Sustainable Transport Solutions for the Concept of Smart City

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Abstract In the year 2008, the world faced one of the worst economic recessions. At this point in time, the idea of a smart city was floated by IBM which was a part of the smarter planet initiative (Paroutis et al. 2013). As per various definitions, a smart city is an urban development that takes the help of technology to manage its assets like its infrastructure, important buildings, community services, transportation. The concept of smart city was welcomed by China, UAE, Korea and others. There are six indicators of a smart city, namely "*smart economy, smart governance, smart citizen, smart living, smart environment and smart mobility*" (Kumar and Dahiya 2017)—mobility or transportation takes the most important position due to its influence on all the other indicators. Statistics show that millions of dollars are invested in research and development of new sustainable modes of transportation systems all over the globe. There are innumerable examples of sustainable smart transport all over the world like Paris, Boston, Germany, Singapore. Each one of these examples lays emphasis on the fact that a well-designed and efficient transport system contributes to economic growth and helps in refining the quality of life of the people, thereby becoming one of the most important sectors of urban development. Post-studying these examples, one can realize that sustainable transportation system contributes to

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all the different indicators or aspects of a smart city. It is projected by the United Nations that in the coming 15 years the population of top 100 cities of India will grow by 60%. Also with growth in opportunities and increase in the buying capacity, personal motor-vehicle ownership doubles every decade. Land is a precious resource, and utilizing it for making roads to meet the needs of the motorized vehicles is not a solution. This chapter examines the Indian scenario and smart city dream and various successful models of sustainable transportation addressing issues similar to the existing Indian cities, and makes recommendations for the same.

Keywords Sustainable transport · Smart city transport system · Indian smart cites Case studies in smart transport · Important lessons for sustainable transport

1   Smart City, Sustainable Smart Transport and Indian Scenario

1.1   Indian Scenario—Transportation

Transportation is one of the key contributors to the GDP as per the Government of India. Its current share is close to 6.7%, and it is projected to grow to about 26% by 2026 (Mehra 2016). The Government of India has framed and adopted various policies and schemes to transform the poor state of urban transport system into an effective system contributing to the smart city vision. The issues like excessive traffic, poor public transport, pollution, poor road conditions, lack of intelligent transport systems, poor infrastructure are some of the inherent challenges and threats in shifting towards smart transportation in India. In spite of advances in transportation technology as well as urban planning, there is a lack in understanding of how cities work and how the infrastructure affects day-to-day activities. Every city in the Indian context has a unique character, unique complexity and a unique set of challenges that need to be addressed before proposing any kind of transport system. It would be wise to implement smart sustainable transport only post a thorough understanding of the need of the city, community and the quality of life that the system will offer. With advancement in opportunities and the smart city mission, Government of India has taken more initiatives towards encouraging smart fuel vehicles and smart technology. However, it will be difficult for India to keep the pace with other countries in terms of application of technological advancements for smart transportation due to the slow pace of development, rapid growth in population, as well as time taken in decision making and implementation. Prime Minister Narendra Modi's vision "Digital India", has set an ambitious plan to build 100 smart cities (http://smartcities.gov.in/content/innerpage/what-is-smart-city.php).   These   cities will be designed on the following key principles or indicators: "*smart economy, smart governance, smart citizen, smart living, smart environment and smart*

mobility". Apart from the 100 smart cities, 500 other cities in India will be rejuvenated and transformed by the provision of better connectivity and infrastructure.

1.2 Smart City Concept and Indian Cities

As per various definitions, a smart city is an urban development that takes help of technology to manage its assets like its infrastructure, important buildings, community services, transportation. However, a smart city would have a slightly different association and meaning in India than Europe or the USA. Even in India, there are many ways of defining a smart city. Various aspirations of citizens define the concept of smart city limited to that particular city. Connectivity and mobility along with services and infrastructure are among the primary aspirations of the citizens for a smart city development. The holistic approach of the Government of India through policies like Urban Transformation Policy 2014, Make in India Scheme, Faster Adoption and Manufacturing of Electric/Hybrid Vehicles, Digital India, AMRUT, etc., will support the smart city mission primarily by transforming the urban transport system (Mehra 2016). In 2016, 13 cities have been selected to be taken up for development as smart cities in the fast track round (http://www.smartcities.gov.in). There are eight pointers given by the Government of India as the interpretation of the smart city in Indian context. These talk about some typical features of holistic development needed in Indian smart cities.

1. Efficient use of land by promoting mixed-use development and making provisions in the building bye-laws to adapt the change statewise.
2. Providing housing opportunities for all.
3. Promoting walkability, reducing traffic, improving air quality, promoting public transport, promoting local economy, providing environment that encourages interaction and ensures safety and designing the road network that provides opportunities to cyclists and pedestrians.
4. Preserving and increasing recreational spaces and green pockets like parks, playgrounds, river banks in order to enhance the quality of life of citizens, reduce the urban heat island effects in areas and maintain a comfortable microclimate as well as ecocity balance.
5. Promoting a variety of smart public transport options—transit-oriented development (TOD), public transport, last mile para-transport connectivity, pods, etc.
6. Measures to bring accountability and transparence in the governance by the means of introducing "e-governance" which is both time saving and cost effective. Forming e-groups for discussions and monitoring of programmes as well as activities.
7. Promoting the local economy by encouraging activities like local cuisine, health, education, arts and craft, culture, sports goods, furniture, hosiery, textile, dairy, which also gives an identity to the city.

8. Promoting smart solutions for infrastructure and services in the area-based development in order to safeguard them from disasters as well as reduce the use of resources and provide affordable services.

From the above pointers, one can conclude that the aim of smart city mission is to promote development of cities that provide adequate infrastructure, clean environment, sustainable transport solutions, respectable housing facilities for all, promote economic growth, etc., and by doing all this, improve the quality of life of its citizens.

2 Learning from Good Examples Around the World

Public transportation in cities is considered as a key aspect to relieve traffic overcrowding and promote environmentally friendly transportation modes. Various cities around the world have developed excellent transportation systems that promote use of more sustainable means of transport over personal motorized vehicles. In such cities, policies and systems both are designed to encourage people to choose more sustainable options for travelling. One of the key aspects noticed in most of the examples discussed here is that planning contributes to reducing private car traffic and increasing the use of alternative forms of transport, namely car pooling, cycling, walking and public transport, by making them more desirable (Duchene 2000).

2.1 Paris

The spirit of the Paris Region mobility plan/urban travel plan (PDU—Plan de Déplacements Urbains) is to provide support for the development of the Paris Region through the enhancement of its facilities. The PDU defines the principles for the organization of transport of goods and people, control of vehicular traffic and parking. The need of a better and smarter transport in Paris was felt way back after the Second World War. At that time, the fast growth led to an unrestrained sprawl of the core area of Paris towards the fringes. Population of the core area rose by 3.3 million from 1945 to 1975, touching the 10 million mark (Trevien and Mayer 2013). The Central Government set up policies to restructure the region and control its growth, viz. redistribution of district boundaries, construction of a new airport, highway and train system, rehabilitation of population from the core area to new towns. To connect these various places, Paris required setting up an integrated public transport network. The lack of evolution of the existing commuter rail network and its poor connectivity within and across Paris created the need of

improving the existing transport system. The new or improvised transport system promoted the following:

- The harmonious and controlled development of the territory.
- The emergence of a common culture on urban and intermunicipal travel.

Along with this, certain policies were also devised so as to ensure efficient operation of transport networks, and increased sharing of publicly accessible spaces. In order to reduce private car traffic and promote public transport, the PDU reduced differences in travel time in-between the various forms of transport used, taking due account of their corresponding zones of significance. This strategy also looks at a tiered system of transport networks, in particular, the rail and expressway network that provides effective conveyance on an urban scale. The primary road network, on which the assorted modes coincide, provides for transport within the high-density zone, while organizing transport in both the inner city and the fringes. Measures were taken to integrate the network so as to make it a more convenient for the passengers. Key actions (STIF 2003) listed below have transformed an inadequate network to one that may be looked upon as a model for other cities to follow.

- With a view to promote intermodality between modes of transport, parking and ride facilities like large car and bicycle parking facilities are set up near metro stations.
- To keep travellers informed with up-to-date information, the STIF (Syndicat des Transports d'Ile-de-France) created an online resource in collaboration with all public transport companies for the region.
- With the introduction of the Navigo smartcard in 2001, for the Paris train, metro, RER (Réseau Express Régional), tram and bus system, travelling within Paris has become easier because separate tickets do not have to be purchased while changing between transport modes.
- The STIF approves future projects before they are implemented to ensure that upcoming infrastructure is integrated well with existing ones.
- Recent initiatives have been launched to integrate public transport with car rental services. This is integrated with the Navigo pass allowing users to rent cars at reduced rates thus renouncing the need to own one.
- The cycle track system is planned to connect various scales across the city and suburban area including long- and short-distance travel within the inner city and the fringe areas.
- Access to public transit stations is given priority by developing pedestrian infrastructure equipping pedestrians to easily walk within their districts and access transit stations.

The collaboration between the STIF and regional council and cooperation from the Ministry of Transport have enabled an integrated transit (urban mobility plan) and land-use plan (regional plan). This ensures that good access to public transport is linked to all future developments. For example, the business district of La

Defense provides good connectivity to inner as well as the suburban Paris Region and 85% of the employees use public transport to get to work (STIF 2003).

Once major action was the decision to implement the 1965 plan and build five new towns outside Paris and decongest the inner city. This plan also ensured good connectivity to Paris via rail services. New smaller centres within these towns would be developed to make them attractive for people and to reduce the need for travel across the city for work, recreation or daily essentials. The extension of two metro lines ensured good connectivity to these counties. To provide good connections with the city, two metro lines were extended to serve these counties.

On the basis of the above-mentioned pointers, three main factors can therefore account for the increase in favour of public transport post-1975:

- Increase in the supply of public transport services
  Long-distance commute has become more attractive via public transport with the suburban rail systems built after 1975 (know as the RER).
- Improved integration of services
  The integrated ticketing system in Paris enables travel on multiple public transport modes with an unlimited number of trips across different companies.
- A reduction of alternative modes of transport
  Integrated season passes for transit has changed some people's decisions to take the bus instead of other transport modes (e.g. private car).

Multiple modes of public transit are being used by a numerous and ever-increasing quantum of persons due to consistent advances in the integration of passes. These enable people to use them across the bus, metro, RER services, etc., and public transport modes. This is in spite of having more than eighty operators.

The following projects could further improve public transport systems in Paris in the future:

- Enabling ticket/pass integration with park and ride facilities adjacent transit stations to make it easier to access to station. The success of the present system will be strengthened with a cohesive tariff system.
- A quality bus network which has communication patterns under a single new agency independent of operators will greatly improve the transport networks. This project, termed "Mobilien", has been mentioned in the urban mobility plan framework.
- Prioritizing interchanges for people, bicycles, taxis, etc., to enable easy access.
- Setting up a centralized information system along with a single point of contact for addressing complaints for public transport users.
- Improving synchronization between taxis and public transit systems. Currently, an independent body is responsible for taxis.
- Concerning space organization on streets, priority is given to pedestrians, cyclists and buses.
- Re-organizing the metro and RER systems to better cater to inner and outer Paris during the day.

- Strengthening the bus network with bus rapid transit systems extending to outer fringes of Paris to ensure connectivity for every area.
- Increasing the usability of public transit between places of interest within Paris.

The city council along with the Paris transport operator has initiated the "Bus 2001" project to be merged with the existing bus network. Amendment of the existing system will be essential for its extension beyond the "Boulevard Peripherique" (ring motorway) in unison with the metro lines (Duchene 2000). For pedestrian's safety and comfort, work on footpaths and road crossings will be enhanced for them. The introduction of new cycle tracks will be considered. Pedestrian paths and cycle tracks between Paris and the adjacent municipalities will be extended. Pedestrian paths and cycle tracks between Paris and the adjacent municipalities will be extended resulting into enhanced urban conditions in the new towns and suburban complex. Pedestrians, bicycles, motorcycles and buses will have easier access to the metro and railway stations. The main bus network will offer an efficient alternative to the private car. The cycle track system, including establishment for bicycle bays, will provide for easy access to stations and public facilities. This network will be interconnected, uninterrupted and clearly identified.

2.1.1 Paris—Lessons Learnt

- The public transit system in Paris is a high-quality case with integration across multiple modes on a wide region (approximately 12,000 km) and with a large number of transport operating companies. The impact of integrating multiple modes of transport on one network resulted in growing patronage of transport systems. Numerous factors are responsible for this high level of integration.
- Due to the presence of several operating companies, it was necessary to offer passengers with integrated tickets among them.
- Integration has been incremental (It took twenty-five years to achieve a single ticket accepted by all transport companies). The positive results of each step encouraged local authorities to take the next one.
- The public transport authority (STIF) was legally given administrative power, to impose its decisions on companies regarding fare policy, travel routes, etc. This ensured compliance from all private companies to a common goal for the betterment of the public transport system.
- Integration of services did not cause losses of incomes to operators since STIF always compensated for the price decrease in ticket fares which it made obligatory on them.
- The two main transport companies (RATP and SNCF) are state-owned enterprises played a positive role in the integration of public transport services at the beginning. Today, the policy framework established by the STIF applies to all private companies as well.

From the Paris example, it is clear that building up an integrated smart transport network is a long-drawn process. But with proper planning strategies, we find a positive measurable outcome is possible over a period of time.

2.2 Germany

The case of Germany is very interesting as it has managed to stabilize high levels of car ownership with sustainable modes of commute like walking, cycling and public transport. As per statistics, Germany has one of the world's highest car ownership rates along with a very powerful lobby of car manufacturing industry. In spite of immense popularity of cars (Wolf 1986; Schmucki 2001 as cited in Buehler and Pucher 2009), Germany has managed to design a transport system that is sustainable and smart by adopting the right policies and strategies. The policy adopted by Germany was to manage public transport, cycling and walking and to discipline the use to cars rather than completely eliminating it. Freiburg, the environmental capital of Germany, is considered as the most sustainable city.

Car ownership grew in Germany from 1950 to 2006 resulting into a 42-fold rise in motorization rate (Buehler and Pucher 2009). Germany made certain policies as well as infrastructure revolutions to promote sustainable transport. The Government policies can be classified into five categories as follows. These have been very important for transport sustainability in Germany.

- Increased taxes and restrictions on car usage
  The strategy adopted by Germany was essentially to make "cars" the least preferred alternative to travel. One of the ways adopted to do so is much higher fees and taxes on car ownership and use along with motor fuel taxes making cars an expensive mode of transport. The increased taxes have generated enough revenue to cover government expenditures on maintenance and construction of roadways. Other strategies apart from taxes, adopted by most of the German cities, are the speed limits and reduced parking spaces as well as car-free zones, restricted entries, deliberate dead ends, turn restrictions, one-way street networks, etc., making it very difficult to travel by cars. Most of the road networks in German cities have speed limits as low as 30 km/h (Beatley 2000; Newman et al. 2009). Most of the developments use strategies like road narrowing, raised intersections, extra curves or zigzag routes as well as speed humps. At many places, ultimate restrictive measures are taken by banning the car altogether.
- Ensuring the provision of high-quality, low-priced, well-synchronized public transport services as a viable alternative to the car
  In recent times, Germany has made considerable improvements in the public transport realm as a result of which more and more people prefer to use it. German metros, trams and buses are reasonably new and do not require as much maintenance or repair cost. German buses and trams are often articulated, carrying more passengers and requiring fewer drivers per passenger (Buehler and

Pucher 2009). All these reasons make public transport an affordable choice. Along with this, public transport is further enhanced by signal priority at the intersections, well-planned spacing of bus and tram stops to reduce the time taken per trip, making it a faster option to travel. This increases the number of people using the public transport resulting in higher revenues. Much of the success of the German public transport is due to its multimodal coordination of public transport services, fares and schedules within the metropolitan areas (Buehler and Pucher 2009) allowing an uninterrupted journey for the passengers. The planning is such that it ties together public transport, cycling facilities as well as walking, giving priority to the people using these means to commute. Safe pedestrian walkways and bike parking and renting facilities near bus and rail stops encourage people to choose more sustainable means.

- Improving pedestrian walkways and well-connected cycle routes that are safe and convenient

  Great improvements have been made to pedestrian walkways and bicycle routes since the 1970s. The facilities created for pedestrians include creation of car-free zones in most of the cities along with well-lit, well-maintained walkways, well-designed street furniture, pedestrian refuge islands, clearly marked zebra crossings and pedestrian-activated crossings (Pucher and Dijkstra 2003). To encourage use of bicycles, well-connected continuous cycle routes, extensive parking for cyclists, shortcut connections for cyclists, etc., are designed. The facilities enable the cyclists and pedestrians to cover any trip without interruptions or issues created by traffic. Government policies are also designed to provide utmost safety to the pedestrians and cyclists.

- Promoting high-density mixed-use development and discouraging urban sprawl, keeping distances walkable

  To decrease the average trip distances, a high-density mixed-use development is planned. This not only enables more people to take advantage of the public transport but also makes it more economically viable by generating higher passenger volumes. The urban development policies are designed to curb urban sprawl.

- Coordination of various policies to ensure their combined effect

  It is difficult to restrict car usage and make it a more expensive choice without offering alternative solutions to car use. Germany, along with its policies to make "car" the least preferred option to travel, has also made sure to provide world-class public transport which is not only cheap but also less time-consuming. The car-restrictive measures have been successful as a result of improved conditions for walking, cycling as well as buses and trams. This made the policy reforms more acceptable to the people. In the majority of the German cities, transport and land-use planning are done through the same department and hence there are more opportunities to coordinate these two (Schmidt and Buehler 2007).

2.2.1 Germany—Lessons Learnt

Germany is a good example of car-restriction policies backed by excellent alternate sustainable means of transport. However, the German scenario was not always sustainable as it is now. Decades ago, German policies as well as development supported the use of cars. Soon more and more people started using cars and issues like traffic congestion, pollution worsened resulting into poor quality of life in most of the neighbourhoods. As a result of this, new land-use policies and reformations in public transport triggered. The 1970s witnessed an era of "car-restrictive" policies that became widespread in most of the German cities. People started realizing the benefits of car-free zones, better walkways, cycling routes over the last four decades. In short, the German situation was not always like it is now. Reformations in policies at various levels and provision of better alternatives for travel have made it possible for people to choose a more sustainable mode of transport. The overall framework for sustainable transport was provided by the German Federal Government, which included not only a hike in petrol taxes but also reduction in money spent on roads and increasing investments on public transport. People played a very important role in the shift from a car-dominated system towards more sustainable options.

2.3 Boston

Boston serves as a feeder, connector and common point of contact due to its strategic location as the centre of six New England states. Boston is a unique example as it uses rail, water, road and air as the part of its transportation infrastructure to move people and goods. The integrated national and international transportation of Boston supports the city's role as a international economic player by promoting expansion in varied economic sectors (bostonindicator.com). The quality of life of people who live and work in Boston depends largely on their capability to travel from one place to another for increasingly assorted purposes. Keeping this in mind, Boston has improved the efficiency of its public transport enabling the people to travel economically. Like Germany and Paris, the policies adopted in Boston were to promote use of a range of transportation options from walking and bicycling to driving or taking public transit for activities like work, educational advancement, shopping, socializing. This not only enabled people to move from one place to another, but also supported the city's environment by reducing pollution, congestion and greenhouse gas emissions. Boston drafted certain sets of policies based on the following indicators to develop an efficient competitive edge in its transportation system after understanding the commuter's needs (bostonindicator.com).

- Transportation system that enhanced the national and global competitiveness of Boston

Boston's Logan airport is one of the busiest airports catering to both domestic as well as international travellers. The well-developed infrastructure to move people, goods and services to national and international destinations reinforced Boston as a port of entry for new immigrants and thus enhanced its reach as a metro city within the national and worldwide economies. As a result, the port of Boston ranked high in total container traffic and hence in volume growth among all North American ports.

- Traffic patterns and travel options
  Traffic congestion in Boston was considered a reason of loss in the number of economic, social and environmental aspects of the metro city. This was because of the economic activity loss which was due to increased journey time, increased pollution levels and social seclusion. Commuters spent long hours in delayed traffic congestions reducing their productive time. By developing and integrating a wide range of available travel options, Boston government helped to offset some of these negative impacts and improve the overall growth of the region.

- Household income spent on transportation
  Transportation costs constituted a major expenditure for most households in Boston, often second only to housing (Hass 2006). Cars were expensive to purchase, and a recurring cost to cover fuel, maintenance, and repair was far-fetched. Thus like housing and medical care, transportation costs affected the decisions people made about where to live, where to start a business or bring up a family. The efficient public transit systems and the infrastructure developed by Boston enabled residents to prefer integrated transport systems, thus reducing the individuals cost of travel.

- Boston's integrated transport system
  Greater Boston's public transit system—the Massachusetts Bay Transport Authority (MBTA)—provides a variety of options for getting around the region. The efficient planning of the rapid transit lines operates along major stations and the light-rail streetcar lines, link surface stops at subway or elevated stations. The rapid bus transit line operates as a feeder for commuters from Dudley Square to downtown and from South Station to the South Boston Waterfront and Logan Airport. A passenger rail network and some local and express bus routes aid the residents to reach their communities comfortably. Para-transit facilities such as "The Ride" are especially provided for elderly and people with special needs. A water transportation system is also provided for travellers to Boston's Inner Harbor and between several Inner Harbor docks, including Logan Airport, Charlestown Navy Yard, Rowes Wharf and Long Wharf.

- Allocation of daily trips and trends in mass transit use
  A strong relationship between annual vehicle miles travelled per household and the availability of public transit systems was observed in Boston. Greater Boston cities and towns with the lowest vehicle mile travelled rates had access to the commuter rail. Multiple modes of travel were made available for the cities and towns in the inner core at fair frequencies. The MBTA being one of the largest

transit systems in ridership; a large number of trips were made using the MBTA on an average working day, thus promoting the use of public transit systems.

- Equitable and high-quality transportation access for all
  People using public transport in Boston were dependent on the availability of amenities like heating/air conditioning, shelters at stops, and comfortable seats as well as provision for persons with special needs in the public vehicle. Measures were taken to improve the quality of these amenities that greatly affected the rider's satisfaction. Sidewalks were also well maintained, thus improving the experience of the commuters walking to catch the transit system, and this in turn improved the equality of urban life. This high level of comfort and safety provided in the transit systems in Boston brought comfort to elderly, families with children and people with special needs. Transit quality and safety also ensured secure travelling of school-going children, who depended on public transportation for mobility and access to school. As streets were now safe, there were more walkers and cyclists, resulting in less traffic, better quality living and more "eyes on the street". As the public transportation was of high quality and served both residential and employment centres, more people opted for it. This created a virtuous cycle attracting more passengers and increase in service frequency, thereby further improving service.
- Access to Healthy and Environmentally Sustainable Transport Systems
  Boston believed that an environmentally sound transportation system can help to maintain health, reduce traffic congestion and improve the quality of life. A variety of sustainable transportation options that can fit different needs, including walking, bicycling, public transit and greener cars were thus provided for. Along with promoting physical activity for children, by walking to school, some of the benefits also included reduced transportation costs for the district and a sense of connection and community between the school and the neighbourhood. Boston known as a bicycling and walking city, released the New Balance Hub—way bicycle sharing system, which logged a number of rides to include annual members and casual riders. Boston governance implemented a policy in which public schools reserves 50% of each school's seats for children within the walk zone which extends 1 mile for elementary schools, 1.5 miles for middle schools and 2 miles for high schools.

2.3.1 Boston—Lessons Learnt

There are four key lessons to be learnt from the Boston example as discussed below.

- Public Transit Systems
  Understanding the numbers involved in transit use, car ownership and transportation systems helped Boston to effectively plan for population growth and a smooth movement pattern. However, Boston's work places still remained challenging to access for individuals without cars, and time taken by public

transit systems remained long and frustrating. Addressing these issues, the MBTA recently completed purchasing sufficient line trains to be built and working by the beginning of 2018. In addition, track advancement will assist in keeping the line free of ice and snow in winter.

- Alternative transportation options to help decrease the city's greenhouse gas emissions

  Due to an increase in automobile ownerships, the scattered development pattern is unsustainable and contributes to air, noise and water pollution. As a solution, in Boston most buses, trucks and construction vehicles use diesel fuel, which produces particulates and nitrogen oxides. City of Boston has an alternative fuel vehicle procurement policy for city vehicles. The city's diesel vehicles run on a cleaner blend of biodiesel and ultra-low-sulphur fuel, reducing emissions by 12–17% (bostinno.streetwise.co). Boston is the largest municipal purchaser of biodiesel in New England. The city has undertaken a large-scale retrofit of its school bus fleet (MIT report 2005), using ultra-low-sulphur diesel, and is being equipped with pollution control technologies, reducing tailpipe emissions by more than 90%. The Boston Bikes initiative seeks to make Boston a world-class bicycle city by creating safe and inviting conditions for all residents and visitors by expanding bicycle lanes, offering Ride-Along Fridays and sponsoring the annual Hub on Wheels event. The new complete streets approach puts pedestrians, bicyclists and transit users on equal footing with motor-vehicle drivers. The initiative aims to improve the quality of life in Boston by creating streets that are both great public spaces and sustainable transportation networks. It embraces innovation to address climate change and promote healthy living. The objective is to ensure Boston's streets are multimodal, green and smart. The City of Boston also launched EV Boston, part of the complete street initiative designed to promote the use of electric vehicles in Boston.

- Adequate public funding

  Transportation infrastructure to include roads, flyovers, public transit, airports and seaports is the supporting systems of economic connectivity and dynamism for Greater Boston and Massachusetts. The existence of a economically sustainable multimodal system is necessary to guarantee a state of maintained system and also to provide future expansions that allow residents, goods and services to remain exceedingly mobile. Hence, a lot of funding is utilized in research and implementation of better and more sustainable transportation technology.

2.4 Singapore

Singapore is an island city-state of 640 km^2 with a population of 3 million (1996). It once used to be a small fishing village of 150 occupants and later expanded to be British regional trading post in 1819, and since independence in 1965 into a major Asian metropolitan centre, Singapore has witnessed significant changes in the

evolution of its economy (Yuan 1997). With limited land, a large populace and an animated economy, the stress on Singapore's roads has been extreme (especially during peak hours). This has resulted in a deteriorating traffic situation, particularly in the city centre. Many of the roads built are too narrow to accommodate the increasing volume of traffic and growth in car population. The ratio of cars to households has risen from 1:4 (i.e. 26 per 100 households) in 1980 to 1:3 (Yuan 1997) (i.e. 31 per 100 households) in 1990. Easing urban traffic congestion can be done in numerous ways. At a conceptual level, one can identify and categorize these measures according to three broad groups. The first set of measures are related to the development of making more urban structures conducive to the distribution of economic activities and improved physical integration between work, recreational facilities and housing with transportation. The second category comprises measures that address the service of transport facilities; i.e. they are basically directed at increasing urban transport capacity by providing better services. Measures in the third category are aimed at creating a more inclusive environment, specifically, in terms of encouraging effective use of existing transport facilities. Singapore has integrated all three types of measures within a single urban land transportation policy. Additionally, Singapore has taken steps towards restricting car possession through a quota scheme executed in 1990, thereby limiting the amount of new cars. Therefore, for cities to function efficiently and provide a liveable environment, urban planning and transportation planning/management must be coordinated and integrated within one strategic package (Yuan 1997). This has been adapted in Singapore. In 1972, a long-term extensive plan was formulated for the complete urban landscape, with the intention of integrating land use with transportation. The plan fulfilled this by focusing on the enhancement of new towns around the core; the decentralization of manufacturing, retail and institutions to the new towns; and the creation of a strategic road and rail network. The objective is to ensure free-flowing traffic such that mobility in all forms within the city is efficient. The Masterplan outlines the pursuit of a "people-centred" transport system (Sun 2013).

- Integration of public transport with land use
  The first strategy aims at integrating transport planning and urban development by strongly relating the development of urban transport facilities with other measures for supporting desired patterns of land use (Yuan 1997). This includes strategies for an appropriate development and focussed high building densities around mass rapid transit stations including more connections where required so as to ensure good accessibility for travellers to their destinations. Additional efforts include plans to decentralize commercial activities from the central area to four new regional centres in suburban areas to minimize the threat of congestion in the central area. It will also incorporate urban development into the current transit bringing work spaces closer to homes. This will result in a less transport-intensive, reasonable and efficient and harmonious urban environment. The Singaporean Masterplan does not absolutely address the issue of land use/ transport integration in any detail. Though it is an outstanding document with strong policy and project directions across a range of transport issues, it does not

directly discuss transit-oriented development concepts such as better neigh-bourhood design, the structure of public spaces with respect to public transport, or typologies for the mixed-use developments that might surround mass transit stations (Hale and Charles 2008). Singaporean planning generally sees a close relationship between mass transit (in particular) and major urban development initiatives.

- Better services
  Singapore's Masterplan gives priority to public transport over private transport. It is formulated over the strategy that expansion of road networks cannot meet the needs of the community at large. The target of 70% of peak hour journeys by public transport is a case in point (Hale and Charles 2008). Another important target is the goal of doubling daily public transport trips to 10 million by 2020 (LTA 2008). The transport system is largely based on the mass rapid transit (MRT) rail network, which appears set for further emphasis under the expansion plans outlined in the LTA (Land Transport Authority) 2008 Masterplan. The bus service receives special attention in the plan for targeted improvement. However, it is functioning efficiently on the ground at the moment. The level of integration between bus and rail provides an important case study.

(a) Mass Rapid Transit: Singapore's Metro
    Singapore has invested in a mass transit system in order to provide citizens and permanent residents with a fast and effective means to commute. Introduced in the late 1980s and first operating on a single line only, the Singaporean metro system or mass rapid transit (MRT) has now become an effective system integral to the city. Within the past three decades, the MRT has evolved into a vast and reliable system of public transport with an objective of 8 out of 10 families within a 10-min walk of a rail station. As is the case with other methods of public transport in Singapore, the MRT network is not owned and operated by a single company. It is rather a joint effort of SBS transit, a subsidiary of the leading transportation company ComfortDelGro, and SMRT trains (Yuan 1997). This does not affect one's commute since tickets and fares are calculated by the distance travelled and are independent of the means of transportation or the operator.

(b) The Bus system
    In 1925, the Singapore Traction Company (STC) was set up to run a bus system based on trolleys. Within 10 years, motor vehicles became sought after and the STC started its motorized omnibuses. The lack of rules for implementation, however, led to privately owned bus companies that provided bus services outside the STC routes. The privately owned buses became a preferred trans-port mode as it offered routes that the STC were not covering. In 1935, the many small operators were consolidated into 10 companies with 144 buses. These buses ran regular services with bus schedules and routes in the different parts of Singapore. However, the bus companies suffered operational difficul-ties and poor management. Each of these companies operated from a different territory without incorporation of timetables, routes or fares making it

complicated for passengers. To solve this problem, the government decided to re-examine the public transport system of Singapore. The government reorganized the bus system in the 1970s, renovating it from one which was uncontrolled with a free hand, to one that had a centrally planned approach. In 1973, the remaining bus companies fused to form the private entity, Singapore Bus Service (SBS). The formation of SBS resulted in the integration of all bus routes and the standardization of fares (Cheong and Loh 2015). In 2009, the Land Transport Authority (LTA) took over the bus planning function from operators in order to plan Singapore's land transport network more holistically. In 2012, the government increased bus services quickly while awaiting for the new rail projects to be completed by launching the Bus Service Enhancement Programme (BSEP). In this S$1.1 billion (US$815 million) scheme, the government partners would introduce 1,000 new buses into the current bus fleet (Cheong and Loh 2015). When the BSEP is fully implemented by 2017, 100% of feeder services will be required to operate at eight-minute intervals during peak periods. The MRT, with its route of 83 km and forty-eight stations, in conjunction with public buses, serves three million users every day and constitutes some 51% of all daily motorized trips (Yuan 1997)

- Providing people centric environment and policy

(a) Facilitate Walking and Cycling

As per the Masterplan, walkers and bicyclists can anticipate increased and improved services in the future. For pedestrians, more than 200 km of new sheltered walkways around transport nodes will be available by 2018 under the Walk2Ride programme, four times more than today's 46 km (Sun and Yew 2015). Currently, all MRT stations and bus interchanges have minimum one barrier-free access route, and most bus stops are barrier-free. The remaining bus stops are to be upgraded where feasible. Additionally, key pedestrian foot overbridges will be gradually installed with lifts. For walkers, a longer green man time at 500 pedestrian crossings is complete around about 2015 under the Green Man + Programme. For cyclists, a cycling network of over 700 km island wide will be completed by 2030 (Sun and Yew 2015). To encourage cycling to the stations, more bicycle racks are installed. A total of 5,800 tracks were installed from 2013 to 2014, at 34 MRT stations. A bicycle sharing pilot is also being planned.

(b) Promote Flexi-Travel

LTA is also encouraging flexi-travel. The Free Pre-Peak Travel on MRT Scheme, launched in June 2013, encourages commuters to travel early and avoid the peak periods. This scheme was extended to June 2015. They are also launching a Travel Smart Network providing companies grants to encourage employers to support flexi-travel arrangements for their employees.

(c) Maintaining Affordable Public Transport

Sustaining an affordable public transport (PT) is an important socio-economic component of sustainable development. Ensuring inexpensive PT for the

general public is also a key factor in supporting the push for greater PT mode share. The Public Transport Concession Scheme is available for select groups or individuals to enjoy reduced travel rates. These groups include children under the age of seven, students from primary to tertiary (polytechnics and universities), full-time national servicemen, senior citizens, persons with disabilities (PWD) and the adult monthly travel card (LTA 2015). Approximately, half a million commuters enjoy the concession schemes.

Future plans

The LTA plans to extend the rail network to about 360 km by 2030 (up from 182 km today). Dozens of new mass rapid transit (MRT) stations shall be built. Additionally, with the distribution of new trains and signalling system upgrading, MRT commuters can expect faster train arrivals and better connectivity (Land Transport Authority 2015). The BSEP will add 80 new bus services and 1,000 new buses, for public bus by 2017 to ease traveller crowds and reduce waiting times. Three more integrated transport hubs will be developed by 2019 on top of the existing seven. Travellers will be able to make more comfortable transfers and enjoy the greater convenience offered by such hubs.

2.4.1 Singapore—Lessons Learnt

In considering best-practice principles for transport planning, it is important to be mindful of the different contexts and operating environments, and other characteristics. Singapore's people-centred land transport system is delivered through a clear set of important "universal values" presents itself, and these should be pursued in any location that is serious about a planned transport future. Singapore has achieved an effective transport system through integrated planning and development, commuter-centric land transport strategies and demand management. In doing so, it has proven sustainable transport to be a key element in the development of sustainable cities.

3 Conclusions and Recommendations for Indian Cities

Transport is a basic need. Urban transit is diversifying. Economic prosperity and growing car use are not necessarily linked together like they were till a decade ago (Newman and Kenworthy 2011). It is expected that public transport trips will increase. Cycling and walking are visibly expanding in many developed countries (Pucher et al. 2010). These developments are supported by substantial supply-side interventions and policies (Santos et al. 2010). Sustainable transport is one that does not rely on natural resources, rather it uses even renewable energy in the best

possible way. Based on the above-discussed cases, the hierarchy for sustainable transport would be as follows:

1. Walk.
2. Bicycle.
3. Public Transport (Bus, train, etc.).
4. Electric/solar/hybrid vehicles (pooling is even better than using individual vehicles).

Sustainable transport focuses mainly on conservation of resources and provision of pollution free safe environment. Indian cities are densely populated and can be transformed into powerhouses of economy by planning them to support sustainable mobility. Technology and problem solving can be used to aid to various sustainable means of transport making it a smart city in a very holistic way. According to Shanghai Declaration on Better Cities, Better Life, it is mentioned that cities should integrate environmental issues into urban planning and administration and accelerate the transition to sustainable development. One of the greatest challenges is to plan and invest smartly in the infrastructure for sustainable smart transport. As mentioned earlier, a blanket smart city strategy may not work in Indian scenario. We come across many cases (including the case studies in this chapter) where smart transport strategies are planned based on the needs of community, post analysing and understanding the anthropology of that community. These are the cities where such strategies have worked best and are endorsed by its people. Transport solution for a smart city has to be a right mix of "smart" and "sustainable". Below are a few suggestions for transforming Indian cities towards a more sustainable smart transport system.

1. Walk
   There are various strategies proposed around the world to promote walking. Safe and well-designed footpaths are a prime requirement. The sidewalks and footpaths should be clean, welcoming and comfortable for all age groups of people. Surveys and studies show that people prefer walking if the basic amenities like a grocery store, school, post office, ATM, etc., are located at a walking distance. Barton et al. (2010), sets criteria for accessibility to promote active travel according to which amenities like school, health centres and local shops must be located within a radius of 600 m. While amenities like library, post office, community centre, leisure centre can be located in the radius of 800–1900 m. Similar strategy is put forth in ecocity proposal where a bus stop, emergency centres, service points, shops, larger public parks, youth centre, schools should be located within 300 and 500 m (Skala et al. un-known; Barton et al. 2010). In short, it should not take more than 15 min of walk for people to reach their desired destination. This encourages them to walk or cycle. Combining smart technologies with this further makes it a more preferable choice. These could be sensor-based solar lighting, seating areas with Wi-fi and charging points, generating electricity by walking on footpaths, information boards, variable messaging signs and interactive information panels.

2. Bicycle

Most of the population in India, walk or use a bicycle due to low affordability. There are also few who use these means for health benefits or leisure purposes. Studying the condition of roads and basic infrastructure in India, there are issues like absence of proper footpaths and bicycle tracks, absence of bicycle parking spaces, low safety on roads, pollution, etc., that discourages people from using bicycles as a daily means of commute. These are over and above the issues posed by urban density and longer travel distances. In the year 2015, Columbia brought together more than 4000 dignitaries from across the world to discuss the challenges and opportunities of urban cycling. Using a bicycle not only offers a health benefit but also reduces the need of car and indirectly the issue of pollution. Like walking, designing a safe and dedicated infrastructure for cycling would encourage people to choose to cycle. A well-knit network of bicycle lanes with proper parking facilities that connect basic amenities and recreational areas is necessary for ensuring safe and uninterrupted cycling conditions as seen in the case of Paris and Germany. Other very good examples for such a network are Copenhagen, Amsterdam, Utrecht, Strasbourg, etc., that fall under top 10 cities designed for cycling. Ideas like bicycle rental and bicycle sharing, digital bicycle parking, glow in the dark bicycle lanes, signages, real-time traffic information for cyclists etc., are some of the smart solutions to promote cycling.

3. Public Transport (Bus, train, etc.)

As said by Gustavo Petro—"A developed Country is not where the poor have cars…. it is where the rich use public transport". Various public transport modes are the backbone of a Smart city. The smart city mission -India has proposed smart transport proposals like metro, smart bus stops, real-time traffic updates, last mile para-transport connectivity, etc. Various cities like Pune, Ahmedabad, Jaipur, etc., have been selected for the provision of smart transport solutions. Making public transport frequent, comfortable and easy to use will promote people to use it. To add to this electric buses and CNG hybrid buses will help reducing air pollution and result in 30% less consumption of fuel as seen in the Boston Case. Solutions like large-scale retrofit of school/office buses using ultra-low-sulphur diesel, and equipped with pollution control technologies, reducing tailpipe emissions by more than 90% as done in the case of Boston, can also be applicable in India. Real-time update of location of the bus and the time it will take to reach the stop, further promotes its usage. Most of the Western cities follow this system. Another convenient aspect is the smart card for payment of the bus/metro fare as seen in the case of Paris and Singapore. The smart bus stops and metro stations can have solar powered lighting fixtures, fans, etc., as well as charging points for mobile and laptop. Wireless Internet can also be provided for the commuters. Safe bicycle parking near the station encourages people to use bicycle to reach the bus stop/metro station if they are not at a walkable distance [Bicycle Metro]. This kind of facilities encourages people to use public transport systems over motorized vehicles. If more and more people start using the public transportation facilities, need for building wider roads and

car parking facilities will reduce. Air and noise pollution on the road will also reduce.

4. Electric/solar/hybrid vehicles (pooling is even better than using individual vehicles)

Apart from using bicycle, walking or using public transport, one can also choose to use personal motorized vehicles. Plug-in electric vehicles that run on battery, solar vehicles or hybrid vehicles are some of the sustainable solutions. With the advancement in the technology and higher efficiency in the electric motors, one can consider switching to the EVs or HEVs (electric vehicles or hybrid electric vehicles) to achieve better fuel economy. Hybrid and plug-in vehicles have considerably lower emissions as compared to conventional vehicles. Of course for an EV, one must understand that the life cycle emissions depend on the sources of electricity used to charge it. The countries having abundant solar power or wind/tidal power should rely on the same for powering the EVs to further minimize the emissions. The countries which depend on fossil fuels for electricity generation may not really benefit from switching to EVs. Several car manufacturing companies such as Ford, Mahindra, Toyota; provide options like eco-boost, hybrid, plug-in hybrid, etc., which are not only eco-friendly but also budget friendly. Apart from personal vehicles being EVs, even public vehicles like taxi, auto-rickshaw can be electric or hybrid. These can provide last mile para-transport and play a major role in enhancing the public transit access (Kaing 2012). Another sustainable option is to carpool. There are various mobile applications as well as NGOs that facilitate car pool. This method is economic, sustainable as well as time saving. If people carpool, the need of parking will automatically reduce. For everyday commuters, availability of shared cars around major transit stations can allow them to reach their final destination quickly and conveniently. As seen in the case of Germany, the policies should discourage people from using cars and the public transit infrastructure should be world class.

To conclude, Indian cities will need a solid sustainable transport system that can cater to the needs of growing population and promote a better lifestyle by providing a better environment. This will happen only if city-specific urban planning and policies related to transport go hand in hand in favour of more sustainable measures for the future.

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