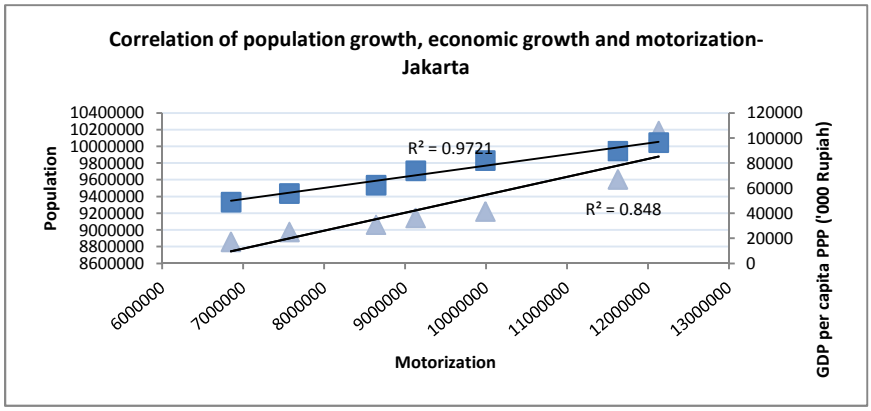


Figure 35: Correlation of population growth and economic growth with Motorization in Jakarta

The social value hypothesis: If people in Bangalore and Jakarta associate vehicle ownership with social status and life style values, then improvements in public transport services will not affect the car ownership and use in the cities.

In Bangalore, car ownership and use is to some extent associated to social status. 31% of the respondents say that the car confirms their status in the society. However, while 53% of them also say that they are using the car because it is the fastest mode of transport available (though the average speed in the city at peak hour is 15km/hr), a staggering 82% say the reason is the bad public transport service quality in the city. Thus, though the car is associated to social status and life style values, all respondents unanimously agreed that health and environmental benefit will significantly dictate their choice of transport mode. Safety, reliability, journey time, convenience, availability of information and available routes will also have a say in their mode choice.

In Jakarta, association of the car with social status and life style is even stronger than it is in Bangalore. 61% say owning a car confirms their status in the society, 51% agree that it is socially obliged, and a striking 85% say it is their right to use the car. Like in Bangalore, respondents in Jakarta also believe that the car is the fastest mode available and all who responded to the question say they use the car because of the bad service quality of the public transport services in the city. Health and environmental benefits are the factors that all respondents say will significantly influence their choice of transport mode. Transit service qualities (Safety, reliability, journey time, convenience, availability of information and available routes) also play equally important role in dictating their choice of transport mode.

From these responses, we can see that even if social status and life style play significant role in driving the motorization trend in Bangalore and Jakarta (more so in Jakarta than Bangalore), residents give priority to health and environmental benefits while choosing a transport mode. They also indicate that they will be willing to switch provided that the public transport in the city improve in service quality. This proves the hypothesis false. The car is associated with social status and life style, but the growing motorization is mainly forced by the bad service quality of the transit services and lack of NMT infrastructure.

The green norms hypothesis: If more environmentally responsible attitudes (environmental attitude, ecological norms & values, feeling of responsibility) are encouraged by governments, then use of personal cars in Bangalore and Jakarta will reduce.

In Bangalore, while 57% of the respondents agree that driving a car is bad for the environment and it is also worth than the public transport, 37% chose neutral or did not agree with the sentences. In Jakarta, 58% agree that personal car has impact on the environment but 37% chose neutral. 56% of respondents in Bangalore and a mere 42% in Jakarta agree that the passenger car has more impact on the environment than public transport. A third and a half of the respondents in Bangalore and Jakarta respectively, did not understand the environmental impacts of the passenger car, while 44% in Bangalore and 58% in Jakarta did not think that the public transport is better for the environment. People must first be convinced of the environmental and health benefits of public transportation and NMT for the transition to happen. An educational or public relations campaign must be launched to sensitize those who have disregarded the environmental benefits of public transportation over the passenger car. People should be familiarized with the environmental, social and personal benefits for present and future generations.

An interesting response from residents of both cities participated in the survey is that they unanimously agree that the pollution in the city is affecting their quality of life. Everyone has a part to play in improving his/her own quality of life and the government should promote awareness-raising campaigns that can better inform city residents of the benefits of using public transport services or the impacts of passenger cars to the local environment. Through this instrument, it is possible to increasing PT ridership and to contribute to alleviating the role of transport in local air pollution (and climate change) as well as relieve congestion and offer mobility to all, hence, improve quality of life in the cities. Therefore, we conclude that, encouraging environmentally responsible attitudes might increase the share of PT in total trips in Bangalore and Jakarta and reduce passenger car use in the cities since health and environmental benefit dictate the choice of transport mode, provided that the public transport services and NMT infrastructure improve (as discussed in the social value hypothesis).

The urban structure hypothesis: the segregated/sprawled urban structures (density, design and diversity) in Bangalore and Jakarta lead to growing motorization.

Another point also addressed by land use and transport planners and managers in both cities is the importance of integrated land use and transportation planning in creating Sustainable Urban Mobility Systems. The question of how to develop Sustainable Urban Mobility Systems should begin with the recognition that an evolutionary relationship exists between urban structure (e.g. urban sprawl) and types of (public) transport mode and these interactions are seen as key mechanisms for automobile dependence. Enforcing the land use legislations and regulation in both Bangalore and Jakarta is very complex, because of the many agencies, hence many documents, involved in planning and provision of permits.

Though the average density of both Bangalore is above the average population density of the India (148 people per sq.km for India), it shows a significant variation between the different zones and employment is spread along several roads and into several clusters (IT cluster, Industrial cluster, educational institutions cluster, etc) at the fringes of the cities where density goes as low as 1 person per hectare. Since the 1980's Bangalore has grown by leaps and bounds. It has seen a steady growth in economic activities and land area, with the developed area of the city increasing from roughly 175 sq. km in 1971 to more than 1000 sq.km in 2011. The government's decision to decongest the city center by restricting the Floor-Space-Index (FSI) in the core has lead to high land prices in the city, pushing the middle-class and lower class to the peripheries. Later, the rising level of affluence combined with long travel times, poor public transportation facilities and the hype by the car industry has led to a rapid motorization in the city.

Similarly, the population density of Jakarta is indeed much higher than the country's average density of 134 people per sq. km. But it also shows big difference between the different municipalities with Thousand Islands administrative district having the lowest density of 22 people per hectare. The large scale housing project in the peri-urban areas of Jakarta between the 1970s and the 1990s, particularly for high and medium income families has resulted in segregation of land use types and lead to longer trips in the city. But the story in Jakarta is different, rather than the city expanding itself, it included the surrounding satellite cities in to its metropolis and took the name JABODETABEK. The land area of DKI Jakarta show very little change in the past three decades with most of the residential settlements happening in the satellite cities surround it. Therefore, the problem for Jakarta is the spill-over of various socio-economic activities from DKI Jakarta to its peripheries that need huge tracts of land, including large scale housing areas and industrial estates, that creates one of the biggest urban agglomeration in the world, JABODETABEK. This has spread the socio-economic activities of Jakarta from 664sq.km to over 6400sq.km and contributed to a large increase in the number of commuters in to Jakarta.

The motorization trend in Bangalore and Jakarta is predominantly led by a combination of growing income, growing population and sprawling city. While income and motorization in Bangalore show an average annual growth of 24% and 21% respectively, in the past two decades, the population grew only at an average annual growth rate of 5% and the land area at 13%. In Jakarta, motorization and income grew at an annual average of 12% each for the last decade, but the rate of population growth was only 0.4% (annual average) and the land area did not show any change. However, the Jakarta metropolitan area has been shifted from the 662 sq.km DKI Jakarta to the 6580 sq.km JABODETABEK region.

Table 19: Annual motorization, income, land area and population in Bangalore and Jakarta- 2001-2011

Year	Bangalore				Jakarta			
	Motorization growth rate	Income growth rate	Land area growth rate	population growth rate	Motorization growth rate	Income growth rate	Land area growth rate	population growth rate
2001								
2002	13.3%	7.1%	11.4%	4.5%	18.5%	n/a	0.0%	3.9%
2003	13.3%	7.7%	3.9%	4.5%	12.8%	n/a	0.0%	-12.3%
2004	13.3%	18.0%	6.4%	4.5%	15.6%	n/a	0.0%	-3.5%
2005	13.3%	10.8%	4.4%	4.5%	18.0%	n/a	0.0%	1.6%
2006	13.3%	16.3%	0.3%	4.5%	10.5%	14.1%	0.0%	1.3%
2007	13.3%	15.4%	7.4%	4.5%	14.1%	11.8%	0.0%	0.9%
2008	13.3%	17.7%	18.0%	4.5%	5.7%	18.5%	0.0%	0.9%
2009	9.6%	12.4%	21.1%	4.5%	9.4%	11.0%	0.0%	0.8%
2010	9.4%	9.4%	8.1%	4.5%	16.4%	9.2%	0.0%	4.2%
2011	8.6%	14.7%	7.5%	0.6%	4.3%	7.5%	0.0%	6.0%

In both cases, the sprawled development and the inclusion of the neighboring cities in to the metropolitan area have contributed to a rapid increase in travel demand. As supported by the theory in chapter 2, the sprawl developments in the cities might have contributed to an increasing motorization level together with the population growth and the income growth. But, because we could not find data on the income categories and car ownership level of residents in the peripheries of the cities, we cannot statistically prove whether the sprawl developments have a major contribution to the increase in motorization. As shown in the table above, the increasing motorization level in both cities seems more driven by the income level than it is by population or sprawl development.

Public transport service quality hypothesis: If the quality of the public transport systems in Bangalore and Jakarta improve accompanied by NMT infrastructure, then PT ridership and the mode switch from other motorized modes of mobility will increase.

36% (plus 28% say neutral) and 83% (plus 7% say neutral) of the survey respondents in Bangalore and Jakarta, respectively, say that owning a personal car is important because the public transport services are not good in the cities. This is despite that 45% (plus 28% say neutral) in Bangalore and 34% (plus another 26% say neutral) in Jakarta believe owning a car is very expensive. Besides, 59% of respondents (plus 25% say neutral) in Bangalore and 75% (18% chose neutral) in Jakarta put the environment in the center of their decision making process while choosing a transport mode for a specific trip. Other factors frequently mentioned for having a significant influence on the choice of transport mode in Bangalore are total journey time taken (70%), poor integration (56%), safety (54%), distance between station and destination (50%), fare (46%), lack of available information (40%), frequency of service (31%), overcrowding (33%), and weather (20%) and in Jakarta lack of available information (55%), distance between station and destination (74%), total journey time taken (71%), overcrowding (58%), poor integration (51%), frequency of service (69%), safety (75%), fare (60%), and weather (38%).

This shows how bad public transport services in the cities are perceived to be; people walk away from an affordable and environment friendly transport mode to an expensive and more polluting mode of transport because the quality of the transit services do not much their expectations. The public transport services in the cities are characterized by unreliability, too long journey times, overcrowding, inaccessibility and insecurity. Accessibility, safety, journey time and integration, according to the respondents, are more important in attracting riders than transport fares and the effect of the weather. Thus, improvements in the service quality of public transport services together with NMT infrastructure will encourage more transit service use by the residents of Bangalore and Jakarta.

Limitation of the study

Although this research was carefully prepared, I am still aware of its limitations and shortcomings.

Adequacy of the sample: we have managed to get roughly half the response we expected, thus only 52 respondents in Bangalore and 45 respondents in Jakarta replied the questionnaire. This is a small number of groups and might not be representative of the actual situation for generalization.

Representativeness of the sample: we established contacts with respondents through Erasmus University alumni networks that resulted in a profile of respondents where 98% are in the age category 15 to 59 and 72% have annual income of more than 3000USD. This too, is not representative of the average age and income category of the cities.

Availability of data: last but not least is the data limitation in most developing countries. In this study, it was difficult to find time series data for a number of variables which we tried to fill by extrapolation.

Readers should therefore approach the findings and conclusions of this study with caution.

Enablers of transition towards SUMS: tackling barriers and creating attractors

Several barriers and attractors are identified in the literature review in chapter 2. Based on the theory we have identified the barriers against and attractors towards SUMS in Bangalore and Jakarta. Below are the enablers that will help tackle the barriers and create new attractors to encourage the implementation and adoption of SUMS in rapid urbanizing cities in developing countries. The Enablers are Policy & regulation, Attitude, Structure (urban), Safety & security, Infrastructure & service quality, Organizations and governance, and Nexus of measures, abbreviated as **PASSION**:

Policy and regulations

Policy documents and development plans in Bangalore and Jakarta emphasize the need for infrastructure improvement in terms of more roads, more intersections and more parking places to facilitate the flow of traffic in the cities. The motorized mobility and specifically the personal car are given priority in the visions and missions of the documents guiding the cities development. This can only act as the positive feedback for the dominant automobile regime and lead to lock-in. The cost of this infrastructure that largely benefits the private motorized vehicle users is carried by the wider community. Building more roads and more parking spaces, as recommended in both cities, will only make car journeys unfairly cheap. One of the ways to reduce car monopoly is making users pay the full costs of their individual trips by means of appropriate economic and regulatory measures. These measures could include ownership charges, fuel taxes, road pricing, congestion pricing, pollution pricing, etc. the measures should be used in combination with other measures that encourage the switch to public transport services like restricting access in certain areas (at certain hours) with private vehicle, public transport subsidies, park & ride schemes, and public transport priority measures. This will help weaken the stubborn regime of car dominance.

Though it is obvious that the motorized infrastructure needs improvements, it is also imperative that the NMT infrastructure is equally important. Cyclist and pedestrian lanes can be built with a fraction of the cost of subways and other rail transit, and they are very important element of SUMS as intermediate transport system. In both cities,

pedestrians and cyclist are not-able to cope with the complex and hostile traffic conditions and are the most vulnerable road users. The trends established today, when the car ownership is still low, will determine the future of these cities for decades to come. We believe that the mobility system in Bangalore and Jakarta need a new attractor to shift the tide from the path to car monopoly to a new path to SUMS.

From the survey, we understood that 87% of Bangalore's residents and 100 % of Jakarta's residents are concerned about the impact of the current mobility system on local air quality, livability and the global climate. This shift in the society towards environment as the core of quality of life and sustainability as the mission of development creates a new attractor for the mobility sector. So that, the transition towards SUMS requires developing a new vision for sustainable mobility focusing on improved quality of life to create new insights and starting points, therefore resulting in a change of attractor.

Any public transport policy can only succeed if it is effectively co-ordinated and integrated with other urban policies (e.g. land use, policing, parking, fiscal etc.). Lack of integration between land use and transport policies is one of the concerns of land use and transport planners in Bangalore and Jakarta. As discuss in the previous section 80% of respondents in Bangalore and 100% in Jakarta believe integration of the land use and transport policies is very important for a well functioning transport system. Land use and transport in cities are cross cutting issues and they are increasingly becoming crucial elements of sustainable development. There is a complex relationship between transport and land use; transport related decision affects land use patterns of a city (transport infrastructures are also part of the land use of a city) and land use patterns also affects the form and modes of transport in the city. Thus it is very important to integrate transportation and land use planning decisions so they are complementary rather than contradictory. This is to ensure that transport policy and planning decisions support land use policy and planning objectives and vice versa.

Attitude

Culture and attitude characterize a society and determine individual's personality and the decision making process (including destination and transport mode choices). Based on the results of the survey, most of the Bangalore residents can be classified as aspiring environmentalists. Amongst most of the respondents, pro-environmental behavior is seen as important and worthwhile, the negative effects of car use enter into the decision making process while choosing a mode, most show willingness to shift to PT provided that the service quality improves, and the large majority judge public transport to be problematic. The survey in Jakarta shows that most residents are somewhere between malcontented motorists and reluctant riders. Though, most of them still agree that their mode choice is motivated by health and environmental benefits, a larger majority associated the car with social status, life style and individual rights. Despite moderately high concern for the negative effects of car use, they perceive several difficulties in alternative modes of transport in the city.

The aspiring environmentalist majority in Bangalore suggests a practical approach to car use, where moral norms and attitudes contribute to a possible shift to sustainable mobility modes if high service quality alternatives could be provided. The case of Jakarta is more complicated than that. The malcontented motorists could be willing to reduce car use because of their concern for the environment and selflessness, but they are held back by their perceptions of the alternative modes available; bad transit service quality, lack of safety and security, inconvenience, and the perception that the PT services do not have better environmental performance than their cars. The reluctant riders do not show an interest in looking at other transport mode options and will not easily shift to other modes for pull measures but require strong push measures to take them out of their cars. Besides, acceptance of policy measures to reduce car dominance and shift from personal cars requires a strong moral suasion and environment-transport related education.

Structure*:*

The urban structure of a city is a stable component of the urban dynamics, as changes are likely to modify the land use structure over a rather long period of time since most buildings, sky scrapers, real estates, industrial complexes and commercial neighborhoods are built to last at least several decades. We can see that, in Bangalore and Jakarta, land use is quite segregated as most of the developments are built either formally driven primarily by the demand for more housing or are built informally. The average population density in Bangalore and Jakarta is 8750 people per sq.km and 14476 people per sq.km, respectively, but with significant variations between the inner city and the fringes. The average densities for efficient operation of public transport services in cities, as discussed in chapter 2, are 10000 people per sq.km for buses, 24000 people per sq.km for trams and 31500 people per sq.km for rail transit (DTLR, 2001). Bangalore's average density is even below the threshold value for efficient operation of bus transit services and density wise no part of the city is suitable for trams and rail transit. Jakarta, on the other hand, satisfies the minimum density requirement for an efficient operation bus transit services but still does not meet the threshold for trams and rail services. In both cases, density takes a central role in the future development of the cities. 90% and 85% of the planners, who participated in the survey in Bangalore and Jakarta, respectively, indicate that density targets are given priority in future development of the city to reduce sprawl developments, but with very few transit priority measures in place or under consideration. Respondents say that while only traffic signal priority is in place in Bangalore, bus only lanes and traffic signal priority are under consideration in Jakarta.

Considering the land use diversity in the cities, we have seen that Bangalore's land use show heterogeneous pattern in general but activities are separated in location. We do not have enough data to calculate the entropy index for Jakarta; however, we understood from organizational records that activities in the city are spatially segregated. From this analysis,

it is understood that in both cases land use activities are quiet segregated, and people have to travel from one part of the city to the other for several activities. In both cases, we do not have enough data to measure the design of the cities.

The segregation of activities in both Bangalore and Jakarta is acting as an attractor to the car monopoly in the transport system and it is also a barrier for the implementation of SUMS. As we can see from the conclusion of the urban structure hypothesis, the low density, segregated neighborhoods of the cities will be dependent on the car. Accordingly, further development of the cities should focus on densifying the less dense areas between the core area and the fringes to make public transport and NMT attractive option for resident. In urban areas, as discussed in chapter 2, a walk of 700-800 meters or less to or from the nearest bus stop is normally regarded as desirable: a distance greater than this is regarded as inconvenient. The integration of residential, business, and institutional uses is mandated not only through zoning but also through planning and direct public investment in transit-oriented development. This mixed-use planning will not only make the transit services attractive for providers, but also makes it easy for a substantial fraction of residents to live in walking or biking distance of their jobs. However, it should be clear that, with the current level of travel demand in both cities, without significant transit service improvements, the higher density development of smart growth would yield more congestion, not less

Safety & security

Safety and security for pedestrians and cyclists is beyond the provision of infrastructure. There is no doubt that good design of infrastructures will help, but insuring safety and security requires awareness creation, protection and law enforcement. The very low trip share of NMT in Bangalore and Jakarta is the result of lack of safe infrastructure together with social stigma.

The feeling of security is also an important factor in public transport system. Travelling on public transport should be a safe and comfortable experience but the feeling of safety and security in public transport services in Bangalore and Jakarta is very low. 87% and 88% in Bangalore and Jakarta mention safety and security as one of the important factors that determine their mode choice for their daily travel. For the public transport services in Bangalore and Jakarta to have an improved public image and to become an attractive alternative to the car, it is necessary to address the issues around security and safety in transit services.

Infrastructure and service quality

The transport network is one element of the complex mobility system considered to be a rather stable component of urban dynamics, as transport infrastructures are built for the long term. In general, cities in developing countries are characterized by low level of income and low car ownership relative to cities in developed countries which is a favorable condition for high levels of transit ridership. Bangalore and Jakarta are working very hard in building large volume transit systems to meet the growing mobility demands; buses and metro in Bangalore, and BRT and MRT in Jakarta. This will create another attractor in the transport system by building large transport terminals, subway systems and high ways that can operate for a very long period of time.

To make public transport services attractive and thereby reduce the growing motorization and car use, Bangalore and Jakarta should be keen to ensure a high quality of service on their public transport system. Transit information, reliability, frequency of services and integration are identified as the most important issues of the public transport services in Bangalore and Jakarta.

Information about transport services, like websites and real time information board, can serve as the bases for more rational decisions in mode choice and are appreciated by users. It is also a critical part of well functioning SUMS, as mentioned in the previous chapters, and lack of information is mentioned several times in factors that made transit services unattractive both in Bangalore and Jakarta.

(Un)Reliability of the public transport services is another quality factor mentioned several times by survey respondents in Bangalore and Jakarta that determines mode choice. Most fundamental is whether a service operates at all, and if it does, whether it operates on schedule, if it has one. Lack of reliability in public transport services, manifested by excessive waiting times due to late arrivals of transit services, results in uncertainty and delays reducing the attractiveness of the mode. To address this concern, transit services should be predictable, information on arrival and departure times must be available, and capacity should increase to match the demand to ensure competitiveness to car use such that it results in modal shift.

Frequency of services is another important factor affecting public transport ridership. Waiting too long for a bus, which is often overcrowded when it arrives, is a common problem in both cities. Only 10% of respondents from Bangalore say that PT services are frequent enough while all respondents from Jakarta say they are very infrequent. An increase frequency (and reliability) of services depend on the number of public transport vehicles and the traffic system in the city. On the average, there are 0.76 and 2.3 buses per 1000 population in Bangalore and Jakarta. On one hand, we cannot comment on the sufficiency of the number of vehicles as it depends on several factors including the operation and management practices. On the other hand, enough attention should be given to the way the transit services go around the daily traffic jams in the cities. The survey shows that, traffic signal priority in Bangalore and separate bus lanes in Jakarta are the only measures implemented in the two cities with other measures being under consideration or not thought about.

Transit services in Bangalore and Jakarta need to be better integrated to make it easier and more convenient for passengers to use more than one service or form of transport. This is important to support passengers who depend on more than one service to get to their final destination. Only 10% of respondents in Bangalore and 22% in Jakarta are satisfied with the integration of within the transit services and with other modes. Finally, public transport should be part of urban lifestyle: creating values aimed at a culture of ownership and pride by the citizens, and consequently creating a strong brand.

Organizations and governance

One of the problems identified in the transport sector in both Bangalore and Jakarta is the complexity and multiplicity of agencies involved in land use and transport planning and regulation in the cities. For a public transport system to function efficiently, an independent planning and regulatory organization/institution that is independent and capable of achieving its objectives is of crucial importance. There needs to be a clear demarcation of mandates between national, state and local government organizations in Bangalore, and between provincial and national government in Jakarta. There are several approaches to managing transport systems in large metropolitan area worldwide that reflect cultural, political and social factors and the level of maturity of the transport system. But that is beyond the scope of this research and we will not discuss it in this study. The first step to an efficient public transport management is capacity building of organization at all levels of government.

Another feature of the public transport system is that small bus, taxi, and intermediary public transport services in Bangalore and the medium and small bus, taxi and intermediary services in Jakarta are provided by individual service providers that are hardly organized. The existence of these large loosely organized transport providers who depend on the transport services for their livelihood in both cities creates its own management problems when it comes to providing financial support and accounting for performance. But this does not mean that services should be centralized and government controlled, but rather it means providing alternatives (formally organized services and NMT infrastructure) and leaving the choice for services providers and users.

Political will and organizational capacity building are also crucial elements of a successful transition towards a sustainable mobility system in cities in developing countries.

Nexus of policy measures & enforcement

Imposing the full cost of individual trips on users cannot be achieved in a short time frame as structural changes in the mobility sector, behavioral changes, technological improvements and adjustment of the supply and demand patterns require time. These changes should also be politically and economically acceptable. Therefore, in avoiding the lock-in in the car dominant regime, appropriate timing and sequencing of measures are inherent. Few cities are successful (simply) because the steps they take are consistent. We have summarized the experience of Singapore in chapter 3, which is perhaps an outstanding example of this consistency. Since the 1960s, the Singapore government has implemented programs and projects to keep car ownership and use at a very low level while improving the transit services in the city. The rules that are followed are very basic, restriction and management of ownership and use of private vehicles are preceded by the provision of good quality public transport services affordable by all segments of the society. Both Bangalore and Jakarta could, and may be should, use this same basic principle in order to prevent the personal vehicle from becoming the king of the road. This requires a clear planning, coordinating of activities from the different departments involved in land use and transport planning, institutional and financial support with an appropriate schedule, consistent law enforcement, competent regulators, and capable operators that serve as a foundation for implementing plans and projects. All this should happen at the right timing and sequence of activities.

Conclusion

In this study we have identified enablers for a successful transition of the mobility sector in developing countries to Sustainable Urban Mobility System based on the barriers and opportunities identified in Bangalore and Jakarta. For an effective transition to sustainable urban mobility systems in developing country cities requires a well functioning, good quality urban public transport system together with a safe and secure NMT infrastructure. Policies that put the environment and quality of life of citizens will help create a new attractor in the mobility system in favor of SUMS. Awareness creation of the impact of the personal motorized mobility on the environment is also an important element of the transition. These measures need to be accompanied by transit-oriented urban development policies and a good quality public transport services that meet the requirements of the fast growing economy and population. A reform in the organizational structure and the governance system is equally important to allow efficiency and increase synergy. Finally, the measures need to be implemented with the right sequence and timing and also need to be enforced.

Recommendation for future research

Socio-technical transition in the mobility sector is a broad and interesting discipline. The focus of this study was to find enablers in the mobility sector to help leapfrog it from the current low/limited level of mobility to a Sustainable Urban Mobility to avoid the lock-in in the car regime. Though the purpose of this study is focused on reducing energy consumption and global GHG emissions, avoiding car dependence in cities has wider social, economical and environmental

benefits. It might be interesting to replicate this study with a bigger research sample involving several cities to ensure the scientific significance of the results. Following this study, it might also be useful to look at success factors for Sustainable Urban Mobility Systems (SUMS) in cities where the system is actually implemented and functioning.

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Annex 1: Survey response

	Bangalore								Jakarta							
Total number of respondents	T	52		P	10	R	42		T	45		P	14	R	31	
Level of education																
Primary or below	0%								0%							
Middle, Secondary	0%								0%							
Higher Secondary	0%								2%							
Under Graduate	37%								18%							
Post graduate and above	63%								80%							
Position																
Gender																
Male	54%								38%							
Female	46%								62%							
Age																
<15	0%								0%							
15 to 59	94%								100%							
>59	4%								0%							
Do you own a driver's license?																
Yes	90%								80%							
No	10%								20%							
If your answer for the previous question is no, then why not?																
Do you own a car?																
Yes	42%								71%							
No	58%								29%							
If your answer for the previous question is yes, how many cars do you own in the household?																
1	64%								59%							
2	36%								31%							
3	5%								3%							
>3	0%								6%							
Income Category (Annual) (1USD=54.2INR- Indian Rupee =9716IDR- Indonesian Rupiah)																
<3000 USD	25%								22%							
3000USD-10000USD	44%								53%							
>10000 USD	25%								22%							
Owning a car is important...																
Strongly Disagree	4%								0%							

Disagree	23%								4%							
Neutral	21%								18%							
Agree	40%								60%							
Strongly agree	8%								18%							
If yes, please rate the importance of this factors (1=not important, 5=very important)	1	2	3	4	5				1	2	3	4	5			
× It might be useful once in a while (for heavy luggage, family trips, when someone is sick, etc)	6%	3%	11%	28%	44%		92%		0%	0%	2%	12%	76%		90%	
× It confirms my status in society	47%	22%	14%	6%	3%		92%		24%	15%	37%	7%	7%		90%	
× Because I have the right to use a car	67%	14%	8%	0%	0%		89%		10%	5%	39%	24%	12%		90%	
× It is the fastest transport mode available	39%	8%	22%	14%	8%		92%		10%	12%	32%	17%	20%		90%	
× It is socially obliged	56%	28%	0%	6%	0%		89%		22%	27%	27%	10%	5%		90%	
× Public transport services are not good	11%	17%	28%	11%	25%		92%		0%	0%	7%	32%	51%		90%	
If no, please rate the importance of this factors (1=not important, 5=very important)	1	2	3	4	5				1	2	3	4	5			
× It is bad for the environment	7%	3%	34%	14%	31%		90%		7%	11%	37%	11%	4%		70%	
× It is difficult to drive in the city (congestion, safety, etc)	0%	10%	14%	34%	41%		100%		4%	4%	15%	30%	11%		63%	
× Public transport services are good enough to move around	10%	14%	34%	14%	24%		97%		15%	4%	26%	7%	11%		63%	
× Owning a car is very expensive	7%	14%	28%	24%	21%		93%		4%	0%	26%	19%	15%		63%	
Which method of transport do you use most frequently for the following journeys?	Walk	Train	Bus	Taxi	Bicycle	Car	Motorbike	Rickshaw	Walk	Train	Bus	Taxi	Bicycle	Car	Motorbike	Rickshaw
× Work/School	13%	0%	23%	8%	4%	29%	42%	8%	16%	22%	33%	13%	0%	47%	16%	0%
× Shopping	29%	4%	15%	8%	2%	27%	42%	8%	4%	7%	13%	27%	0%	64%	16%	0%
× Leisure	15%	17%	38%	8%	4%	42%	23%	4%	4%	16%	11%	16%	2%	76%	7%	0%
× Family/friend visit	6%	4%	21%	10%	4%	50%	37%	4%	0%	9%	13%	20%	0%	78%	4%	0%
× Other	4%	13%	27%	4%	0%	6%	2%	10%	0%	11%	7%	7%	2%	22%	2%	0%
Please rate how important the following factors are in preventing you from using public transport: (1=not important, 5=very important)	1	2	3	4	5				1	2	3	4	5			
× Lack of available information	23%	10%	15%	17%	23%		88%		9%	2%	33%	22%	33%		100%	
× Distance from home to bus stop/train station	17%	8%	17%	19%	31%		92%		2%	11%	11%	31%	44%		100%	
× Distance from bus stop/train station to work place	15%	6%	15%	19%	29%		85%		2%	13%	9%	33%	36%		93%	

× Fare	17%	6%	13%	15%	31%		83%		11%	18%	11%	31%	29%		100%
× Total journey time taken	13%	0%	17%	17%	35%		83%		0%	13%	16%	31%	40%		100%
× Weather	33%	17%	19%	8%	12%		88%		2%	18%	40%	16%	22%		98%
× Safety	10%	10%	17%	23%	31%		90%		4%	7%	13%	24%	51%		100%
× Frequency of service	17%	15%	25%	12%	19%		88%		4%	7%	20%	33%	36%		100%
× Overcrowding	19%	10%	10%	6%	27%		71%		0%	0%	11%	16%	42%		69%
× Poor integration	4%	6%	13%	8%	48%		79%		0%	2%	13%	13%	38%		67%
× Poor bus quality	0%	0%	0%	0%	6%		6%		0%	0%	0%	0%	18%		18%
Driving a passenger car has an impact on the climate.	Str. Dis.	Disagree	Neutral	Agree	Str.Agr.				Str. Dis.	Disagree	Neutral	Agree	Str.Agr.		
	0%	10%	27%	13%	44%		94%		0%	4%	33%	22%	36%		96%
Passenger cars have more impact on the climate than public transport.	Str. Dis.	Disagree	Neutral	Agree	Str.Agr.				Str. Dis.	Disagree	Neutral	Agree	Str.Agr.		
	8%	10%	21%	19%	37%		94%		4%	9%	44%	22%	20%		100%
Rate how important the following factors are in dictating your choice of transport: (1=not important, 5=very important)	1	2	3	4	5				1	2	3	4	5		
× Relaxing	8%	8%	25%	21%	35%		96%		0%	2%	18%	42%	38%		100%
× Health	2%	8%	15%	29%	42%		96%		0%	4%	13%	42%	40%		100%
× Environmental benefits	4%	10%	25%	21%	38%		98%		0%	7%	18%	33%	42%		100%
× Cost	6%	12%	13%	31%	31%		92%		2%	2%	20%	40%	33%		98%
× Weather	6%	19%	23%	15%	29%		92%		2%	4%	22%	38%	33%		100%
× Safety	0%	10%	10%	19%	58%		96%		0%	0%	11%	29%	60%		100%
× Reliability	4%	2%	8%	25%	60%		98%		0%	0%	7%	31%	62%		100%
× Time taken	0%	4%	10%	25%	60%		98%		0%	0%	13%	20%	67%		100%
× Convenience	0%	2%	8%	23%	65%		98%		0%	0%	4%	42%	53%		100%
× Route	2%	6%	17%	19%	54%		98%		0%	2%	7%	33%	58%		100%
× Other															
Rate how effective you think the following measures would be to encourage sustainable transport use: (1=not very effective, 5=very effective)	1	2	3	4	5				1	2	3	4	5		
× More bus routes	6%	10%	10%	31%	42%		98%		0%	0%	18%	24%	56%		98%
× Cheaper Fares	12%	13%	21%	27%	21%		94%		2%	4%	24%	24%	44%		100%
× Less parking space	12%	12%	19%	27%	21%		90%		4%	2%	31%	38%	24%		100%
× Extended U-BUS service	2%	0%	12%	29%	56%		98%		0%	2%	11%	20%	67%		100%
× Higher parking fees	23%	12%	21%	19%	15%		90%		7%	2%	22%	31%	38%		100%
× More cycle parking	15%	12%	15%	19%	25%		87%		9%	13%	31%	22%	22%		98%
× Car-sharing scheme	15%	19%	21%	13%	21%		90%		7%	9%	31%	29%	24%		100%
× On-board Entertainment	31%	17%	29%	6%	10%		92%		4%	11%	40%	24%	20%		100%
× Cycle lanes	17%	12%	13%	29%	21%		92%		9%	9%	29%	33%	20%		100%

× More reliable service	0%	4%	10%	13%	71%		98%		0%	0%	11%	24%	62%		98%
× Other															
The current public transport fare is...	V.Expensive	Expensive	Affordable	Cheap	V.cheap				V.Expensive	Expensive	Affordable	Cheap	V.cheap		
	10%	19%	37%	14%	4%		84%		0%	2%	16%	2%	11%		31%
How do you rate the ease of the payment system for the public transport services in the city?	V.difficult	Difficult	Neutral	Easy	V.easy				V.difficult	Difficult	Neutral	Easy	V.easy		
	2%	4%	25%	27%	37%		94%		3%	7%	30%	33%	30%		103%
How do you rate the accessibility of the transit system for people with disabilities? (access paths, maneuvering areas, ramps, boarding devices, allocated spaces, handrails, doorways, controls, symbols, signs, payment of fares)	V.inacc.	Inacc.	Neutral	Accessible	Easily Acc.				V.inacc.	Inacc.	Neutral	Accessible	Easily Acc.		
	80%	10%	10%	0%	0%		100%		44%	16%	9%	0%	2%		71%
How do you rate frequency of Public transport service in peak hours?	V.Infreq.	Infrequent	Neutral	Frequent	V.frequent				V.Infreq.	Infrequent	Neutral	Frequent	V.frequent		
	20%	20%	50%	10%	0%		100%		64%	14%	7%	14%	0%		100%
How reliable is public Transportation for your daily travel? (reliable refers that it will come and leave at the designated time)	V.unreliable	Unreliable	Neutral	Reliable	Very reliable				V.unreliable	Unreliable	Neutral	Reliable	Very reliable		
	20%	50%	10%	20%	0%		100%		23%	21%	20%	0%	4%		69%
How do you rate the Integration (ease of transferring within the transit system and with other travel modes) of the transit service in the city?	Very bad	Bad	Neutral	Good	Very good				Very bad	Bad	Neutral	Good	Very good		
	50%	30%	10%	10%	0%		100%		24%	42%	20%	9%	4%		100%
How do you rate the feeling of security in public transport?	V.insecure	Insecure	Neutral	Secure	V.secure				V.insecure	Insecure	Neutral	Secure	V.secure		
	20%	20%	50%	10%	0%		100%		36%	31%	20%	9%	4%		100%
How do you rate the ease/difficulty to recognize and find the public transport going on your route?	V.difficult	Difficult	Neutral	Easy	Very easy				V.difficult	Difficult	Neutral	Easy	Very easy		
	30%	40%	10%	20%	0%		100%		18%	27%	33%	16%	4%		98%
How do you rate the ease of using the transit services while carrying luggage??	V.difficult	Difficult	Neutral	Easy	Very easy				V.difficult	Difficult	Neutral	Easy	Very easy		
	50%	40%	0%	10%	0%		100%		40%	18%	7%	4%	2%		71%

How do you rate the ease/difficulty of obtaining information for transit services?	V.difficult	Difficult	Neutral	Easy	Very easy				V.difficult	Difficult	Neutral	Easy	Very easy		
	40%	30%	20%	10%	0%		100%		16%	36%	14%	5%	0%		71%
How do you judge the pedestrian friendliness of the city?	Very unfriendly	Unfriendly	Neutral	Friendly	Very friendly				Very unfriendly	Unfriendly	Neutral	Friendly	Very friendly		
	70%	20%	10%	0%	0%		100%		40%	20%	5%	0%	4%		69%
How do you judge the bicycle friendliness of the city?	Very unfriendly	Unfriendly	Neutral	Friendly	Very friendly				Very unfriendly	Unfriendly	Neutral	Friendly	Very friendly		
	90%	0%	0%	10%	0%		100%		37%	25%	7%	0%	2%		71%
How do you judge the availability of car parking spaces in the city?	Very limited	Limited	Neutral	Available	Highly available				Very limited	Limited	Neutral	Available	Highly available		
	35%	33%	17%	10%	2%		96%		21%	11%	23%	12%	3%		69%
Parking price have impact on commuters' behavior.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree				Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
	19%	29%	19%	13%	6%		87%		3%	11%	38%	14%	5%		71%
Integration of Land use and transport policies in the city is very important.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree				Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
	10%	0%	0%	30%	50%		90%		0%	0%	7%	14%	79%		100%
Density target in the land use plan of the city is very important.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree				Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
	10%	0%	20%	40%	30%		100%		0%	7%	14%	14%	64%		100%
Is there any tax or other incentives to encourage compact development in the city? If yes, please indicate which.	Yes	0%		No	100%				Yes	0%		No	50%		
The current plan/design/policy of the city support transit-oriented development.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree				Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
	40%	20%	30%	10%	0%				7%	7%	43%	29%	14%		100%
The future plan/design/policy of the city support transit-oriented development.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree				Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
	30%	10%	10%	40%	10%				7%	7%	14%	36%	36%		100%
What are the transit priority measures in place in the city?	Not in place	Under consideration	In place						Not in place	Under consideration	In place				
× High occupancy vehicle lanes	50%	30%	10%						57%	29%	0%				86%
× Bus only lanes	70%	10%	10%						21%	57%	0%				79%
× Transit priority intersections	40%	30%	20%						64%	14%	0%				79%
× Traffic signal priority	30%	10%	50%						43%	50%	0%				93%
× On-street parking restrictions	40%	30%	20%						36%	21%	0%				57%

× Transit exemptions for general traffic regulations	60%	20%	10%						71%	7%	0%				79%	
× Advance stop bars	50%	30%	10%						64%	14%	0%				79%	
× "Demand for service" indicators	50%	30%	10%						64%	14%	0%				79%	
× Other measures																
Please use the box below for additional comments related to the subject of this questionnaire.																
The pollution from motorized transport negatively affect the health and quality of life in the city.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree				Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
	0%	0%	14%	33%	48%				0%	0%	6%	19%	74%		100%	