Moving Toward Integrated Transport Planning: Energy, Environment, and Mobility in Four Asian Cities

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Around the world today, cities face serious problems of congestion, air pollution, and energy consumption that are directly related to transport system growth. To meet growing transport needs, cities require new solutions that will allow them to simultaneously develop economically and minimize the negative effects of transport system growth. The experiences of four very different Asian cities—Bangkok, Thailand; Surabaya, Indonesia; Islamabad, Pakistan; and Varanasi, India—demonstrate the clear need for a new planning approach that allows consideration of all available options. This new approach—integrated transport planning—emphasizes as the primary goal accessibility for citizens rather than mobility for individual vehicles. The integrated approach considers environmental, social, and energy use costs of transport systems to be inherent to the planning process and values projects that provide multiple positive benefits and complement a city's urban development goals. Finally, the integrated approach seeks to develop long-term, proactive solutions that make the best use of scarce investment dollars. The worldwide use of the integrated transport planning approach will lead to a network of efficient, economically viable, environmentally sustainable cities.

A complex web of interrelated human needs and activities makes up an urban area. To ensure the efficient commerce of goods and services, the fulfillment of residents' needs, and sustained long-term economic growth, urban areas require an efficient transportation system. To endure over time, such a system must therefore be sustainable—meeting the basic transportation needs of all citizens without depleting the economic and natural resource base. A well-developed transport system promotes economic growth by allowing efficient commerce, attracting new business activity, and providing access to fulfill residents' daily requirements. Indeed, like any other urban public service—sewage, clean water, electricity—expansion of transport services must accompany development to ensure healthy growth.

Today the transportation systems of many cities are not accomplishing their basic tasks; instead they inefficiently clog space, pollute air, consume large quantities of petroleum products, inadequately provide for residents, require large portions of financial resources for operation and maintenance, and hamper economic growth. Traditionally, most cities and lending agencies have responded to transport shortfalls and inefficiency by expanding the road network. Although the development of road networks is important, roads are only one part of the entire transport system. Focusing only on a single system component rather than the system as a whole leads to piecemeal solutions, and system growth easily overwhelms individual component progress. Such approaches—relying on a nonrenewable natural resource base, polluting the environment, devouring financial resources, and inadequately servicing all residents' needs—have led many cities to their present congested state.

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LINKS BETWEEN TRANSPORTATION, CONGESTION, OIL USE PROBLEMS, AND ENVIRONMENTAL DEGRADATION

Historically, motorization and its accompanying congestion, oil dependency, and air pollution have plagued the cities of the industrialized world. Today, however, motor vehicles and the adverse effects of their intensive use have spread worldwide.

Motor Vehicle Fleet Growth

Much of the future growth in motorization will occur outside the industrialized world. Motor vehicle growth rates in many of the developing and newly industrialized countries of Asia, Africa, and Latin America far outpaced those of the Organization for Economic Cooperation and Development (OECD) countries (which include the United States, Canada, most European countries, and Japan) during the 1980s. Between 1988 and 1995, the motor vehicle fleet in the Asia-Pacific region (excluding Japan) is projected to grow 96 percent, compared with a projected 12 percent growth in Western Europe during the same period (*1*). If present trends continue, the global motor vehicle fleet will double in the next 20 to 30 years (*2*).

Economic Strain of Petroleum Consumption Growth

Increased motor vehicle use comes at an economic cost, particularly because of the consumption of petroleum necessary to fuel fleets. Rising transportation petroleum consumption—already accounting for over half of petroleum consumption in most developing countries (*3*)—requires depletion of foreign capital reserves to import oil. Many of these countries already spend as much as 15 percent of their export earnings on oil and some actually spend over 50 percent of export earnings (*4*).

Furthermore, rising oil consumption in one country implies rising global oil demand—and prices—felt in all countries, jeopardizing the stability of the global economic climate. History shows the economic and social ramifications of overdependence on oil—seen during the Arab oil embargo of 1973, the Iranian revolution of 1979, and the 1990 Persian Gulf crisis.

Effects of Congestion

The rising worldwide demand for oil is aggravated by traffic congestion, which squanders millions of barrels of oil annually. For example, in Bangkok (Thailand), an estimated U.S. $1.4 million worth of fuel is wasted every day by vehicles idling in traffic. In addition, a study by the engineering office of the Bangkok Metropolitan Administration estimates that had the person-hours lost from the average 44 working days spent in traffic each year been put to productive use, Thailand's gross domestic product would have grown another 10 percent (*5*).

Environmental and Social Impacts of Transport

Congestion also intensifies motor vehicle emissions, contributing to rapidly deteriorating air quality. In some cities—including Mexico City (Mexico), São Paulo (Brazil), Manila (the Philippines), and Kuala Lumpur (Malaysia)—between 70 percent and 86 percent of total airborne pollutants can be attributed to road transport (*6*,p.196). Transport vehicles burning fossil fuels emit lead, hydrocarbons (HC), nitrogen oxides (NO_x), carbon monoxide, sulfur oxides, and suspended particulate matter—all health hazards. The combination of HC and NO_x in the presence of sunlight forms ozone, a key ingredient of urban smog and a danger to health and local vegetation. The noise from intense traffic leads to hearing loss and the stress of dealing with traffic is linked to many psychological disorders.

Other negative effects of congestion and related pollution include loss of potential investors who stay away to avoid the inefficiency—as is occurring in Bangkok, Thailand, and San Francisco, California, and harm to the tourism industry, which many countries rely on for foreign exchange earnings.

Motor vehicle emissions also threaten the global ecosystem by emitting greenhouse gases, implicated in potential global warming. Worldwide, the transport sector accounts for 14 percent of the world's carbon dioxide (CO_2) emissions—the most significant greenhouse gas (*7*).

EXPERIENCES IN FOUR ASIAN CITIES

To minimize the negative impacts of traditional transportation development, developing countries require new solutions that enable them to meet transport needs within energy, environmental, and economic constraints simultaneously. To address this need, in November 1990 the International Institute for Energy Conservation (IIEC) initiated a project entitled "Assessment of Transportation Growth in Asia and Its Effects on Energy Use, the Environment, and Traffic Congestion." The goal of the assessment was to identify options for cities of various levels of infrastructure development that would enable them to meet transport needs while minimizing environmental degradation, oil consumption, and traffic congestion.

Four cities were selected as case study sites for the assessment. The four cities—Bangkok, Thailand; Surabaya, Indonesia; Varanasi, India; and Islamabad, Pakistan—were selected because each represents a different level of infrastructure development. Bangkok typifies those cities that have highly developed road transport systems and are experiencing crises in their transportation sectors with regard to energy use, pollution, and congestion. Surabaya typifies those urban regions that are growing rapidly in transport infrastructure; although they have not yet reached the pollution and congestion levels of a city such as Bangkok, they are proceeding rapidly along this path. Varanasi is representative of smaller cities whose transport sectors are still dominated by traditional, nonmotorized transport modes but are expected to increasingly use motorized modes in the future. Because these cities are in their transportation infrastructure infancy, implementation of long-term planning strategies can help them avoid the transport-related problems now suffered by highly motorized cities. Finally, Islamabad—a small city whose development has been carefully planned and managed—provides a comparison between its careful development planning and the unmanaged growth of the other cities.

City Descriptions

Information about each city is drawn from case studies published by IIEC (*8–11*), Washington, D.C. Each of the four cities represents distinctly different phases of demographic, economic, cultural, and historical development. Bangkok, the capital of Thailand, was founded 200 years ago and has grown into one of the world's major metropolitan areas, serving as the economic, administrative, and spiritual hub of a rapidly growing country. It is home to about 8.5 million people—14 percent of the country's population—and accounts for almost half of the nation's annual economic growth. Surabaya, the capital of Indonesia's East Java Province, has historical roots tracing back to at least the 13th century and traditionally has served as a bustling trading port. It has a population of about 2.5 million and continues to thrive as an important regional and international port, an administrative center, and a focus of industry and education. In contrast, Islamabad, the capital of Pakistan, is only 30 years old and represents just 0.5 percent of the nation's population—about 600,000 people. Islamabad plays a relatively small role in the domestic economy and serves primarily administrative, diplomatic, cultural, and religious purposes. Varanasi, with historical roots leading back at least 3,000 years, is a revered spiritual center for Hindus and Buddhists, home to some of India's most important temples and mosques, and a center of higher education and art. Varanasi has just over 1 million inhabitants.

Just as the four cities contrast greatly in historical development and in their respective roles in regional and national activity, they also differ in their transportation systems and levels of urban infrastructure development.

Bangkok

In Bangkok private motor vehicles such as cars, pickup trucks, and motorcycles account for the majority of daily motorized trips taken by residents. Bangkok's transport system is severely congested for up to 16 hr/day, and the city suffers tremendous air and noise pollution, oil wastage, and economic problems as a result. Significant contributors to Bangkok's reliance on private motorized transport include its sprawling urban development, infrastructure investment emphasis on large road-building projects, and congestion-constrained public bus system.

Because its transportation-related problems are so great, Bangkok requires short-term solutions to stem the current crisis and

long-term solutions that prevent such a critical situation from occurring in the future. Such solutions run the gamut of transportation options, such as improvements in fuel quality, vehicle technology, maintenance, and driver handling improvements; mass transit options; traffic management; measures that decrease the need and desire to operate vehicles; and long-range land-use planning. Because Bangkok is central to the Thai economy, policies created in Bangkok for such items as individual vehicle emissions or fuel economy will set a positive standard for the country as a whole.

Surabaya

Surabaya provides a major economic growth center for Indonesia's East Java province and is experiencing the initial stages of problems resulting from rapid transportation system growth. Although its congestion problems are nowhere near the crisis levels of Bangkok's, its problems will become much more acute within the next decade if present trends are not aggressively reversed. Surabaya's transport system, characterized by short discontinuous road links, a winding one-way network on many of the main roads, and a few major north-south transport corridors traversing the city, has been constrained by existing city structures and natural physical barriers. Private motorized transport is dominated by a relatively high population of motorcycles and a smaller number of automobiles. Buses and minibuses provide most of the public transport services with auxiliary service from taxi and taxi-like services.

To steer the city's transport system development away from the path of Bangkok, Surabaya requires options that are forward thinking to put in place a system that can handle future dynamic growth. Surabaya's best available options include policies to ensure priority to public and nonmotorized transport, land use planning to manage development in a transport-oriented manner that discourages urban sprawl, and better traffic control. Improvements in vehicle and fuel quality will require national and provincial level leadership; thus Surabaya can play a model role in pushing for these changes.

Varanasi

In Varanasi, nonmotorized transport modes and two-wheeled motorized vehicles dominate the city's vehicle population, with few buses and cars on the city's streets. The diverse vehicle types crowding Varanasi's streets, the almost complete lack of a formal public transport system, absence of traffic management, and traditional, narrow center-city roads contribute to long periods of peak traffic.

Because it is an ancient city now facing the advent of modern transport vehicles and needs, Varanasi's challenge is to create a system that addresses tourist and resident needs while preserving its historic and religious character. Its solutions must be long-range in focus, concentrating on providing public transport and nonmotorized and pedestrian access for the majority of residents who neither can afford to drive a car nor would be able to drive effectively in the large portion of the city not designed for four-wheeled vehicle traffic.

Islamabad

Finally, Islamabad, a city designed on a grid road network, benefits from wide, relatively well maintained streets designed with future vehicle population growth levels in mind. No visible traffic or pollution problems exist, although residents notice that traffic volumes have increased over the years. Private motorized vehicles such as cars and, to a lesser extent, motorcycles dominate 44 percent of Islamabad's passenger travel, with buses satisfying only 28 percent of residents' demand for mobility.

Islamabad enjoys the unique position of a city having effectively controlled growth; thus it has time to examine its options. To meet the transport needs of Islamabad's citizens in the most environmentally sustainable manner, it must consider whether its current system allows for the most efficient movement of people and goods. Although its transport emissions and energy use problems are relatively minor, Islamabad has an opportunity to argue for progressive improvements in vehicle maintenance and technology, reduction of lead in gasoline and sulfur in diesel fuel, a better pedestrian and bicycle travel environment, and an attractive bus system for both school children and workers.

City Commonalities

Despite their differences, the cities' transport systems share common characteristics that point to general trends within urban areas in developing countries. First, the cities have rapidly growing urban populations, with annual growth rates over the past decade ranging from 2.2 percent in Bangkok to 6.6 percent in Islamabad.

Second, three of the cities—Varanasi, Bangkok, and Surabaya—have high central area densities, ranging from 300 people per hectare in Bangkok to approximately 700 people per hectare in Varanasi. Moving away from the city centers, population densities slowly decline. As shown in Figure 1, per capita energy use in the four cities tends to increase when density declines. [The apparent negative correlation between per capita energy use and urban area density is consistent with a similar correlation from an international 32-city study by Newman and Kenworthy (*12*).] At the same time, center city dwellers are increasingly fleeing to less congested suburbs. Bangkok and Surabaya already display urban sprawl characteristics, developing uncontrolled in all directions

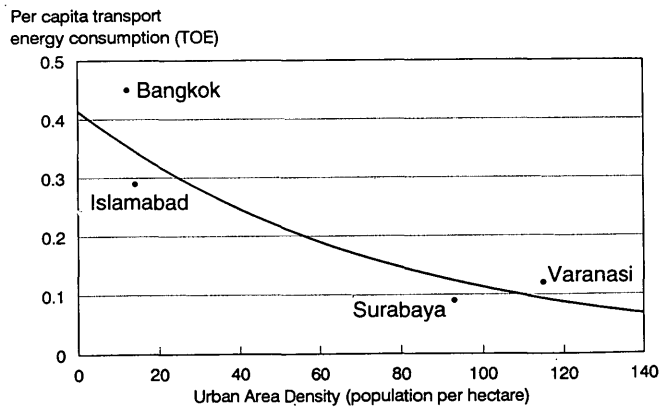
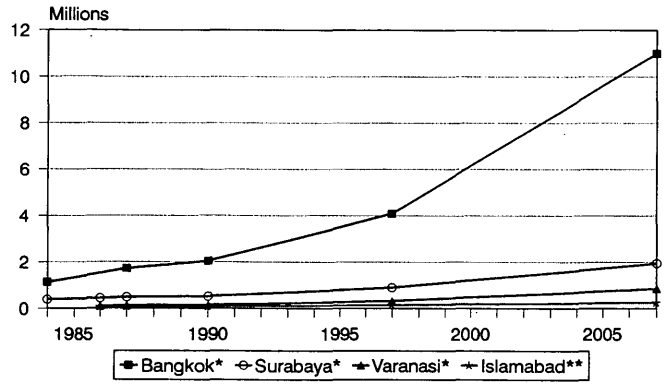


FIGURE 1 Per capita transport energy consumption and urban area density.



*Projections based on most recent fleet growth rate calculations: Bangkok 10.4%, Surabaya 8%, Varanasi 10%
**9, p.37.

FIGURE 2 Comparison of vehicle fleet growth: 1984 to 2007.

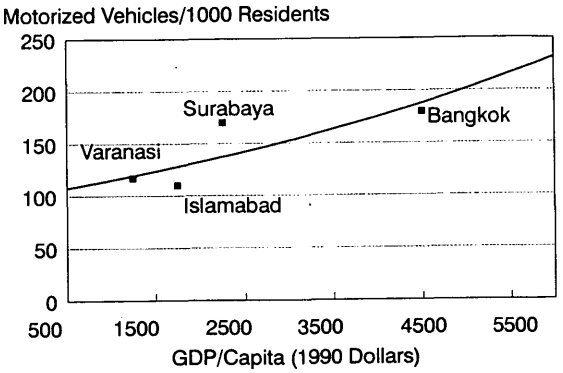


FIGURE 4 Motorization rates and income levels.

with many areas not reached by public transport, forcing residents to rely on private vehicles for daily travel, and thereby increasing per capita transport energy demand.

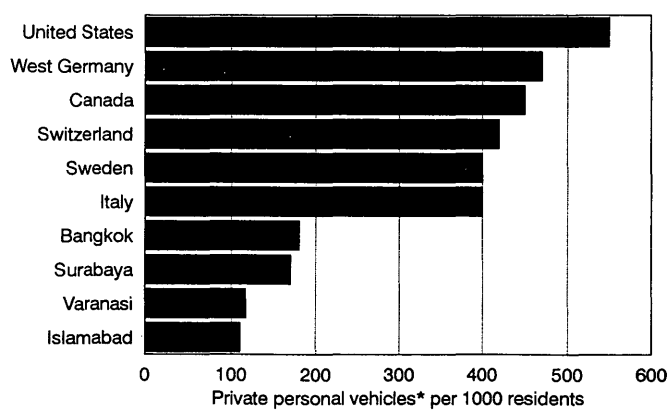
Third, public transport (referring to transportation available to the general public rather than to publicly owned transport) in the case study cities is often insufficient and poorly equipped to handle future transport needs. Consequently, residents without access to private vehicles turn to paratransit modes such as cycle rickshaws, privately owned minivans, and three- and four-wheeled taxis. Compared with overall motor vehicle fleet growth, the bus fleet growth in all four cities has been insignificant, with the share of bus travel to meet overall travel demand declining.

Fourth, each city has consistently registered high motor vehicle fleet growth rates because of increased economic and population growth, urban sprawl, and lack of mass transport alternatives. In Varanasi in recent years, the motor vehicle fleet grew by an average 13 percent per year, in Islamabad, 8.5 percent, in Bangkok, 11.5 percent, and in Surabaya, 5 percent (Figure 2). In contrast, vehicle fleet growth rates in many industrialized countries during recent years (motor vehicle fleet growth from 1984 to 1989 for the United States, United Kingdom, Sweden, Japan, Italy, West Germany, France, Canada, Belgium, and Australia) have averaged only 3.7 percent per year (*13*). The high relative growth registered in these cities will likely continue as a result of currently low levels of per capita vehicle ownership (see Figure 3), rising personal incomes (Figure 4 correlates income with vehicle ownership), and growing domestic motor vehicle manufacturing industries.

Fifth, all four cities face rapid growth in road energy consumption and average annual emissions in large part because of growing transport systems.

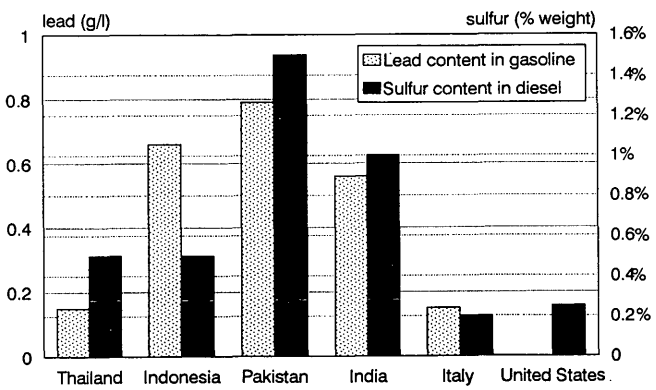
Sixth, each city has relatively high levels of lead and sulfur in its petroleum fuels (see Figure 5) and relatively poor levels of vehicle technology and maintenance. These characteristics lead to serious emissions problems that can be reversed by raising fuel quality, vehicle technology levels, and maintenance requirements.

Finally, each city has created urban development plans, which, with the exception of Islamabad, they have had difficulty implementing. All have failed thus far to integrate urban development plans with transport plans. The lack of clear authority in Bangkok,



*Note: The four city numbers include motorized two-wheeled personal vehicles whereas all others are automobiles only.

FIGURE 3 Per capita vehicle population (*9–11*;*18*,p.280).



NOTE: The fuel specifications for Thailand are as of January 1992; the fuel specifications for Italy are as of 1991; in the U.S., leaded fuel is unavailable at nearly all retail outlets; presently in the U.S. sulfur content of diesel is an estimated average 0.25%, as of October 1993, the U.S. government will mandate a maximum sulfur content in diesel of 0.05%.

FIGURE 5 International comparison of lead in gasoline and sulfur in diesel.

Surabaya, and Islamabad for designing and implementing comprehensive plans is a major cause of this failure.

OPTIONS FOR REDUCING TRANSPORT ENERGY CONSUMPTION, EMISSIONS, AND CONGESTION

Because of these commonalities, similar types of options can be applied to their very dissimilar situations and still achieve results. Implementation of the right combination of these will lead to urban transport systems that are efficient, clean, and highly accessible, thus satisfying the citizens' needs while boosting the economy and leaving a minimal impact on the environment. Options for improving urban transport services range from raising the efficiency of individual vehicles to enacting policies that encourage more transit-oriented urban development. Generally, transport system improvements fall into six categories:

- *Urban land use planning.* Urban land use planning is a crucial element of development, as it can often dictate travel patterns and modal choice. Land use planning must be coupled with transport planning decisions to maximize citizens' access to transport services. For example, the city of Curitiba, Brazil, requires that much development occurs along express, exclusive bus routes, thus increasing densities to support public transport use. More than 70 percent of Curitiba's residents use the bus system for daily mobility. The Netherlands has similar land use planning principles guiding its development toward compact, nonmotorized, and public transport–friendly cities.
- *Encouraging more energy-efficient modes of transport.* The highest priority for transport development in a city is to promote modes that satisfy the needs of citizens, rather than vehicles. Thus, cities should develop and encourage use of modes such as buses, subways, trolleys, and heavy rail, moving people at the lowest pollution and fuel consumption per person (see Table 1). Similarly, nonmotorized transport modes, such as bicycling and walking—moving people at little societal cost—must play a major role in transport system development.
- *Managing the transport system.* Transport system management measures aim to manage traffic and vehicle speeds by working within the existing infrastructure, typically requiring little or no expansion of the present infrastructure supply. Such measures can be advanced technologies, such as computer-synchronized traffic lights, or strict policies, such as vehicle bans in city centers. Other measures include implementing pricing mechanisms that discourage driving, improving telecommunications systems to decrease the number of urban trips, reducing the availability of parking, and using parts of the existing infrastructure exclusively for buses and high-occupancy vehicles.
- *Expanding the transport infrastructure.* Many cities require considerable expansion of the existing transport infrastructure to accommodate growth in transportation demand. Transportation infrastructure expansion measures can provide citizens with access to previously inaccessible areas. Such measures include construction of roads to divert traffic from city centers and construction of exclusive mass transit facilities.
- *Improving the efficiency of individual vehicles.* Energy-efficient vehicles use less fuel and generally discharge fewer pol-

TABLE 1 Comparison of Emissions, Energy Use, Space Use, and Cost of Different Modes of Transport (per passenger-km) (*2,17*)

Mode of Transport	Persons per Hour per Lane	Energy Consumption per Seat-km (kWh) (2)	Total Cost per Person-km (US cents) (1)	Total Emissions per Passenger-km (Grams) (3)
Walking	1,800	0.04	NEGLIGIBLE	NONE
Bicycling	1,500	0.06	0.2	NONE
Motorcycle	1,100	NA	NA	27.497
Car	440-800	0.29	8.6	18.965
Bus:				
Mixed Traffic	10,000	0.12	1.4	1.02
Busway	19,000	0.09	0.9	0.89
Light RailTransit	18,000	NA	NA	Coal: 4.3520 Gas: 0.1876 Fuel Oil: 0.6261
Rapid Rail Transit	54,000	0.15	2.4	Coal: 4.9651 Gas: 0.2307 Fuel Oil: 0.7102

Notes: 1. Total Cost in US cents includes track capital and maintenance costs, and vehicle operating costs. 2. Energy Consumption in kWh includes energy needed to construct guideways, manufacture vehicles and operate the system. Calculated values assume full occupancy of vehicles with no standees. 3. Total Emissions includes CO, HC, NOx, SOx, Aldehydes, and SPM.

lutants than less efficient ones. Technical measures to improve the efficiency of vehicles include reducing aerodynamic drag and the rolling resistance of tires through design changes, substituting lightweight materials, and reducing the amount of energy lost to friction in the engine, transmission, and drive train. Vehicle maintenance and energy-efficient driving techniques also are crucial to efficient operation.

- *Switching to cleaner and alternative fuels.* Decreasing the lead content of gasoline and the sulfur content of diesel will significantly reduce emissions of those pollutants. Switching to cleaner-burning fuels—such as compressed natural gas, liquid petroleum gas, ethanol, methanol, and electricity—can decrease pollution and the dependence on gasoline and diesel and, in some cases, increase the efficiency of fuel use.

Many measures that might improve transport conditions in the short run may, in fact, exacerbate long-term urban transport conditions. For example, the new roads under construction in Bangkok worth hundreds of billions of dollars will likely reduce congestion, emissions, and energy use only in the very short term because of the high demand for road space. In fact, studies (*14*) suggest that the new roads will have no net impact on congestion. Placing priority on the motor vehicle as the primary means of delivering transport services—through enhanced roadways, parking facilities, and traffic flow programs—not only improves the motor vehicle-based transport system but often degrades other transport options, such as bicycle use, mass transit, and pedestrian facilities.

Once cities are developed to service the automobile, it is very difficult to change travel habits and growth patterns. Consequently, cities must consider the long-term effects of all the available options before considering one over another. None of the options will succeed individually; each must be viewed as part of a system and each should be considered for integration into a comprehensive transport system improvement plan. Because each urban area is unique in layout, transport modes, design, and size, each requires a program of options for its own situation and demands.

SHIFTING GEARS: TOWARD AN INTEGRATED TRANSPORT PLANNING PARADIGM

Despite the wide range of options available to help cities meet their citizens' transport needs, little progress has been made toward accomplishing this goal. The problems of today's transport systems—rising motor vehicle fleets, increasing congestion, increasing air and noise pollution, and dangerous reliance on fossil fuels—were identified decades ago, yet the situation has worsened. Although the four Asian cities examined for this report vary widely in level of development and infrastructure, they share one critical need: to develop new methods of transport planning and implement the options available to help.

Envisioning a New Paradigm

To ensure that cities do not follow an unsustainable path in developing urban transport systems, a new development paradigm needs to be created. Cities in developing countries, many of which have not yet sunk substantial investments into transport infrastructure, have the opportunity to lead the way in devising this new transport planning paradigm. By preparing now for a transport system that promotes thorough evaluation of a diverse range of traveling modes, developing countries can create new pathways to achieve lower-cost transport sustainability.

Integration of Options

The first step in developing a new transport paradigm entails the integration of transport options into comprehensive plans. In the four cities studied for this report, each case study team developed action plans to correct short- and medium-term transport system problems. Each team also developed long-range strategies to examine options to resolve the city's recurrent problems or prevent traditional problems from occurring. Each team first analyzed the city's urban development trends, transport system components, fuel consumption, and transport emissions and used this information to develop a comprehensive matrix of transport options, ranging from traditional infrastructure supply options, such as road-building and maintenance, to public transportation development, traffic management, vehicle maintenance, and land use planning.

Although the various measures were compiled in option-oriented action plans, the Asia case study teams found great need for a comparative methodology to allow them to decide which transport options would produce the most effective services for the money invested. Such a methodology, an integrated transportation planning (ITP) process, would enable planners to compare the costs of road building with other available options, such as enhancing an existing mass transit system, for achieving the goal of moving people or goods. In comparing these options, transport planners also would have a mechanism to incorporate the value of environmental costs, security costs of increasing dependence on imported oil, and the costs of rising congestion, into estimated project costs of building additional roads, mass transit infrastructure and improvements, or other transport options.

Conditions for ITP

To begin building an ITP process, causes and effects of transport planning not explicitly considered in the past will need to be considered in the cities.

Enhanced Accessibility

Cities must first consider options that ensure that each citizen has access to the daily needs and wants of urban life. Because most people need to travel to work, take the children to school, and accomplish daily errands, a menu of options should be considered by the city as the best way to provide these services. The most efficient option would be to eliminate the travel need entirely by creating a compact multifunction zone with the person's home, place of work, school, and shops within easy walking or biking distance. Another option would be to design an effective bus, rail, or car pooling system allowing for efficient travel between these destinations. The most energy-intensive, cost-intensive, and polluting option possible would be to spread the destinations out, providing a network of roads without mass transit options, and compelling the person to drive a private vehicle to fulfill the de-

sired need. A transport policy must work to ensure all citizens accessibility, whether by walking, biking, taking a bus or other mass transit, or driving, to the key elements in the complex economic and social processes that make a city thrive.

With enhanced accessibility as the major transport goal, planners, together with city officials and concerned residents, can develop a set of criteria by which cities can judge whether a given project or program of options is the least-cost path toward providing services. Such a list of criteria would replace the traditional cost-benefit analysis that analyzes a project's value solely on its short-term monetary merit, without considering long-term economic, social, and ecological sustainability.

Social Sustainability

Cities must judge whether a proposed transport program utilizes space in the most equitable way for all residents. As such, the transport system as a whole should be oriented to value people transported rather than vehicles moved. As can be seen in Table 1, the persons moved per meter-width of lane per hour greatly vary depending on the mode of travel. Not surprisingly, mass transit, pedestrian, and bicycle traffic come out far ahead of automobiles in the efficient use of road space while contributing the least to air pollution and energy consumption.

Equity plays a crucial role in maintaining social sustainability, particularly in developing countries. Current transport policies tend to favor car ownership for the elite, with a disproportionate amount of public money going to imports of fuels, vehicle components, and vehicles themselves. The majority of developing country citizens do not, however, own cars; hence they remain immobilized without access to the economic and social fabric of the city. In Surabaya, for example, only about 27 percent of residents use private motorized vehicles for daily travel, whereas the rest walk, bicycle, take cycle rickshaws, or use public transport. In Varanasi, nearly 50 percent of travelers use nonmotorized modes or motorized three-wheeled taxis, and in Bangkok about 50 percent of motor vehicle trips are taken by bus or paratransit. Despite the large number of people in each city that do not own or use a private motorized vehicle daily, the bulk of transport funding goes toward building and maintaining roads designed for private motor vehicles. A more equitable system would allocate transport funding to services that mobilize the whole population, rather than just a small portion of it.

Cities should also consider the potential impacts, such as displacement of communities, reduction of public recreational facilities, increased traffic noise in neighborhoods, and detraction of aesthetic quality in affected areas, of the proposed transport projects.

Ecological Sustainability

Every potential transport project should be evaluated according to its ecological sustainability. As is occurring in all four cities, pollutant emissions tend to increase in parallel with the growth of road-based transportation. Present environmental impact statements—when and if they are carried out—are limited usually to short-term impacts, thus ignoring whether short-term environmental gains will likely erode over time. A new road, for example, will improve emissions in the short term as traffic flows faster, but in the long term the road will likely generate more traffic and reach gridlock once again. Impact assessments should quantify a road's future effects on air quality. Transport projects should also undergo rigorous environmental impact analysis on such aspects as lost watersheds and other land.

Energy Use Analysis Each environmental impact assessment should project future energy consumption levels that will result from a given project or plan. The projection should be drawn out to 10, 20, and 30 years to account for population growth and motor vehicle fleet growth. Similar to emissions, a new road may have a positive energy consumption gain in the short term (smooth traffic flow means lower-energy consumption; congested conditions decrease vehicle efficiency), but after 5 or 10 years may be overwhelmed by traffic, thus causing a significant energy consumption increase. A monetary value for the additional energy costs should be calculated and a determination made as to how much energy (likely to be petroleum) will need to be imported to satisfy the demand. Those projects demonstrating a lower energy consumption impact should receive preferential value because of their lower long-term cost. Such rankings help ensure economic and political security by minimizing vulnerability to energy supply disruptions while benefiting local and global environments by minimizing energy-related pollutants, including greenhouse gases.

Internalizing Costs The key to determining ecological and social sustainability is quantifying the long-term environmental costs or benefits, thereby "internalizing" those costs that are left out of a traditional cost-benefit analysis. Transport decision making generally does not fully consider the economic, environmental, health, and social costs of passenger and freight transport options; instead, only the direct costs of the option (i.e., building a road) are considered. Failing to consider these costs constitutes a public subsidy to road-based transport. In the United States, according to the World Resources Institute in Washington, D.C., road transportation subsidies approach $300 billion per year, including

- $174 billion in highway construction, repair, and services (police, fire, etc.) and parking not borne by drivers;
- $10 billion in health costs from air pollution;
- $27 billion for reducing national CO_2 emissions from motor vehicles;
- Over $25 billion in military expenditures to protect the Middle Eastern oil flow;
- $55 billion in accident costs not borne directly by drivers; and
- $9 billion in noise damage to property in urban areas from cars and trucks (*15*).

The quantification of environmental externalities is a subject of great research and debate, although all agree that the value of such externalities is more than zero. Despite the lack of consensus on how to value such costs, they are being incorporated, albeit cautiously, into other sectors such as power generation. Assigning values, no matter how rudimentary, to social, environmental, and energy use impacts would begin establishing a level playing field so that a variety of options to provide transport services can be considered equally.

Multiple Impacts

Cities must give priority to those projects with multiple positive effects over those with a single effect. For example, designating part of a city center as a nonmotorized zone, as has been done in Vienna, Austria, and Curitiba, Brazil, minimizes vehicle pollution and petroleum consumption in that area. Nonmotorized zones can increase revenue for merchants who have more visible store fronts unencumbered by parked vehicles, more space outdoor to set up tables or attractive sales mechanisms, easier access for loading and delivery, and increased clientele from the additional people accommodated in the areas. Nonmotorized zones provide an incentive for residents to use public transport, if it is available, rather than individual cars, allowing all residents equal access to the system. In contrast, the Third Stage Expressway in Bangkok, currently under construction, will have minimal impact on congestion, air pollution, and fuel consumption and will mostly help city residents who own cars or motorcycles.

Adherence to Urban Development Plan

Projects must also be evaluated for their compatibility with overall urban development goals, which are inextricably linked with transport provision. The cities studied all created 5-year urban development plans, and some created longer-term plans as well. However, transport projects are rarely analyzed as to whether they complement or detract from urban development plan intentions. When analyzing current and future transport projects, planners must consider how transport decisions will affect land uses and urban development. Because development hinges on the efficient exchange of goods and services and the accessibility to urban necessities, both land use and transport planning should be viewed as the means by which a city's functions are available to all citizens (*16*).

Long-Range Planning

Project selection should be based on the long-term goal of providing transport services at the least total cost to society. The present system of 5-year urban development plans does not adequately serve cities' growth. Although projects with short-term impacts alleviate transport crises, the key to establishing a comprehensive transport planning process is to decrease the need for a short-term, reactive decision-making process and to put in place a long-term, proactive decision-making process. The establishment of exclusive bus lanes, for example, improves bus services in the short term, which will improve ridership, establish mass transit as a viable travel mode, induce land uses favorable to mass transit, and pave a long-term path for future conversion to higher-capacity transit modes such as rail.

Authority

The case studies demonstrate that cities must first define transportation services and accessibility as the goals to meet citizens' needs. Second, cities must integrate all transport options into a program addressing short-, medium-, and long-term objectives. Finally, cities must judge projects by new criteria, including social sustainability, ecological sustainability, and multiple benefits. Once a city begins to operate under these precepts, a government institution must have the authority to implement the decisions made that will affect the city's transport system development. By integrating energy, transportation, and land use planning within an institution at the local level, the city can ensure that all policies will form an integral part of all urban planning. This institution must work with, but have authority over, all departments working on transport so that decisions can be integrated among the differing policy makers.

In Curitiba, Brazil, for example, the Instituto de Pesquisa e Planejamento Urbano de Curitiba (IPPUC, or Research and Urban Planning Institute of Curitiba) since the 1970s has held the reigns in designing and implementing a wide range of ideas, many of them cutting across several government departments. The bus system, for example, was implemented by IPPUC, which coordinated agencies involved in highway and road design, bus companies and the regulating bodies, emissions control agencies, and eventually, because the old buses were taken out of service because of emissions violations and used for mobile classrooms, the education authorities and the private sector. The authority given to IPPUC, as well as its abilities in coordinating the differing agencies, has fueled Curitiba's success.

In three of the four cities—Bangkok, Varanasi, and Surabaya—no implementing body has the authority to control and coordinate the various aspects of transport planning, even within the context of their 5-year urban development plans. The result, particularly in Bangkok, has been ongoing planning with few positive results. Each 5-year plan reacts to the developments that occurred since the last plan, with each subsequent plan pointing out the planning deficiencies in the previous plan. Very few aspects of the actual plans have been implemented.

In Islamabad, on the other hand, the Capital Development Authority (CDA) is the authority charged with implementing the city master plan and coordinating the various agencies involved in urban development aspects such as transport, sewage, education, and energy supply. Much of Islamabad's success in adherence to the master plan can be attributed to the CDA's clear responsibility and power to act out its role. Most problems in Islamabad's development path relate to the plan content and policies themselves.

THE LAST WORD

By redeveloping the goals and objectives of transportation, cities in the region and around the world could

- Improve citizens' mobility, safety, and health;
- Minimize economic costs by reducing oil payments, congestion costs, and infrastructure investments;
- Stimulate urban economies by creating jobs in local industries such as mass transit;
- Improve other aspects of urban life by promoting city revitalization and urban livability; and
- Improve local and global environmental conditions by minimizing pollutants.

All cities must establish responsibility at the local level for a process that will guide future transport while balancing different modes, minimizing travel demand, and reducing the costs of urban land development. Only then can they effectively identify finan-

cially and ecologically sustainable principles as guidelines for development of urban environments. An integrated approach to transport planning will help reverse the negative trends experienced by cities around the world. The integrated approach will thus guide cities toward a brighter future—a future in which the transport system boosts and benefits the health and economic welfare of all citizens.

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