

Urban Transport and Sustainable Transport Strategies: A Case Study of Karachi, Pakistan*

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Abstract: The uncontrolled growth in urbanization and motorization generally contributes to an urban land use and transportation system that is socially, economically, and environmentally unsustainable. This paper uses Karachi as a case study, which is the largest urban and economic centre of Pakistan, passing through an uncontrolled phase of rapid urbanization and motorization. The paper first reviews research related to sustainable transportation systems to comprehend the concept of sustainable development and transportation. The paper then evaluates the existing transportation and infrastructure system, national transportation policies, and urban transportation projects to determine if the current paradigm is moving toward or away from sustainable transportation. Furthermore, the principles for sustainable urban transportation are developed to see what significance national transportation policies have given to urban transportation from a sustainable transportation point of view. Finally some strategies are suggested, adoption of which may lead to a sustainable urban development and transportation system in Karachi.

Key words: sustainable development; urbanization; motorization; socio-economic; integrated land use and urban transportation system

Introduction

Urban transportation is a pressing concern in mega cities around the world. The rapid urbanization and motorization in these cities have a direct impact on sustainable development. The transport sector's energy consumption and greenhouse gas emissions will likely be doubled by the year 2025^[1]. Moreover, the environmental and social impacts of urban transportation are increasingly being seen as a menace to the sustainability of the global ecology^[2].

The mitigation of transportation externalities requires a shift towards sustainable transportation systems. The idea of sustainable transportation emerges

from the concept of sustainable development in the transport sector and can be defined as follows^[3], "Sustainable transportation infrastructure and travel policies that serve multiple goals of economic development, environment stewardship and social equity, have the objective to optimize the use of transportation systems to achieve economic and related social and environmental goals, without sacrificing the ability of future generations to achieve the same goals".

Adoption of the principles of sustainable transportation has become more important in Karachi, where the inefficient public transportation system and rising incomes have stimulated the demand for personal mobility with increased automobile ownership and use. Growing motorization combined with inadequate traffic management strategies, an aging and ill maintained vehicle stock, and inadequate land use and transportation planning, has all led to a significant level of traffic congestion resulting in longer travel times, additional

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fuel consumption, high pollution levels, and a deteriorating urban environment that has a direct bearing on sustainable development.

The concept of sustainable development and sustainable transportation systems can be understood by exploring their evolution. In the 18th century economist and philosopher Thomas Malthus hypothesized that improvements in the quality of life would stimulate population surges that would outpace increases in the means of subsistence^[4]. The term sustainable development was first used by World Conservation Strategy (WCS) in 1980 to emphasize the significance of resource conservation without which humanity has no future^[5]. Sustainable transportation is an expression of sustainable development in the transport sector. A review of the literature has shown a growing emphasis on developing sustainable transportation systems as well as policy-oriented studies^[5-7] to address transportation related negative externalities such as air and noise pollution, accidents, congestion and social exclusion, and to meet current and future mobility and accessibility needs without creating excessive negative externalities. The reviews also established that sustainable transportation systems require a dynamic balance between the main pillars of sustainable development, i.e., environmental protection, social equity, and economic efficiency for current and future generations^[8-10]. Balancing of the various economic, social, and environmental factors is difficult so various attempts have been made^[8,11,12] to list indicators that may assist examination of the sustainability of transportation systems. However, one deficiency in the literature seems to be the lack of consensus on which policies or initiatives will result in a sustainable transportation system, while another deficiency is the lack of social aspects/indicators because of a lack of knowledge and of techniques for assessing the social impact of transportation system changes.

The research is based on a case study of Karachi, Pakistan. Karachi is a mega city having a population of over 14 million. The city is the financial and business hub of Pakistan and being the only port city, serves Pakistan and the landlocked central Asian countries. The study using available data evaluates the city's urban development, transport and infrastructure systems, environmental situation, transport policies, and transport projects. This evaluation seeks to identify if the current paradigm is moving the city towards or away from sustainable transportation. Some strategies are suggested based on the evaluation.

1 Overview of Karachi's Urban Development

Karachi is characterized by an accelerating rate of suburban growth. Its growth rate has been phenomenal as shown in Table 1. The city has seen a 35-fold increase in its population and an almost 16-fold increase in its spatial expansion since the emergence of Pakistan. Moreover, estimates are that by the year 2015, the city may reach a population of 19.2 million with an annual growth rate of over 5%^[13].

Table 1 Karachi metropolitan population and area growth rates

Year	Population (million)	Area (km ²)
1947	0.4	233
1981	5.3	1994
1998	9.8	3527
2004	14.0	3566

The population density of the city according to the 1998 census is tabulated in Table 2, which shows that the density of different areas varies from the central city (33 014 persons/km²) to the outskirts (433 persons/km²). Karachi is basically a mono centric city where over 70% of the business services and about half

Table 2 Area, population, and population density of Karachi in 1998^[14]

Location	Area (km ²)	Population (persons)	Density (persons/ km ²)	Urban proportion (%)
Karachi East	139	2 746 014	19 756	100.0
Karachi West	929	2 105 923	2267	90.7
Karachi South	122	1 745 038	14 304	100.0
Karachi Central	69	2 277 931	33 014	100.0
Malir	2268	981 412	433	67.3
Total	3527	9 856 318		

of the retail trade and personal services are located in the central business district (CBD). About 50% of the employment in the wholesale trade and transport sector is in the CBD.

Rapid population growth and spatial expansion have led to a sharp increase in demand for urban transport facilities and services as the densification and spatial expansion have occurred with no development planning. Since 1949 five development plans have been prepared for Karachi^[15], but never implemented. As a consequence the city suffers from a chronic shortage of basic facilities like dwelling units, water supply, electricity, and public transport. The shortage of dwelling units has been largely responsible for the emergence of squatter settlements. At present, about 55% of the total population resides in these squatter settlements^[16]. The socio-economic and environmental conditions in these settlements are dismal with the majority of these squatter settlements located far from the major job markets. The residents of these areas are poor and are captive riders of limited and low quality public transport services.

2 Evaluation of Transportation and Infrastructure Systems

The increased urbanization and economic growth in the city has put a tremendous pressure on travel demands. The increased demand has quickly filled the roadway infrastructure as about 33% of all motorized vehicles in the country throng on its roads and expressways.

Figure 1 shows that in 2002 the total registered vehicles and cars were growing at twice the growth rate of the population while Fig. 2 shows that the vehicle fleet is dominated by cars and motorcycles, which account for 92% of the vehicles as compared to 6% for para transit vehicles and 2% for public transport vehicles. This rapid rise in personal vehicle ownership and the lack of economic instruments, such as charged parking and road pricing, has led to enormous congestion especially in the central part of the city which increases the average commute travel time in Karachi by over 45 min^[17].

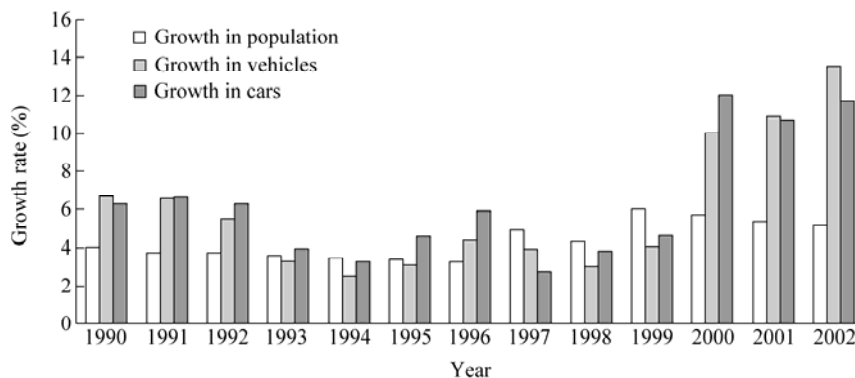


Fig. 1 Growth trend of vehicles and cars versus population^[18]

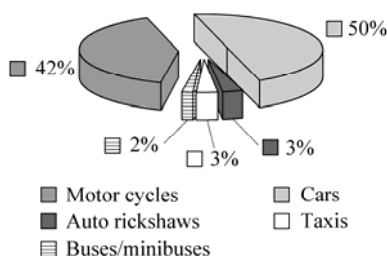


Fig. 2 Share of passenger vehicles fleet in 2003^[18]

2.1 Road network and mobility

The urban transport system is mainly road-based with Karachi Circular Railway (KCR) providing a

negligible share as the system ceased operation in 1999 due to heavy losses. Recently the KCR has been partially revitalized but no recent statistics have been released about its percentage of rides. Karachi maintains a 7400 km road network with a density of 207 km road per 100 km² of area. This limited road space combined with poor maintenance, delayed repair work, bad quality construction, and absence of essential support functions creates problems in satisfying the traffic demand. There are many places where large numbers of commuters move at the same time from one location to another, however, the access roads and links offer extremely few choices. Many neighborhoods have only

one access point/road to link them to adjoining locations. Unfortunately, these limited choices cause congestion which is further aggravated by encroachments and on street parking on the main and collector streets.

2.2 Travel demand and modal split

The urban transport needs of a city are cyclic in nature and largely depend on the travel behavior of the citizens. Table 3 lists the mode shares of two surveys carried out in 1987 and 2004 by the Traffic Engineering Bureau of Karachi. Although the trips made by private and para transit vehicles are increasing, the noticeable feature is that the buses/minibuses still continued to provide over 50% of the travel demand. Therefore, the buses/minibuses are the most important mode of public transport in Karachi and better transport management strategies, service, accessibility, and affordability can help reduce the use of private vehicles.

Table 3 Trend of mode split at Karachi

Year	Mode share (%)		
	Public transport	Private/para transit	Walking/cycling
1987	57	31	12
2004	52	48	—

2.3 Non-motorized transport

Non-motorized transport is one of the most sustainable means of transport but unpopular in Karachi and only used by the low income group who cannot even afford the public transport. The statistics in Table 3 show that percentage of trips made by walking/cycling was 12% in 1987 with no data in 2004. The alarming security and safety problems, the absence of policy and planning for pedestrians/cyclists, and the encroached/ill maintained footpaths are some of the main reasons that lower middle and middle income groups do not use non-motorized transport. Pedestrians, besides being exposed to air and noise pollution, are also the largest group of victims of road accidents as almost 600 people die in road accidents every year in Karachi with over 50% being pedestrians^[19].

2.4 Public transport

The road-based public transport system in Karachi is mostly in the hands of the private sector with very little public sector involvement. The existing public

transport system is not capable of meeting the increasing travel demand. The public transport system constitutes only 2% of the total vehicle fleet and serves more than half of the passenger demand but receives no preferential treatment in terms of dedicated lanes or traffic management. Table 4 shows that the number of vehicles and routes in operation are much lower than the actual demand. The deficiency in the vehicle fleet is due to the fact that the majority of Karachi's urban public transport (81%) is comprised of low capacity (27/32 passenger's carrying capacity) minibuses/coaches. Therefore, the ratio of available seat capacity on public transport to the population in Karachi is 1:40 as compared to 1:12 in Mumbai and 1:8 in Hong Kong^[20]. Furthermore, Fig. 3 shows how this deficiency compels the commuters to travel in overcrowded buses, minibuses, and coaches, exposing themselves to serious hazards by traveling on footboards, roof-tops, and even on the rear guards of the vehicles.

Table 4 Present public transport fleet and routes (road-based)^[21]

Modes	Number of on road vehicles	Routes	
		Classified	Operative
Buses	2300	110	48
Minibuses	6284	197	104
Coaches	3562	96	67
Total	12 146	403	219



Fig. 3 A daily routine scene of traveling on footboards, roof tops, and rear guards

Karachi is the only mega city in the world without a rail based mass transit system. The KCR, which acted as a suburban railway system and started its operation in 1964, used to serve as a cheap, reliable alternative mode of public transport for the urban poor. Until 1978,

nearly 0.3 million commuters traveled on the KCR every day^[22]. Beside the urban poor the system was also very popular and convenient for the middle and lower-middle income urbanites.

The deterioration of the KCR services reportedly began in 1979. The negligence of successive governments in maintaining infrastructure and stations and 23 level crossings which obstructed the circular railway trains from arriving on time were the main reasons for declining numbers of riders.

The Pakistan Railway record shows that its service had dropped from 104 daily trips in 1970s to the only 1 in 1999, which caused the operation to cease as the losses exceeded Rupees 6 million (US\$ 0.104 million) per-annum^[23].

3 Environmental Degradation

Urbanization and motorization have proceeded with inadequate government and technological support for sustainable development plans. The negative externalities of the transport sector have gradually harmed the environmental conditions in urban areas and are continuing to exacerbate the quality of life. The unchecked growth in the vehicle fleet combined with an aging and ill maintained vehicle stock has degraded the road environment which has resulted in severe congestion on the roads along with serious levels of air and noise pollution. The data in Table 5 illustrates the urban air and noise level pollution due to vehicular traffic.

Table 5 Air and noise pollution in Karachi in 2003-2004^[24]

Pollutants	Pollution level	Permissible limit	
		USEPA	NEQS
TSP ($\mu\text{g}/\text{m}^3$)	390	260	—
PM ₁₀ ($\mu\text{g}/\text{m}^3$)	280	150	—
SO ₂ (10^{-9})	44	38	—
NO _x (10^{-9})	22.8	10.0	—
CO (10^{-6})	42	50	—
Noise (dB)	99	—	85

Note: USEPA denotes the United States Environmental Protection Act, NEQS denotes the National Environments Quality Standard, TSP denotes the total suspended particulate matters, and PM₁₀ denotes the particulate matters.

4 Transport Policies

Since 1998 three national transport policies have been drafted in Pakistan by the Chartered Institute of Transport Pakistan (CITP), the Planning Commission Paki-

stan (PCP), and the National Research Transport Center (NTRC), but none of them were approved. Therefore, Pakistan lacks urban transport policies. Before devolution in 2001, provincial governments were responsible for urban transport but the city district governments are now responsible for urban transport. Table 6 illustrates the significance of some principle indicators of sustainable transportation for the urban transport system in these draft policies.

Since these policies were drafted for national transport policies, the data in Table 6 shows that not much emphasis was put on urban transportation system development, especially from a sustainable transportation point of view. If the city government of Karachi wants to mitigate its urban transportation issues in a sustainable manner, the city must formulate a master transportation plan which is environmentally, economically, and socially balanced.

Table 6 Analysis of national transport policies

	CITP	PCP	NTRC
Environment			
Resource utilization	*	×	*
Waste utilization	×	×	×
Emission reduction measures	**	*	***
Noise reduction	×	×	*
Depletion of non-renewable energy	×	×	×
Promoting clean fuel technology	×	×	×
Promoting research & development	×	*	***
Economic			
Accessibility	*	**	***
Economic instrument	×	×	***
Economic productivity/efficiency	**	**	**
Proportionate investment on transport infrastructure	*	×	**
Social			
Affordability	**	×	***
Safety & security	***	**	***
Equity	×	*	****
Health impacts	**	*	**
Planning			
Integrated transport and land use planning	****	×	×
Promoting non-motorized transport	×	×	***
Promoting public transport	****	**	**
Personal vehicle reduction strategy	×	×	×
Public participation	×	×	***
Institutional development	**	**	**

* illustrates the intensity of emphasis ranging from * to ****

5 Development Projects in the Transportation System of Karachi

5.1 Urban bus scheme

This scheme proposed a strategy to revamp the road-based public transport system in the city by replacing the mini buses with large buses using environmentally friendly fuels like compressed natural gas (CNG) to provide efficient, comfortable, reliable, safe, and environmentally friendly transport to the general public. Presently, more than 300 large capacity buses have been deployed on the roads and 8000 more CNG buses will soon be included in the fleet with the government allocating Rupees 5 billion (US\$ 83.3 million) for the city transport^[25]. This allocation is being made to mitigate the issues of severe over crowding, congestion, deteriorating service, and environmental pollution associated with the existing 81% of individually owned, low capacity, environmentally damaging minibuses/coaches.

5.2 Lyari expressway and Northern bypass

The construction of the 32.1 km long 4 lane Lyari expressway will improve inner city vehicular movement, while the 57 km long 6 lane Northern bypass planned to divert heavy upcountry traffic outside the city will hopefully ease traffic pressure in the city and will give a much cleaner and pleasant environment to the people. Moreover, for fiscal year 2005-2006, the city government has approved Rupees 6.00 billion (US\$ 100 million) for construction of roads, bridges, flyovers, underpasses, bus terminals, and other development works^[26] and US\$ 225 million for construction of a 24-km-long elevated expressway^[27]. However, the current modernization of the transport infrastructure (construction of the elevated expressway, underpasses, flyovers, etc.) which seeks to solve Karachi's traffic congestion will provide no more than temporary relief. The experience of other mega cities suggests that a huge investment on construction of high capacity roads and the provision of a large number of flyovers and underpasses will not mitigate traffic congestion or enhance vehicle speed. For example, the congestion in Beijing can be quantified from the declining vehicle speeds from 45 km/h in 1994 to 10 km/h in 2005 especially between the second and third ring roads, which is now extending beyond

fourth ring road and along major radial and arterial roads^[28].

5.3 Rail-based mass transit system

A rail-based mass transit master plan has identified three corridors with the revival of the KCR as an integral part of the system. The whole project will be built on the Build Operate Transfer (BOT) basis. Figure 4 shows that Corridor 1 that runs northeast and southwest will be constructed in two stages. Stage one is a 15.2-km route which will have some elevated and some underground portions, with Stage two extending the system to another 8 km. Corridor 2 will have a 13.4-km line along the north and south axis of the city. The KCR line needs revitalization for 50 km of length.

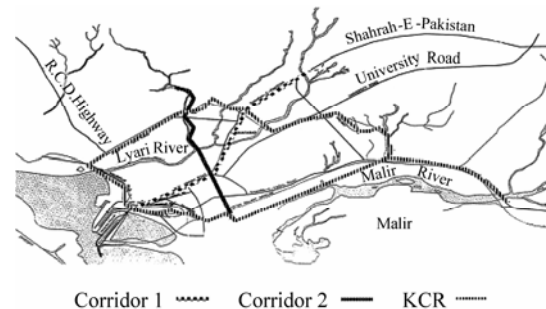


Fig. 4 Priority corridors of rail-based mass transit system^[20]

6 Suggested Strategies

The evaluation of the transport and infrastructure system, transport policies, and development projects for the Karachi urban transportation system in Sections 2, 4, and 5 leads to some strategies for sustainable development of the transportation system in Karachi. Suggested strategies on urban transportation system are evaluated in Table 7.

6.1 Change the urban form and land use patterns

Karachi is basically a mono centric city where a large proportion of activities are carried out in the CBD resulting in a great mismatch between jobs and residence locations. To avoid overdevelopment of the CBD the urban functions should be decentralized by developing new urban areas and urban fringes by constructing multiple business areas. Moreover, these multiple centers should be developed on the principles of smart growth which requires balance between job and

Table 7 Evaluation of suggested strategies on urban transportation system

Serial	Policies	Purpose	Effects
1	Change the urban form and land use pattern	To avoid centralization and over-development of the CBD	Development of new urban areas and urban fringe areas will decentralize the urban functions and will keep a dynamic balance between work and residential areas.
2	Integrated transport and land use planning	To maximize the urban transportation system efficiency for environmental and city resource constraints	Transport accessibility alters people's travel behavior and land use intensity. Integrated transport and land use planning will maximize the efficiency of resource use and transport mode choices to enable a sustainable transport system.
3	Promote public transport and transit oriented development	To promote public transport, a compact mixed community layout and reduce excessive personal car usage	Compact mixed community layout with public transport as the focal point will stimulate public transport use and reduce personal car use.
4	Integration of transport operators	To provide an integrated transport system with interoperability between road and rail based public transport	This will improve the interaction between rail-and road-based public transport, capacity distribution, and passenger transfer, and mitigate the wasted carrying capacity and inconvenience to passengers.
5	Low transport fares for low income groups	To provide vertical equity to low income groups	This will help low income groups to commute with subsidized fares.
6	Formulate and implement urban transportation laws and policies	To develop a sustainable urban transport system by implementing transport laws and policies	This will identify the status of transport modes, transport financing sources, transport planning principles, the operation and management of transport systems, and other transport related issues.
7	Use economic instruments to restrain car usage	To discourage excessive car usage and encourage public transport use	This will help reduce the road congestion and will ensure transport access for all social groups.
8	Provide a non-motorized transport network	To promote non-motorized transport being one of the most sustainable modes of transport	Non-motorized transport is an energy efficient, environmentally friendly transport mode which will enhance urban mobility and reduce transport related pollution.

residence locations and connection of local centers by multiple traffic modes with large capacity transit systems as optimal modes.

6.2 Integrated transport and land use planning

The absence of integrated transport and land use planning means that development projects are implemented by various departments without taking into account urban ecological systems, resources, and social and economic factors. Different city structures (land use patterns) need different transportation systems. The planning should aim at maximizing the urban transport system efficiency for the environmental and city resource constraints. A dynamic relationship between the city structure and the urban transportation systems will help maximize social benefits and sustainable development.

6.3 Promote public transport and development based on transit oriented development (TOD)

The recent efforts to ease traffic congestion by building wider roads, flyovers, and elevated expressways are unlikely to ease traffic congestion in the long run because these initiatives are not linked to social and environmental land-use planning and the transport needs of the non-car owning majority. Sustainable development of the urban transportation system needs to place a priority on the development of an integrated urban transport system with public transport as the core. Therefore, transit oriented development which prefers a compact mixed community structure with transit station as the core will improve transit ridership and support the main pillars of sustainable development, i.e., economic growth, environmental protection, and social diversity in the community.

6.4 Integration between transport operators

Integration and coordination of road and rail transport operators is essential for the Karachi transport system. The city has already suffered from the absence of rail-based urban transport, as the KCR has remained inoperative for almost six years due to the lack of riders, the low level of service, and the absence of an integrated bus service routes to shuttle travelers back and forth between KCR stations, their homes, and their place of work.

6.5 Low transport fare for low income groups

The rail-based mass transit system for Karachi will be built using a BOT scheme. Without major government subsidies, the fares will be too high for the poorest segment of Karachi to pay the fares. Therefore, a sustainable funding source must be identified to give subsidies to the poorest segment of the population.

6.6 Formulate and enforce urban transportation laws and policies

Urban transportation policies should be formulated to clarify the status of transport financing sources, transport planning principles, rights to roads, operation and management of transport systems, and other transport-related issues. Enforcement of transportation laws in collaboration with education would promote the use of public transport.

6.7 Use economic instruments to restrain car use

Karachi transport development projects can be made successful by managing the rapidly increasing number of private cars through congestion pricing, area licensing schemes, cordon pricing, and high parking fees in the CBD. These schemes have been successfully implemented in Singapore, Hong Kong, and London. Such schemes restrict the over use of cars and help mitigate traffic congestion and pollution and enhance quality of life and improve public transit use in the CBD.

6.8 Provide a non-motorized transport network for bicycle users and pedestrians

Non-motorized transport is an energy efficient, environmentally friendly transport mode that can play a

significant role in urban mobility. In Karachi the security and safety issues, poorly maintained pedestrian paths, and the absence of a separate right of way for bicyclists have made this mode unattractive among commuters. However, providing non-motorized transport related facilities such as sidewalks, crosswalks, well-timed crossing signals, street lighting, and dedicated bicycle lanes can revive this mode for commuting and other activities as the majority of the population in Karachi is poor.

7 Conclusions

This paper has reviewed Karachi's urban development, transport and infrastructure system, transport policies, environmental situation, and transport development projects. The evaluation shows that the transport system is in crisis and that the present urban design and transport policies have not provided a holistic approach to urban transport development. The urban bus development and the rail-based mass transit projects will improve urban transport in the future but at present the transport system is economically, environmentally, and socially unsustainable. This paper suggests some strategies which may lead to a sustainable urban development and transportation system in Karachi.

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