Sustainable Urban Transport System: A Case Study of Manpada Road

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Abstract: ***Transport in India is an important part of nation's economy. India has been experiencing continuous growth and change over the last decade. Indian cities face the huge challenge of meeting the rapidly growing urban mobility demand in a low carbon and sustainable manner. To guide the cities to move towards the sustainable mobility path, the Government of India is implementing its National Urban Transport Policy that advocates planning for the 'movement of people, not vehicles'. As cities grow exponentially, an effective and sustainable urban transport system for people and goods is a prerequisite for sustainable economic growth. Motor vehicle ownership is growing faster than population and the rapid growth of cities is putting tremendous pressure on urban infrastructure including housing, transportation, power supply, water supply, and sewerage systems. Transport, which is demand-driven, plays a very important role in the overall growth of the economy. Planning for sustainable urban development focuses on improvements in all of these characteristics of the functioning of cities. Sustainable urban ropeway transport has many advantages over present modes of transport of Mumbai. Since the system is not used in general, the cost-benefit analysis of the same will emphasis need of ropeway in smart city project for Smart cities.***

Keywords: Sustainable urban transport system, Cost benefit Analysis.

1. Introduction

Sustainable transport refers to any means of transport with low impact on the environment, and includes walking and cycling, as well as technology to move people, goods, and information in ways that reduce its impact on the environment, the economy, and society. Ropeways may well provide the most elegant connection between urban centres and passenger transport systems on both sides of the water, while ferries and, possibly bridges, can be optimised for vehicle and goods transport. Smaller and medium-sized developing cities, especially ones which are dense and compact, have great potential to develop sustainable transport systems. Ropeways don't provide a free ride and a number of energy consumptions do contribute to the operating bill. The ropeway's unique advantage is of course its capacity to climb steeply and to fly over obstacles and geographical barriers, which seduce many urban planners. The most thrilling opportunities, however. The idea of using ropeways for urban passenger transport is not new, but it has evolved gradually.

2. Literature Review

Dorina Pojani 1,* and Dominic Stead 2,* ISSN 2071-1050 , 17 June 2015 :-
In the space of just a few decades, urban areas across the world, in both developed and developing countries, have become increasingly automobile-dominated and less sustainable.

In developing countries in particular, cities have experienced a rapid growth in transport-related challenges, including pollution, congestion, accidents, public transport decline, environmental degradation, climate change, energy depletion, visual intrusion, and lack of accessibility for the urban poor. In more developed countries, particularly in Northern Europe, some cities have witnessed a trend of reclaiming urban space from the automobile and prohibiting cars from major parts of downtown areas and/or confining them in other ways. Today, these places are often considered as leading examples of sustainable urban development, as cities across the world strive to meet urban sustainability standards by improving public transport, encouraging non-motorized modes, creating pedestrian zones, limiting the use of private cars, and otherwise trying to undo the transformation of cities caused by automobile dominance.

Mackett R. and Sutcliffe, E. B. ,11:151–164, 2003:-
Transport systems and city character are interlinked. Land use characteristics of a city can determine the type of transport system it needs, and once a transport system is put in place, it influences land use characteristics of the city over time. Therefore, the type of public transport system you want in a city will depend on the vision you have for the future of your city. If an economically vital large central business district (CBD) exists, it can become the main centre for both employment and retail, and thus contribute to the success of an urban rail system (if the system serves the CBD) because it can generate and attract trips onto the system. However, low-income neighbourhoods would still be unsuitable for urban rail operation.

3. Objective

- To study and address problem related to present transport system for Manpada road.

- To highlight need and advantages of ropeway urban transport system.
- To study and compare various features of sustainable and traditional transport system using cost benefit analysis

4. Scope

- Clean energy systems as part of smart city project.
- Sustainable solutions for Energy and Transportation.
- Urban Ropeway as Part of Sustainable Urban Transport system integrated with other transport systems.

5. Role of Sustainable urban transport in smart city project:-

- Better integration of transport and land use planning.
- Better public transport services and facilities.
- Better use of clean energy as the backbone of the passenger transport system.
- Better environmental protection.
- Better use of advanced technologies in transport management (ITS).

6. Urban Transit Challenges

Solving the mobility challenges in a clean, safe, smart, enjoyable and affordable manner presents an enormous opportunity for innovation. Cities are engine of development as innovation centre. They are also the major source of carbon emission causing climate change. City efficiency largely depends upon the transport system throughout the city. Poor transport systems stifle economic growth and development, and the net effect may be a loss of competitiveness in both domestic as well as international markets. Overcoming obstacles is useful and will probably lead to the creating of several modern urban systems in the coming years.

Sustainable urban transportation planning provides not only a good mobility of transport but also play decisive role in reducing the climate change by minimizing the emission of carbon to the atmosphere. On an average, during peak hours in Mumbai, the actual occupancy in a suburban train is in excess of 4000 passengers, which have maximum desirable capacity of 2600.

Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and carbon dioxide emissions. Mumbai city has its own mobility needs and challenges based on density, topography, existing infrastructure, etc. and while we can learn from other cities, we must develop our own benchmarks and targets around areas of need and opportunity.

The purpose of this evaluation is to identify and highlight the gaps in the mobility plans so that these gaps can be addressed by cities that are in the process of developing their mobility plans or are yet to begin.

7. Urban transport scenario in India

The Indian road transport sector has been marked by an unprecedented growth in the number of personal vehicles. As shown in fig. , the number of personal vehicles i.e. cars and two-wheelers added to Indian roads in the last decade (2001-2009) has been higher (52.1 million) as compared to the total number of cars and two-wheelers added in the first five decades (1951-2000) after independence (45.6 million). During the same period, the share of public transport has declined steadily. A significant share of the cars and two-wheelers in the country is concentrated in just 22 cities having a population of over 1 million. These and other such large cities in India, which are growing at a very rapid pace, are witnessing a growing demand for mobility. In the absence of organized public transport services and infrastructure for non-motorized transport in these cities, the demand for mobility is being met either by personal modes (for those who can afford) or by informal modes (for those who cannot afford personal vehicles).

Cities are witnessing an exponential increase in the use of personal transport and a steady decline in the modal share of public transport and non-motorized transport.

There has been a growing realization, both internationally and nationally, that the current unsustainable trends in urban transport should be arrested and urban transport placed on a low carbon and sustainable path.

The current pattern of urban transport growth in most developing countries is marked by an explosive growth of personal vehicles and declining share of public and non-motorized transport leading to traffic congestion, road accidents, air and noise pollution, growing dependence on fossil fuels and increasing CO_2 emissions. Indian cities are no exceptions. Rapid urbanisation, rising per capita incomes, growing aspirations and sprawling cities have resulted in transport demand increasing at a rate much faster than the rate of growth of transport infrastructure.

The public and non-motorized transport shares in most big cities in the country have been declining gradually.

Figure 1: Traffic related problems in Mumbai

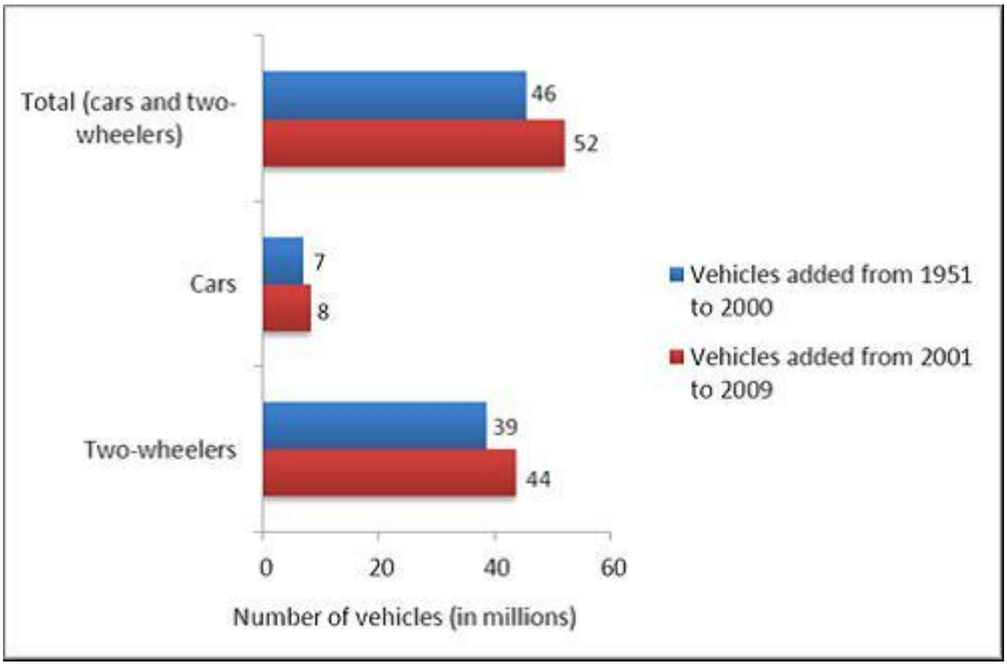

Figure 2: Unprecedented growth in the number of personal vehicles in India in the last decade

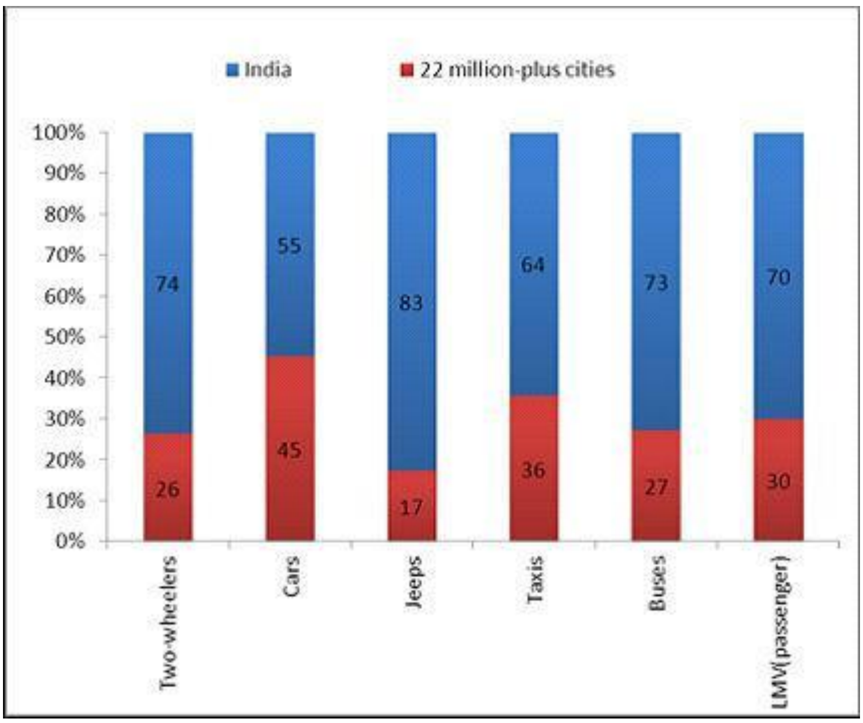

Figure 3: Share of passenger vehicles in 22 cities with population above 1 million (Year- 2009)

8. Sustainable Urban Ropeway Transport System

1) Basic Concept

Joachim Bergerhoff & Jürgen Perschon (2012), explains
Technology and operational concepts, however, have evolved to make them a reasonable and attractive proposition for mainstream urban public transport, too. Unlike the other facility, urban cable cars are easy to board and alight, even for mobility impaired travellers and wheelchairs.

Basically, two types of aerial ropeways must be distinguished: The so called "aerial tramway" with two large cabins permanently attached to each leg of the pulling cable which alternatively turns in one direction and the other obviously stops when the cabins reach the station; and the so-called "gondolas", with a pulling cable revolving constantly in one direction, to which smaller gondolas are attached and detached when entering and travelling through a station.

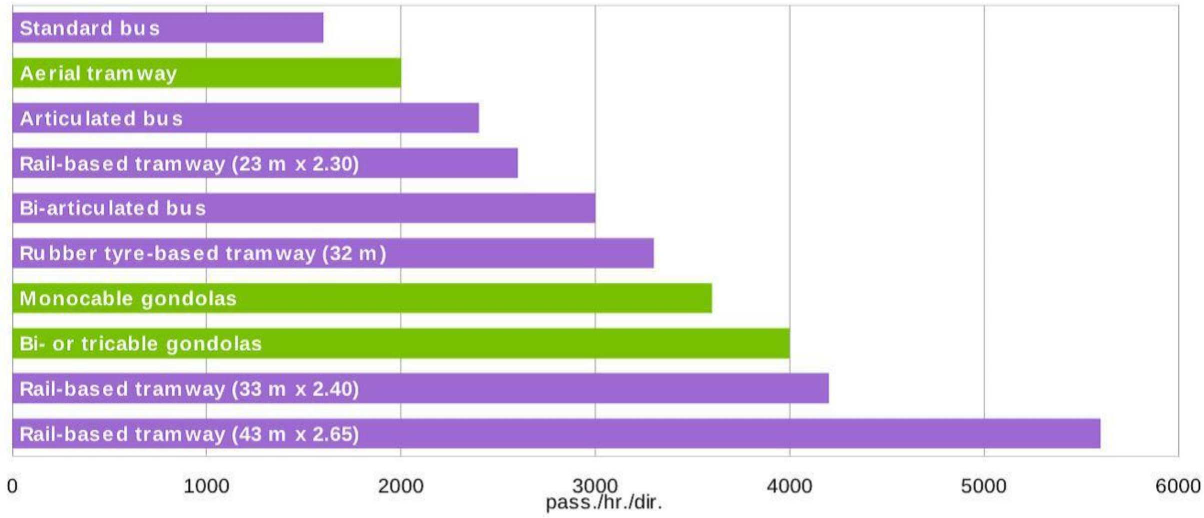

Figure 4: Comparison of capacity no. of passengers per hour per direction.

In regard to capacity, ironically, an aerial "tramway" service is rather comparable to that of a standard bus, while the cosy word "gondola" refers to a system offering capacities comparable small to medium sized tramways on rail tracks with a comfortable and safe ride at around 25 km/h. Gondolas also offer a number of additional advantages, which make them the preferred system in urban transport applications:

- The large number of gondolas offers continuous service, with several departures/minute and thus reduces waiting times (as opposed to come go tramway services where waiting time travel time. i.e. several minutes between departures)

- The small gondolas offer seating for most passengers and a more private atmospher1e, and double hourly capacity. Typical small gondola systems have up to around 10 seats, with latest cab in innovations cover 35 passengers.
- It is easier to adapt system performance to service demand, by modulating the travel speed and the number of cabins in circulation.
- The infrastructure required for smaller cab is lighter, more flexible (including curves and intermediate stations) and less expensive.

A ropeway was built in Caracas as early as 1952. But it was closed in the late 1970's and rebuilt (and extended) in the first decade of this century to a length of 3,5km, served with 70 gondolas, following the archetypical urban transport gondola ropeway, "*Metro cable*" of Medellin, Colombia, built in 2004 and openedin2006.In Caracas and Medellin, the gondolas are planned and operated as feeder lines connecting hillside neighbourhoods to the existing rail based high capacity public transport in the valley.

2) Energy efficiency and operating costs

The ropeway's unique advantage is of course its capacity to climb steeply and to fly over obstacles and geographical barriers, which seduce many urban planners. The most thrilling opportunities, however, can only remain dreams if the economics don't match.

By design, ropeways are highly energy efficient transport systems, for a number of reasons:

- A single stationary electric engine moves the entire system at a steady, efficient pace.
- The gondolas do not have to carry engines, fuel, wheels, suspensions and reinforced chassis and thus are of relatively low weight and drag.
- Descending gondolas help pulling up ascending gondolas; hardly any additional energy is required for acceleration of individual cabins or is lost when slowing down cabins in (rare) stations.
- And, apparently, the aerial ropeway does not suffer rolling resistance.

However, ropeways don't provide a free ride and a number of energy consumptions do contribute to operating bill:

- The revolving cable itself represents a considerable moving weight and it also suffers rolling resistance and torsions, when passing through the guiding and revolving wheels.
- The numerous flying cabins meet manifold wind resistance

- In gondolas, like in all other vehicles, the ancillary systems like heating and cooling consume a large part of the total energy required.

Despite the inevitable losses, ropeway energy efficiency is significantly higher than that of other electric or combustion energy driven transport systems, provided that the number of passengers is significant.

In a ropeway system, the entire cable and the entire fleet of gondolas attached must be mobilised for the first passenger. This is relatively inefficient. But very little energy is required for every additional passenger and, when approaching a reasonable occupancy rate, the gondola becomes the most energy efficient transport system of all.

A similar arithmetic of high fixed costs and low variable costs applies to the other operating expenditures: all staff required for running the system must be present for the first passenger, but no additional drivers are required as patronage rises. The only possibility for the ropeway to adapt operating costs to patronage is to reduce or increase speed, within the margins of customer acceptance and technical efficiency.

The graph below, comparing the operating costs of bus, tram and ropeway with the hourly patronage context: in its domain of excellence of about 2000 to 5000+ passengers per direction and hour, the ropeway is probably the most efficient operation of all. Below, buses and maybe trams are better suited, above, heavy rail takes its turn. Only BRT, with long vehicles and no traffic problems can compete with ropeways within this range of patronage.

Ropeways may well be the most rational choice, even where buses or trams could do the job on the same itinerary. But in many cases, ropeways can go the shortest way where buses or trams would have to go long detours. In these circumstances, their efficiency in relation to effective passenger x km is simply unbeatable.

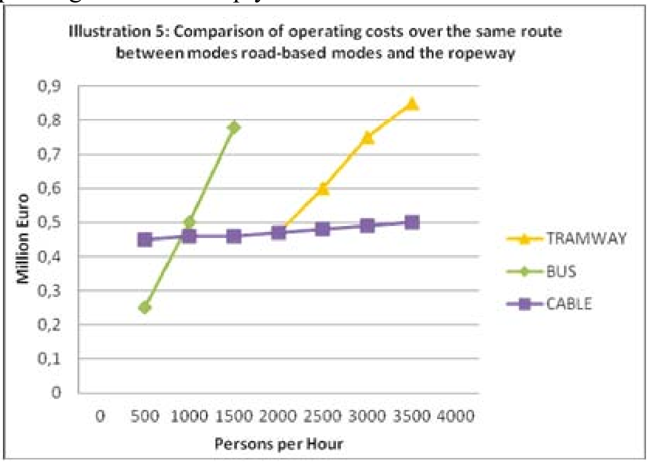

Figure 5: Comparison of operating cost of BRT, Tramway and Ropeway.

3) Physical barriers and Investment costs

Ropeways are best known for coping with, and even taking advantage of, hilly terrains. This feature alone already provides for a variety of applications. However, ropeways do not require hills. Even on flat land, they can be used to overcome many other types of natural and manmade obstacles, such as rivers, lagoons and estuaries, harbours, railways and motorways. Depending on the possibility to place intermediate masts, obstacles of several hundred meter width can be overcome without physical interference with surface or underground infrastructures.

Cities usually grow gradually and organically around these barriers, integrating them into their fundamental structure and habits. Consequently, many barriers are not constantly seen as such, because city dwellers and planners have grown up living with them. But growth changes urban patterns. Formerly peripheral neighbourhoods may gain in importance and formerly neglected barriers are becoming real obstacles to social and economic development. The ropeway may well be the appropriate solution in these situations. Rivers, estuaries and lagoons probably are the most common example for such situations: ferryboats may no longer provide satisfactory service to increased demand and bridges are very costly and intrusive infrastructures.

Ropeways may well provide the most elegant connection between urban centres and passenger transport systems on both sides of the water, while ferries and, possibly bridges, can be optimised for vehicle and goods transport.

Overcoming obstacles is useful and will probably lead to the creating of several (dozens) modern urban ropeways in the coming years.

The construction of a tramway or BRT with similar transport capacity would have cost the destruction of many hundreds of houses and created a new barrier for pedestrian movements and source of noise and air pollution. One considerable advantage of ropeway system thus lies in their reduced so called external costs. But the system infrastructure costs themselves are also considerably lower than those of surface or underground systems of comparable capacity:

- The cable itself is rather inexpensive compared to rail or tarmac tracks of the same length. Not to mention bridges or tunnels. Traffic lights are obsolete. But of course, masts are required every couple of hundred meters (very variable according to terrain and the number of cables). The masts are solid infrastructures and their cost cannot be neglected. But, in any case, they are considerably less expensive than the foundations of a new road or rail track, especially if you include the need to refurbish, redirect or create all sorts of underground infrastructures for water and electricity. Orders of magnitude, in Europe, for mono cable gondolas, such as the systems mentioned in this paper: cable: 70 EUR/meter; masts: 100.000 EUR/mast.
- The stations need stronger foundations than those of BRT and LRT. On the other hand, they are much more compact since they do not need to provide berths for several long vehicles. The machinery, is a considerable investment. Order of magnitude: 2.5 million EUR for station with engine, 1 million EUR for station without engine. A gondola may cost up to 30.000 EUR.

Hence, as a rough estimate of order of magnitude, a mono cable gondola system similar to those described in this paper of 2 km, with 3 stations, 10 masts and 30 gondolas may infer investment costs of around 0.14 + 1.0 + 4.5 + 0.9 = 6.54 million EURO.

Its life cycle costs are necessarily much lower than those of individually motorised vehicles, because the maintenance costs are drastically smaller for the very robust stationary engine and all other moving parts that are heavily and solidly built and operated in a controlled, safe, environment. Anybody familiar with the difficult task of rolling stock maintenance knows the benefit of this.

4) Intermodality & Governance

On the contrary, modern installations are several kilometre long, feature several stops and are integrated into an intermodal public transport network at the metropolitan scale. Furthermore, ropeways are not only a possible alternative to surface and underground transport. They also offer totally new opportunities to access neighbourhoods which cannot reasonably be reached otherwise and which can, thanks to improved accessibility and urban structure created by the ropeway, gradually evolve to become particularly sustainable neighbourhoods.

The ropeway may well be an alternative to small to medium-sized BRT projects, because it overcomes a series of typical BRT (let alone LRT) project obstacles in developing metropolises:

- The physical barrier: it is extremely difficult or almost impossible to secure several kilometres right of way for BRT in the right place. If a corridor can nevertheless be found, it most likely is at the expense of handicapping concessions leading to unsatisfactory situation, access, priority, robustness. Ropeways can be built in the wrong place, too. However, it is relatively easy to find and secure the right spot for a first ropeway implementation across a water or relief barrier. For the rest, "bad compromises" are not allowed.
- The governance barrier: BRT projects often suffer the opposition of well organised informal road transport operators, because, after all, BRT, buses and taxis compete for the same customers on the same lines. Only massive BRT schemes that include a total re-creation of the entire road transport governance and market structure can overcome this obstacle. Ropeways that go where public transport services could hardly go before are not competitors. On the contrary, they bring new customers to the market and works as feeder to massive BRT and metro systems.
- Cost is the ultimate obstacle. BRT infrastructure is expensive and if it is built cheaply, it makes operations expensive and unattractive. BRT infrastructure investment must be massive, because BRT corridors shorter than 10 km are unlikely to make a difference in the transport system. BRT rolling stock is expensive and many projects are proposed with an operating subsidy. Developing cities cannot afford loss making public transport. A relatively short ropeway at the right place, on the contrary, can be less costly to implement and generate profit thanks to its efficiency and unique service.
- The point is that in many developing metropolises, it will be more appropriate to begin the implementation of modern, high quality public transport services with the ropeway projects, because:
- Ropeway projects are easier to implement and to operate than BRT projects.
- Ropeway projects provide greater added value and less financial risk
- Therefore, ropeway projects act as a catalyst for public transport, creating public support, institutional and technical know-how as well as economic resources for further projects, including the necessary BRT or LRT projects.

9. Outlook

Ropeways have always been highly efficient. The latest technical innovations made them a comfortable, high capacity public transport system. They can create direct links where other modes require long detours or massive infrastructure. And the gondolas still offer an enchanting experience at each ride.

Once awareness and knowledge on the key characteristics of modern ropeways are have been widespread among planners and political decision makers as well as the public, ropeways have the potential to become an important complement to established metropolitan transport systems, as feeder lines, for access to entire neighbourhoods, as landmarks and icons.

In many developing country metropolises, it will eventually be better to begin the implementation of modern, high quality ropeway projects. Especially in smaller and medium-sized cities without rail or BRT systems they can be pioneers in changing urban mobility and achieving sustainable cities and safe and secure neighbourhoods. Of course the relevance and feasibility of ropeways vary greatly between cities. It is least obvious in spacious cities built on flat and sandy terrain. In all other cities, ropeways will not be able to weave a full net of public transport for the entire city. But

- They offer unique opportunities to provide public transport where it was deemed to the impossible.
- They offer a sound technical and economic model for mass public transport at a fair and inexpensive price
- They well can be first high level public transport system in many developing cities, opening the minds and creating the environment for entire multi-modal systems.

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