Non-Motorized Vehicles in Asia: Lessons for Sustainable Transport Planning and Policy

by Michael Replogle

Abstract

This paper provides an overview of the current use of non-motorized vehicles (NMVs) in Asian cities, the characteristics of NMVs and facilities that serve them, and policies that influence their use. The paper identifies conditions under which NMV use should be encouraged for urban transport, obstacles to the development of NMVs, and identifies desirable steps that might be taken to develop a Non-Motorized Transport Strategy for a city or region, in Asia and other parts of the world.

NMVs offer low cost private transport, emit no pollution, use renewable energy, emphasize use of labor rather than capital for mobility, and are well suited for short trips in most cities regardless of income, offering an alternative to motorized transport for many short trips. Thus, they are appropriate elements in strategies dealing with poverty alleviation, air pollution, management of traffic problems and motorization, and the social and economic dimensions of structural adjustment. NMVs have a most important role to play as a complementary mode to public transportation.

Cities in Asia exhibit widely varying modal mixes. NMVs -- bicycles, cycle-rickshaws, and carts -- now play a vital role in urban transport in much of Asia. NMVs account for 25 to 80 percent of vehicle trips in many Asian cities, more than anywhere else in the world. Ownership of all vehicles, including NMVs, is growing rapidly throughout Asia as incomes increase. However, the future of NMVs in many Asian cities is threatened by growing motorization, loss of street space for safe NMV use, and changes in urban form prompted by motorization. Transport planning and investment in most of Asia has focused principally on the motorized transport sector and has often ignored the needs of non-motorized transport. Unless Non-Motorized Transport Strategies are adopted to slow or reverse this trend, problems related to traffic safety, air pollution, energy use, traffic congestion, urban sprawl, and the employment and mobility of low income people may spiral out of control, while increasing the speed of global climate change.

As cities in Japan, the Netherlands, Germany, and several other European nations demonstrate, the modernization of urban transport does not require total motorization, but rather the appropriate integration of walking, NMV modes, and motorized transport. As in European and Japanese cities, where a major share of trips are made by walking and cycling, NMVs have an important role to play in urban transport systems throughout Asia in coming decades. Transport investment and policy are the primary factors that influence NMV use and can have an effect on the pace and level of motorization. To maximize transportation efficiency and sustainability, transport planning in Asian and other cities will need to focus more closely on stratifying different travel markets by trip length and encouraging different travel modes for various market segments.

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Introduction

NMVs -- bicycles, cycle-rickshaws, and carts -- play a vital role in urban transport in much of Asia. NMVs account for 25 to 80 percent of vehicle trips in many Asian cities, more than anywhere else in the world. Ownership of all vehicles, including NMVs, is growing rapidly throughout Asia as incomes increase.

However, the future of NMVs in many Asian cities is threatened by growing motorization, loss of street space for safe NMV use, and changes in urban form prompted by motorization. Transport planning and investment in most of Asia has focused principally on the motorized transport sector and has often ignored the needs of non-motorized transport. Without changes in policy, NMV use may decline precipitously in the coming decade, with major negative effects on air pollution, traffic congestion, global warming, energy use, urban sprawl, and the employment and mobility of low-income people.

As cities in Japan, the Netherlands, Germany, and several other European nations demonstrate, the modernization of urban transport does not require total motorization, but rather the appropriate integration of walking, NMV modes, and motorized transport. As in European and Japanese cities, where a major share of trips are made by walking and cycling, NMVs have an important role to play in urban transport systems throughout Asia in coming decades.

Transport investment and policy are the primary factors that influence NMV use and can have an effect on the pace and level of motorization. For example, Japan has witnessed major growth of bicycle use despite increased motorization, through policies providing extensive bicycle paths, bicycle parking at rail stations, and high fees for motor vehicle use. Denmark and the Netherlands have reversed the decline of bicycle use through similar policies.

China for several decades offered employee commuter subsidies for those bicycling to work, cultivated a domestic bicycle manufacturing industry, and allocated extensive urban street space to NMV traffic. This strategy reduced the growth of public transport subsidies while meeting most mobility needs. Today, 50 to 80 percent of urban vehicle trips in China are by bicycle and average journey times in China's cities appear to be comparable to those of many other more motorized Asian cities, with much more favorable consequences on the environment, petroleum dependency, transport system costs, and traffic safety. Unfortunately, since the early to mid 1990s, the Chinese government transport policies have shifted to favor rapid motorization and bicycle traffic is being forceable displaced from many urban centers, with predictable negative consequences for traffic congestion and overall sustainability.

Extent of Ownership and Use

Bicycles are the predominant type of private vehicle in many Asian cities. Bicycle ownership in Asia is now more than 400 million and growing rapidly. Bicycle ownership in China increased more than 50 fold between 1952 and 1985, to 170 million[1], with nearly half of them in cities. Since then it has risen to 300 million and is anticipated to grow to 500 million by

2000[2]. In many Chinese cities, bicycle ownership rates are one bicycle per household or more. Between 1980 and 1988, the number of bicycles in Beijing grew more than 12 percent a year to 7.3 million. In India, there are roughly 25 times as many bicycles as motor vehicles and urban bicycle ownership is growing at a fast pace. Table 1 shows the number of non-motorized vehicles in a number of Asian countries and cities.

The majority of the world's 3.3 million cycle rickshaws and goods tricycles are found in Asia. Despite recurrent efforts made by some local authorities to suppress cycle rickshaws in preference to motorized transport modes, the number and use of these vehicles is growing in many cities in response to otherwise unmet transport needs. The Indian Planning Commission in 1979 estimated that the number of cycle rickshaws in India would increase from 1.3 million in 1979 to 2.2 million by 2001.

In Bangladesh, the cycle rickshaw fleet is estimated to grow from two-thirds of a million in 1988 to over one million by 2000.[3] More than three-fourths of Bangladesh's cycle rickshaws are in urban areas. These urban cycle rickshaws each annually account for an average of over 30,000 passenger-miles and nearly 100 ton-miles of goods movements. Together, bicycles, rickshaws, bullock carts and country boats account for about 75 percent of the value added, 80 percent of the employment, and about 40 percent of vehicle assets employed in the transport sector. On secondary roads, non-motorized transport vehicles make up about 85 percent of traffic. [4]

NMVs account for a substantial share of trips made in many Asian cities, ranging as high as 80 percent of vehicular traffic in NMV dependent cities. There is, however, substantial variability, depending on many factors, including topography, income, metropolitan structure, level of motorization, climate, and transport policies. Table 2 shows the variation in mode shares for selected cities is Asia.

In Indian cities, bicycles typically account for 10 to 30 percent of all person trips (including walking) and for 30 to 50 percent of the traffic on primary urban roads. Walking and cycling account for 60% of total trips and 40% of work related trips in Karachi, Pakistan. In Chinese cities, bicycle use has grown dramatically in recent decades. As Figure 1 shows, bicycles have largely replaced buses as the principal means of urban vehicular transport in Tianjin. Buses are generally slower for the same trip made bicycle. Less pronounced, but similar trends occurred in Shanghai in the 1980s.

Cycle-rickshaw traffic typically accounts for 10 to 20 percent of the traffic on primary urban roads and for 5 to 20 percent of all person trips in Indian and Pakistani cities. These vehicles, along with hand-carts, account for a major share of urban freight movement in Chinese cities. Of all land transportation in Bangladesh, NMVs produced 60 percent of all passenger-km and 36 percent of freight ton-km in 1985. [5] There were estimated to be 200,000 cycle rickshaws in urban areas and another 50,000 in the rural areas in 1982. Urban bicycle rickshaws were estimated to have put in 32,810 passenger miles per vehicles per year and carried 94 ton miles of goods per vehicles per year in Bangladesh.[6]

A large portion of cycle rickshaw trips appear to be of a nature not readily replaceable by overcrowded buses. Surveys on several main roads in Dhaka, Bangladesh, in 1989 showed that on average, 22 percent of cycle rickshaws (including rickshaw vans) were carrying goods, although in industrial and shopping areas this share was more than doubled. Depending on location, between 8 and 18 percent of rickshaws carried passengers with small children. Nearly one-third of all cycle rickshaws carried female passengers, with nearly one-fifth carrying females alone. Many of the remaining share of trips were by males traveling as passengers without goods, often for short distance trips on irregular routes.[7]

In a number of Indonesian cities, becaks, also called cycle-rickshaws or pedicabs, play an even greater roles in urban mobility than the bicycle. In Bandung, for example, cycle-rickshaws accounted for 12 percent of all work trips and an even higher share of non-work trips in 1985, while bicycles account for about 6 percent of trips.[8] In Jakarta, where the government is actively suppressing cycle-rickshaws (becaks) through banning and confiscation, these vehicles accounted for 4.6 percent of all trips in 1985, while bicycles held only 2.4 percent mode share.

Relationship of Income on Bicycle Use

Income plays a significant role in influencing transportation choices people have. People with low incomes face extremely limited transport choices. Where there is extensive poverty, it is most important to ensure that the modes used by the poor continue to remain available as travel options. Despite rising incomes in many cities across Asia, the distribution of wealth and income remains skewed in much of the region. Rapid urbanization and economic growth throughout much of Asia has left behind hundreds of millions of people, who continue to live in desperate poverty. Indeed, two-thirds of the poorest of the poor in the world live in India, Bangladesh, Pakistan, and China.

Many low income people in Asian cities cannot afford even subsidized public transport fares and have no choice but to walk or cycle, even for travel distances of 10 to 20 km. For most poor households, walking accounts for the majority of all trips. When incomes are low, the value of time relative to cost for travelers is low as well. Although walking costs nothing, it takes a lot of time for all but short trips. Cycling often offers four or five times greater speed and is cheaper than public transport, once a bicycle is in hand. When a bicycle that will last years costs the equivalent of six or eight months of bus fares, there is good profit for a poor person in having one and using it. Thus, for the poor in Asia, increases in personal mobility are most commonly expressed in expanded use of bicycles. Increased mobility for goods movement and the transportation of children and families is often expressed in greater use of cycle-rickshaws, where these are available, or bus public transportation where this is available.

Low income households are forced to spend a higher share of their income on transportation than higher income households. A number of factors contribute to this -- the poor often have to live far away from their jobs to find cheap housing, they often hold multiple part time jobs, and, since their income is so small, a single bus fare represents a larger share of earnings than for others. The poor in general make fewer trips than higher income people and engage in little discretionary travel. Irrespective of city size, the poor will continue for the foreseeable future to be dependent on non-motorized transport modes for mobility in Asian cities.

However, it is not only the poor who use bicycles. The travel time and convenience offered by the bicycle attracts people of all income levels to bicycles in many cities, particularly where measures have been taken to facilitate cycling. As traffic congestion in Asian cities increases, public transport schedule reliability and average travel speeds both decrease, making bicycles competitive at longer trip lengths due to their flexibility, convenience, and greater reliability.

Employment Generation by NMVs

Direct manufacturing accounts for only a small share of the large amount of total employment related to non-motorized transport. Additional people are employed servicing and repairing NMV fleets, mostly through small informal sector businesses. Throughout Asia, NMVs form the foundation for a large informal sector providing goods or services on the street or transporting people and goods on a for-hire basis.

In Dhaka, Bangladesh, for example, about 380,000 people are directly employed as cycle-rickshaw pullers, and another 80,000 are employed in ancillary services related to cycle-rickshaws, together accounting for nearly one-fourth of all employment in metropolitan Dhaka. In all of Bangladesh, cycle-rickshaws in 1988 were estimated to provide employment for over one million people and ancillary employment to another 250,000, representing about 3.5 percent of the nation's recognized labor force.[9]

Together, motorized and non-motorized public transport services provided direct employment to 28,000 people in Patna, India, in the mid-1980s. When indirect employment linkages were considered, 42,000 jobs and the livelihoods of nearly 150,000 were dependent on the public transport sector in Patna. The non-motorized portion of this sector accounts for the larger share of this and is especially vital in providing employment for unskilled low income workers. A 100,000 rupee (US$ 8,000 at 1984 exchange rates; US$ 5,000 at 1991 rates) investment in a conventional bus system in Patna, India, was estimated to produce two new direct jobs. If invested in the motorized auto-rickshaw system, six direct jobs were created. The same sum was estimated to create 75 jobs if invested in cycle-rickshaw transport.[10]

Small informal sector enterprises, as well as formal private sector firms, have played and will continue to play a major role in non-motorized transport systems. Promotion of the NMT sector can stimulate substantial employment growth and microenterprise development, especially in low income cities, particularly benefitting the poor. Where cycle-rickshaws are declining, frequently due to regulatory suppression, taxes, licensing requirements, bans, and even confiscation, hundreds of thousands of low income people are threatened with loss of employment.

Most developing countries are heavily dependent on imported oil. Over half of low and lower-middle income countries import more than 90 percent of their commercial energy, with most of these imports in the form of petroleum.[11] Low income developing countries (excluding China) spent an average of 33 percent of their merchandise export earnings in 1985 on energy imports, with many spending more than half.[12] In non-oil-exporting Asian cities, consumer expenditures on motorized private and public transport usually require more foreign exchange and less local labor than expenditures for alternative non-motorized modes. Thus, a shift from NMVs to motorized modes may have significant impacts on regional economies and foreign exchange requirements.

NMV Facilities

In many low income Asian cities where NMVs predominate, there has been little need to create a separate cycle network because large numbers of NMVs define their own legitimacy to right-of-way. However, as motorization increases, or as traffic congestion worsens, it becomes increasingly important to develop modal separation in high traffic flow corridors. This is particularly vital in mixed traffic cities where NMV use is declining due to competition from growing motorized traffic.

Motorized modes are heavier, faster, and often accorded higher social status than NMVs. When street space is scarce, NMVs are vulnerable to displacement from mixed traffic streets unless they are present in sufficient numbers to assert an almost continuous claim to their share of road space. A key function of bicycle or NMV facilities is to protect the legitimacy and safety of NMVs in the transport system where it would otherwise be threatened by motorized traffic. Isolated bikeways and fragmented segments of bicycle paths cannot be expected to overcome the problems faced by urban cyclists. Comprehensive networks of bicycle safe roads and paths are needed to attract less skilled cyclists to use the bicycle for a significant share of their short daily trips in motor vehicle dependent cities and to avoid the diversion of cyclists to motorized modes in mixed traffic and NMT dependent cities.

What kind of facilities do NMVs need for safe operation? Depending on the level and mix of traffic flow, the answer may range from the simplest street of common design to fairly elaborate grade-separated intersections. There are as many types of cycling or slow transport facilities as there are different types of highway facilities, with multiple potential solutions to many types of system problems.

While the design of individual NMV facilities is important, the quality of the connections of these facilities into networks is of equal or greater importance. Many factors need to be considered in appropriate development of cycle networks, including continuity, facility standard and function, degree of separation of modes, anticipated traffic flows by mode, and available rights-of-way.

The concept of network functional hierarchy used in classifying highways and evaluating their spacing is equally useful in planning and designing cycle networks. Conditions for cyclists and other slow traffic can be optimized if NMVs have available a fine grained network of **collector** facilities -- often shared with pedestrians and slow motorized traffic-- along with a coarser network of **primary** slow traffic facilities, some shared with pedestrians and slow motorized traffic and many reserved for exclusive NMV use, and a coarse network of exclusive **arterial** facilities designated for NMVs.[13]

While the spacing of networks must be adjusted for city patterns and densities, this network concept has been used successfully in a number of highly motorized cities, mostly in Europe, to arrest and often reverse the decline of NMV use during times of rapid motorization. Many cities in the Netherlands, Denmark, and Germany have developed effective cycle networks, with Delft, in the Netherlands, Copenhagen, in Denmark, Malmo, in Sweden, and Hannover, in Germany, clearly standing out as successful examples.[14] Several cities in developing countries are noteworthy for their cycle networks, including Curiteba, Brazil, and Tianjin, China. Pune, India, has been working to develop an extensive cycle network for a number of years.

In many NMV dependent cities, bicycle networks can best be preserved by keeping cars and motorcycles out of many existing streets in neighborhoods. Creation of "environmental districts" -- motor vehicle restricted and traffic calmed areas -- can be a most effective strategy for supporting use of NMVs, walking and public transport. Such districts are increasingly common in many affluent cities in Europe and Japan. In some cities, extensive alley systems offer opportunities for creating NMV networks while improving traffic management, as in a World Bank project in Shanghai.

The safety and congestion problems associated with automobiles and pedal-powered modes have much in common when comparing situations where one or the other of these has clear local dominance in traffic. Different problems occur when there is a more even mixture of automobiles and non-motorized traffic. In the developed world, the response to automobile-induced traffic congestion has been to control the pace and pattern of land development, to institute better traffic management, and to program additional infrastructure and transit services. In cities where bicycle traffic congestion is a major problem, similar approaches should be considered. Better traffic management and design might include improved traffic signal systems that are explicitly designed for slow traffic, as in Holland, creation of one-way modally segregated street systems, and especially where high NMV volumes exist or are anticipated, grade-separation through use of underpasses.[15]

Officially dedicated NMV facilities are rather common in Chinese cities, but not widely found elsewhere in Asia. Instead, where NMVs make up a major portion of traffic flows, they frequently define NMV "lanes" through their physical presence in large numbers. However, especially where NMV lanes are not well defined by physical separation, extensive mixing of NMV and MV traffic often fosters poor traffic discipline among all modes, which exacerbates traffic congestion and safety problems. In a recent Chinese urban road traffic manual, bicycle facilities were appropriately divided into five types, with the first two types being recommended for large and mid-size cities: [16]

(1) **Special Bicycle Roads**, independent of the road network and dedicated to bicycle use only. A network of such roads is being created in the CBD of Shen Zhen City.

(2) **Semi-Independent Bicycle Roads**, positioned on one or two sides of motor vehicle lanes with physical separation.

(3) **Non-Independent Bicycle Roads**, positioned on one or two sides of motor vehicle lanes but without physical separation.

(4) **Mixed Traffic Roads**, where motor vehicles and bicycles share the same right-ofway.

(5) **Pedestrian-Bicycle Roads**, where bicycles and pedestrians share the same right-ofway.

Capacity of NMV Facilities

The rapid growth of bicycle traffic in Chinese cities in the 1980s has led to serious traffic congestion problems in many cities. Peak hour flows at many main intersections in Beijing and Tianjin exceed 15,000, with 29,000 per peak hour observed at one main junction in Beijing. [17] As a result, interest in assessment of the capacity of bicycle facilities has been a serious matter for Chinese planners. In Beijing, China, practical saturation capacity of a separated bike tracks has been estimated at 0.5 bicycles per second per meter width, or 1800 bicycles per hour per meter width. Cycle rickshaws typically require 1.5 to 3.0 times the capacity of a single bicycle, depending on size and weight.[18] Mixed traffic streets typical of Beijing, China, show a saturation capacity of about 0.37 bicycles per second per meter width, or 1330 bicycles per hour per meter width. Separation of motorized and non-motorized traffic at intersection approaches with fences is becoming increasingly common in China as a traffic safety measure. Recent studies indicate that this strategy likely increases motorized traffic capacity of intersections without diminishing bicycle traffic capacity.[19]

Allocation of Road Space Between MVs and NMVs

The capacity of different types of rights-of-way to move people at different speeds has been the subject of some debate in recent years. Different analysts have calculated different relative efficiencies in road space utilization or person-throughput for transportation facilities. Global theoretical analysis has sometimes been misused to castigate entire modes of transport as inefficient and worthy of being suppressed, not recognizing the complementary function of different transport modes. Proper analysis of transport modal efficiency must differentiate based on trip length, cost, and function.

For a given amount of road or corridor space, the most efficient modes of transportation are generally rail or bus modes operating on their own dedicated rights-of-way. The least efficient use of road space is low occupancy automobiles. Bicycles fall in between this range, as Table 4 shows, with road space utilization approaching that of buses in mixed traffic. Motorcycles, scooters, and other two-wheeled motorized vehicles may be somewhere in between automobiles in bicycles in their road space utilization, but further research is needed to identify empirical studies of this. All of these estimates of road space utilization are subject to a great deal of variation in the real world, depending on vehicle occupancy, level of traffic congestion and traffic mix, topography, frequency of public transport stops and other details of public transport operations, quality of track or road surface, and other factors. Further research should be undertaken in different cities to develop better models of facility capacity under different modal mixes and conditions. Research is also needed to identify the capacity of two-wheel motor vehicles, such as motorcycles, scooters, and motorbikes when they compose a significant share of traffic flows. Broader economic analysis of the total cost of street space per traveler for different trip lengths by different modes, at different speeds and traffic levels would be most useful. This could contribute to development of long-term cost-benefit analysis of different modes for different travel markets.

The function of modes and distribution of trip lengths that must be accommodated within travel corridors is an important consideration in evaluating how scarce road space should be most efficiently allocated. If a large share of traffic is of short to moderate trip length, rail modes are not likely to be cost-effective or practical to accommodate these trips. If a large share of traffic is of long trip length, bicycles and walking are not likely to be the most efficient or practical modes. If resources are unavailable to provide bus transportation sufficient to meet demand, bicycles may be more efficient than an overburdened public transport system, even for longer trips.

In most travel corridors travel demand is in fact composed of a spectrum of trip lengths, some short, some long. Thus, it is uncommon for a single mode of transport to be the most efficient for a corridor. Rather, a combination of modes need to be accommodated in a complementary fashion to meet the needs of diverse travel markets, recognizing limitations on road space, affordability of transport modes in the community, and the required speed and distance of trips made in the corridor. Where road space is most scarce, traffic management should be the first step in dealing with traffic congestion problems. This can include turn restrictions at intersections, introduction of one-way street systems, improved traffic signalization, and management of encroachments on transportation rights-of-way. These steps can all affect the relative efficiency of different modes in using road space.

The segregation of different modes of transportation can result in far greater system efficiency. This has been demonstrated in numerous cities where dedicated busways have separated bus traffic from motor vehicles or non-motorized vehicles to achieve better public transport speed, reliability, and capacity. If street space is insufficient to accommodate demand even with separation, it is often useful to dedicate different streets to different modes and to impose or expand restrictions or costs for private automobiles, the most inefficient mode. This is especially the case where private automobiles are used by only a small share of travelers in the corridor. Such measures could be complementary to road pricing, another effective but little used method of allocating scarce street space.

Even in cities where streets are generally quite congested, it is often possible to find underutilized street space. For example, an ongoing World Bank project in Shanghai has identified opportunities to use alleys to provide right-of-way for a dedicated bicycle network, relieving some pressure from main roads and intersections. Similar opportunities exist in other cities, such as Bangkok. Where space cannot be found, NMVs and public transport should be favored in allocating street space.

The design of transportation facilities can significantly affect traffic safety. Segregation of slow from fast traffic, careful design of intersections to maintain good sight distances, to reduce turning conflicts, and to channelize traffic to enhance predictability of flows can all reduce safety problems while improving operational performance. Poorly designed and improperly maintained separate cycle facilities can lead to an increase in safety problems, particularly if there are many intersections or driveways crossing the cycle paths and sight distances are poor. This is a problem that afflicted many bicycle paths created in the U.S. in the 1970s and led to opposition from some U.S. cyclists to creation of additional bicycle paths.

Traffic discipline is often rather lax in Asian cities for both NMVs and motor vehicles. Congested conditions, extensive encroachments of non-transportation activities into rights of way, bus stops and rickshaw stands that are not provided space out of the primary right-of-way, and other unsuitable facility designs often exacerbate this problem. Provision of off-street locations for such activities can enhance transport system efficiency.

In some countries, design standards from highly motorized countries have been used with insufficient tailoring to local traffic conditions and economic realities. This has often led to unsafe designs that have not taken advantage of opportunities to create greater separation of slow NMV traffic from fast heavy vehicle traffic, contributing to safety problems. Further research is needed on appropriate design standards for different types of traffic mixes under various conditions and right-of-way opportunities.

Integration of Bicycles with Public Transportation

Bicycles are not a substitute for public transport. Instead, these are complementary and partially overlapping modes of transport. Each has unique strengths and weaknesses. In combination, they offer a strong potential competitor to private motorized transport for many types of trips. To reduce long-distance bicycle commuting and free up congested road space, the Chinese have been establishing bicycle-subway and bicycle-bus exchange hubs, which have been very popular in Beijing and other cities.[20] Bicycle access to railways is also important in India, where hundreds or thousands of bicycles can be seen parked at some stations.

Bicycle access expands the potential market area of high-speed public transport services at low cost. This is one of the most valuable potential functions of NMVs in megacities, where average trips lengths are long. Integration of bicycles with public transport is also an important strategy for sustaining non-motorized and public transport mode shares in rapidly motorizing cities with mixed traffic systems, for reintegrating NMVs into motor vehicle dependent cities, and for dealing with network capacity saturation in NMV dependent cities.

In Western Europe and Japan today, the fastest growing and predominant access mode to suburban railways is the bicycle, accounting for one-fourth to one-half of access trips to stations.[21] Adequate supporting infrastructure, including secure parking at station entrances and safe access routes, is essential to this intermodal integration. Between 1975 and 1981, the number of bicycles parked at Japanese rail stations quadrupled to 1.25 million. By the end of the 1980s, more than two million bicycles were used daily to access suburban railway stations in Japan. Use is heaviest in the lower density suburban fringe areas of large cities, where 15 to 45 percent of rail station access is by bicycle. Japanese and European transportation policy and investment has encouraged bike-and-ride system development. In Japan, more than 730,000 new bicycle parking spaces were built at rail stations between 1978 and 1981, supported by national subsidies available to both public and private sector parking developers. By 1981, there were 636 garages at Japanese rail stations accommodating more than 500 bicycles, with 5,456 other station parking garages of lower capacity. An increasing number of these facilities are computerized or automated multi-story structures providing very high density parking.[22]

Bike-and-ride strategies offer opportunities for increased public transport system efficiency when factored into public transport network and operations design. With expanded station catchment areas, inter-station spacing can be greater, creating higher line-haul public transport speeds and efficiency in equipment utilization, with a level of service comparable to that obtained with denser station spacing relying on pedestrian access.

In the long-run, increased inter-station and inter-line spacing may permit public transport networks to concentrate more frequent service on fewer lines for the same size vehicle fleet, reducing average waiting time for public transport services and increasing efficiency in use of rights-of-way. This is particularly important in megacities where average trip lengths are long and resources for express public transport service provision are insufficient to meet demand. By reducing average point-to-point travel time throughout metropolitan areas, bike-and-ride systems can improve the competitiveness of public transport with private motorized transport. This influences mode choice and, at least in some cases, may influence individual decisions regarding acquisition of motor vehicles. Thus, bike-and-ride systems can be important as an element in transportation system management and efforts to manage the evolution of metropolitan modal mix and pace of motorization, especially in large cities. In cities where public transport services are inadequate to meet demand, it may be productive to shift some less efficient short distance public transport trips to NMVs, allowing concentration of public transport resources on longer trips, with bike-and-ride access systems expanding market catchment areas.

Regulations and Policies Influencing NMVs Use

Regulations and policies, including taxes and import duties, fuel taxes, vehicle registration and licensing fees, and credit financing systems for vehicle purchase, all have a major influence on the cost and availability of various transport modes. Frequently in Asia and other parts of the world, regulations and policies have been used to discourage or suppress the use of NMVs, especially cycle-rickshaws, while fostering motorization of transport.

In some Asian countries, import duties are structured to favor motorized transport. In Bangladesh, for example, the trend over the past two decades has been towards encouraging motorized public transport, discouraging imports of bicycles and their components to protect local bicycle manufacturers, and offering concessions to affluent private motor vehicle buyers. In 1989, Bangladesh taxed imported bicycles and most bicycle components at 150 percent, while buses, mini-buses, and trucks were taxed only 20 percent, baby-taxis at 5 percent, small-engine automobiles (850 cc or less) at 50 percent, jeeps and station wagons at 30 percent, and motorcycles at 20 percent. Import duties on bicycles and bicycle parts are greater than those on motorcycles and their components, with taxes as high as 170 percent for imported bicycle tires. While such taxes are intended to protect domestic bicycle producers, two-thirds of bicycle components needed in Bangladesh must be imported, raising significantly the costs of bicycle and cycle-rickshaw ownership and operation. Smuggling of bicycles and their components from India is widespread, but this alleviates only part of the regulatory cost burden on end users.[23] Such stiff protectionist policies aimed at aiding domestic NMV producers impose a high cost on cyclists and cycle-rickshaw users while often failing to create viable industries. When combined with low taxes on motor vehicle imports, such policies foster economically inefficient choices.

Vehicle licensing is commonly used to raise revenue, to ensure vehicle safety, and to regulate vehicle use. In many cities, however, it has been used to try to suppress cycle-rickshaws and other informal sector public transport services, such as jeepnies, jitneys, motorized auto-rickshaws, and pirate taxis. In Karachi, cycle-rickshaws were banned in 1960 and replaced by auto-rickshaws, which in turn were subjected to restrictions on new registrations from 1986 onwards. In Manila, the motorized tricycles which replaced cycle rickshaws in the 1950s were later banned from main roads, and now operate mostly on smaller roads as feeder services. [24] Only in Singapore have restrictions been placed on private motor vehicle registrations, beginning in 1990, although such vehicles are the least efficient users of road space in Asian cities.

In a number of cities in India, Indonesia, and Bangladesh, restrictions have been placed on the number of cycle-rickshaw registrations that will be permitted, often freezing registrations at a fixed level for many years. Restrictions on licenses create a lucrative black market in duplicate or falsified licenses. It also makes cycle-rickshaw drivers and owners vulnerable to extortion and abuse from local police, who can threaten to seize their vehicle, causing at a minimum, loss of a full day's pay and at worst, loss of livelihood. Indeed, Jakarta authorities have seized some 100,000 cycle-rickshaws in the past five years, dumping at least 35,000 into Jakarta Bay, as they seek the complete elimination of these vehicles from the city. Thousands more cycle-rickshaws have been seized and destroyed in Delhi in the late 1980s.

Wherever rickshaws are licensed in Bangladesh, cycle-rickshaw pullers must also hold driver's licenses, under laws that date back to the 1920s. However, in many cities as few as 15 percent of all pullers are actually licensed. Although the licensing fees are usually minimal -- on the order of one-tenth of a day's income -- it typically takes ten or more times this amount to secure a license, as a number of signatures are required.[25]

A key objective of urban transportation system development and management should be the preservation of modal diversity, so that travelers can choose among multiple competing travel modes to select the one that offers the highest efficiency of resource utilization and acceptable speed and comfort within a limited budget. When modal diversity decreases, people are often left with no choice but to use an inefficient travel mode or to give up traveling all together. Market forces can work in transportation mode choice only when multiple choices are available and given a level playing field on which to compete. This sometimes requires protecting weaker but desirable modes of non-motorized transport from stronger but less efficient motorized transport mode, just as economic regulation is sometimes needed to ensure competition and prevent the emergence of monopoly or oligopoly in other markets. However, rather than protecting NMVs, some governments in Asia have put into place policies to suppress NMV use, particularly cycle-rickshaws.

Many cities have imposed constraints on non-motorized modes of travel, particularly cycle rickshaws, claiming these cause congestion or unfairly exploit human labor, or that they represent backwardness. In Kuala Lampur, Malaysia, and Jakarta, Indonesia, cycle-rickshaws have been mostly displaced by such measures. The suppression of cycle-rickshaws is comparable to the removal of slums and squatter settlements. Just as slum clearances destroy real housing resources for the poor, cycle-rickshaw bans eliminate real transportation resources for the poor, hurting hundreds of thousands of people who frequently lack the political power to defend their mobility systems and jobs.

Chinese transport policies were, until recently, quite different from this pattern. In the 1950s, China began offering employee commuter subsidies for those bicycling to work, accelerated bicycle production, and allocated extensive urban street space to bicycle traffic. Today, 50 to 80 percent of urban trips in China are by bicycle, while providing travel speeds comparable to those of many other more motorized Asian cities, with much more favorable consequences on the environment and petroleum dependency.

Many planners in Chinese cities have been discussing problems caused by widespread violation of traffic regulations by cyclists. Very heavy bicycle traffic flows frequently lead to overflow of cycle traffic into motorized traffic lanes and violation of traffic signals. Many Chinese planners call for public education about traffic regulations. In many Chinese cities, workers have recently been organized to help the police enforce traffic order. The Chinese government stopped collecting a use tax for bicycles in 1980. Some Chinese planners suggest a restoration of such fees to slow further growth of bicycle ownership.

Most Chinese transport experts agree tend to agree that different policies need to be pursued in cities of different sizes. In large cities with severe bicycle traffic congestion, bus, subway, and rail public transport should be better developed to attract long-distance cyclists, reducing mean bicycle trip lengths. Many think that costs of bicycle use should increase to moderate further bicycle fleet growth.[26] The retention of motorcycle registration limits in major cities should be continued to avoid worsening traffic congestion and severe traffic safety problems. Despite recent policy changes, the bicycle will continue to play a predominate role in Chinese cities for some time, although continuation of bicycle bans and motor traffic growth will diminish its role. Improved traffic management and public transport provision should seek to insure a continued heavy use of bicycles as an affordable and sustainable mode. Strategies for transport system modernization without total motorization will offer the best prospects for sustainable development.

Land Use, Investment Patterns and NMVs

The characteristics of NMVs cannot be well understood without discussing their interaction with land use and motorized transport modes, as well as the diverse nature of urban trip-making. More than all other modes, the utility of walking and cycling are dependent on the micro-scale character of neighborhoods and the built environment, which is strongly influenced by investment patterns. Urban transport and land use interact as a complex and self-regulating system, much like ecological or biological systems. The available resources, vehicles, networks, rules of operation, and cost structures can be influenced by policy makers. Individual travelers make their choices within the constraints provided, based on their own habits. Land uses, once set into place, act like a genetic code for the future evolution of the city and its mobility system. Changes come slowly once patterns are set in place. The pattern of buildings and transport infrastructure in a neighborhood tells people how to travel, within certain broad choice parameters.

Urban form has a major influence on mode choice but also responds to the predominant transport mode in use when a city neighborhood is under development. Cities most dependent on a diverse mix of walking, cycling, and public transport tend to be compact in form and become multi-nucleated as they expand in size, with heterogeneous land use at a small scale, mixing residential, retail, and often some production functions. Where public transport is predominant over non-motorized modes, average trip lengths and transport costs are higher. In contrast, cities highly dependent on the automobile generally sprawl at low densities, with long average trip lengths, spatial separation of different land uses from each other, and little diversity of mode choices.

The trip length distribution of a city, set by the current land use and general costs of transport, determines to a large extent the opportunity for interchangability of motorized and non-motorized trips. For person trips with small loads, walking is typically the most efficient mode for short trips of up to one kilometer. Cycling is usually the most efficient mode for trips of half a kilometer to several kilometers. The maximum efficient range of walking and cycling for individuals depends on income. Cost sensitive low income people commonly prefer to walk or cycle much longer distances to avoid the expense of public transport fares.

Especially as cities grow larger, the need to make longer trips usually grows. Since walking and cycling are too slow to be efficient for longer trips, motorized transport become the optimal mode choice. For trips longer than several kilometers, aggregate point-to-point corridor travel demand is a key determinate of which motorized mode may be more efficient. If demand is very high, rail or dedicated busway services are usually most efficient, but must often compete with less efficient automobiles and motorcycles. If travel demand is relatively low or if origins and destinations are highly dispersed, automobiles, motorcycles, or paratransit are the most efficient modes. Between these extremes, buses provide the greatest energy efficiency, but this is often reduced when the buses are caught in traffic congestion.

Motorized transport efficiency varies widely, depending on many factors. Reallocation of street space and the creation of new reserved rights-of-way for public transport, pedal-powered transport, and pedestrians can lead to significant increases in public transport speed, reliability, and productivity, and increased use of all of these modes. Traffic calming strategies becoming widespread in Europe and Japan are means of enhancing alternatives to private motorized transport while accommodating automobile traffic. Clustering new growth at higher density with mixed uses within walking distance of public transport can lead to high levels of mobility with high energy efficiency and minimized dependence on motorized transport.

NMV potential is greatest where there are large existing bicycle fleets, safe places for them to operate, secure places for NMV parking at destinations, and where land use patterns do not require long travel distances to meet daily needs. NMV potential is limited where motorized vehicles fill the streets, leaving few safe places for cyclists, where the security of parked vehicles is poor, and where average trip lengths are long. However, even under such unfavorable circumstances, there are opportunities for expanding NMV use for short trips through better traffic management.

Preserving modal diversity so that people have the freedom to choose the most efficient and appropriate mode of transport for a particular need should be one of the central goals of transport system management and transport investment policy. Unless transport policies, investment patterns, and decisions about the allocation of street space recognize the vital role of non-motorized transport, the modal diversity now enjoyed by Asian cities will decline, resulting in much higher transport system economic and environmental costs. In low income Asian cities, resource allocation should be reexamined. There may be benefits in shifting some investment from expensive motorized transportation infrastructure and heavily subsidized public transportation to instead provide subsidies or credit to low income workers to expand access to NMVs.

Evaluation of transport investments solely on the basis of cost-benefit analysis fails to account for broader objectives of transport system management. For example, an assessment that considers that the time savings of car occupants are a benefit is quite inappropriate where there is a policy of containing or reducing the volume of car traffic.[27] Evaluation methods that consider the potential of projects to meet several key multiple objectives may offer more promise for the development of efficient multi-modal transport systems.

Conditions Under Which NMVs Should Be Encouraged

Non-motorized modes are the most efficient means of mobility over short distances in cities, while motorized modes offer greater efficiency for longer trips. The distance at which motorized modes become more efficient than non-motorized modes for consumers depends on income levels, the value of time, and the price and speed of various transport modes. For societies as a whole, it depends as well on how environmental costs, social costs, and other externalities related to transport are assessed. Determination of the most efficient modal mix for a city also requires consideration of constraints on street space, patterns of land use, existing investments in transport vehicles and infrastructure, and funds available for new investment and transport operations. It should also take into account current and anticipated problems in the overall transportation and land use system, such as traffic congestion, air pollution, economic impacts of growing petroleum use, access of housing to employment, motorization trends, and goals for poverty alleviation. Given the wide variation in these factors, urban non-motorized transport strategies must be tailored for different types of cities. The integration of urban development and transport planning and policy is vital to expanding opportunities for NMT use.

Bicycles should be encouraged as the most efficient transport mode for short trips in cities of all types and income levels, particularly for trips too long for walking and too short for express public transport services, particularly where travel demand density or economics do not permit high frequency public transport services. Bicycles are most important for personal transport, but also accommodate light goods hauling, being capable of carrying loads of 100 to 180 kg. Bicycles should be considered as an integral part of urban transport planning and management for cities across the world, just like public transport, private motorized transport, and walking. In smaller cities, bicycles should have a primary role on their own for work, shopping, and other travel. In larger cities, where trips lengths are longer, bicycles should be seen as most important in providing access to efficient public transport services for work trips and in serving some short distance shopping and other trips. The integration of bicycles with public transport can facilitate efficient polycentric metropolitan development patterns. By linking multiple urban centers together by public transport on its own right-of-way and expanding the service areas of public transport stations with bicycle access, such strategies can favor the evolution of megacities into more manageable constellations of small cities.

The primary market for efficient bicycle use is generally from six or eight hundred meters to distances of five to seven kilometers. The utility of bicycles is reduced, but not entirely eliminated, in cities with many hills or steep topography, where they may still serve a role, especially following waterways. Bicycles should be encouraged as a key element in access and egress to and from public transport, particularly for intrametropolitan express services in large cities of all types. The catchment area for convenient and efficient access to rail or bus stops and stations can be enlarged by a factor of 20 to 40 times by encouraging bicycle-based access systems. Bike-and-ride strategies offer an important means for improving public transport system efficiency, performance, and use. In large, low income cities where public transport services are insufficient to meet demand, and in low income areas of more affluent cities, bicycle use should be encouraged as the most efficient mode for trips of up to 10 kilometers or more, at least until public transport service provision can catch up with demand. The diversion of some public transport travelers making trips shorter than several kilometers from buses to bicycles can permit a larger portion of public transport vehicles to be concentrated on longer distance, limited stop, express services, where they can operate at higher efficiency. In non-motor vehicle (NMV) dependent cities where public transport is insufficient to meet demand, where street space is saturated, and where a large number of cyclists ride distances over 10 or 15 kilometers, such as in some Chinese cities, express limited stop public transport services should be upgraded and long distance cyclists should be encouraged to use bike-and-ride. The diversion of such cyclists to public transport should not be achieved through suppression of bicycle use or constriction of street space for NMVs, but rather through improvement of public transport to provide more competitive travel time. When scarce street space in cities is allocated to different modes, less efficient private automobiles should be restricted rather than bicycle traffic in setting aside added space for high efficiency public transport and pedestrians.

In cities of all types, sizes, and income levels, bicycles should be encouraged as a means of reducing air and noise pollution, petroleum use, global warming, and traffic congestion, and as an important means of increasing the mobility of low income people. By meeting a larger share of urban mobility needs using low-cost bicycle transportation, cities can reduce total transport system costs or free up resources for other unmet needs.

Cycle-rickshaws are not as efficient as bicycles for personal transport, but should be encouraged as a complementary mode to motorized goods transport and as a passenger paratransit mode, particularly in countries where wages are low and there is substantial surplus labor. These vehicles are a major source of jobs and in some Asian cities they account for over 10 percent of total employment. They provide many useful services to urban residents that cannot always be readily replaced by motorized modes, acting as a non-motorized taxi, school bus, ambulance, delivery service, and small freight hauler in some cities. Cycle-rickshaws are quiet, non-polluting, use no petroleum, and can traverse very narrow streets. Improvements should be encouraged in vehicle design and patterns of vehicle ownership and operation, however, to improve safety, vehicle performance, the quality of working conditions for cycle-rickshaw drivers. Where they are in use, they should be accepted as a useful part of the transportation system that fills market-expressed needs, rather than as a nuisance or a barrier to transport system modernization. They are a thoroughly twentieth century, efficient, and sustainable mode of transport, used even today in aerospace factories in North America. Even in high income motor-vehicle dependent cities, there are opportunities for appropriate use of cycle-rickshaws for short distance person and goods movement and as the basis for microenterprises providing goods and services at dispersed locations. There, they will find greatest utility where slow modes are allocated right-of-way separate from motorized traffic, in dense pedestrian-oriented neighborhoods or central areas with slow traffic speeds, in large factories and shopping districts, and areas where private motor vehicles are restricted.

Cycle-rickshaws should be separated from motorized traffic when possible, except in areas where traffic speeds or motor vehicle volumes will remain low. On higher speed roads, the speed differential and combined vehicle width of motor vehicles and cycle-rickshaws can produce unsafe conditions. Where traffic congestion is most serious in cities and there are large volumes of cycle-rickshaws, it may make sense to enhance bicycle or bus modes to gain greater efficiency in street space utilization. However, the wholesale banning of cycle-rickshaws from large areas of cities where they fill market needs is inadvisable on economic, environmental, and social grounds.

Key Barriers to NMVs

The key barriers to NMV use include affordability of vehicles, NMV-hostile street environments, vehicle theft, negative social and government attitudes to NMVs, and excessive and inappropriate regulation of NMVs. Overcoming these barriers may require changes in transport investment patterns, infrastructure design standards, street space allocation, credit and financing systems, regulatory policy, public education, and marketing, depending on local circumstances. Such changes should be part of much larger efforts to manage the modal mix of cities to favor greater efficiency of resource utilization in the transport sector while enhancing accessibility. However, few institutional structures focus on non-motorized transport and little data is collected on its attributes or problems. Many national and local transport planning organizations are indifferent or hostile to non-motorized transport and focus solely on motorized transport issues. Training and institutional reform is needed to address these problems.

Many of these factors can be changed only over the course of a number of years and some are difficult to control. However, actions by multi-lateral and bi-lateral development finance organizations, governments at various levels, and non-governmental organizations can influence the direction and nature of change in many of these factors. Such actions should be accomplished through development and implementation of a Non-Motorized Transport Strategy (NMTS) by such organizations and by individual countries and cities in Asia and elsewhere.

Formulation of a Non-Motorized Transport Strategy (NMTS)

A NMTS, whether for a city, a country, a region, or for an international development agency working in various contexts, should be developed to establish and support the appropriate use of NMVs to maximize transport system efficiency, equity, and environmental quality. While some elements described below are undertaken in transport sector and project appraisal studies today, many aspects related to NMVs are often neglected.

A NMTS should identify the extent, pattern, and current trends related to non-motorized transport availability and use, including variations based on income, cost, trip length, and other factors. It should assess the overall pattern of travel demand for different modes of transport for low, moderate, and high income groups to identify particular trip lengths where modal options are limited to inefficient transportation choices. A key focus should be on road safety problems, particularly those facing pedestrians and bicyclists. Road safety improvements offer a potential for widespread social and economic benefits in terms popular with all classes of society.

An urban NMTS should identify key traffic congestion locations and gather data on the composition and attributes of traffic flows, their trip length distribution and pattern, and the extent of encroachment on the transportation right-of-way by non-transportation activities and uses. This information should be used to identify opportunities for improved traffic management in congested locations, including separation or channelization of different modes within the right-of-way or on parallel routes to separate slow and fast traffic, improvement of intersection design and operation to reduce turning movement conflicts and delays, using turn prohibitions, one-way systems, grade separations, traffic signalization, and grade separated under and over passes, where appropriate. It should consider restriction of private motor vehicle traffic in congested areas by limiting peak hour entry or by creating automobile restricted areas, streets, or traffic cells, which discourage short trips by private motor vehicles. It should consider pricing changes for public and private transport to influence travel demand. Where poor traffic discipline or encroachments are problems, stepped up enforcement, public education, and advertising campaigns and the provision of low cost off-street market areas should be considered.

An urban NMTS should identify and evaluate opportunities for shifting longer distance trips made by private motorized and non-motorized vehicles to bike-and-ride systems, with express public transport operating on reserved rights-of-way. It should identify strategies for reducing average trip length in the long run through changes in land use patterns and the distribution of housing, markets and shops, and employment both in relationship to each other and the public transport system. It should identify appropriate networks for NMV use to strengthen their utility for short to moderate length trips within cities and evaluate the appropriateness of shifting long walk trips and short public transport trips to NMVs.

Barriers to the NMV manufacture and ownership and strategies for overcoming these should be identified as part of NMTS work. These may include NMV-related trade barriers, local NMV industry structure and performance, affordability of NMVs to the population, credit systems for NMV purchase, and licensing and registration requirements. Regulatory policies inhibiting NMV use should be identified along with strategies for influencing them, including changes in traffic regulations, parking policies, and licensing requirements.

Research Needs

There is great need for more research, education, training, and institutional development related to non-motorized transportation in Asia and elsewhere. Relatively little research has been conducted on non-motorized transport modes in Asia and elsewhere. A high priority should be placed on data collection, research, demonstration and development related to non-motorized transport, especially in Asia.

Key areas for future research include --

(1) Collection and analysis of data on the extent of NMV ownership and use, including variation based on income and other factors, in cities and countries throughout Asia and the world. This should include analysis of the employment multiplier effects of transport investments in different sectors of the motorized and non-motorized transport industries in different countries and collection and analysis of more complete information about NMV manufacturing and trade flows in Asia and elsewhere.

(2) Research and analysis on the role of NMVs in the informal and formal economy, especially in mixed traffic and NMV dependent cities of Asia, including attention to NMV assembly and repair workshops, goods hauling services, mobile retail services, courier services, and secure bicycle parking services.

(3) Identification of opportunities and strategies for fostering development of small scale credit systems, such as the Grameen Bank in Bangladesh, to aid NMV-dependent informal sector enterprises.

(4) Analysis of the impact of growing petroleum use and motorization on foreign exchange requirements, debt accumulation and servicing, investment and savings, income distribution, and accessibility in various countries,

(5) Research and demonstration of appropriate facility designs and strategies to improve non-motorized transport safety in countries undergoing rapid motorization. This should include research and demonstration of strategies for traffic calming and traffic safety in cities with high motorcycle traffic flows, methods for managing mixed NMV/motorcycle traffic, and appropriate traffic management and design strategies for managing very high volume bicycle traffic flows within constrained street space.

(6) Technology transfer efforts that could transfer low-cost human-powered transportation technologies from Asian countries where they are successful to those in need of low-cost mobility, especially to oil-importing African and Latin American countries.

(7) Analysis of the impacts of motorization in Asia and elsewhere on CO2 and other greenhouse gas emissions and the extent to which NMV encouragement might reduce growth of transport-related contributions to global climate change and air pollution.

Conclusions

The transportation systems of many Asian cities are at a crossroads. If they continue on their present path of rapid and uncontrolled motorization, they may face very high long-term economic and environmental costs with diminishing benefits. If they instead follow the models of China, Japan, and the Netherlands, they may be able to stabilize or increase the appropriate use of non-motorized vehicles with large positive long-term economic and environmental consequences.

NMVs offer no panacea to growing problems of traffic congestion, air pollution, energy use, global warming, and regional economic development, but they should be seen as a potentially important element in addressing these problems. As we enter the 21st century, instead of declining, NMVs may play a growing role in urban transport systems world-wide.

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