

# Role of Nonmotorized Transport Modes in Indonesian Cities

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The importance and role of nonmotorized transport—including walking—in Indonesian cities and the need to provide appropriate infrastructure for nonmotorized modes are discussed. Characteristics, costs, and utility of different Indonesian transport modes are analyzed. Constraints in the development of motorized public transport are determined and problems facing nonmotorized transport users are categorized. Management strategies, policies, and design standards for reducing intermodal conflict and increasing transportation system effectiveness are outlined.

The importance and role of nonmotorized transport—including walking—in Indonesian cities, and therefore the need to provide the necessary infrastructure, are discussed.

Indonesian cities range in size from metropolitan cities with populations of over 1 million to small towns with populations of less than 50,000. In each of these cities, nonmotorized modes are still an important part of the transportation system. Nonetheless, not enough attention is given to this subsector. Planning the development and construction of the city's road network is always oriented toward the needs of motorized transport.

This bias creates a vicious circle. Planning for the city's land use development assumes the provision of a road network for motorized transport only. Distance standards are calculated on the basis of motorized transport. Nonmotorized transport is not included in the planning of the city's transport network. Therefore, as the city grows, people are more and more dependent on transport modes. The lack of special infrastructure and traffic regulation for nonmotorized transport results in conflicts with motorized transport in high-density areas.

Because the majority of the population in Indonesian cities does not have access to motorized transport—financially and sometimes also physically because of the physical limitations of the city—nonmotorized transport still has a major function and in the future will still be an important part of the urban transport system. Therefore, it is necessary to consider it as part of the city's transportation system. Planning and development of Indonesian cities should include nonmotorized transport as an integral part of the city's transport system. Three important conditions need to be met. First, there should be political intent and policy backup from the government to include nonmotorized transport as part of the city's system. Second, nonmotorized transport should be considered in planning the city's structure and transport infrastructure. Where

necessary, special infrastructure should be provided. Finally, traffic management and regulation should also be addressed for this transport subsector.

## CONCEPTUAL BACKGROUND

### Speed-Distance Relationship in Transport Demand and the "Transport Gap"

The strong correlation between trip length and the demand for speed in all forms of travel is familiar both in everyday experience and in transportation theory. Bouladon (1) attempted to formulate it as a simple relationship:

$$T = 7.62d^{0.46}$$

where  $T$  is the time in minutes that people are prepared to spend on a journey of  $d$  kilometers. This relationship includes the access time of the vehicles concerned, that is, the time it takes on average for the traveler to reach the relevant transport mode and attain its running speed.

Although time is money, speed costs money, so the actual speed-distance relationship prevailing in a given community will depend on the perceived relative value of time, which is in turn dependent on cultural and economic factors.

For comparison, origin-destination survey results from Bandung, quoted by Soegijoko (2), yield the following relationship:

$$T = 18.34d^{0.411}$$

giving considerably higher travel times for given urban trip distances than those postulated by Bouladon's formula. In terms of speed and distance, this relationship can be written as follows:

$$d = 0.133V^{1.70}$$

where  $V$  is the speed in kilometers per hour.

Soegijoko's results indicate a high degree of correlation between speed and distance (correlation coefficient  $r = 0.39$ ). Assuming that the cost of travel increases with the speed of the mode used, this relation seems to indicate that for maximum cost-effectiveness the intrinsic speeds of the transport modes used for trips of a given length should be within the orders of magnitude reflected in these relations.

An automobile, with an intrinsic speed of, say, 80 km/hr is therefore appropriate under the (presumably European)

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conditions assumed by Bouladon's formula up to a trip length of 75 km, and under Indonesian conditions up to one of 230 km, with slower transport modes making trips significantly shorter.

In developed countries, such slower modes generally do not exist and their absence has been described as a transport gap (3), which has resulted in the prevalent use of the automobile for most trips that cannot conveniently be made by walking. The urban use of the automobile is therefore predominantly under conditions inappropriate to its intrinsic speed, power, and size characteristics and has led to a number of serious problems.

In Indonesia, as in many developing countries where cost efficiency is the overriding consideration, a variety of transport modes have arisen to fill this gap, creating a transport hierarchy, the lowest levels of which consist of the various kinds of nonmotorized modes. One result is that the converse of the transport gap—the mutual interference of a multiplicity of modes—necessitates a correspondingly different approach to urban road design and traffic management.

### Hierarchical Nature of Transport Systems

The concept of a road hierarchy is a familiar one in the field of traffic engineering and traffic management. In a correctly functioning road hierarchy the needs of traffic movement increasingly predominate over the needs of access at successively higher levels of the hierarchy, the efficiency achieved through this specialization of function being the hierarchy's main purpose. In Indonesian cities studied by the authors, reasonably clear road hierarchies exist, although use does not always correspond to function. These road hierarchies consist of the following:

- Primary arteries (intercity roads passing through the city, with road widths usually more than 8.0 m);
- Secondary arteries (main roads linking major activity centers in the city, including the central business district of widths about 7.0 m);
- Secondary collectors (roads connecting the secondary arteries with the residential areas or other urban activity locations, of widths between 6.0 and 8.0 m); and
- Local roads (of width between 4.0 and 6.0 m) and roads within a community consisting of narrow paved streets (width between 2.5 and 4.0 m) and paved and unpaved footpaths, often inaccessible to four-wheeled motorized transport (of widths between 1.0 and 2.0 m).

Conversely, urban transportation demand arises from hierarchies of activities taking place in a hierarchy of urban communities as known in Indonesian cities: the *Kecamatan* (about 20,000 households), the *Kelurahan* (5,000 households), the *Rukun Warga* (250 households), and the smallest community, the *Rukun Tetangga* (25 households).

The location of these activities generally determines trip distances. Because the destinations of frequent trips on average are closer to the residential areas and those less frequently visited are further away, the demand for shorter trips is generally much greater than it is for long ones. Generally, those less frequent venues serve the whole city and are cen-

trally located, whereas those that people visit more frequently tend to be dispersed throughout the city.

Because most of these short trips are at the bottom of the speed hierarchy and also take place on the lower levels of the road hierarchy, for maximum efficiency the modal mix should be different at different levels of the road hierarchy, as certain modes are more appropriate than others for certain trip lengths. In this respect, traffic conditions in Indonesia differ markedly from those encountered in developed countries.

A working knowledge of how these hierarchies operate and interact in typical Indonesian cities is therefore required as a basis for deducing a rational approach to urban road planning, traffic management, and the selection of the most cost-effective infrastructure designs in terms of road widths, pavement designs, and provisions for public transport and pedestrians.

## INDONESIAN URBAN CONTEXT

### Physical Structure of Cities

Indonesian cities are similar in basic physical form to cities elsewhere in the world in having a central area and a main street surrounded by residential areas. However, in the course of the cities' development some specific characteristics began to emerge that affected the transportation system. The difference was due to several factors, including the historical factor. In most of the older (and also the larger) cities, specific distinctions could be observed in the city's form and structure between the European and the indigenous sections. The former were characterized by large plots and houses with wide road networks and were generally of low density with many open spaces and parks. These were the areas where the Dutch resided during the colonial period. In contrast, the areas where the Indonesians lived were generally of high density with narrow roads and small housing plots; open space and parks were limited or nonexistent. Cities such as Bandung, Semarang, Malang, and others were the result of this historical development, in which the distinction between the European section and the indigenous section was obvious. In Bandung, the low-density area is in the northern part, whereas the high-density area is in the southern part of the city. In other cities, the situation is more mixed so that there are pockets of high-density areas surrounded by low-density areas. As the cities grew, this distinction tended to disappear. However, because of economic considerations, the newly developed residential areas are mostly high density with small plots and houses and narrow streets. These tend to be located on the fringes of the city—sometimes even outside the city's boundary—where land is still cheap. Following the growth of these new residential areas, new commercial centers started to emerge. In most cases, these new areas are not linked to the central part of the city with adequate roads, creating congestion during the rush hour.

As a result of this city structure, not all areas could be adequately served by motorized public transportation such as buses. Various types of public transport emerged as a response: minibuses with a capacity of 15 to 20 passengers, scooter- or motorcycle-based vehicles (called *bemo* and *bajaj*) with a capacity of 2 to 7 passengers, and *becaks* (pedicabs)

with a capacity for 2 passengers. Some high-density areas can barely be served by *becaks*. People travel on foot, using bicycles and, if they can afford it, motorcycles. A multitude of travel modes exists in most Indonesian cities as a result of the cities' physical structure. Tables 1 and 2 present access and street structure in some cities and communities.

### Urban Trip Characteristics

As an illustration, some findings of a household survey undertaken in 1985 in three medium-sized cities in Jawa will be described. The profile of the three cities is presented in Table 3. Trip characteristics of household members surveyed are presented in Tables 4 and 5.

In all three medium-sized cities, walking is the dominant mode of transport—for work, shopping, and education trips. The lowest proportion of walking trips is perhaps for Cirebon because of its relatively larger size, and therefore trip distances are longer. However, in larger cities such as Jakarta (population more than 3.5 million) walking still accounts for 40 percent of total trips (1985), whereas in Bandung (popu-

lation about 1.5 million) and in Yogyakarta (population about 0.6 million in 1976) walking trips account for about 49 and 50 percent of total trips, respectively. This proportion has not changed much in recent years.

Next to walking, bicycles and pedicabs are the other non-motorized modes in the three sample cities. Although their use is limited, some part of the population is still dependent on these modes. In 1985, even in a city like Jakarta, *becaks* and bicycles account for 4.6 and 2.4 percent, respectively, of the total trips. For some cities like Yogyakarta and Bandung, this proportion is even higher. For example, in Bandung in 1976, 9.7 and 5.8 percent of total trips were made using *becaks* and bicycles, respectively. A later study in some high-density communities in Bandung (4) concluded that work trips using *becaks* are even more frequent, about 12 percent of total trips. In that study, there was also evidence that the use of *becaks* is more significant for nonwork trip purposes.

In the three sample cities surveyed, work trips are relatively short. In Cirebon, 72 percent of total work trips are less than 5 km. In Tasikmalaya, 74 percent and in Bandung 78 percent of these work trips are less than 5 km. Most of the work trips in Bandung are between 2.5 and 4.9 km. Only 21 percent are

TABLE 1 ACCESS CATEGORY IN THREE COMMUNITIES IN BANDUNG (4)

Access Category	Household % in each category			
	(Jamika %) (460 persons/ha)	(Padasuka %) (460 persons/ha)	(Pasteur %) (460 persons/ha)	All
Walk, cycle, motorcycle	72	54	87	71
Walk plus becak	19	25	3	16
Four wheeled access	9	21	10	13
Percentage	100	100	100	100
Total number of sample household	69	67	70	206

TABLE 2 ROAD NETWORK COMPOSITION AND PATTERN IN FIVE INDONESIAN CITIES (5)

CITY	AREA (HA)	POPULATION (00)	TOTAL ROAD LENGTH (KM)	ROAD CLASSIFICATION		ROAD PATTERN
				Arterial	Collector & Local	
Bandung	8,098.0	1,408.0	4,000.0	11.3	85.5	Radial & Concentric
Sole	4,404.0	502.0	367.3	7.6	92.3	Grid iron East-West major arterials
Magelang	1,812.0	123.0	NA	NA	NA	Linear North-South major arterials
Salatiga	1,728.0	84.0	NA	12.9	87.1	Linear North-South major arterials
Banjarnegara	1,510.0	41.0	NA	NA	NA	Linear North-South major arterials

TABLE 3 PROFILE OF THREE MEDIUM-SIZED CITIES IN JAVA (6)

CITY	AREA (HA)	POPULATION (000)	NUMBER OF PRIVATE VEHICLES		
			Bicycles	Motorcycles	Cars
Serang	11.6	111.5	10,000.0 (1983)	3,000.0	246.0
Tasikmalaya	19.2	156.7	16,000.0	14,600.0	2,250
Cirebon	60.1	275.0	9,700.0	3,600.0	876.0

Note: Becak, Minibus and other Types of public transport are available in all three cities.

TABLE 4 PERCENTAGE OF TRIP PURPOSES IN THREE MEDIUM-SIZED CITIES (6)

CITY	WORK	EDUCATION	SHOPPING	OTHERS	TOTAL
Serang (60 households)	49	29	8	17	100
Tasikmalaya (60 households)	40	28	13	19	100
Cirebon (159 households)	28	30	21	21	100

TABLE 5 TRIP PURPOSE AND TRANSPORT MODES IN THREE MEDIUM-SIZED CITIES (6)

CITY	WORK (%)			SHOPPING (%)			EDUCATION (%)		
	S	T	C	S	T	C	S	T	C
W A L K	48	58	29	80	72	57	83	70	53
B e c a k	9	8	6	4	3	1	3	4	7
Bicycle	4	2	12	0	5	6	6	2	7
Motorcycle	12	7	11	0	15	23	0	8	5
C a r	6	0	8	0	0	1	2	0	0
Minibus	21	25	34	16	5	12	6	16	28
	100	100	100	100	100	100	100	100	100

S = SERANG  
T = TASIKMALAVA  
C = CIREBON

more than 5 km. Shopping trips are mostly less than 2.5 km. Some are even less than 1 km. The proportion of shopping trips that are less than 1 km is 84 percent in Serang, 48 percent in Cirebon, and about 60 percent in Bandung. Education trips are generally even shorter in the smaller cities. But in larger cities like Bandung, education trips are longer, mostly between 1.0 and 5.0 km.

What can be concluded from the above discussion is that in Indonesian cities—from the medium-sized to the larger cities, including metropolitan cities like Jakarta—nonmotorized modes such as walking, bicycle, and pedicab still have an important function as a travel mode. Walking is especially important, perhaps because trip lengths in these cities are short. Shopping trips are especially short trips, less than 1 km. Another fact or might be the limitations of the motorized public transport service in terms of area coverage and services.

#### Constraints in Development of Motorized Public Transport Service

The low private vehicle ownership rates and the high percentage of work trips indicate the need to develop a more extensive and adequate public transport service. However, the existence of high-density communities with narrow roads and the limited length of wider roads (collectors and arterials) have made difficult expanding the coverage of the present motorized public transport service using regular (standard-sized) buses. Minibuses have been used to complement standard bus service in larger cities such as Jakarta and Bandung. Nonetheless, because of the width of the streets and the structure of the city, minibuses also have limited coverage. Widening of roads can only be done in parts of the city.

Other constraints are the financial and management aspects of the operation. At present, the standard bus service is op-

erated by government companies and is subsidized. If government is to continue this responsibility, covering all large cities in the country will be a major drain on the government budget. Participation of the private sector is expected to increase. Encouragement, coordination, and form of participation of the private sector are aspects that need careful consideration.

Physical constraints that limit the development of motorized transport indicate the need to also use nonmotorized transport modes as part of the public transport service. However, at present there is still a negative attitude toward pedicabs because of the government perception about this transport subsector.

## INDONESIAN TRANSPORT MODES

### Transport Mode Hierarchy

In order to give an overview of common Indonesian transport modes, a representative member of each of the main categories has been selected and is defined as follows. The numbers in parentheses indicate rated passenger capacity, including driver, values that are normally exceeded by 50 to 100 percent under peak demand conditions.

#### Private Transport Modes

1. Pedestrian (1),
2. Pedestrian with push cart (*gerobak* or *kakilima*) (1),
3. Bicycle (1),
4. Motorcycle (Honda OC) (2), and
5. Automobile (Toyota Corolla) (5).

#### Public Transport Modes

1. *Becak*—a three-wheeled, nonmotorized pedicab specific to Indonesia (3);
2. *Andong*—a four-wheeled horse-drawn carriage in a number of varieties, such as the two-wheeled *dokar* (7);
3. *Ojek*—a motorcycle for hire in the manner of a taxi (2);
4. *Bajaj*—a motorized tricycle using a 150-cc scooter engine, steered like a scooter (3);
5. *Bemo*—a three-wheeler with 360-cc engine (8);
6. Mikrolet I—a motorized vehicle using a 1000-cc engine such as the Hijet Zebra (10);
7. Mikrolet II—a motorized vehicle using a 1500-cc engine such as the Toyota Kijang (11);
8. Minibus—a small bus using a 3300-cc engine such as the Mitsubishi FE-114 (26); and
9. City bus—a Mercedes model using a 5675-cc engine (51).

### Mode Characteristics

The most important attributes of transport modes in the Indonesian urban context are described in the following paragraphs.

### Speed

Table 6 presents the dimensions, capacity, power, fuel consumption, and cruising speed of these transport modes. From the information presented in the table, the modes can be arranged in four speed bands, as follows:

Speed Band	Mode
1 (about 5 km/hr)	Pedestrian Pushcart
2 (10 to 20 km/hr)	Bicycle <i>Becak</i>
3 (25 to 40 km/hr)	<i>Bemo</i> <i>Bajaj</i>
4 (50 to 100 km/hr)	Motorcycle (low-power) Mikrolet Minibus City bus Motorcar

### Cost

Table 7 presents the cost per passenger-kilometer in rupiahs (Rp.) for each of the modes listed with the exception of the *andong* (for which no reliable data were available) and walking. The cost was based on an estimation of depreciation, the cost of maintenance, the cost of fuel, and the cost of a driver and a conductor (*kenek*), where appropriate.

### Road Space Utilization

A factor not yet covered in the cost calculation is a transport mode's efficiency in the utilization of road space, that is, the obstruction per passenger that the mode offers at different road widths and traffic velocities. A higher efficiency in this regard results in lower traffic volumes per passenger and hence makes possible narrower roads and less disruptive traffic management measures. The road utilization efficiency of a transport mode therefore makes an important contribution to its true economic cost.

This road utilization function depends on more than the plan area or "footprint" of the transport mode; it is a function of vehicle length  $L$ , width  $W$ , width of the road  $w$ , mode's maximum speed  $V$ , free flow speed of the surrounding traffic  $v$ , number  $P$  of passengers, average distance  $s$  between stops, and possibly other factors as well, so that

$$RUF = f(L, W, w, V, v, P, s, \dots)$$

This function can be thought of as analogous to a mode's PCU value, which is defined in developed countries as a vehicle's contribution to saturated flow compared with that of a standard car. In developed countries, however, because of fairly standard road and traffic conditions, PCU values are conveniently regarded as intrinsic to a transport mode and generally independent of the extraneous factors mentioned earlier. This characteristic makes the concept not very useful in Indonesia except at the higher levels of the road hierarchy.

The RUF is determined empirically by measuring saturated flows with different modal mixes and with different values of the variables. It provides city planners with a useful tool in

TABLE 6 INDONESIA TRANSPORT MODES: MECHANICAL CHARACTERISTICS

TRANSPORT MODES	LENGTH (m)	WIDTH (m)	OFFICIAL PASSENGER CAPACITY (ng)	EXTRA FREIGHT CAPACITY (kg)	ENGINE DISPLACEMENT (cc)	FUEL CONSUMPTION (km/Lt)	CRUISING SPEED (km/g)
<b>Private</b>							
Pedestrian	1.00	0.60	1	30	NA	NA	5
Ped & Pushcart	2.10	0.80	1	200	NA	NA	5
Bicycle	1.75	0.60	1/2	50	NA	NA	16
Motorbike (Honda GC)	1.60	0.80	2	30	125	SUPER 20	80
Automobile (Toyota Corolla)	4.05	1.60	5	100	1290	SUPER 9	100
<b>Public</b>							
Becak	2.25	1.00	3	30	NA	NA	10
Andong	3.50	1.50	7	100	NA	NA	10
Cjeg (Honda GC)	1.60	0.80	2	15	125	SUPER 20	60
Bajaj	2.50	1.20	3	30	150	SUPER 30	40
Bemo	2.90	1.25	8	30	360	SUPER 16	40
Mikrolet I (Hijet Zebra)	3.80	1.80	10	70	1000	SUPER 9	60
Mikrolet II (Toyota Kijang)	4.25	1.25	11	80	1500	SUPER 10	60
Minibus (Mitsubishi FE-114)	5.40	1.90	26	NA	3298	DIESEL 8	60
City Bus (Mercedes)	9.30	2.50	51	NA	5675	DIESEL 5	60

Source: TDC-SA, 1988

calculating road capacity and designing infrastructure at the local and village road level and serves as a means of identifying the traffic levels at which modal conflicts become critical.

It is hoped that the work currently under way on an Indonesian highway capacity manual will shed more light on this aspect of Indonesian transport mode performance.

### Safety

At present, insufficient data are available to assess the safety of these transport modes scientifically. Statistical analysis of accident data coupled with extensive mechanical testing will be required in the future to achieve this assessment.

In the context of the role of nonmotorized traffic modes, the provision of adequate infrastructure will have the greatest impact on safety, because these transport modes with their low speeds are inherently safe.

### Nonmotorized Modes and Infrastructure Requirements

In the following more detailed discussion of nonmotorized traffic, the cruising speed or speed limit is taken from Table 6, average speed is from the origin-destination survey referred to; ideal trip length is that derived by applying Bouladon's formula to the cruising speed, whereas average trip length is obtained by applying Bouladon's formula to the average speed. The cost per passenger-kilometer is taken from Table 7.

#### Characteristics of Nonmotorized Modes

**Pedestrian** Characteristics of the pedestrian mode are as follows:

Characteristic	Amount
Cruising speed or speed limit	5 km/hr
Average speed	3.5 km/hr

TABLE 7 INDONESIAN TRANSPORT MODES: ECONOMIC CHARACTERISTICS

TRANSPORT MODES	CAPITAL COST (M Ep.)	USEFUL LIFE (yr)	MAINTENANCE COST (ERp./mc)	DAILY TRAVEL (km/day)	FUEL COST (ERp./mo)	DRIVER & ASSISTANT (KRp.mc)	COST PER PASSENGER (KM) Rp.
<b>Private</b>							
Bicycle	0.15	15	2	20	0	0	6
Motorbike (Honda GC)	0.65	15	10	50	33	0	16
Automobile (Toyota Corolla)	15.00	8	30	50	73	0	35
<b>Public</b>							
Becak	0.70	8	5	20	NA	75	69
Ojeg (Honda)	0.65	10	15	100	66	75	54
Bajaj	3.00	5	20	70	31	100	48
Bemo	5.00	8	25	70	58	100	18
Mikrolet I (Hijet Zebra)	13.50	8	35	100	147	275	22
Mikrolet II (Toyota Kijang)	16.50	8	50	100	132	275	21
Minibus (Mitsubishi FE-114)	31.00	10	75	100	75	275	10
City Bus (Mercedes)	80.00	12	100	100	120	300	8

Source: TDC-SA, 1988

Characteristic	Amount
Ideal trip length	400 m
Average trip length	1.1 km
Cost per passenger-kilometer	Nil

Walking is the predominant transport mode for short trips in Indonesian cities. The Bandung study (7) found that 40 percent of all household trips were walking trips that constituted 50 percent of all travel time and 32 percent of all traveled distance. Similar results from a number of other studies indicated that walking was the most important urban transport mode, from the point of view of economic and basic needs.

In Indonesian cities, pedestrian problems essentially break down into the following categories:

- At the village community level, the lack of paved surfaces and poor drainage constitute a major lack of amenities in the rainy season.

- In areas where motorized traffic predominates, the lack of continuous networks of footpaths, sidewalks, and adequately enforced pedestrian priority crossings forces pedestrians to compete with motorized traffic for use of the road space.

- At all levels, there is a lack of an adequate standard of design of pedestrian facilities.

In the most congested areas, sidewalks are routinely subordinated to the needs of informal vendors and the parking needs of motorized vehicles.

**Pushcart** The pushcart mode has the following characteristics:

Characteristic	Amount
Cruising speed or speed limit	5 km/hr
Average speed	NA
Ideal trip length	400 m
Average trip length	NA
Cost per passenger-kilometer	NA

These are of two kinds, the *gerobak*, a pushcart for carrying freight and merchandise of all kinds and also solid waste, and the *kakilima*, which mostly serves as a mobile facility for selling food and groceries. These vehicles usually run on bicycle wheels and have various widths, but most are designed to go down the narrowest footpaths.

No surveys were found relating to this mode, but the presence of pushcarts in large numbers in all the cities studied by the authors indicates that they fulfil important economic functions. The *gerobak* and the *becak* are the few means of freight access for the large percentage of houses not served by roads accommodating motorized transport, whereas the *kakilima* is the principal source of meals away from home in Javanese cities.

**Bicycle** The bicycle mode has the following characteristics:

Characteristic	Amount
Cruising speed or speed limit	15 km/hr
Average speed	6.0 km/hr
Ideal trip length	3.3 km
Average trip length	2.8 km
Cost per passenger-kilometer	Rp. 5

The bicycle is the most efficient of the transport modes in economic terms at Rp. 5 per passenger-kilometer. It is therefore comparable with walking, but its long history of mechanical refinement has led to an efficiency in the use of human energy that has permitted an eightfold increase in the ideal trip length (from 0.4 to 3.3 km).

The bicycle does not lend itself to multistage journeys because parking it in public places is not practical. Bicycles also present a high degree of obstruction to fast-flowing traffic. For these reasons, on roads that carry a high volume of motorized traffic bicycles should be accommodated in a bicycle lane or bikeway.

Bicycles do not perform well above a gradient of 4 percent or on roads with potholes or excessive roughness. Indonesian bikes are rarely provided with gears, which would be especially useful when bicycles are adapted for the carriage of freight, as they often are, with the addition of deep baskets on either side of the rear wheel.

In spite of its clear advantages, the bicycle is not in widespread use in all Indonesian cities. This may be caused by a negative social connotation (7). There is a tendency for cyclists to disobey traffic regulations.

**Pedicab (*Becak*)** The characteristics of the pedicab mode are as follows:

Characteristic	Amount
Cruising speed or speed limit	10 km/hr
Average speed	5.3 km/hr
Ideal trip length	1.5 km
Average trip length	2.3 km
Cost per passenger-kilometer	Rp. 69

The pedicab, or *becak*, is the public transport equivalent of the bicycle and is the highest-cost transport mode in terms of passenger-kilometers. The reason for this high cost is its unproductive use of the driver's time rather than high capital or running cost, in which respects the *becak* is extremely economical. When alternative employment is scarce and the opportunity cost of the driver is reduced, the *becak* can become more competitive.

The *becak* has been studied in some depth (7,8), both from the social and transport points of view. The conclusion of

these studies—as well as of this paper—is that the *becak* fills a valuable role in the road transport hierarchy because it has a unique combination of advantages:

1. Its extremely low capital cost and relatively informal licensing arrangements place it within easy reach of the permanently or temporarily unemployed.

2. It can negotiate the narrow village roads and therefore provide services for which there is at present no alternative, such as

- Taking produce to markets,
- Carrying the elderly,
- Transporting small children to school,
- Providing freight and passenger capacity for housewives, and
- Going to market.

3. It uses no scarce economic resources, its maintenance is easy, and it can carry freight.

4. It provides a flexible and personalized service.

The *becak* has come under fire from time to time, mainly from two points of view—it obstructs traffic and it is inhumane. The need for segregating *becaks*, as well as other non-motorized traffic, from high-speed motorized transport flows is clear, and this segregation can be achieved through *becak*-free corridors (rather than zones) or bikeways along major transport corridors as in Solo.

The issue of inhumanity seems less clearcut, because the sale of personal services involving physical labor is a common and well-accepted element of life in Indonesia, and although the job of a *becak* driver is physically taxing, the surveys mentioned report better-than-average health records among *becak* drivers.

From the point of view of infrastructure, *becaks* require a smooth riding surface. Because of the load they carry, *becaks* are even more sensitive to gradient than the bicycle, and it has been suggested that their effectiveness would drop off sharply above a gradient of 2 percent.

The most useful design improvement to *becaks* would therefore be the addition of gears. Cheap ones manufactured in the region would not add substantially to the capital cost of the vehicle. The addition of a motor would appear to be less useful, however, because this would convert the *becak* into a different type of vehicle, competing with the *bajaj* and the *bemo*. It is not clear whether the mechanical behavior of the traditional *becak* at higher speeds would be acceptable.

**Andong** The characteristics of the *andong* are as follows:

Characteristic	Amount
Cruising speed or speed limit	10 km/hr
Average speed	NA
Ideal trip length	1.6 km
Average trip length	NA
Cost per passenger-kilometer	NA

The *andong* is one of many types of horse-drawn carriage still in use, some of which are smaller, carrying five passengers or fewer. In general, the horse-drawn carriage is increasingly



relegated to rural and peripheral urban areas, but it still plays a significant role in small cities.

With its relatively large size and slow speed, the *andong* is not suitable for negotiating narrow urban community roads, whereas the obstruction they present to motorized traffic is considerable. Their value is therefore only in areas with reasonably wide roads where motorized traffic is still sparse.

### Infrastructure

The provision of a continuous network of walkways designed for the needs of pedestrians and compact slower-moving transport modes that accommodate the greater part of the demand for short trips would relieve the higher-class roads of modal conflict and much unnecessary traffic.

These networks would typically consist of

- Village footpaths and community roads with no motorized access or restricted access,
- Local roads with a low volume of motorized traffic,
- Sidewalks or nonmotorized lanes along roads with a higher volume of motorized traffic,
- Pedestrian crossings and nonmotorized crossings on roads with higher traffic volumes, and
- Pedestrian bridges or underpasses on roads with the highest traffic volumes.

Greater segregation of fast-moving motorized modes, slow-moving modes, and pedestrians at all levels of the road hierarchy is required, favoring the fast-moving modes at the higher levels and the slow-moving modes at the lower levels, with priority for pedestrians at the lower levels.

The cutoff traffic volume at which mode separation is required (which is a function of road width) needs to be studied further.

Junctions of footpaths and local roads frequently serve as pick-up and set-down points of informal motorized public transport services and act as focal points around which *becaks*, fulfilling a feeder function, cluster. The resulting obstructions can only be avoided if suitable parking areas are provided for this function.

## PREREQUISITES TO ACTION

### Political Will and Policy Requirements

As discussed earlier, nonmotorized transport is still important and can have a function in the total urban transport system. However, to optimize its role requires some action such as providing special infrastructure where necessary, modifying present road design standards to accommodate the operation of these nonmotorized transport modes, and including them in the design of traffic management and traffic regulation. The prerequisite for this action clearly is the support and political intent of the government. It is important for the government to appreciate the role of these nonmotorized modes and the need to include them in the total urban transport system.

Policies are required at the national level to indicate the government position on this subsector and to formulate national policies supporting the use of nonmotorized transport modes in relevant situations. Policies at the local level deal mostly with the operational aspects: regulating their operation, management, and integration with the motorized transport system.

Another set of policies are those dealing with safety aspects, which are also important for motorized transport. Safety aspects that need to be dealt with are protection for riders and passengers and traffic safety measures. The latter is especially important in areas of high population density and of high traffic density where there will be competition for road space with motorized transport (and sometimes even with nontransport activities such as sidewalk vendors).

### Traffic Management Approaches

The second aspect necessary to optimize nonmotorized modes is a traffic management approach, including traffic safety aspects, efficient and convenient routing, and the interface with motorized traffic. The basic issue with regard to traffic safety is trying to minimize competition and conflict with motorized traffic. One of the options is to separate their service areas. For example, nonmotorized traffic together with low-speed motorized modes is to serve short-distance trips, and therefore its area of operation is mainly on local or community streets and in residential areas and other areas of low traffic-generating activity. This policy is also in line with the role or function of nonmotorized travel in the urban transport system. Another option is to provide special infrastructure facilities such as special lanes separated from the motorized transport, pedestrian sidewalks and crossings, traffic lights, and parking space. Low-cost design is available for this without reducing the main function of the nonmotorized modes.

### Infrastructure Design Standards

The third aspect is the design standards for transport infrastructure. This aspect is to accommodate the need for special lanes in areas where it is necessary to separate the motorized transport from the nonmotorized traffic. In areas where the two can be mixed—usually in areas of low population and traffic density—street width should be sufficient to accommodate the operation of both the motorized transport and nonmotorized traffic so that they interfere least with each other.

Pedestrian areas and sidewalks should be included to allow people the choice of walking. An important factor is the need for continuity of the special lanes for pedestrians and motorized transport modes. Pedestrian crossings could be made above grade level, but for nonmotorized traffic modes they should be at grade level.

Specifically, it is essential that local authorities be provided with countrywide design standards for pedestrian and nonmotorized traffic modes. This will involve the following:

1. Investigation into the cutoff traffic levels at which traffic in the various speed bands needs to be segregated.

2. Investigation into the transport infrastructure needs at the community level corresponding to various trip purposes and trip lengths, with special focus on the needs of pedestrians, nonmotorized traffic, and motorcycles; the collection of quantitative data to enable benefit-cost and economic return calculations for such infrastructure provision to be carried out.

3. Countrywide standardization of appropriate design details for pedestrian and nonmotorized traffic provisions, to include

- Standard drainage ditches;
- Low-cost footpaths and community roads of various widths appropriate to the smooth riding surface and light wheel loads of bicycles, *becaks*, and pushcarts;
- Waiting areas for *becaks* at intersections of community roads and village roads;
- Stopping places for microlets and minibuses;
- Low-cost sidewalks for pedestrians and pushcarts;
- Low-cost bikeways for bicycles, *becaks*, and animal-drawn vehicles;
- Standard intersection design incorporating pedestrian and bikeway crossings; and
- Standard details for communal areas to accommodate *kakilimas* and food vendors' stalls.

These designs should preferably be tried out and assessed in the form of pilot projects at the community level and involving the future users in decision making.

Finally, in areas where it is necessary to have an interface between the two subsectors, facilities should be provided to accommodate this interface. Among others, these facilities would include parking places, stalls, and waiting areas.

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