TWO-WHEELERS – THE BACKBONE FOR A SUSTAINABLE TRANSPORT SYSTEM IN CITIES

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1 INTRODUCTION

The bicycle was the first technical sustainable intervention for mechanical modes after 7.000 years of pedestrian mobility, horse-drawn and ox-drawn carts. This 18th century intervention went through different forms in the 19th century till it got its finale version which is the common bike of today around hundred years ago. Rubber tires and chain transmission enhance human speed for mobility three to four times of a pedestrian on the same body energy level. The bicycle is the only mode, which can theoretically compensate the energy needed for construction and maintenance by saving human body energy in the whole transport system. Riding a bike for more than thousand kilometers compared to walking gives this “breaking point” for system energy. But if the opportunity to carry goods is added into this calculation, this break point – distance is far much shorter.

1.1 Cycles – the most intelligent mechanical modes

Intelligence means to react on problems with problem solution activities. If accessibility with technical modes (beside pedestrians) is the problem, only the bike can fulfill these needs in an intelligent way. The amount of space for parking and riding a bike is limited and is not exceeding very much the amount of space of pedestrians. The bike is driven by solar energy from the human body and in some cases by gravity or wind from the back. The weight is low, the bike is flexible and of multifunctional use. Bike can not only be used to ride it, but it can be also used to carry heavy goods by pushing the bike or ride the bike. The occupancy rate of a bike can reach two or even more persons (which is generally forbidden), but it is close to the occupancy rate of the car in the Western societies. If we compare the physical and planning indicators of different modes, non-motorized transport system users are by far the most efficient modes.
Concerning the speed the bike is competitive at least in urban areas. The average travel speed of a car in an urban environment in Western cities is around 11 km/h in the secondary road and on the primary road network (expressways and motorways) the average speed is not more than 27 km/h. The average travel speed from house to house in urban areas for

public transport is around 14 to 20 km/h. And this speed range is also the speed range of cyclists.

1.2 City size and modal split

The city size is limited by the speed of the transport system users. The population of ancient cities was limited due to the speed of the pedestrian. Ancient cities could therefore not exceed about one million of inhabitants. The bike can extend the distance three to four times compared to a pedestrian. If the city has access to enough resources to feed the people and provide for them enough material for their needs, a city can grow up to ten to fifteen millions based on bike (plus external ships or railways). This is not only a theoretical figure, this has also been practiced in several Chinese Megacities. Therefore there is no need for car traffic for cities up to ten million of inhabitants. If public transport is introduced in addition rail-based or bus-based on corridors serving business, administration and population with good access for cyclists and pedestrians, a city has in principle no limits to growth. A sustainable urban structure is therefore possible for all human settlements without any car.

1.2.1 The damage of urban structures by car traffic

Cars are not agreeable with the urban life, urban economy and future needs of the society. It is not only the problem of the oil peak and external energy flow, which is necessary to operate a car-oriented transport system, it is mainly the waste of space for the same purpose. Cars are occupying too much space for a sustainable city, since they need two parking places at the origin and destination and a huge amount of space for mobility in principle for the same purpose like all the other modes. If cars are occupying this precious public space, they destroy the dense, social and economic network of the cities. But cars are the most convenient modes on the individual level, on the level of society and the level of system cars are the most damaging modes for the urban body.

1.3 The step from two-wheelers to three-wheelers

If one wheel is added to the bike we get one of the most efficient urban transport modes human society has ever developed: the cycle rickshaw. The average speed of a cycle rickshaw in the flat terrain is comparable to an urban taxi or urban transport. It is therefore a competitive mode. And since it is competitive in distance and speed we have to look to the other parameters. The occupancy rate of a rickshaw is the same like a taxi. Its energy consumption is the energy consumption of a human body without external fossil energy. In some countries the occupancy rate of a rickshaw is even higher than the occupancy rate of cars since two or three adults or even up to ten pupils use this environmental friendly mode providing enough income for the driver of the rickshaw and his family. It is one of the most social agreeable modes ever invented, but not only in social terms, but also in environmental terms. There is no other mode with this high degree of social agreement and at the same time this small ecological footprint. In a rational way a rickshaw can never be beaten by any artificial driven mechanical mode neither by bus, streetcar or car.

1.3.1 The advantage of good transport

Three wheels make a vehicle stable. And if it is stable, it is not necessary to keep it in balance. Huge amount of goods are therefore transported in an extremely intelligent way in many parts of the world. Not only in India or China but also in Japan where even small restaurants on three wheels are very common in the urban center.

1.4 Urban structure stabilities and cycles

Urban structures are dependent on the transport system they rely on. For thousands of years all cities were built on the human scale. Each sustainable city is therefore a human scale city. The variety of functions and richness of environment in a city is dependent on a slow multifunctional transport system with the ability of a multifunctional use of public space. This historical structure stability of all settlements is based on human's body energy for movements. This might be the secret why cycle traffic is the only mechanical mode, which has not changed the urban structures so far. Cycle traffic is used as an addition to pedestrians for longer distances either to have accessibility to more centralized functions, which are not in the ordinary daily travel patterns accessible or to have easy access to public transport in the total transport chain. All modes driven by artificial energy change the urban structures, because they make distant activities better accessible but restrict local activities more and more. The effect is the loss of urban variety, the loss of vitality of a city and a violation of fair competition in the economic arena. The urban developments can be organized in a harmonic way only with pedestrians, cyclists and public transport. Under these circumstances it is possible to develop a sustainable urban development.

2 THE ROLE OF MOTORIZED TWO AND THREE WHEELERS

Motorized two-wheelers as basic elements of urban transport are a specialty in Vietnam. They use the advantage of artificial fossil energy and the flexibility for a low price mechanical mobility. The advantages of motorized two-wheelers are: low costs and less space. The disadvantages of motorized two-wheelers are

a) speed
b) accidents
c) air pollution
d) noise and
e) parking problems

Therefore they have to be treated in a similar way like cars. They have to be kept away at least as far as public transport stops are organized. They shouldn't be allowed to penetrate into historical urban centers. Motorized three-wheelers as feeder systems to public transport stops and as a taxi are much more efficient compared to cars.

The following two reports describe the situation of two countries, in which two wheelers, motorized and nonmotorized are still a substantial part of the urban transport system.

The Indian case was written by Prof. Dinesh Mohan, the situation in Hanoi by Msc. Ho Anh Cuong.

3 USE OF MOTORISED TWO-WHEELERS IN INDIA – ISSUES AND CONCERNS

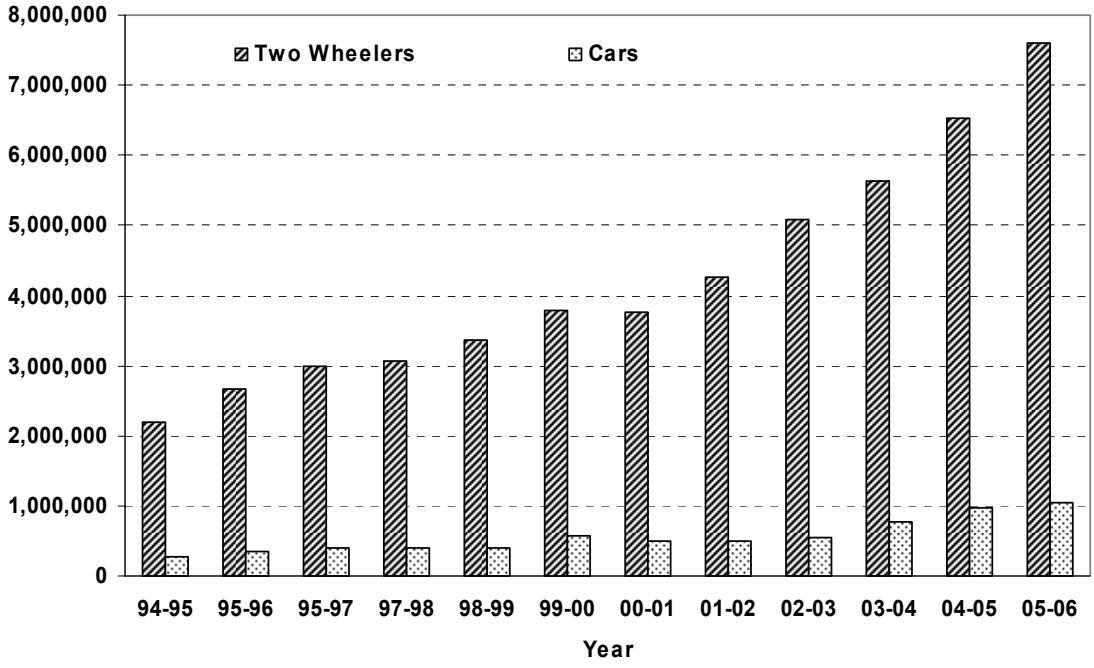

Figure 1: Annual production of cars and motorised two-wheelers (motorcycles, scooters and mopeds) in India.

Figure 1 shows the number of motorised two-wheelers (MTW) and cars produced annually in India over the past decade. The ratio in the financial year 1994-1995 (April-March) between cars and MTWs was 8.3 which has changed to 7.3 in 2005-2006. While the ratio has not changed very much the difference in numbers has changed greatly. In 1994-1995 India manufactured 1.9 million more MTWs than cars and this difference changed to 6.6 million in 2005-2006. These numbers exert a major influence on how roads get used in India, in particular in the cities. In smaller cities MTWs far out number cars whereas in the capital city of Delhi the modal shares on the road between cars and MTWs range between 1:2 and 1:3 on different roads. Figure 2 shows this difference on the roads of different size cities. This is mainly due to the fact the per capita income in smaller cities is much lower than that in the large prosperous cities. The presence of MTWs decides how roads get used as these vehicles can weave in and out of traffic streams, collect in front of the vehicle queue at red lights and pass cars from both left and right directions.

Figure 2: Two wheeler modal share is much larger in smaller cities (above left) compared to mega-cities like Delhi (above right) in India.

Presence of MTWs in such large proportions is a relatively new phenomenon our experience with traffic analysis over the past century. There is little precedence for this in the highly motorised countries (HMC). The same road space gets used by modern cars and buses, along with locally developed vehicles for public transport (three-wheeled scooter taxis), scooters and motorcycles, bicycles, rickshaws, and animal and human drawn carts. The infrastructure design based on homogeneous traffic models, has failed to fulfill the mobility and safety needs of this traffic.

The HMCs have never experienced road traffic that includes such a high proportion of motorcycles, buses and trucks sharing the same road space with pedestrians and bicyclists. When the present HMCs had low per capita incomes in the earlier part of the last century, motor vehicles (including motorcycles) were relatively more expensive and not capable of high velocities and accelerations. Therefore, speeds were lower and number of vehicles using the roads was less than that seen today. In a sense, motor-vehicle technology, roadway quality and social systems were more compatible. On the other hand, in India new designs have to be developed for use of technologically advanced vehicles using relatively "less advanced" roadways and enforcement systems. The fact that these patterns are new and that they need to be understood through careful scientific research is not realised by most policy makers. If we just depend on HMC standards and research results to solve problems in India, we may find the outcome very unsatisfactory.

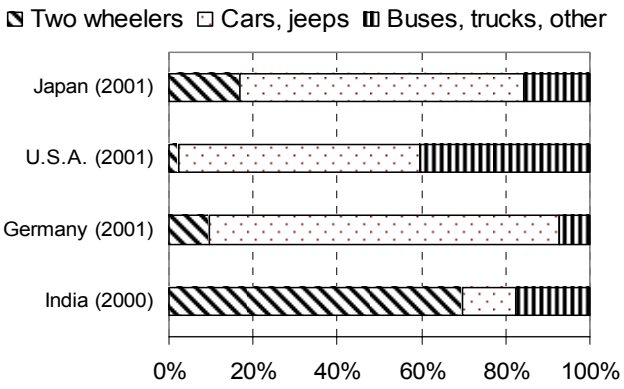

Figure 3: Proportion of vehicles registered in India, Germany, Japan and USA

Figure 3 shows the proportion of vehicles registered in India and three HMCs These data show that car population as a proportion of total motor vehicles is much less in India than in the HMCs (13% vs 56-80%) and that the proportion of motorised two-wheelers (MTW) much higher (70% vs 5-18%). These differences in fleet composition affect the traffic and crash patterns enormously.

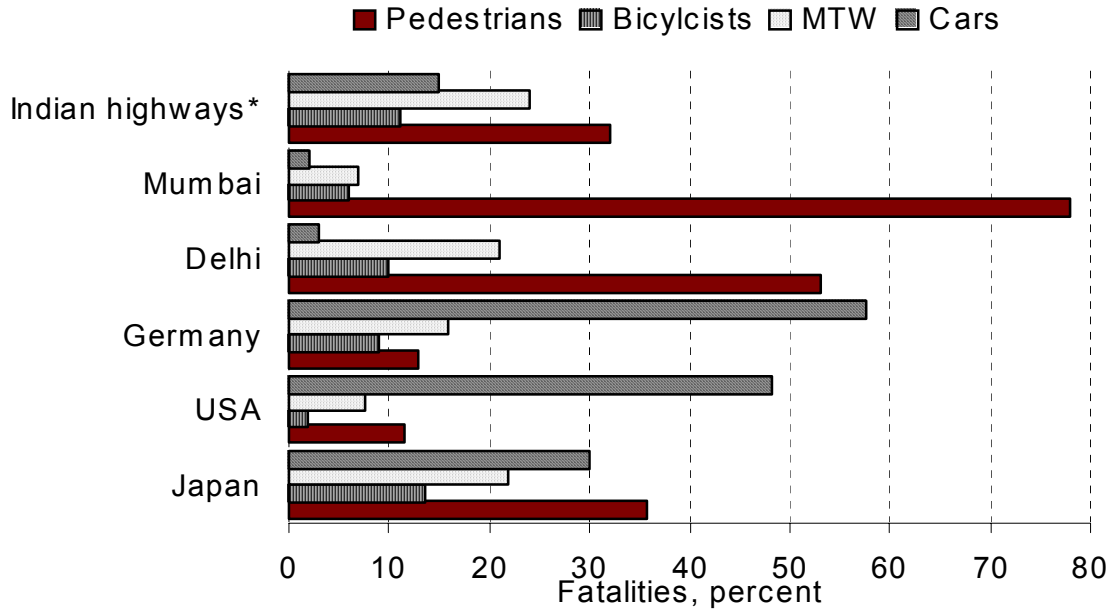

Figure 4: Proportion of different types of road users killed in Delhi, Mumbai, national highways in India and in highly motorised countries (* Average for 14 locations, MTW – motorised two-wheelers).

Figure 4 shows that pedestrians, bicyclists and MTW riders constitute a larger proportion of road crash victims in India than in HMCs [1-3] and Table 1 shows the proportion of MTW as proportion of all vehicles registered in Indian cities [4]. Pedestrians, bicyclists and MTW riders, who constitute the vulnerable road users, constitute 60-80 per cent of all traffic fatalities in India. This flows logically from the fact that this class of road users forms the majority of those on the road. In addition, because metallic or energy absorbing materials does not protect MTWs, they sustain relatively serious injuries even at low velocity crashes. In all these cities car occupants constitute less than 5% of all the fatalities. In Delhi MTW comprise 22% of the fatalities and on national highways an average of 24%.

3.1 Alcohol

Data for alcohol and other drug involvement in road traffic crashes are not available for Indian cities. A study done in Delhi documented that about one third of two-wheeler riders admitted to a neuro-surgery ward admitted to driving under the influence of alcohol at the time of the crash [5] and another form Bangalore found that 44% of crash involved two-wheeler riders seeking treatment had alcohol involvement [6]. It is clear that much more work needs to be done to understand the exact role of alcohol and other drugs in road traffic crashes in India. However, the limited information available suggests that this may be a significant risk factor.

3.2 Safety

City	Percent	City	Percent
Ahmedabad	77	Jaipur	74
Bangalore	73	Kanpur	79
Kolkata	44	Lucknow	80
Delhi	66	Chennai	73
Cochin	60	Nagpur	78
Mumbai	41	Patna	69
Hyderabad	87	Pune	74

Table 1: Share of motorised two-wheelers in Indian cities.

In south-east Asia, there are several countries with a large proportion of two-wheeled and three-wheeled vehicles whose growth in numbers has been associated with a large rise in road traffic injuries. Examples are Cambodia (where 75% of all vehicles are motorized two-wheelers or motorized three-wheelers), the Lao People's Democratic Republic (79%), Malaysia (51%) and Viet Nam (95%). In Viet Nam, the number of motorcycles grew by 29% during 2001; at the same time road deaths rose by 37% [7]. An increase in use of motorized two-wheelers in China, Province of Taiwan, where such vehicles comprise 65% of all registered motor vehicles, was also associated with increasing deaths and injuries [8]. Two-wheelers also cause injuries to other road users and a hospital-based study in New Delhi found that 16% of injured pedestrians had been struck by motorized two-wheelers [9].

The traffic patterns in Delhi are very different from most metropolitan cities in high-income industrialised countries mainly because of the large variety of vehicle types present on the road and the differences in their masses and velocities. Riding speeds are also affected because majority of MTW riders in Delhi are in general older than MTW riders in Europe and the U.S.A, and they do not use their vehicles for sporting purposes. Studies from HMC countries [10];[11] report that a very large number of MTW riders have less than 1 year's experience whereas only 2 out of 72 of the crash victims in a sample of hospitalized riders in Delhi reported driving experience of less than two years [12]. This suggests that driver education may not effect MTW fatality and serious injury rates in Delhi. This may also account for the
lower percentage of single vehicle crashes. Therefore in Delhi more attention would have to be given to reducing conflict between MTWs and high mass vehicles like buses and trucks. For some time the curbside lane was reserved for buses on many roads in Delhi but this was not successful partly because the very slow vehicles
(animal or human powered) also used these lanes, This practise has now been virtually given up. Some other innovative ways of traffic management have to be developed to separate traffic.

A large proportion of riders, both in the fatal and the hospitalized sample in Delhi were hit on the straight road and not at intersections, especially at night [12],[13],[14]. In both samples more than 40% were hit from the rear. The proportions are much higher than reported in most other studies. Crash details recorded in the police reports and those given by the hospitalized riders suggest that inconspicuity of the rider and motorcycle maybe a serious problem as many streets are not well lit. Because of the tropical weather conditions it is not possible for

riders to wear bright coloured jackets like the ones worn in colder climates all the year around. Therefore it is very important for the MTWs and the helmets to be made much more conspicuous. We suggest that all MTWs and helmets should be painted only in bright colours like yellow and orange and their conspicuity further enhanced by use of reflectors and bigger head and tail lamps. Head injury data and helmet analysis quite clearly indicate that though the sides of the head are most vulnerable it is the crown of the helmet which has been designed to provide maximum protection. Even the most expensive Indian helmets have liners which are far too soft especially in the left-right direction. However, our results indicate that even the cheapest helmets available in India do provide some protection. The degree of protection can be improved by helmet liners extending much further down on the sides of the head and with stiffer compression proper-ties. These properties can be optimised given the maximum thickness allowable and for velocities at which maximum protection is needed.

Serious thought should be given to the advisability of retaining the present helmet penetration standard. Helmets also have to be developed with much better side protection without the discomfort perceived by wearers in tropical climates. Some of this work has been initiated and it is possible that lighter helmets with ventilation can be designed [15].

Our studies also show that some riders sustained serious head injuries in falls in single vehicle crashes at estimated velocities as low as 15 km/h. Some of these riders included Sikhs who are exempted from wearing helmets as their religion requires them to wear turbans. Some Sikhs believe that turbans provide some protection but our study showed no evidence of this. MTW use is growing rapidly in lower income countries and safety counter measures specifically suited to local conditions have to be evolved. Our experience in Delhi suggests that conspicuity and better helmet design are the most important issues facing us.

3.3 MTW, mobility and public transport

MTWs have provided a great amount of mobility to the “middle class” of low and middle income countries. MTW occupancy rates are about 1.3 in Delhi, which is not much less than that of a private car [14]. The MTW occupies less than half the space than the smallest car while in motion, takes up less than 20% parking place and because of light weight wears out the road much less. However, because of the high risk associated with use of MTWs – about ten to twenty times greater than the car – it places a high cost on society in terms of death, disability, injuries, cost of treatment and an extraordinary amount of physical and psychological pain and suffering. In this context it is clearly not a sustainable transport option. At present there are no design solutions in sight that might change this scenario significantly.

An unintended consequence of the availability of MTWs has been the competition it provides to public transport. Because of easy accessibility, easy parking, high manoeuvrability and low capital and operating costs, it is a preferred option for travel for short trips (say < 10 km) as compared to any kind of public transport for young and middle age commuters. At present the marginal cost of operating an MTW is less than € 0.02. No public transport option can compete with this at the fare box. This has set a limit on what public transport fares can be in many Asian cities. At best, only bus based efficient public transport systems can compete with this marginal cost of operating a MTW. MTWs have effectively priced out grade separated metro systems from Asian cities both financially and in efficiency and it is unlikely that this situation will change in the future.

4 TWO-WHEELERS – CAPACITY (EXAMPLE FROM HANOI)

4.1 Development of two-wheelers in Hanoi separated into bicycles and motorized two-wheelers (Msc. Ho Anh Cuong)

4.1.1 Status of means of transport and market share participating in traffic

The traffic flow in Hanoi is a mixed traffic flows composed by: vehicle, motorized two-wheelers, bicycles, cycle (three - wheelers). In there, the number of two-wheelers is nearly all.
During recent years, the number of vehicles in Hanoi is increasing considerably, especially motorized two-wheelers (Figure 5). Within 10 years (from 1994 to 2004) the number of Motorized two-wheelers is increased 3.7 times and the number of cars is increased 2.8 times.
Nowadays, using cars rate attains to 41.4 cars/1,000.00 people (in the Asian countries, it attains to 90 cars/1,000 people on average). Meanwhile, there are 412 motorized two-wheelers/1,000 people.

Two-wheelers
The result of investigating from reality of transports in Hanoi area, the primarily is bicycle and motorized two-wheelers. Motorized two-wheelers is the transport which is liked most in the country as a whole, and in Hanoi Capital in particular.
Motorized two-wheeler's advantage is higher speed than one's bus, mobile, initiative of time and convenient moving. The great majority journeys of people in the city are by motorized two-wheelers, in proportion 3/4 traffic people.
Motorized two-wheelers occupy about 65% total means of transports, that mean occupies excess (Figure 6). This is the only case in over the world with a city that has such size.
In the next, the journeys by bicycle, the number of bicycles in Hanoi is about over 1,000,000.00. Although the number of bicycles now decreases but it's very major. In the past, bicycles in formerly occupies very big rate, but now, they occupy about only 22%, and 1/10 people Hanoi still use it (essential pupil, student and old people).
However, maybe on the main corridors, there are a few bicycles. But on the more narrows road, bicycles still appear a lot to satisfy moving demand with short distance or in areas near common schools or universities.

Number means of transport until 09/12/2004
- Many kinds of car: 149,000.00 cars, growth speed ~ 10%/ year.
- Motorized two-wheelers: 1,550,000.00 growth speed ~13%/ year.
- Bicycles: 1,000,000.00, there isn't an increasing tendency.
- Pedi cab (cyclo): > 6,000.00
- Average: (435.00 cars + 4,520.00 motorized two-wheelers)/1km road.

Rate means of transport in Hanoi in last years has many changes as follows: (Figure 5, Figure 6)

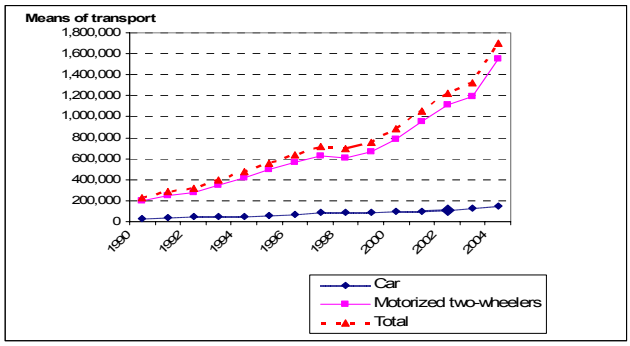

Figure 5: The means of transports development in Hanoi area (1999 – 2003)

Source: The accident management office (People' s Hanoi city committee)

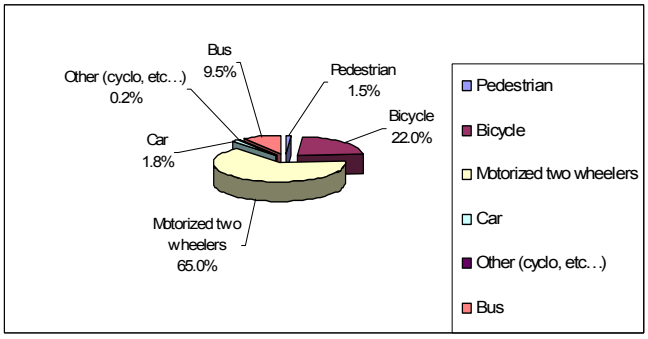

Figure 6: Using transports rate in Hanoi area – 2003

Source: Cuset 2000, compilation Tran 2001 & TUPWS 2003

Figure 7: Proportion of two – wheelers is 87%

Source: Others

4.1.2 Some problem of two-wheelers

a) Two – wheelers user's violation

One of the biggest problems of two-wheelers is user's behaviour. The two-wheeler's user often has bad sense to obey the rule of transport and missing enough attention. We can indicate some general violations:

- Encroach on the lane of vehicle (Figure 8)

- Driving contrariwise (Figure 9)
- Stop and obstruct the lane non-motorized, lane turn right and pedestrians. (Figure 10, Figure 11, Figure 12)

Figure 8: Encroach on the lane of vehicle

Figure 9: Driving contrariwise

Figure 10: Stop and obstruct the lane Non-motorized – “Culture shopping along the road”

Figure 11: Stop and obstruct the lane turn right

Figure 12: Stop and obstruct the lane pedestrians

Figure 13: Carry big goods in the two-wheeler

- “Culture shopping along the road”. It’s a bad habit of Vietnamese people. The habit appeared for many tens years. Especially, since the open of economics, goods is copious, people can buy and sell anything in anywhere. Businesses is on the sidewalk is the best choice. And, nothing to hinder the two-wheelers to stop on the road to sell something. (エラー! 参照元が見つかりません。)
- There are still many phenomena thread one's way of motorized two-wheeler, 3-4 people on one motorized two-wheeler make danger and worry to traffic people.

- Carry big goods in the two-wheeler. This phenomena obstruct not small to the capacity of visibility and movement of other means transport. (Figure 13)

b) It's the main cause of accident

Certain phenomena upper can explain why that the motorized two-wheelers is the main cause of accident (66% ~ 67%) in Hanoi. It's a big challenge to Hanoi in the development of this means of transport.

Theses datas in the part follow will indicate clearly this problem.

4.2 Traffic Accident in Hanoi

Although the situation of traffic accident decreased since 1996, however, the number of accident and fatality are still big.

+ Since 2000, the number of fatalities increased at a rate 21 – 23% per year.
+ In 2003: total 1,331.00 accidents to cause 460.00 fatalities and 1,138.00 injuries.

- The hot-point of accident concentrate on national highway enters in the city or on ring road.
- In Figure 14, during 3 years from 1994 – 1996, the number of traffic accident increased quickly. This number explain the development sudden of means of transport in these years, at once, perhaps, at that time, the statistic of traffic accident had just applied.

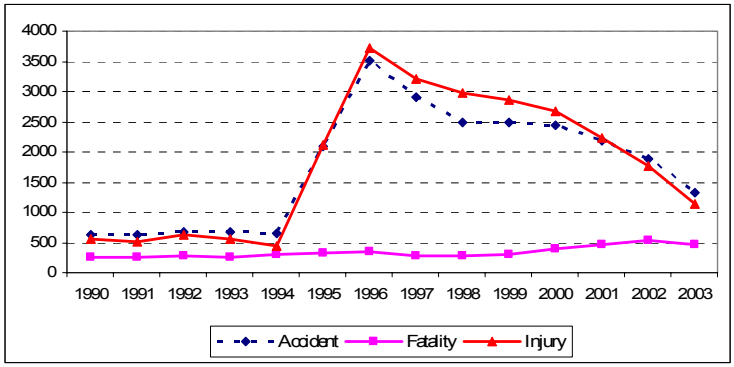

Figure 14: Trend of traffic accident, 1990 – 2003

Source: Evolution Traffic Safety in Hanoi (JICA – 2004)

The analysis of serious traffic accident in the two years 2001 – 2002 (Table 2) indicate that almost 68 % the cause of accident is by motorized two-wheelers.

So, how can we decrease the cause of traffic accident by motorized two-wheelers is one big question to promote the role of this kind of transport?

No	The cause by	Analysis of 2187 TA in 2001	Analysis of 1444 TA in 2002
1	Vehicle	29,4%	31,65%
2	Motorized two - wheelers	67,99%	66,34%
3	Non - Motorized and other	2,61%	2,01%

Table 2: Means of transport make Traffic Accident (TA)

Source: Evolution Traffic Safety in Hanoi (JICA – 2004)

4.3 Traffic capacity

The big volume of traffic

The volume of traffic medium per hour (two ways) is 7,500.00 – 22,000.00 veh/h. It's one of biggest volume of traffic in the world.

In comparison with Lyon city – France (as big as Hanoi), the number maximal of vehicle in the urban corridors is only 7,000.00 veh/h (one way) in the peak hour.

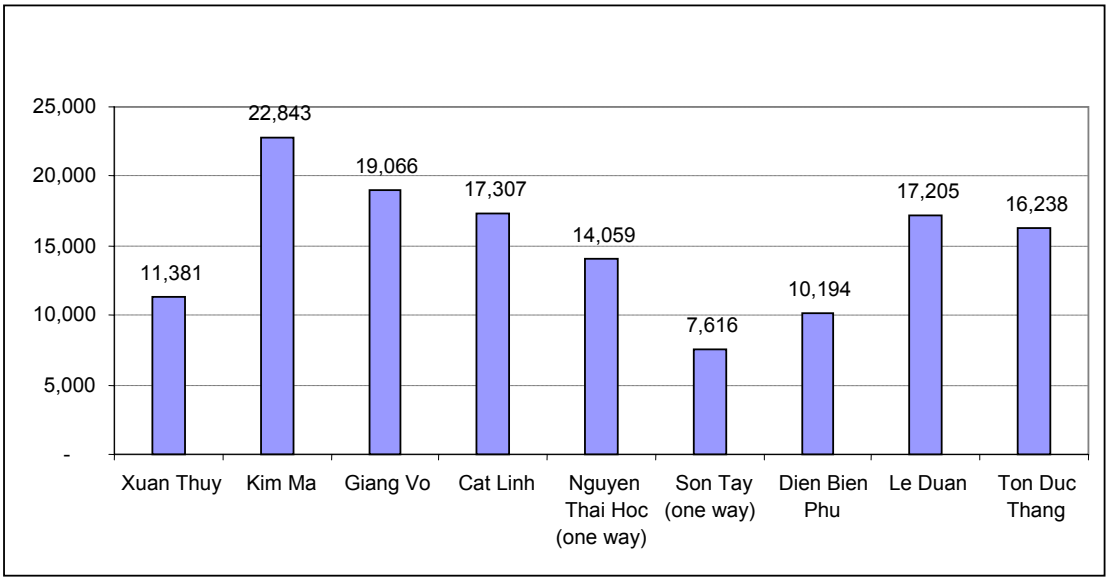

Figure 15: Total Vehicle/hour in 9 corridors (Medium Peak hour morning an afternoon

Also in the study [16], they compared the Passenger Car Unit/hour theoretic (PCU) and the data of which corridors in the campaign.

To estimate the PCU theoretic maximal in which corridors, study base on some characteristic follows:

- Wide of 1 lane = 3m. To determine the wide of lane, they divide the wide of corridors into 3 but not base on the lane mark. Because, the lane divide by lane mark is too big.
- Volume of traffic maximal in one lane = 1,000.00 PCU/hour.

The analysis indicated: Almost PCU real (red colour) upper than PCU theoretic – tab 2.

Also, from the Table 3, we can estimate that, nowadays, the network road even can circulate this real heavy traffic volume which nearly all motorized two-wheelers although the speed traffic it's slows. But, when people change the motorized two-wheelers from vehicle, it's sure that, the traffic will be saturate.

Corridors		**Number lane**	PCU/h theoretic maximal	PCU/h maximal real (peak hour morning or afternoon)	Difference
Xuan Thuy	Outbound suburb	3 lanes	3 000	2135	-29%
	Inbound city	3 lanes	3 000	2415	-20%

Kim Ma	Outbound suburb	3 lanes	3 000	4002	33%
	Inbound city	3 lanes	3 000	5175	73%
Giang Vo	Outbound suburb	3 lanes	3 000	3732	24%
	Inbound city	3 lanes	3 000	3883	29%
Cat Linh	2 ways	2 x 2,5 lanes (no separate lane)	5 000	6065	21%
Nguyen Thai Hoc	1 way	4 lanes	4 000	5454	36%
Son Tay	1 way	2,5 lanes (8m)	2 500	3176	27%
Dien Bien Phu	2 ways	2x2 lanes (no separate lane)	4 000	3379	-16%
Le Duan	2 ways	2x2,5 lanes (no separate lane)	5 000	6188	24%
Ton Duc Thang	Outbound suburb	3 lanes	3 000	2832	-6%
	Inbound city	3 lanes	3 000	2819	-6%

Table 3: Comparison between PCU/h theoretic and PCU /h real

Source: [[16]]

4.4 Conclusion

With the situation existing nowadays, two-wheelers (primary motorized two-wheelers) still and will be the first – good choice of Hanoi people in the next 10-15 years. It's the reality that we must acknowledge. Beside its weakness above, we can not to dent the positive role of motorized two-wheelers in the people's life. If there any change of motorized two-wheelers will influence to almost habitant of Hanoi. And Hanoi learned many lessons from theses unreasonable changes.

Motorized two-wheelers still its considerable role in the economic development in general and development transport planning in particular in there the development of kinds of transport.

The problem we must resolve that restrict the weakness above, and as well as to ensure for motorized two-wheelers a complete infrastructure to promote its positive role for people's life.

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