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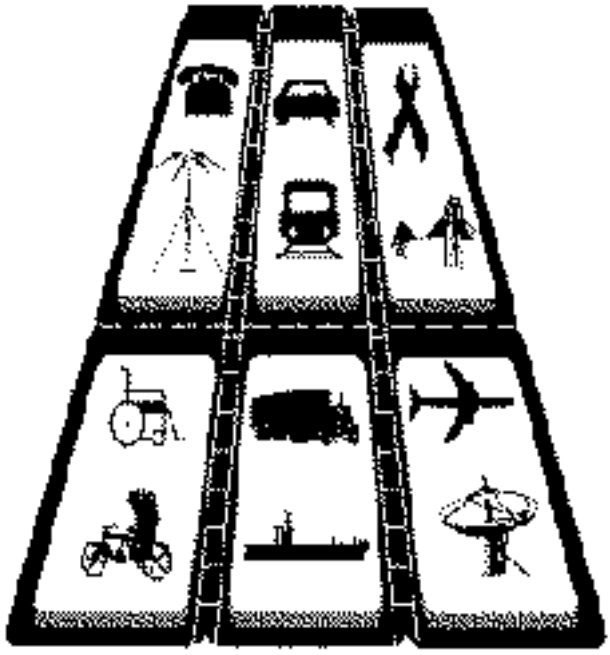

TRANSPORT AND COMMUNICATIONS BULLETIN FOR ASIA AND THE PACIFIC

No. 68

Urban Transport in the Asian and Pacific Region

UNITED NATIONS

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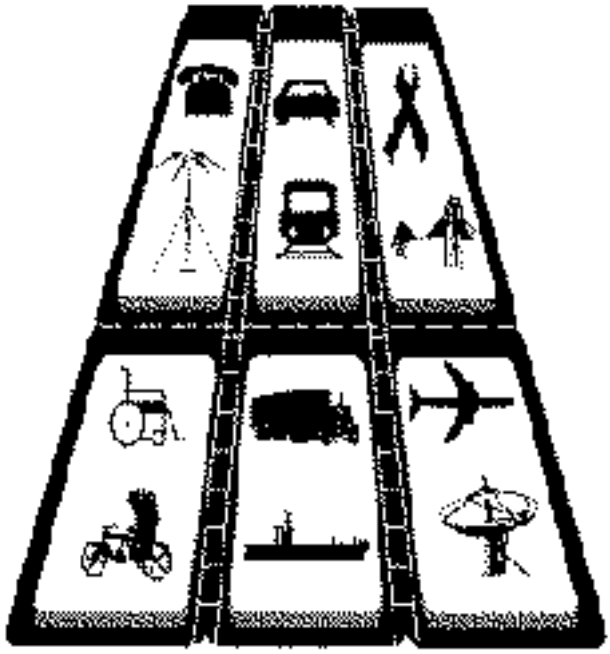

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Editorial Statement

The *Transport and Communications Bulletin for Asia and the Pacific* is a journal published once a year by the Transport, Communications, Tourism and Infrastructure Development Division of the Economic and Social Commission for Asia and the Pacific (ESCAP). The *Bulletin* is intended to provide a medium for the sharing of knowledge, experience, ideas, policy options and information on the development of transport infrastructure and services in the Asian and Pacific region, to stimulate policy-oriented research and to increase awareness of transport policy issues and responses. It is hoped that the *Bulletin* will help to widen and deepen debate on issues of interest and concern in the transport sector.

The current issue of the *Bulletin* (No. 68) has a "new look", which has been adopted with a view to increasing the usefulness of the journal to ESCAP members and associate members, professionals, policy makers, academics and researchers in the Asian and Pacific region. It has been completely reoriented in terms of both content and format, and is intended to contain empirically based, policy-oriented articles, as well as examples of "best practices" in the areas of transport infrastructure and transport services.

Each volume of the *Bulletin* will focus on a particular theme of interest, primarily in the transport sector. The theme chosen for this issue of the *Bulletin* is urban transport in the Asian and Pacific region. Space is limited, but an attempt has been made to select topics that focus on some of the urban transportation issues in the region, such as traffic impact mitigation for new developments, sustainable transport and air pollution. It is hoped that these articles will increase awareness of policy implications and generate further debate.

The editor of the *Bulletin* welcomes analytical articles on topics that are currently at the forefront of transport infrastructure development and services in the region and on policy analysis and best practices. Articles should be based on original research and should have analytical depth. Empirically based articles should emphasize policy implications emerging from the analysis. Book reviews are also welcome.

Manuscripts should be addressed to:

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TRAFFIC IMPACT MITIGATION FOR NEW DEVELOPMENTS: A WAY TO REDUCE TRAFFIC CONGESTION IN MAJOR CITIES

Kazunori Hokao* and Shihana Sulaiha Mohamed**

New developments are one of the major causes of traffic congestion in many of the major cities of developing countries, due to the absence of adequate mitigation measures. The purpose of this paper is to review the various measures that are being taken to mitigate the traffic impact of developments and to make suggestions for the wider and more effective implementation of these measures. The process of traffic impact mitigation in Bangkok is examined in detail, together with two case studies in Bangkok.

Mitigation measures can be divided into two categories: those related to land use and those related to transportation. It was found that measures related to land use were effective in reducing congestion in the area surrounding a development, while traffic-related measures were useful in alleviating site-specific impacts. Both must be implemented by city administrations, developers and traffic consultants, working cooperatively. The present study also shows that in the city centre of Bangkok the ineffective implementation of measures related to land is one of the major causes of traffic congestion. It is recommended that the Bangkok Metropolitan Administration (BMA) should develop more explicit policy tools for mitigating the traffic impact of new developments in Bangkok. Although the procedures used by BMA are not very effective, they can reduce the traffic impact to a certain degree, and similar procedures could therefore be adopted for the same purpose in other cities of the region where laws and regulations are not well formulated. For such action to be effective, it is necessary to incorporate all possible mitigation

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measures into the integrated land-use and transportation planning of the city. Although this has been recognized, and taken account of in the city planning policies of the major cities of many developing countries, as in Bangkok, it has not received sufficient attention. Also, many developing countries have been slow to establish a sound institutional mechanism to incorporate and implement zoning laws or land-use controls for systematic land-use planning. It is hoped that the present study can provide an insight into ways of developing more comprehensive and innovative measures to mitigate the traffic impact of new developments in the major cities of developing countries in the future.

INTRODUCTION

Traffic congestion is reaching intolerable levels in many metropolitan areas in both developed and developing countries. New building developments are considered one of the major causes of congestion-related problems in these cities, owing to inadequate mitigation measures. The purpose of this paper is to review the various measures that are being taken to mitigate the traffic impact of developments and to make suggestions for the wider and more effective implementation of these measures. The roles of the different parties involved in a traffic impact study of a development project are identified, and two case studies conducted in Bangkok are discussed. It is hoped that the present study can provide an insight into ways of developing more comprehensive and innovative measures to mitigate traffic impact of new developments in the major cities of developing countries in the future.

The study is divided into four sections. The first reviews the current traffic impact mitigation process. An analysis of all possible mitigation measures is made in the second, together with an examination of their effectiveness. The measures taken by the Bangkok Metropolitan Administration (BMA) to mitigate the traffic impact of new developments are described in detail in the third section, and two case studies are discussed. Conclusions are drawn in the fourth section, based on the review of the mitigation methods in practice, the theoretical concept of traffic impact mitigation, and the experience of and lessons learned from Bangkok.

I. REVIEW OF THE TRAFFIC IMPACT MITIGATION PROCESS

New developments generate new or additional traffic. Traffic impact mitigation is a process aimed at minimizing the impact of this new or additional traffic on the road system surrounding a new development. The process of traffic impact mitigation is carried out in two major phases: traffic impact assessment and the application of mitigation methodologies. The overall process is a cooperative effort by the developer, city administration and the traffic analyst or consultant.

A. Traffic impact assessment

The traffic impact assessment of a proposed development is undertaken by a traffic analyst who conducts an impact study. The impact study was made a requirement in urban areas in an attempt to control unplanned growth and unmanageable traffic loads. However, a traffic impact study is not required for all developments. A study may be necessary if a new development is expected to generate at least 100 new inbound or outbound trips during the peak period of the day along the peak direction of traffic. This corresponds to developments of substantial size. But in some cases, smaller developments that may create traffic hazards or which are located in traffic-congested areas may also necessitate a traffic impact study. Sometimes, the metropolitan authorities may request a traffic impact study for reasons relating to city planning policies.

The traffic impact study for a new development is undertaken to assess whether the road network surrounding the proposed development will be able to handle the additional traffic while still maintaining an acceptable level of service. The main functions of a traffic impact study are:

(a) To determine the existing traffic conditions on the network surrounding the proposed development;

(b) To estimate the traffic likely to be generated by the proposed development;

(c) To assess the impact of additional traffic on the existing and future road network system;

(d) To identify roadway improvements and changes in the site plan of the proposed development necessary to minimize traffic impact.

A traffic impact study generally contains the following elements:

(a) A description of the proposed development and its access routes;

(b) Details of existing and probable future traffic conditions;

(c) An estimation of the traffic likely to be generated by the development as proposed;

(d) Traffic impact and capacity analysis;

(e) Recommendations on improvements to mitigate the impact;

(f) An assessment of the degree of compliance with city regulations of the proposed development.

The traffic impact study may reveal many traffic-related deficiencies that need to be corrected. In some cases, the deficiencies may be so critical that the design of the project may need to be changed. An impact study may recommend many types of improvements such as additional traffic lanes, pedestrian walkways, making possible U-turns, changes in lighting, and so forth, to minimize the impact of the additional traffic caused by the proposed development.

B. Mitigation methods in practice

Measures for dealing with the traffic impact problem may differ in different situations; various mitigation methods are in use in many major cities. However, these different methodologies have many common elements. Most mitigation measures can be integrated into land-use and transportation system planning, provided proper coordination among state and city administration authorities takes place.

There are a number of technical solutions available, which are used at present to mitigate the traffic impact caused by new developments in urban areas. These include the drawing-up of a master plan, zoning ordinances, building regulations and by-laws, the issuing of permits, and charging impact fees. The common strategies are discussed below.

(a) Land use growth control

In many countries, the government controls the location of developments, often by some form of zoning regulations, in order to slow down or restrict development in urban areas.

(b) Building regulations

Building regulations are applied to regulate the intensity of land use by enforcing standards in building coverage and construction. Some of them are, however, concerned with fire protection and structural safety. These regulations also have an influence on reducing the traffic impact.

(c) Impact fees

Impact fees are the charges assessed against new developments to recover costs incurred by a city administration in providing the public facilities required to serve the new development. These fees are paid by the developer of the proposed development.

(d) Negotiated agreements

Developers lend assistance to transportation projects in the form of rights-of-way, technical assistance, financing and monetary contributions.

(e) Impact exactions

These are charges (land and/or fees) imposed on developers for improvements of the new development as conditions of regulatory approval by the authority.

The strategy of land use regulation (a) is applied to control the types and densities of development while the strategy regarding building control regulations (b) is useful to control the intensity of development and to ensure adherence to building standards. Strategies (c), (d) and (e) represent complementary funding sources for additional roadway facilities and other improvements needed to accommodate the traffic generated by new developments.

C. Responsible parties in the traffic impact mitigation process

There are three main parties involved in the implementation of traffic impact mitigation measures for a new development: the developer, the city administration and the traffic analyst or consultant. The roles of each of these parties vary from locality to locality. Each city administration must deal with traffic impact mitigation measures according to its particular circumstances.

For the efficient implementation of mitigation measures, it is necessary to define clearly the roles and responsibilities of each of these three parties. In general, the state and city authorities responsible are reluctant to bear the expenses of additional infrastructure improvements to facilitate the traffic generated by new developments. Thus, in many cities, impact fees for developments have been established to fund such improvements. In some cases, schemes for the shared funding of network improvements by the public and private sectors have been introduced.

However, in the process of negotiation, both the developer and the city administration or municipality try to reduce their share of the contribution for the improvements. It is therefore the responsibility of the analyst to provide comprehensive and accurate information to work out the fair share of each party. The developers must be willing to contribute in an equitable way to the planning and funding of the transportation improvements required to serve the new traffic generated by developments such as shopping centres, and housing estates.

II. ANALYSIS OF MITIGATION MEASURES

A. Identification of mitigation measures

Transportation and land use are interrelated. In essence, while land use generates traffic, the existence of transport facilities makes some locations more attractive than others for urban development and thus influences land-use development. Therefore, it is recognized that new developments tend to change traffic behaviour as well as land-use patterns. Hence, whatever measure is taken to mitigate traffic impact should address both of these changes.

Mitigation measures can be categorized into two broad groups, land use-related and transportation-related. Again, measures related to land use can be divided into two subgroups namely, land-use planning measures and land-use growth management measures. Similarly, transportation measures can be divided into two subgroups; namely, traffic-related measures and pricing/financial measures. Table 1 shows the classification of the different mitigation methods according to these groupings.

Table 1. Traffic impact mitigation methods for new developments

Land-use measures		*Transportation measures*	
Land-use planning	*Land-use growth management*	*Traffic-related measures*	*Pricing/financial measures*
1. Land-use and transportation coordination 2. Regional and local plans 3. Land-use policy planning 4. Development of analytical tools	1. Zoning regulations 2. Performance zoning 3. Phased development policy 4. Areas of critical planning	1. Improvements within the site: access improvements, internal circulation, parking facilities, demand management, provision of adequate parking arrangements, etc. 2. Road network capacity improvements: intersection, arterial road, and expressway interchange improvements, etc.	1. Impact fees 2. Negotiated development agreements 3. Impact exactions 4. Shared funds 5. Private sector contributions

Measures related to land use are effective at the site selection stage of a development. In other words, the developer should follow the city policy and regulations on land-use management established by the government and city administration in selecting the site for the development. Once a site has been selected, the traffic impact of the development is assessed by conducting a traffic impact study. Based on the findings of the study, transportation measures are recommended to mitigate the traffic impact on the surrounding network. Primarily, these improvements are related to the traffic flow within the site, and may include access locations, internal circulation, parking facilities, and so forth. Pricing measures may also be recommended as a source of funding for additional infrastructure facilities and other improvements that are required on the road network to handle the traffic generated by new developments.

1. Land-use measures

(a) Land-use planning measures

Land-use planning is a very useful tool to guide the development of a city and to attain the desired land-use pattern. The most commonly used planning tools include master plans, strategic/structure plans and local area plans. These plans should be formulated by adopting integrated land-use and transportation planning strategies to address transportation-related issues. Though this is not a new concept, owing to a lack of resources it has not always received sufficient attention. The following are some of the land-use planning measures which are in current use in many countries:

(i) Land-use and transportation coordination;
(ii) Regional and local plans;
(iii) Land-use policy planning;
(iv) Development of analytical tools.

(b) Land-use growth management measures

Land-use growth management measures are intended to control the density of development so that trip generation by different land uses remains within the capacity limits of the existing infrastructure. These measures limit the growth of traffic congestion through controlling the land use by imposing traffic-related conditions for real estate

development. The land-use growth management techniques are particularly important for developing strategies to deal with traffic congestion in urban areas where new developments are likely to take place. These techniques are not aimed at halting new developments, but rather to ensure their location in areas where the impact will not be critical. However, their implementation is often influenced by vested interests.

The following are the most commonly used techniques for land-use growth management in many cities of developed, as well as some developing, countries.

(i) *Land-use zoning regulations*

Zoning regulates the use of land by defining the purposes for which the land can be used and what can be built on that land. Some zoning ordinances apply "bulk" control over land and buildings with the aim of controlling the density of population and the generation of traffic. Zoning regulations are usually passed by local authorities, although in some countries provincial or central governments retain the power to approve zoning regulations;

(ii) *Performance zoning laws*

Performance zoning augments traditional zoning laws by establishing incentives for local developers when they buy land in low density areas, as opposed to restricting land use by traditional density and usage-control measures;

(iii) *Phased development*

This regulates the timing of and geographical distribution of development by tying it to existing municipal infrastructure and services. Each project can be ranked based on its proximity to other facilities such as public transportation, retail services and utilities. The permission for development is granted based on the ranking of the projects, with an annual limit on commercial development permits;

(iv) *Areas of critical planning*

This is an attempt to protect mainly coastal areas and other unsafe land. Critical area programmes are comprehensive, combining many different techniques to determine the impact of a prospective development. The goal of critical area planning is to strike a balance between development pressure and resource conservation.

2. Transportation measures

(a) Traffic-related measures

(i) *Improvements within the site*

The main improvement measures that can facilitate the smooth flow of traffic within a project site are discussed below.

a. *Access improvements*

These improvements facilitate the traffic flow entering or leaving a site. Potential improvements may include the widening of entrance and exit points, and providing bays (exclusive lanes) for turning movements. Queues should not impede either internal circulation or out-of-site movements. Exit and entrance lanes should have sufficient storage capacity to ensure that the performance and safety of operations are not compromised.

b. *Internal circulation improvements*

These measures facilitate the traffic flow within the site. Proper pavement markings must be made and signs put in place to ensure the safety of operations. The radii of curves should be sufficient to accommodate the turning of large vehicles, while bridges and other landscaping elements should be able to withstand the stress from heavy vehicles. Loading and unloading ramps should also be carefully designed: they should be practical, spacious and, if possible, concealed from public view, to enhance aesthetics.

c. *Demand management methods*

Demand management measures are applied to reduce the number of vehicles using the road network to go to the site and using its internal network and parking space. Cooperation with the transit authority for the rerouting of buses to pass by the site, and programmes for matching commuters, as well as incentives for ride sharing (for example, bonuses, free parking, special permission to park closer to the entrance, and so forth), have good potential for reducing the number of on-site vehicles.

d. *Adequate parking arrangements*

These can reduce conflict points within the site and also reduce the accumulation of vehicles at access points. The provision of adequate signs is valuable in managing vehicles in the parking area. Parking layouts should allow sufficient space for the manoeuvring of heavy vehicles, and vertical clearances should be sufficient for over-sized vehicles.

(ii) *Road network capacity improvements*

Various measures for improving the capacity of an existing road network can be adopted. The major ones are discussed here.

a. *Intersection improvements*

Intersection operation may be improved by redesigning signal phasing, cycle length, coordination of timings, an so forth. In some cases the intersection geometry could be changed by including additional lanes, widening, shifting central reservation, and so forth. When the addition of lanes is not feasible, an underpass or overpass could be constructed to reduce the traffic at the intersection close to the development. Also, the installation of traffic signals at intersections not previously provided with them may be required to handle the additional traffic generated by the site.

b. *Arterial road improvements*

These include the provision of pedestrian crossings, making U-turns possible, providing walkways and other supplementary facilities. In addition, arterial roads would have to be equipped with proper traffic signs and lane markings to guide drivers.

c. *Expressway interchange improvements*

If the site is close to an expressway facility, new access ramps may be introduced or existing ramps improved, together with proper channelization in the merging and weaving areas.

(b) *Pricing/financial measures*

Roadway infrastructure improvements are costly and therefore many municipalities and city administrations are not in a position to fund infrastructure improvements to facilitate the traffic generated by new developments. Thus, in many cities, pricing/financial measures have been introduced to levy charges to cover the costs of such improvements. Some of the pricing/financial measures in use are described below:

(i) *Impact fees*

These are charges paid by developers to cover the additional cost of capital improvements required by new developments. In many cities this is a prerequisite for obtaining a permit for a new development;

(ii) *Negotiated development agreements*

Cooperative agreements for infrastructure provision have been made between developers and local authorities or communities. In contrast to impact fees, negotiated agreements are made on a case-by-case basis, giving the developer and the city authority an opportunity to determine the acceptable level of cost-sharing for the required physical improvement measures. This approach is increasing in popularity, as it provides an alternative to the more traditional regulatory approach of zoning laws;

(iii) Impact exactions

Impact exactions are charges (land and/or fees) imposed on developers for public improvements made necessary by new developments as a condition for regulatory approval of the development. They can be in the form of obliging the developer to purchase the land required for improvements, or to bear the cost of construction for necessary improvements. Authorities may also require developers to install, at their own expense, improvements such as pedestrian crossings, streets, transit/bus stops, pavements, kerbs and gutters, and other physical elements;

(iv) Shared fundings

Network improvements are funded through schemes of shared funding from public and private sector contributions;

(v) Private sector contributions

In some cases, voluntary donations or contributions to improve the road network system are made by the private sector.

B. Evaluation of mitigation measures

The mitigation measures described in the previous section are regarded as a set of actions that may be employed to achieve some or all of the following policy objectives:

1. Reduction of congestion;
2. Reduction of points of conflict at access points;
3. Achievement of a smooth flow of traffic within the site;
4. Control of unmanageable traffic loads;
5. Improvement in the level of service of the road network;
6. Improvement of road safety;
7. Reduction of environmental degradation;
8. Improvement of quality of life for residents, pedestrians and visitors.

Although there are other areas of concern, these eight objectives are the major ones. The effectiveness of the policy instruments discussed in the previous section are now examined against each of these policy objectives. The evaluation outcomes are tabulated in table 2. The results

are based on the general understanding of each concept and therefore the findings are illustrative rather than definitive.

It was found that the measures related to land use are useful in achieving objectives such as congestion reduction, control of environmental degradation and for achieving better quality of life. On the other hand, transportation related measures were more effective in improving conditions at the project site and in the surrounding areas, and in reducing the traffic impact. It was observed that the role of land use measures in relieving congestion and in revitalizing urban areas is very important. Since transportation measures can solve only a part of the problem, it is vital that city authorities consider land-use measures during the process of policy planning.

A review of the literature reveals that recently in many cities, rather than relying on traditional transportation measures, land-use management measures have been seriously considered to reduce congestion. Wachs (1990) describes the experience of Southern California in regulating traffic by controlling land use. He mentions that in Los Angeles the emphasis in transportation planning shifted from facility construction to transportation system management, and land-use was controlled with a view to slowing down the growth of traffic congestion. Two major policy instruments, direct land-use regulation and impact exaction, were also under consideration to reduce the traffic congestion caused by new developments rather than relying on improvements to highways and transit facilities.

The importance of a regional perspective is stressed by Meyer (1990) in the context of traffic congestion in the state of Massachusetts, United States of America. He observes that many of the transportation and land-use measures were focused on a specific site or at most a part of the metropolitan area. He argues that congestion in many cases was an area-wide phenomenon that required consideration from a regional perspective. A ten-point congestion relief programme was developed for eastern Massachusetts. The actions included in this programme were aimed at reducing the existing level of congestion and avoiding future congestion through land-use management. He highlights the vital role of land-use management in regulating the location, geographic pattern, density, quality and rate of growth of development.

Table 2. Evaluation of traffic impact mitigation methods: relationship between policy instruments and policy objectives

Policy instruments	*Policy objectives*							
	Reduction of congestion	*Reduction of points of conflict at access point*	*Achievement of a smooth flow of traffic*	*Control of unmanageable traffic loads*	*Improvement in the level of service of the road network*	*Improvement of road safety*	*Reduction of environmental degradation*	*Improvement of quality of life*
Land-use measures								
Land-use Planning	A	C	C	B	B	B	A	A
Land-use growth management	A	C	C	B	B	B	A	A
Transportation measures								
Traffic-related								
1. Improvements within the site	C	B	A	A	C	C	C	C
2. Road network capacity improvements	B	B	B	B	A	A	C	C
Pricing/financial	C	A	B	B	A	C	B	C

Note: A: very strong positive relationship B: strong positive relationship C: weak positive relationship

III. TRAFFIC IMPACT MITIGATION PROCESS IN BANGKOK

A. Land-use measures

1. Land-use planning and regulation in Thailand

The process of development planning in Thailand is directed towards the formulation and implementation of five-year national development plans. The national socio-economic development plans for the country are prepared by the National Economic and Social Development Board. The main urban land-use policies in the Seventh National Economic and Social Development Plan for the period 1992 to 1996 were concerned with: land-use planning and its administration; the revision of laws and regulations; the formulation of appropriate general and specific plans for target development areas; a spatial development framework and basic infrastructure; the conservation and preservation of historical sites; the defining of industrial zones; and environmental protection (Mekvichai 1998).

The Eighth National Economic and Social Development Plan for the period 1997 to 2001 is currently being implemented. There has been no fundamental change from the previous plan. The policies in this plan include the following areas related to urban land-use planning: the development of the Bangkok Metropolitan Region; traffic problems in the Bangkok Metropolitan Area (BMA); guidelines for efficient land-use planning; environmental problems and environmental conservation; the designation of cultural preservation areas and green belt areas; and the coordination of the public and private sectors in organizing and managing urban planning (Association of Southeast Asian Nations (ASEAN), Association for Planning and Housing (AAPH) 1999).

The rapid growth of Thailand's urban settlements has led to uncontrolled urban sprawl and contributed to many environmental, social and economic problems. The Government realized the need to regulate land-use and the quality of development. The regulatory tasks can be categorized into three groups:

(a) Land-use planning

The Department of Town and Country Planning (DTCP) under the Ministry of the Interior and Local Government is responsible for urban and community land-use planning. This is carried out through the offices of the mayors in the cities, the presidents of sanitary district councils, and provincial governors for all other areas;

(b) Building construction and use controls

The Department of Public Works and Local Government approves and oversees building construction and use;

(c) Land subdivision controls

The Department of Land is the sole authority responsible for approving and overseeing land subdivisions for housing, commercial areas, and industrial projects (Mekvichai 1998).

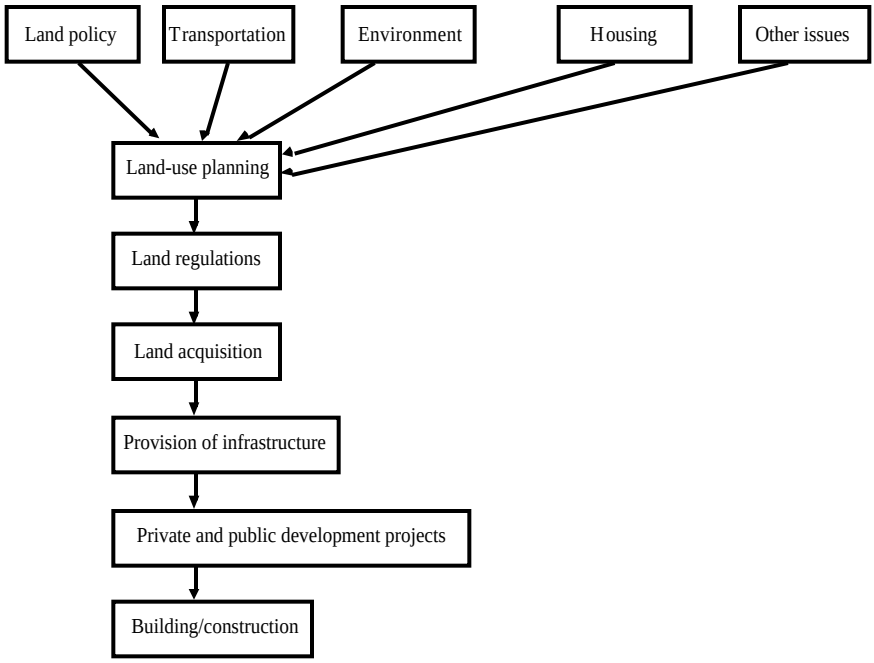
For useful and effective land-use planning, all land development projects by the public and private sectors at all levels are supposed to follow the framework illustrated in figure 1. However, the various agencies involved in urban land development and related works carry out their works within their own areas of responsibility. Coordination among these agencies is weak, in particular with respect to project implementation. Figure 2 describes the actual process of land development in Thailand.

Thailand has a number of Acts related to land development and control. These are briefly describe in the following sections.

(a) Town and Country Planning Act of 1975

The Town and Country Planning Act of 1975 repealed the earlier City and Town Planning Act of 1952. This Act deals with the following main aspects: the city and local city planning committee; the survey for the comprehensive city plan and the project plan; the formulation and preparation of the comprehensive plan; the enforcement of the comprehensive plan; the enforcement of the project plan; and modifications to buildings.

The planning procedures established under the Town and Country Planning Act of 1975 were amended in 1992 to include a democratic



Source: B. Mekvichai, "A review of urban land management in Thailand", in J.H. Ansari and N.V. Einsiedel, eds., *Urban Land Management: Improving Policies and Practices in Developing Countries of Asia (*United Nations Centre for Human Settlements, Nairobi, 1998).

Figure 1. Formal procedure of land development through land-use planning in Thailand

process involving the participation of local residents. Under this Act, the plans are prepared by officials of DTCP with the assistance of concerned local government officials. DTCP has greater responsibility in formulating the plans, but has no control over their implementation. Local authorities have sole responsibility for plan implementation.

(b) Land Development Act of 1992

The stipulations of the Land Development Act of 1992 were set by the Land Development Control Board, in accordance with the provisions of Announcement No. 286 of the Revolutionary Council of 24 November 1972. This Act provides the necessary specifications in the following areas: the criteria for making land development diagrams,

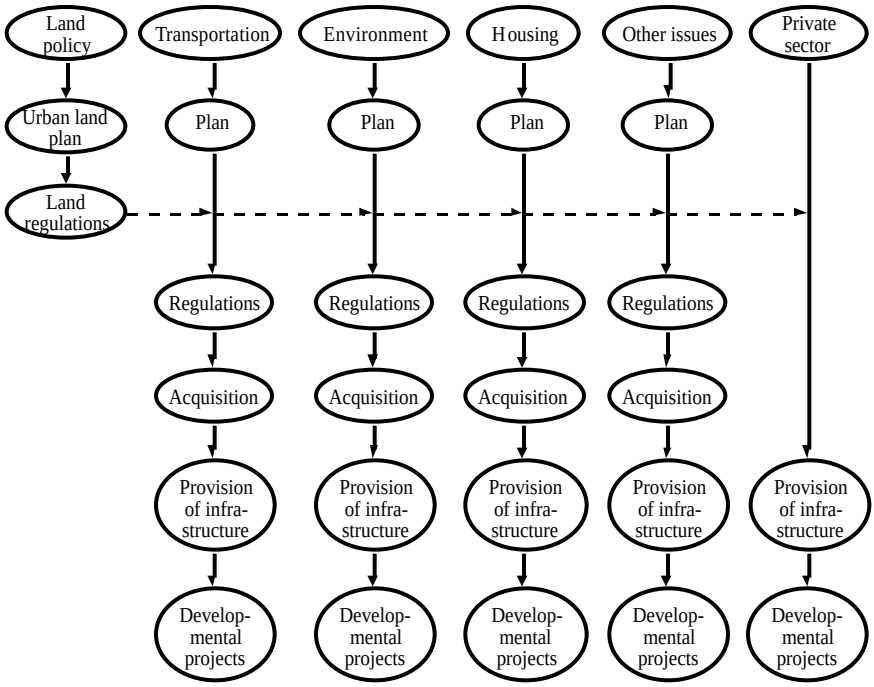


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Figure 2. Actual procedure of land development in Thailand

projects and methods; the size and area of development land; systems and standards of roads and footpaths; the size of buildings including commercial buildings; road, pavement, access/exit road and footpath standards and dimensions; the size of areas to be left undeveloped in front of buildings; recreational areas in the development; the distances from roads to buildings; the improvements in main roads required; water discharge systems and waste water treatment systems; electrical systems, waterworks systems, telephone systems; standards for infrastructure and public services; and traffic signs and markings.

(c) Building Control Act of 1992

This Act replaced the provisions of the Building Control Act of 1979. The Building Control Act of 1992 is concerned with building regulations and the procedures for obtaining a building permit. The specific aspects covered are: building permit application procedures; distances from buildings to other buildings, lands, roads and footpaths; the procedures for the construction of, modifications to, the demolition of, the moving or transfer of any type of building; the appeals Consideration Committee in the Bangkok Metropolitan Area and in the provinces; and penalties and fines.

Further to the provisions contained in this Act, Ministerial Regulation No. 39, issued in 1994, explains the requirements on types of, and procedures for installation of, fire prevention systems, the design of interior elements, and lighting and ventilation systems. Ministerial Regulation No. 41, issued in 1995, provides specifications on parking areas and parking unit dimensions in buildings.

(d) Enhancement and Conservation of National Environmental Quality Act of 1992

This Act was passed following the review of the Improvement and Conservation of National Environmental Quality Act of 1975 and its 1978 amendment. The Act provides guidelines on the following areas: the environmental fund; environmental standards; environmental quality management planning; environmental conservation and protection areas; the preparation of reports on environmental impact assessment; and the control of pollutants.

2. Land-use measures in Bangkok

Land-use plans are made to improve the environment for the community, to build a city where the quality of life of its residents is satisfactory, and to provide good living conditions for them, including adequate housing, public spaces and other facilities. With these objectives in view, BMA has prepared its fifth development plan for the period 1997-2001, with the goal of making Bangkok a "pleasant city to live in". The fifth BMA development plan is based on the following: the Eighth National Economic and Social Development Plan (1997-2001); the Sixth Ministry of Interior Plan (1997-2001); the report on the evaluation of the fourth BMA development plan (1992-1996);

suggestions and recommendations from agencies under the supervision of the BMA; and public needs and public opinion.

The Fifth Plan has the following major components: a plan for urban system and land-use development; a plan for traffic and transportation system development; and a plan for an environmental management system.

Although the plan for Bangkok incorporates the zoning of allowable types of land use, enforcement is inconsistent. Planning tools did not appear to be effective in the areas of control, and limitation of the scale or location of development projects, and consequently failed to limit the traffic and environmental impacts of new development projects. The failure to control development has led to the uncontrolled growth of commercial developments in the city centre. As a result, these developments have caused additional traffic loads on the already saturated traffic syestem, with a further deterioration in the traffic congestion situation in these areas.

B. Transportation measures

1. Traffic-related measures

A report on the traffic impact study undertaken has to be submitted to BMA in connection with the approval of new commercial developments that are expected to cause traffic-related problems. The levels of generated traffic and the size and type of developments that require a traffic impact study are not however, clearly specified. Nor are guidelines given for the preparation of these reports. The traffic impact study is initiated by the Building Control Division under the Department of Public Works of BMA.

All buildings, including commercial developments, have to follow all relevant specifications given in the building and other relevant codes, established by the Building Control Division (BCD) of BMA, in their planning and design procedures. These codes were prepared in accordance with the Building Control Act of 1979, the Town and Country planning Act of 1975, and with reference to the Land Development Act of 1992. The project plans, design details and drawings prepared in accordance with the given specifications are submitted to BMA with the request for permission to proceed with construction. Developments

designed with more than 300 parking units in their parking areas are then forwarded to the Traffic Engineering Division (TED) under the Department of Traffic and Transportation of BMA for the assessment of the traffic impact and the access capacity of the proposed development. Such developments are required to conduct a detailed traffic impact study.

The required traffic impact study is normally conducted by a traffic consultant/analyst on behalf of the developer. According to the recommendations made by the traffic analyst/consultant, the TED of BMA assists the developer in selecting the appropriate infrastructure improvements needed for the road network to carry the additional traffic generated by the development. BMA emphasizes the following mitigation measures for developments along major roads:

(a) Number of access points limited to two along major roads to reduce conflict points;

(b) Pedestrian walkways;

(c) U-turn facilities for in-and-out traffic;

(d) Channelization measures for traffic along main roads;

(e) Areas for taxi drop-off and pick-up;

(f) Sufficient pavement areas for pedestrian use;

(g) Slip lanes and short lanes for in-and-out traffic.

Apart from these, TED can also instruct the developer to adjust the size of access roads, levels, slopes, turning points, parking, U-turn areas and any other elements that may facilitate traffic flow, stability, security, aesthetics, discipline or urban planning. When TED comes to an agreement with the developer on the improvements required to mitigate the traffic impact of the development, it reports back to BCD to proceed with the required approval procedures. This process of traffic impact mitigation for new developments is shown in figure 3. Since there are no established BMA rules for traffic impact mitigation, factors such as the influence of the developer, social factors, and political factors can affect this assessment process directly or indirectly. Nevertheless, in the absence of any guidelines or regulations BMA tries to implement mitigation measures by negotiation with developers.

Detailed traffic impact studies are generally required for the following types of new development in Bangkok:

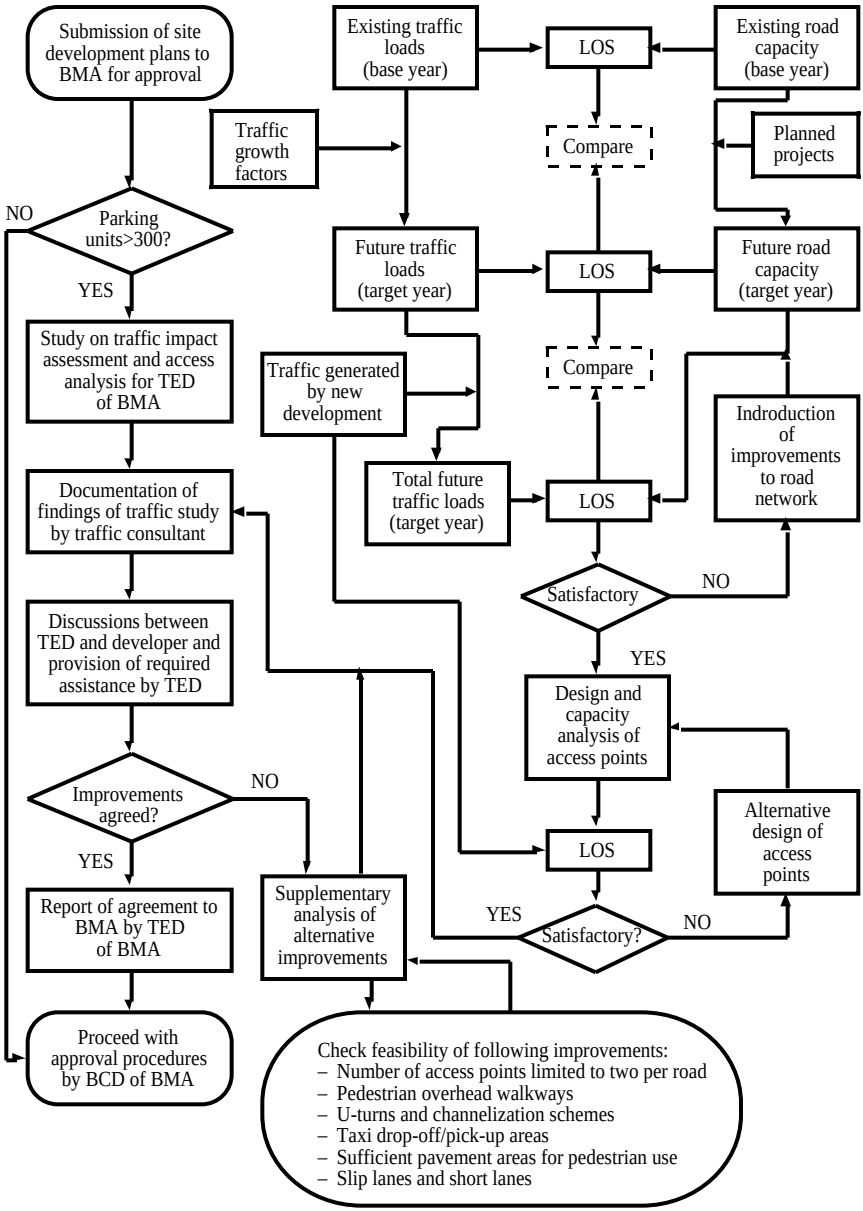

Figure 3. Process of traffic impact mitigation for new developments in Bangkok

(a) All public transportation projects;

(b) All developments located in traffic-sensitive areas and historically important areas;

(c) All developments located close to critical junctions, intersections and interchanges;

(d) High-rise buildings which are expected to generate considerable traffic.

2. Pricing/financial measures

The city planning policy of BMA does not incorporate any pricing/financial measures to be imposed on developers. However, BMA requests developers to bear the total cost of the agreed infrastructure improvements to support the additional traffic generated by new developments. This arrangement is somewhere between a negotiated agreement and an impact exaction, but cannot be classified as either. Once BMA and a developer come to an agreement about cost sharing, the permit for the proposed development is issued under the agreed conditions.

C. Case studies in Bangkok

1. Outline of case studies

A brief outline of two case studies conducted in Bangkok are given below, together with their recommended traffic impact mitigation measures.

(a) The case study 1 – shopping centre A

Proposed shopping centre A is to be located within the BMA area. The project site is a triangular plot in a critical location, with a highway, a railway line and a residential area as boundaries. The highway in front of the site has a flyover above the railway crossing together with an at-grade U-turn. The development was designed with a single access point, which was very narrow as land space was limited at that point.

An impact area around the development, including all critical road sections and intersections, was selected for traffic impact assessment. This selection was primarily based on the level of service

(LOS) of the road network system. Thus, an impact area with road sections with low LOS reflected by higher traffic loads, and intersections with long delays and queues were selected.

A traffic impact study was conducted in compliance with the requirement of the policy of BMA for the approval of new developments. Traffic impact analysis indicated that traffic growth due to the development in the target year (4 years from the base year) would be around 3 per cent. The acceptable limit of traffic growth due to the development was assumed to be 5 per cent of the total traffic forecast for the road network in the target year. It was expected that the forecast additional traffic due to the development could be supported by the increased capacity of the road network resulting from the implementation of committed highway projects.

It was thus concluded that shopping centre A would not have any serious adverse impact on the road network.

However, the following improvements were recommended in the traffic impact study for the management of traffic at the access point to the shopping centre with proper turning facilities, in order to reduce conflicts and allow the smooth flow of traffic along the major highway in front of the shopping centre:

(i) Improvements within the site:

   a. Access improvement with a 40 m slip lane for incoming traffic;

   b. An additional lane for outgoing traffic with a merging length of 50 m;

   c. Internal circulation arrangements and a parking area.

(ii) Road network capacity improvements:

   d. An additional lane for a planned U-turn facility and related other improvements;

   e. Channelization schemes for the U-turn facility.

The developer was requested by BMA to acquire land from the State Railway Authority and the other private owners for improvements (a) and (b). Also, the construction costs of improvement (d) had to be

borne by the developer. After a number of meetings between the developer and BMA, it was decided that BMA would grant approval on condition that the developer should buy the land required for the above improvements and bear the related construction costs of infrastructure improvements.

(b) Case study 2 – convention centre B

Proposed convention centre B is also located within the BMA area, but away from the central business district. At present, the road network adjacent to the project area is composed of minor feeder roads. However, there are a number of committed projects in the project area which are at the planning stage. Among them are a highway project and an expressway project planned along one side of the proposed convention centre.

There are four access points designed for the development: one is to the east and a second to the west of the proposed highway; the two others are connected to minor roads. The location planned for a ramp to the new expressway project was very close to the west entrance, which could cause conflicts in the future.

Traffic impact analysis indicated that convention centre B would not have an adverse impact on the traffic flow along the highway network. The growth of traffic along the proposed highway due to the development was estimated to be within the acceptable levels. It was believed that the implementation of future highway projects would enable the additional traffic generated by the convention centre to be accommodated by the system.

Considering the site location, the availability of space and the major corridor traffic and capacity, the following two types of facility improvements were recommended to improve future traffic conditions on the proposed highway. These improvements were also considered to be generally beneficial.

(i) Improvements within the site:

a. Access improvement with a 3 m wide and 30 m long slip lane for incoming traffic;

b. An additional slip lane of 30 m length and 3 m width for outgoing traffic;

c. Internal circulation arrangements and a parking area.

(ii) Road network capacity improvements:

d. Improvement of adjacent intersections;

e. Channelization schemes for the U-turn facility.

It was agreed that the additional costs of these infrastructure facilities were to be borne by the developer. A number of meetings took place between BMA, the developer, the traffic consultant and officials from the Expressway and Transit Authority of Thailand (ETA), at which the location of the ramp and the improvement measures required to reduce conflict at access points to the development were discussed. Finally, ETA agreed to relocate the ramp further away from the development in order to reduce conflicts at the access points and at the ramp entrance.

2. Analysis of case studies: evaluation and suggestions

The above case studies were analysed using the method of evaluation of policy instruments and policy objectives described in Section 3, and the results are summarized below.

(a) Analysis of case study 1

(i) Since the location of proposed shopping centre A was critical, the impact on the adjacent road network was likely to be significant. If land-use measures had been being enforced a location such as this, for this type of development, would have been an unlikely choice. This case clearly illustrates the need for coordination between land-use and transportation planning. Due to the lack of strict regulations, financially viable developers can choose any location in Bangkok for their developments. These are consequently springing up all over the city and have become one of the major causes of severe traffic congestion both there and in the adjacent urban areas. If proper land-use planning had been used, such a situation could have been avoided.

(ii) The access point to the site was very narrow as planned, which would have caused incoming traffic congestion, spreading back to the road network. Improvements within the site, together with an additional lane for U-turns, could help to relieve the queuing. A thorough understanding between BMA and the developer is crucial to the proper planning of the negotiated improvements.

(iii) An additional lane would help in the smooth merging of outgoing traffic with external traffic. However, the acquisition of the land required for this from private owners could be costly and time-consuming, if indeed private owners could be persuaded to sell. If BMA had had strict written regulations on new developments, the developer may never have purchased the site for this kind of development.

(b) Analysis of case study 2

(i) In the case of convention centre B, one of the access points to the development was designed in such a way that it was too close to the planned ramp to the new expressway. Negotiations with ETA resulted in the location planned for the ramp being changed, rather than the access point to the development. This illustrates the willingness of the authorities to change the designs of major road projects, rather than force developers to alter their plans by implementing strict laws on developments.

(ii) Since the proposed convention centre was to be located away from the central business district, it was likely to attract extra traffic to the planned expressway and generate revenue for ETA by way of toll charges. Due to the unique characteristics of this development, it was expected that traffic would be attracted from all over the metropolitan area and congestion was not anticipated in any one area, nor at specific access points to the development. The measures proposed for easing pressure at access points were therefore believed to be sufficient to counteract the adverse impact of the development on the proposed highway.

3. Summary of analysis of case studies

Table 3 summarizes the mitigation measures proposed in the above case studies. It is clear that due to the lack of land-use measures the following problems are likely to arise in the project area and surrounding areas:

Table 3. Summary of traffic impact mitigation measures proposed in case studies

		Case study	
		Shopping centre A	*Convention centre B*
Land-use measures	Land-use planning measures	–	–
	Land-use growth management measures	–	–
Transportation measures	Traffic-related measures	1. Improvements within the site: (a) access improvements; (b)internal circulation arrangements; (c) parking facilities. 2. Road network capacity improvements: (a) additional lane for U-turns; (b)addition of short lanes; (c) channelization schemes for U-turn facility.	1. Improvements within the site: (a) access improvements; (b) internal circulation arrangements; (c) parking facilities. 2. Road network capacity improvements: (a) intersection improvements; (b) U-turns to proposed highway; (c) channelization schemes for U-turn facility.
	Pricing/financial measures	1. Impact exactions 2. Acquisition of required land 3. Bearing of costs of improvements	1. Impact exactions 2. Acquisition of required land 3. Bearing of costs of improvements

(a) Problems of traffic congestion;

(b) An unsatisfactory level of service provided by the road network;

(c) Environmental problems; and

(d) Adverse effects on the quality of life of the local community.

These problems will definitely aggravate the present situation in BMA further. It has been estimated that in 1995 traffic congestion in Bangkok led to the loss of 91,461 billion baht (Tangpaisankit 1998), despite investment by the Government of 1 billion baht in the construction of expressways and main roads during the period of the seventh National Economic and Social Development Plan (1992-1996). It is clear that in focusing on the supply side alone, the problem of the uncontrolled growth of developments has been overlooked. The importance of land-use measures has been ignored in master plans and regional plans, yet in a major city such as Bangkok, transportation measures alone can provide only short-term solutions. Sustainable improvements can only be achieved through long-term land-use planning.

IV. CONCLUSIONS AND RECOMMENDATIONS

This study has shown that land-use measures are effective in reducing congestion in the area surrounding a development, while traffic-related measures are useful for alleviating site-specific impacts. In other words, land-use measures are important for relieving congestion, and they serve to revitalize urban areas, whereas transportation measures can only partially solve the problem. It is essential to incorporate land-use measures in the process of traffic impact mitigation for new developments in major cities. It was noted that for impact mitigation to be effective, land-use measures should be used at the start of the mitigation process, while transportation measures should be introduced at a later stage, when the site plans are finalized. Both types of measure need to be implemented, as they are complementary.

This study has also shown that ineffective implementation of land-use measures is one of the major causes of traffic congestion in the city centre of Bangkok. The uncontrolled growth of commercial developments negatively affects the quality of city life and aggravates environmental and safety problems. In Bangkok attention has always focused on the supply of roads and road infrastructure and the management of demand to alleviate the traffic congestion problem. It is important to understand that new developments are major contributors to the traffic congestion problem. BMA needs to develop more explicit

policy tools to mitigate the traffic impact of new developments in Bangkok. This could be done by looking at the traffic levels of the road network system in the city area and identifying sensitive areas which require attention. Also, guidelines and specifications on the level of generated traffic and the size and type of developments that require a traffic impact study should be provided.

The procedures for the mitigation of the traffic impact of new developments used by BMA are based on the provisions of the Building Control and Land Development Act of 1992. Although they are not very effective, they can reduce the traffic impact to a certain degree, and similar procedures could therefore be adopted for the same purpose in other cities of the region where laws and regulations are not well formulated.

For such action to be effective, it is necessary to incorporate all possible mitigation measures into integrated land-use and transportation planning. Although this has been recognized, and taken account of in the city planning policies of the major cities of many developing countries, as in Bangkok, it has not received sufficient attention. The relationship between traffic and land use has been incorporated into the regional and city transportation planning models in many cities, but seldom applied to local development projects. Moreover, many developing countries have been slow to establish a sound institutional mechanism to incorporate and implement zoning laws or land-use controls as part of a systematic land-use planning process.

More effort needs to be devoted to developing analytical tools which will permit the detailed evaluation of alternative methods of mitigating the traffic impact of new developments. More project-level case studies are needed, to examine the effects of traffic impact mitigation methods. This will require major research initiatives in the future.

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A "STEP" TOWARDS SUSTAINABLE TRANSPORT: A CASE STUDY OF PENANG, MALAYSIA

Ganesh Rasagam*

Ownership of cars and motorcycles in the state of Penang, Malaysia, is increasing at average rates of 9.5 per cent and 7.2 per cent a year, respectively. The total number of private vehicles registered in the state doubled between 1985 and 1995. This has resulted in urban traffic congestion, with increased delays and travel times, higher rates of injury and death from traffic accidents, as well as environmental degradation.

While the rapid increase in vehicular traffic is usually attributed to economic growth and urbanization, in this case it is because current transportation policy and investment in transportation projects are disproportionately skewed towards meeting unabated demand for road space. The needs and concerns of pedestrians, cyclists and bus users are seldom, if at all, taken into consideration in national and state transportation policies and plans.

The transportation requirements of mobility-impaired and vulnerable groups such as people with disabilities and the elderly, as well as vulnerable groups such as children and the poor, are almost always neglected when transportation planning is undertaken and investments are made.

Sustainable Transport Environment in Penang (STEP) was established in 1998 by a group of concerned citizens and voluntary groups in Penang, with the primary aim of addressing the concerns and advocating the interests of pedestrians, cyclists, public transport users and mobility-impaired groups.

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This paper provides a brief discussion of the transportation issues in Penang and highlights concerns such as the environmental impact of road traffic, with emphasis on vehicular traffic-generated noise and air pollution.

The paper then proceeds to describe the formation and the various initiatives of STEP, following its participation in the Sustainable Penang Initiative (SPI). Successful lobbying initiatives, such as improvements to a major bus terminal in Georgetown, Penang, and the efforts of the group known as Sustainability, Independence, Livelihood, Access (SILA) are also mentioned.

The paper also discusses the advocacy experience of STEP and the issues for the future.

INTRODUCTION

The planning and provision of transportation infrastructure for urban travel in the state of Penang has been largely oriented towards the needs of private car users. National transportation policies and state development priorities have consistently been geared towards meeting the ever-increasing demand for road and parking space by private vehicles, while public transportation and non-motorized land transport modes have been largely neglected.

Also the government has targeted the motor vehicle industry as a key economic growth sector and has actively promoted private car ownership and use by making a range of Malaysian-assembled cars affordable and readily available. Coinciding with the period of rapid economic growth and increasing affluence over the past 10 years, private vehicle ownership and use has almost doubled in the state.

This trend has resulted in a situation where, due to the limited availability, capacity and quality of public transport facilities in Penang and the current pattern of land use and town planning, people have little choice but to own and use their own motor vehicles. At the same time, facilities and services for bus- and taxi-users, pedestrians and cyclists are mostly inadequate, while traditional modes of transport in Penang such as the trishaw and the ferry are rapidly declining in significance.

It is therefore hardly surprising that traffic congestion has worsened in the major urban centres such as Georgetown, Bayan Baru, Butterworth and Bukit Mertajam and has become a major social and political issue in the state. However, the problem is usually perceived in terms of the delays and inconvenience faced by motorists, rather than as a problem of accessibility and mobility for the entire population. The needs and concerns of pedestrians, cyclists, the mobility-impaired and captive users of public transport are seldom acknowledged, let alone addressed by policy makers and planners.

Sustainable Transport Environment in Penang (STEP) was the result of the coming-together of concerned individuals and voluntary groups to address this vacuum. This paper will briefly describe the urban transport issues and concerns in Penang and the background to the formation of STEP. This will be followed by a discussion of the initiatives taken by STEP and an indication of the future directions of the group.

I. BACKGROUND

The state of Penang in the northern part of peninsular Malaysia is the second smallest state in Malaysia and consists of Penang Island and Seberang Perai on the mainland. Penang Island consists of about 293 sq km, with an estimated population of around 610 thousand, while Seberang Perai occupies an area of about 738 sq km, with a population of 670 thousand. The major urban centres on the island are Georgetown, which is the administrative centre, and Butterworth and Bukit Mertajam on the mainland. Penang Island has an international airport and is linked by a ferry service and a bridge to the mainland. The major port facilities are on the mainland, while passengers and minor cargo vessels are handled at Swettenham Pier on the island.

Penang is a highly urbanized state, with a vibrant economy driven primarily by manufacturing industry and tourism. Known as the "Silicon Valley of Asia", it is home to most of the major electronics and semiconductor giants in the world and is a major centre for international industrial investment. With its beaches, multicultural and heritage attractions, Penang is also a leading tourist destination for both domestic and international visitors. Until the current financial crisis, the state was experiencing a rapid rate of economic growth with an average of 12 per cent growth in gross domestic product between 1992 and 1997.

II. CURRENT URBAN TRANSPORT ISSUES IN PENANG

A. Rapid growth in private vehicle ownership and use

The total number of motor vehicles registered in the state in 1995 was 752,438 (of which 64 per cent were motorcycles and 31 per cent cars) while the total length of paved roads in the state is estimated presently at about 3,000 km. Car and motorcycle ownership in the state is increasing at an average of 9.5 per cent and 7.2 per cent per year respectively and the total number of private vehicles registered in the state doubled between 1985 and 1995.

While the growth rate of motorcycle ownership between 1970 and 1990 has been consistently higher than that of cars, since 1990 the latter has overtaken the former. This could be explained as a consequence of rapid economic growth and rising income levels, as well as car-friendly policies such as the ready availability of the made-in-Malaysia Proton cars.

Previous projections for per capita vehicle ownership (or persons per vehicle) in Penang were 6.1 persons per car and 5.7 persons per motorcycle by the year 2000 (JICA 1981). However, these levels were reached even before 1990. At around 5 persons per car, ownership levels in Penang are reaching those of developed countries.

Data from the 1991 census indicated that 40 per cent of households in the state owned at least one car, while 58 per cent owned at least one motorcycle. This distribution indicates that there is still a huge latent demand for car ownership, as, with increasing income levels, motorcycle users will eventually shift to cars. While 44 per cent of households own a bicycle, this high ownership is not reflected in the pattern of trips by mode of transport. It is therefore likely that these bicycles are used by children and young persons for short leisure or school trips.

B. High private vehicle dependency

It has been estimated that in 1986 more than 80 per cent of all personal trips in the state were private vehicle trips, with 44 per cent car trips and 38 per cent motorcycle trips (JICA 1986). The current situation is not expected to be much different, although the share of motorcycle trips may have increased slightly. Recent traffic surveys in the state

show that between 80 per cent and 90 per cent of the total hourly traffic volume on major urban roads consists of cars and motorcycles. It is also estimated (based on data from a recent transport study) that more than 70 per cent of private vehicles entering Georgetown during the morning peak hour are single occupancy vehicles.

C. Low levels of use of public transport

The limited capacity, poor reliability and quality of public transport facilities in the state is a major determinant of mode of transport choice. Presently, over 60 per cent of those travelling by bus (schoolchildren, factory workers, migrant workers, the poor and elderly) are captive passengers who do not own a private vehicle *(*Penang State Government 1995). Despite significant improvements having been made to the bus system in the last few years, such as the introduction of air-conditioned buses and minibuses and the expansion of routes, the proportion of bus passengers on the busiest routes is estimated to remain below 30 per cent. While bus users complain about delays and missed schedules, bus operators are frustrated by buses being unable to follow fixed schedules due to traffic congestion during peak hours.

D. Increasing traffic congestion

Traffic congestion in Penang has reached fairly serious levels due to the rapid increase in traffic volumes on the major urban roads. Traffic volumes between 1975 and 1995 more than doubled on most roads, with increases of up to 5 times on certain road sections in Seberang Perai. In terms of vehicle concentration, there has been an increase of almost 40 per cent since 1980, with an estimated doubling in travel delays. Traffic is growing at an average of 7 per cent annually on most of the major roads in the state (Highway Planning Unit 1995) in close correlation with the average 8 per cent annual growth rate in the total number of cars and motorcycles. While congestion reduces travel speed, which causes much inconvenience and economic loss, it also results in higher vehicle emissions due to engine idling and the frequent acceleration and deceleration associated with stop-and-go conditions, as most vehicle emissions (except nitrogen oxides) typically decrease with speed.

E. High rate of traffic accidents

The number of road accidents in the state more than doubled between 1991 and 1995, while the number of casualties and deaths increased by 235 per cent and 175 per cent respectively. Casualties per 1,000 vehicles also increased from 3.5 in 1991 to 9.4 in 1995. The rate of fatalities in 1995 (34 per 100,000) was more than twice that in 1991 (13 per 100,000) and significantly higher than the level considered acceptable (5-10 per 100,000). More than 50 per cent of fatalities and 60 per cent of casualties are motorcyclists. It is also significant to note that between 1992 and 1996, 12 to 15 per cent of total fatalities and 10 to 13 per cent of total casualties were pedestrians, and 5 to 7 per cent of total fatalities and 5 to 6 per cent of total casualties were cyclists.

F. Inadequate facilities for pedestrians, cyclists and the mobility-impaired

Existing pedestrian footways are of inadequate quality and do not provide sufficient levels of safety and comfort to encourage walking. Facilities for cyclists, such as bicycle lanes, are non-existent. The transportation needs of the mobility-impaired such as the elderly and the disabled, as well as those of young children have also been seriously neglected.

G. Environmental impacts

A study carried out in 1990 on the levels of traffic noise at five locations on Penang island found that traffic noise levels were consistently and significantly higher than the World Health Organization recommended level of 55 dB (A) at all the locations surveyed. Average noise levels for Georgetown and Butterworth are 73.2 dB (A) and 72.8 dB (A) respectively, with the most significant contribution being from road traffic (DOE 1992).

It is estimated that 75 to 80 per cent of the total air pollution emission load is due to mobile sources, that is, primarily road traffic (DOE 1994). Data on levels of gaseous pollutants in the air is extremely sketchy and it is therefore not possible to determine precisely the correlation with road traffic. Average annual concentrations of TSP (Total Suspended Particulate) in Georgetown, which has 24-hour monitoring already exceed the Malaysian recommended guideline

standard of 90 $\mu g/m^3$ by over 40 per cent (DOE 1996). Air pollution from traffic is therefore an increasingly serious problem.

III. THE RESPONSE FROM THE STATE

While the state authorities of Penang grapple with the plethora of urban transportation issues highlighted in the previous section, their limited policy, regulatory and financial capacity prevents them from adopting a holistic and integrated approach. In the absence of any innovative national policy on integrated urban transport, Penang, like most state and municipal authorities, has adopted conventional road-based transport solutions.

The major transportation proposals in the state are a coastal expressway to be constructed on reclaimed land (Jelutong Expressway), a Penang outer ring road, a Butterworth outer ring road and a second fixed link (a combination of bridge and tunnel) between the island and the mainland. The state authorities depend on the private sector to build these roads, in exchange for either the right to collect tolls or for parcels of land for development.

The rationale behind these proposals seems to be that building new and wider roads and providing more parking spaces in urban centres (within multi-storey car parks) will reduce traffic congestion. The authorities no doubt have intentions to upgrade public transport and improve facilities for pedestrians, but these are often measures that only tinker with the existing system and are insignificant when compared to the amount of investment and priority accorded to building roads.

The state government recently commissioned an international consultant to carry out an urban transport study of Penang in an attempt to formulate state-level measures and projects to deal with the problems of traffic congestion. This plan has not yet been formally adopted by the state, but it is expected to incorporate the major road projects mentioned in the previous paragraph.

In summary, while the state says that it is committed to sustainable development in principle, concerns have been expressed as to whether the transportation policies and projects being proposed would contribute towards a sustainable transportation system for Penang.

IV. SUSTAINABLE TRANSPORT ENVIRONMENT IN PENANG

A. The sustainable Penang initiative (SPI)

Sustainable Transport Environment in Penang (STEP) was initiated by a small number of concerned individuals in Penang who came together to discuss the issues and concerns highlighted in the previous sections. The momentum for this first meeting came from the launching of the Sustainable Penang Initiative (SPI), which was officially launched in November 1997 as a community-level project in Penang.

The SPI was carried out by the Socio-Economic and Environmental Research Institute (SERI), a government-backed think tank for the state of Penang. The project was supported by the Canada-Association of Southeast Asian Nations (ASEAN) Governance Innovations Network Program, which is funded by the Canadian International Development Agency and managed by the Institute on Governance, a private non-profit organization based in Canada.

B. The STEP initiative

The SPI had selected five themes for a round-table consultation process, and in three of these round-table discussions (ecological sustainability, economic productivity and social justice) the issues and problems of transport were highlighted. Individuals who were keen to pursue follow-up action after the Ecological Sustainability round-table meeting were invited to a transport study group meeting initiated by the SPI project coordinator.

At the first meeting it was decided that STEP had to reach out to individuals and groups interested in and concerned about sustainable transport issues and provide a mechanism for them to come together as a coalition to exchange ideas and formulate a plan of action. A pro tem committee was formed and a mission statement for STEP was drawn up.

The STEP mission statement expresses:

(a) Concern that existing government transportation policies cater primarily to the needs of private motor vehicles;

(b) The belief that all urban development policies should ensure efficient, affordable and equitable access for all residents;

(c) Concern over the negative consequences of the transportation policies in Penang, such as increased travel times, deteriorating environmental quality and dangerous road conditions;

(d) Opposition to the policy of allocating more resources to support unrestricted access to private motor vehicles because it is environmentally unsustainable and socially inequitable;

(e) The belief that change is urgent in view of the national economic crisis.

The group decided that the best way to launch the STEP initiative was to organize a public meeting under the auspices of the SPI project and invite members of the public, representatives from the state government and municipal council, public interest groups and non-governmental organizations (NGOs), academics, transport industry representatives and the media.

The group also decided that it was necessary to initiate a first activity of some kind to convince the people attending the meeting of the credibility and seriousness of purpose of the STEP group. It was decided that a cycling action plan for Penang would be initiated by the group and assistance from the Embassy of the Netherlands in Kuala Lumpur was sought for the services of a Dutch consultant to help facilitate the plan. The Embassy provided a grant to cover the expenses of a Dutch expert and those of a small pilot study for a few areas in Penang Island, with a matching grant to be requested from the municipal council.

The inaugural public meeting of STEP, called the Sustainable Transport Options for Penang (STOP) conference, was held on 23 August 1998 and was attended by over 80 people, including the state cabinet member responsible for transportation and the regional coordinator for the United Nations Development Programme for Asia and the Pacific. Panel members included the coordinator of Sustainable Transport Action Network for Asia and the Pacific (SUSTRAN), a regional sustainable

transport advocacy network based in Kuala Lumpur, as well as a Dutch expert from the Interface for Cycling Expertise (I-ce) of the Netherlands.

The meeting was a success, producing a lively discussion on many urban transport issues, and the programme ended with the coordinator of STEP inviting interested participants to a follow-up meeting to decide a plan of action for STEP. As a parallel event, a public meeting was arranged between cycling enthusiasts and the I-ce expert who gave a talk and video presentation on cycling in the Netherlands. The I-ce expert was also taken on a cycling tour of Georgetown to explore the possibilities of establishing a cycling route in the heritage area of the city as a prelude to the cycling action plan study.

C. First STEP

The first follow-up meeting to the STOP conference was attended by a wider range of individuals and groups. After some discussion, STEP decided to form three working groups, as follows: a cyclists' group, a bus users' group and a pedestrians' group which were to work closely with the group called Sustainability, Independence, Livelihood and Access (SILA). STEP also decided to become a focal point of SUSTRAN and join the regional network of individuals and groups advocating sustainable transportation issues.

A number of activities were suggested for the purpose of generating public awareness on sustainable transport issues, and five activities were chosen, to be undertaken over a twelve-month period.

The five activities were:

(a) The issuing of statements to the media on public transport issues;

(b) The making of campaign materials on sustainable transport;

(c) The conducting of a survey of the central bus terminal (known as the Complex Tunku Abdul Rahman (KOMTAR) bus terminal) in Penang;

(d) The holding of fun cycling event in a residential neighbourhood;

(e) The drawing-up of a Cycling Action Plan for pilot areas in Penang.

1. Media campaign on the bus transport system

After the success of the STOP conference, which received good media coverage, STEP decided to publicize the inadequacies of the bus transport system in Penang, with the intention of sensitizing bureaucrats at the state and federal levels to the needs of bus users. The issue that was chosen to highlight the overall weaknesses of the public transport system in the country was the rejection of the application by the Penang municipal council to provide a free shuttle-bus service in the city area to alleviate traffic congestion.

All bus routes and service conditions are determined by the Commercial Vehicles Licensing Board, which is under the authority of the Federal Ministry of Transport. The Board rejected the application by the Penang Municipal Council on the grounds that there were objections from existing bus and taxi service operators. STEP succeeded in generating some debate and discussion in the media on the need for decentralization in public transport planning and policy-making, and even managed to elicit a public response from the Board on the subject. The need for the comprehensive planning of bus services involving local participation was also highlighted.

The STEP media campaign has assisted the Penang municipal council in appealing against the decision of the Board and a final decision on the free shuttle-bus service is still pending.

2. Campaign materials on sustainable transport

STEP prepared three different leaflets for mass distribution, to promote the merits of walking, cycling and public transport. The leaflet on walking, entitled “Feet First, highlighted the benefits of walking as a mode of transport and described the rights of pedestrians to clean air, safe streets, respect from motorists and motorcyclists and adequate facilities. Similarly, “Pedal Power” described the merits of cycling and the rights and needs of cyclists, while “Bus is Better” did the same for bus users. These leaflets were well received, due to the simplicity of their ideas and the fact that people from diverse social backgrounds could identify easily with the issues being discussed.

3. KOMTAR bus terminal survey

STEP carried out a photographic survey of the conditions at the KOMTAR bus terminal early in 1999 and released the findings of the survey to the local media. The wide press coverage given to the poor state of the terminal and the fact that this terminal was situated in KOMTAR, at the heart of the administrative centre of the state government, made it quite difficult for policy makers and administrators to claim ignorance. Within a remarkably short period of time the confusion over which authority was responsible for the maintenance of the facility was resolved (something which several polite requests from STEP had been hitherto unable to achieve) and the terminal was given a facelift, with a new paint job and lighting.

4. Fun cycling event in a residential neighbourhood

STEP is in the process of planning this event, to be held in a place called Pulau Tikus, a middle-class neighbourhood which has become severely congested after the development of a number of shopping complexes in the area. There is a serious shortage of parking spaces which has resulted in vehicles being parked along residential roads. A one day "Fun Cycling Event" is being planned to get people to cycle to an open space in the area, where there will be a carnival and other events organized around the theme of sustainable transport. Efforts will be made to secure sponsorship and support from the business community for this event, such as special discount vouchers for cyclists and secure parking facilities for bicycles. The objective of this event is to promote cycling as a means of transport in the area and generate community support and enthusiasm for better facilities for non-motorized modes of transport.

5. Cycling action plan

A technical and financial proposal for a cycling action plan in two pilot areas on Penang Island was submitted to the municipal council for the purpose of securing support and a matching grant to supplement the grant from the Embassy of the Netherlands. Although the proposal has not been formally turned down, it has been understood that the municipal council is unable to support this initiative. It was then decided to conduct a smaller study using the available funds and expertise available from SUSTRAN in Kuala Lumpur, without paying for the

services of the Dutch expert. This study is ongoing and is expected to be ready by the end of 1999.

D. STEP and SILA

The disabled persons community in Penang was well represented in the SPI round tables and accessibility problems faced by the mobility-impaired segments of the population were a major issue that came up in these discussions. A loose coalition of groups and individuals with disabilities emerged from the SPI process and became known as SILA. Recognizing the overlap of interests between STEP and SILA, the common goals and objectives, STEP is represented in SILA and vice versa.

The first activity SILA undertook involved highlighting the need for improved access for the disabled to the Penang Botanic Gardens, KOMTAR (a 65-storey building in Georgetown which houses the state administrative centre and other government agencies, as well as shopping complexes) and in the vicinity of the St. Nicholas Home for the Blind.

This initiative was successful as drain covers in the Botanic Gardens were retrofitted to facilitate wheelchair access within the grounds, and the President of the municipal council made a public commitment to improve access for the disabled to priority public areas.

SILA and the Socio-Economic & Environmental Research Institute (SERI) were also selected by ESCAP to conduct a training workshop for the promotion of non-handicapping environments (held in Malaysia from 8 to 15 November 1998). Activities in the eight-day programme were designed to encourage teamwork and coordinate efforts across disability groups. A follow-up workshop was held in April 1999 to train an additional 20 disabled persons, this time to include instruction on the production and use of videotapes to document the practical situations encountered by disabled persons in their daily life.

SILA also organized the International Day of Disabled People Walk from the St. Nicholas Home for the Blind to the One-Stop Centre shopping mall. This event provided an opportunity for SILA to publicly acknowledge the efforts of Penang Municipal Council in improving access for the disabled as well as highlighting outstanding issues.

E. Next STEP?

STEP has enjoyed a fair degree of success in its first year of existence, both in terms of highlighting sustainable transport issues in Penang, and in achieving modest changes such as the upgrading of the KOMTAR bus terminal. While STEP is not a formal organization and, technically speaking, is not a legal entity, nevertheless it has been able to operate in the public domain under the umbrella of the SPI project, which enjoys the support and patronage of leaders of the state government. This political space enjoyed by STEP is not necessarily a given and may be largely due to the political connections of the current STEP coordinator.

However the political space for STEP to function effectively may be jeopardized if STEP decides to adopt a more critical or confrontational stance. STEP has steered clear of public criticism of the state government over controversial transportation projects and proposals. For example, STEP did not endorse a joint press statement of NGOs and concerned individuals critical of a government proposal to build a massive bridge/tunnel to link Penang island to the mainland. Nor did STEP make any media statements on the controversial "autopont" flyover project of the municipal council, which is facing widespread public criticism, or join in the public debate over metered fares for taxis.

While STEP did make private submissions to the state government on the above issues, not taking an open public position poses some credibility problems in the eyes of members of the public and other public interest groups.

With the completion of the SPI project, STEP no longer has any legal status and has to decide which way to proceed. One option is to apply for registration with the Registrar of Societies as an NGO and take a more independent stance. Another is to establish itself as a company limited by guarantee and apply for non-profit status. Yet another option is to function under the umbrella of SERI. These options and the future direction of STEP are currently being discussed.

An advocacy group similar to STEP has now been established in the Klang Valley; FEET has recently started to become active and there are exciting possibilities for coordination between STEP and FEET on a national campaign on sustainable transport.

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TOWARDS A SUSTAINABLE URBAN TRANSPORT SYSTEM: PLANNING FOR NON-MOTORIZED VEHICLES IN CITIES

Geetam Tiwari*

A sustainable transport system must meet the mobility and accessibility needs of people by providing safe and environmentally friendly modes of transportation. This is a complex and difficult task in the mega-cities of developing countries because the needs of people belonging to various income groups are not only different, but also often conflicting in nature. For example, if a large section of the population cannot afford to use motorized transport – private vehicles or public buses – they have to either walk to their place of work or use bicycles. Providing a safe infrastructure for cyclists and pedestrians means either physically segregating road space for cyclists and pedestrians from motorized traffic, or, if that is not possible, reducing the speed of motorized traffic. Both measures imply restricting the mobility of car users to ensure the mobility of bicycle users.

In this paper we show that pedestrians, cyclists and non-motorized rickshaws are the most critical elements in mixed traffic. If infrastructure design does not meet the requirements of these three all modes of transport operate in sub-optimal conditions. It is possible to redesign existing roads to provide a safe and convenient environment for non-motorized modes of transport. This also results in the improved efficiency of public transport vehicles and an enhanced capacity of the transport corridor when measured in number of passengers per hour per lane.

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I. NON-MOTORIZED TRANSPORT IS AN INTEGRAL ELEMENT OF URBAN TRANSPORT

The transport and land-use patterns found in South Asian cities are different from those in the West. Most of these cities can be classified as "low-cost strategy" cities (Thomson 1977). Compared to cities in the West, these cities consume less transport energy. High population densities, intensely mixed land use, short trip distances, and high proportions of pedestrians and non-motorized transport characterize these urban centres (Newman and Kenworthy 1989). Their transport and land-use patterns are so complicated by poverty that it becomes difficult to analyse their characteristics using the same indices as are used for cities in highly motorized countries (HMCs).

A. Urban transport and land use plans

Most of the metropolitan cities of South Asia prepared master plans in the 1960s. Included in these were the following:

(a) Demographic projections and decisions on the levels at which the population should be contained;

(b) Allocation of population to various zones, depending on existing population density level, infrastructure capacity and future density levels;

(c) Land-use zoning to achieve the desired allocation of projected population and activities in various zones as projected;

(d) Large-scale acquisition of land with a view to ensuring planned development.

The planning framework usually adopted in the preparation of master plans was completely divorced from resource assessment. The process also did not include any procedures for involving the community and bringing about consensus on contentious issues. The net effect of the inadequacies of the planning process was that most urban growth took place without formal planning. Informal residential and business premises and developments increasingly dominated new urban areas. Even in South Asian mega-cities, where may economic activities are located in informal settlements, urban planners still rely on traditional master-planning approaches, which serve the minority, high income

residents. A few weak attempts have been made to bring some coordination of development and services to informal areas through slum-improvement schemes.

For example, the Delhi Master Plan is a typical example of integrated land-use and transportation planning. The new Master Plan was developed in 1990. The land-use distribution and density patterns proposed in the Plan are intended to minimize average trip lengths. In the Plan a five-tier system of commercial activities is proposed, to accommodate the shopping, commercial office and recreational needs of the population (Delhi Development Authority 1990). The proposal includes the provision of district centres designed to serve as focal points for multi-nodal activities of the community. Seven district centres have already been developed and twenty more have been proposed. Rising land prices have contributed significantly to the growth of mixed land-use patterns and higher population densities. In the past decade, a large number of single-family dwelling units have been converted to multi-storey apartment buildings. Commercial and institutional organizations have rented or bought space by outbidding the residential occupants. Mixed land-use patterns have successfully curbed the number and length of non-work-related trips by motorized modes of transport. The number of trips per household for different purposes remains constant, regardless of whether people live in the "inner area", which has a heavy concentration of employment and commercial activities or the "outer areas", with the planned new developments (Central Road Research Institute 1992).

In other metropolitan cities transport and urban planners have followed similar standard procedures in dealing with urban sprawl and traffic congestion. Large-scale integrated land-use transport models have supported policies and plan documents. These policies and plan documents recommended high-density planned neighbourhoods, and capacity expansion of arterial corridors to meet future travel demands. Despite these efforts to promote mixed land-use planning, the presence and growth of "unauthorized settlements" and pavement dwelling defy the master plans. Nearly 40 to 65 per cent of the population of South Asian mega-cities live in sub-standard living areas, which are notified slum areas and slum rehabilitation colonies, with minimal supplies of drinking water, sewage disposal and electricity. It is mainly, migrant workers who have set up these dwelling units in places not designated for residential units. Even in the Delhi Master Plan there is no living

area envisaged for workers earning low wages in Delhi's industries. Many factories and small-scale production units operating in Delhi work entirely outside the law. The government agencies themselves admit their failure and powerlessness to enforce the current minimum wage, which does not account for housing costs. Therefore, the low-income section of the population, ends up in sub-standard housing on public land owned by various government agencies. The rising cost of transport within the city and the long working hours force workers to live right next to their factories. Violating the law becomes a precondition for survival in the city. A large number of people living in these units are employed in the informal sector, providing various services to the outer areas of the city where the new developments had been planned. However, due to the lack of employment opportunities, people living in these areas have to commute long distances across the city in search of employment. Unlike the traffic in the cities of high-income countries, bicycles, pedestrians and other non-motorized modes of transport are present in significant numbers on arterial roads and intercity highways. Their presence persists, despite the fact that engineers designed these highway facilities for fast-moving, uninterrupted flows of motorized vehicles.

B. Captive ridership

The share of bicycle trips as a proportion of total trips has declined over the years. However, a large number of commuters are still using bicycles and other non-motorized modes of transport in spite of long trip lengths. For example, in the outer areas of Delhi, non-motorized vehicles and pedestrians are present on most intercity highways and have comparatively long trip lengths (Tiwari 1995). This shows that at present a large number of people use these modes not out of choice but owing to the absence of other options.

Increasing numbers of the poor continue to live without services in slums and unauthorized colonies in Delhi. It is estimated that there are currently over 1,500 unauthorized colonies without civic amenities and that as much as 60 per cent of the population lives in sub-standard housing. Recent sample surveys from these colonies indicate that these citizens are largely dependent on walking (20 per cent) or cycling (44 per cent) to work. This is true for people employed in the informal sector, with household income of less than Rs. 2,000/month (US$ 50).

Table 1 gives indicators for selected Indian cities. In large cities such as Mumbai, Delhi and Madras, more than 60 per cent of people are employed in informal sector. For this population walking and cycling to work are the only modes of transport available. A sustainable transport system must cater for this captive ridership of non-motorized transport users in the cities of the south.

Even a subsidized public transport system remains beyond the means of a significant segment of the population. Assuming a minimum of four trips per household, per day, at a cost of four rupees per trip, a household would need to spend Rs. 320 per month on transportation. For low-income people living on the outskirts of the city, the cost per trip may be between 4 and 6 rupees, depending on the number of transfers. On average, a low-income household cannot spend more than 10 per cent of its income on transportation. This implies that a household's income must be at least Rs. 3,200 for it to be able to use the public transport system at minimum rates. According to "Household travel surveys in Delhi" (Operations Research Group 1994), approximately 28 per cent of households in Delhi have a monthly household income of less than Rs. 2,000. For these people cycling and walking are the only logical choices.

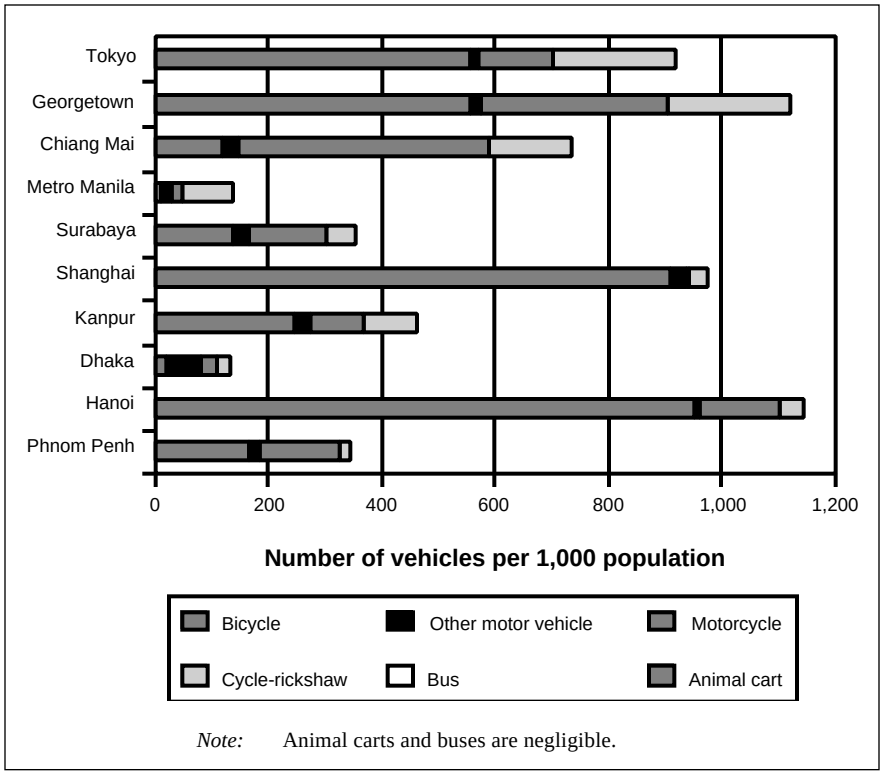
C. Traffic and travel characteristics in South Asian cities

Asian cities are characterized by heterogeneous traffic (a mix of non-motorized and motorized modes of transport) and mixed land-use patterns. Non-motorized vehicles are owned and used by a large section of the population (figure 1). Car ownership rates in Asian countries are low compared to those of North America and Organisation for Economic Cooperation and Development countries. In 1993 car ownership was 29 cars per 1,000 residents in East Asian countries, compared to 561 cars per 1,000 residents in North America, and 366 in OECD countries (AAMA, 1995). Although the growth rate in motor vehicles ownership is expected to be greatest in many Asian countries, most of these increases in absolute numbers of vehicles will result from increases in the numbers of motorized two- and three-wheelers (World Resources Institute 1996). In Thailand, Malaysia, Indonesia and Taiwan, two- and three-wheelers make up more than 50 per cent of all motor vehicles. The number of two- and three-wheeled vehicles is expected to grow most rapidly in China and India.

Table 1. Indian city indicators, 1993

Indicator \ City	*Mumbai*	*Delhi*	*Madras*	*Bangalore*	*Lucknow*	*Varansi*	*Hubli*	*Mysore*	*Gulbarga*	*Tumkur*
Population (million)	10.26	8.96	5.65	4.47	1.80	1.08	0.68	0.70	0.33	0.19
Household income distribution (Quintile boundaries US$)										
I (poorest 20 per cent)	374	290	347	385	291	268	284	373	258	287
II	620	679	531	670	482	426	698	746	660	433
III	939	1 082	772	1 144	762	634	845	1 176	1 052	641
IV	1 553	1 496	1 492	1 437	1 331	1 230	1 473	1 511	1 435	923
V (richest 20 per cent)	2 497	3 292	2 781	2 487	2 181	2 084	2 009	2 372	1 951	1 761
Informal Employment (percentage)	68	66	60	32	48	49	31	31	27	63
Motorized vehicles (per 1,000 population)	51	205	102	130	130	85	49	123	60	63

Source: World Resources Institute, 1996. *World Resources: A Guide to the Global Environment*, (Washington DC, World Resources Institute).



Note: Animal carts and buses are negligible.

Source: World Bank, 1991, *Urban Transport in Asia* (Washington DC, World Bank).

Figure 1. Comparison of vehicle populations

In Indian cities the share of non-motorized transport (NMT) at peak hours varies from 30 to 70 per cent. The proportion of trips made by bicycle ranges between 15 and 35 per cent, the share tending to be higher in medium- and small-sized cities. The patterns of NMT use vary according to city size. In most NMT-dependent, low-income cities, bicycles are used for the entire trip (for example, commuting, shopping). In a high-income city like Tokyo, bicycles are increasingly used as a feeder mode to rail stations as well as for shopping and other purposes (World Bank 1995:27). Every motorized public transport trip involves access trips by NMT at each end. Thus, NMT, including walking, continues to play a very important role in meeting travel demand in Asian cities.

In addition to bicycles, non-motorized rickshaws are used for the delivery of goods such as furniture, refrigerators and washing machines. Semi-skilled workers, carpenters, masons, plumbers, postmen, and courier services use bicycles. The demand for bicycles and rickshaws is therefore considerable at present and is likely to continue to be so. This situation is not explicitly recognized in policy documents and very little thought is given to improving facilities for non-motorized modes of transport.

D. Buses: principal means of transport in Asian countries

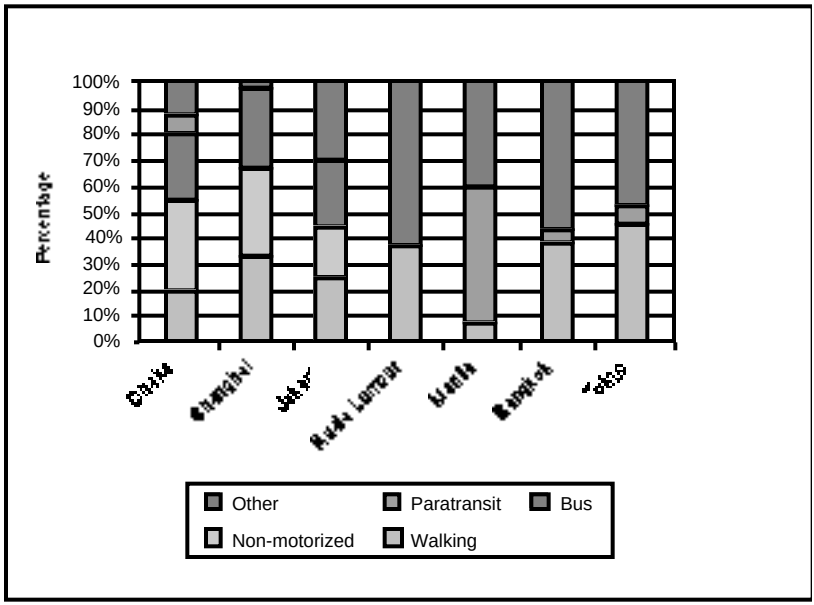
The populations of most cities in low-income countries (as defined by the World Bank in its World Development Reports) are heavily dependent on buses. They are the major means of mobility, particularly for the low-income population (World Bank 1991:38-39). The share of public transport trips is shown in table 2.

Table 2. Modal split of passenger traffic in selected European and Asian countries, 1996

Country		*Private road transport (percentage)*	*Public transport (percentage)*	*Rail transport (percentage)*
Europe	France	5.4	86.4	8.1
	Germany	8.7	84.0	7.2
	United Kingdom	6.3	89.0	4.6
	Spain	12.1	81.5	6.3
Asia	Japan	6.9	61.9	31.1
	Hong Kong, China	51.8	22.5	25.7
	Republic of Korea	36.3	40.0	23.6

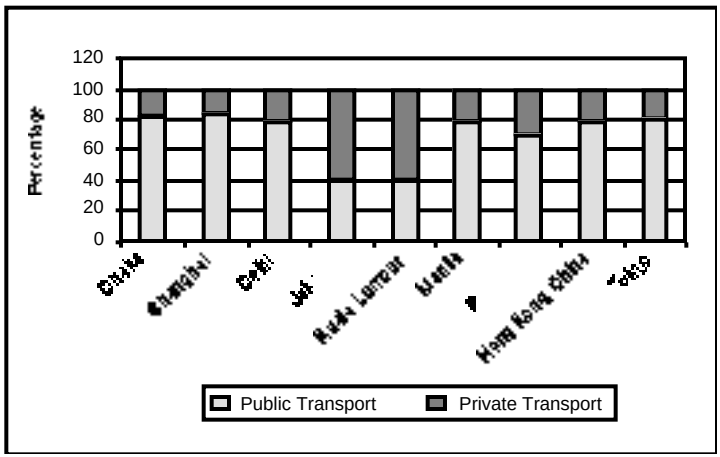
Source: International Road Federation, 1998. *World Road Statistics 1998* (Washington DC, International Road Federation).

In most cities in low-income countries walking and non-motorized vehicles are the main travel modes (figure 2) and public transport is the predominant mode of motorized travel (figure 3). Walking and non-motorized modes of travel are less significant in middle-income Asian countries and bus use predominates.



Source: World Bank, 1991, *Urban Transport in Asia* (Washington DC, World Bank).

Figure 2. Distribution of trips by travel mode in selected Asian cities



Source: World Bank, 1991, *Urban Transport in Asia* (Washington DC, World Bank).

Figure 3. Trips by public transport and private transport in selected cities

The travel characteristics of large cities in high-income countries differ from those in low- and middle-income countries in the use of mass rapid transit and commuter rail systems. Throughout Asia buses form the backbone of urban public transport services. However, overcrowding, the increased incidence of breakdowns and poor service frequency have resulted in a decline in general levels of service and comfort. Consequently, a large number of indigenously designed vehicles are operating as paratransit modes in Asian cities. This service is mostly provided by the informal sector. Paratransit operations provide an important service in cities throughout the region, with the notable exceptions of China and high-income countries such as Australia, Japan and Singapore (World Bank 1991).

E. Vehicle ownership in Asian countries

Asian countries have low rates of vehicle ownership: 50 per cent of the world's population live in Asia, but they own only 11 per cent of the world's cars and 28 per cent of its trucks and buses (World Bank 1990:35-36). In the low-income countries of Asia, vehicle availability rates range from a high of 63 persons per vehicle in Sri Lanka to 250 persons per vehicle in India. In the middle-income countries, they range from a high of 10 persons per vehicle in Malaysia to 124 persons per vehicle in the Philippines, and in the high-income countries they range from 2.3 persons per vehicle in Japan to 18 persons per vehicle in Hong Kong, China.

Economic growth, urbanization and population trends in Asian cities indicate that the urban populations of Asian cities will have to depend heavily upon public transport for their travel needs, unlike people of European cities, who are heavily dependent on private transport.

Though average income levels in Asian countries are expected to rise, these countries will still have 53 per cent of the world's poor people by the year 2000 (World Bank 1990). Thus, travel demand is likely to increase in low-income Asian countries having 50 per cent of the world's poor. Ownership of private vehicles and the availability of public transport vehicles will continue to be low, despite an increase in the number of vehicles.

As is evident in high-income Asian countries, the existence of large public transport demand on the main travel corridors of large urban areas leads necessarily to the implementation of high-capacity systems.

These have been successfully operating in the cities of high-income countries (World Bank 1991:25-27). Since most Asian countries have a scarcity of resources and low income levels, operating a bus-based public transport system is the only option which is economically and financially viable.

II. TRAFFIC FLOW CHARACTERISTICS

The road network of Delhi is used by at least seven categories of motorized and non-motorized vehicles. Vehicles ranging in width from 0.60 m to 2.6 m and capable of maximum speeds ranging from 15 km/h to 100 km/h share the same road space. All these vehicles, which have varied dynamic and static characteristics, share the same carriageway. This traffic is characterized by a lack of any effective channelization, mode segregation or speed controls. To the formally-trained traffic planner it looks like chaos moving toward total gridlock. Yet the people and goods keep getting through and may by some measures actually be doing better than in some controlled conditions.

Detailed traffic studies in Delhi show that all modes of transport use one-, two- and three-lane roads all over Delhi. Delhi traffic laws do not segregate non-motorized and motorized modes, and the enforcement of speed limits is very limited. Motor vehicles (MVs) and non-motorized vehicles (NMVs) have different densities at peak traffic hours at different locations. A study of mid-block conflicts in Delhi gives information regarding the use of road space by different road users (Tiwari et al. 1997). Data from the fourteen sites studied show that maximum mixing of NMVs and MVs occurs at bus stops, but at other locations interaction is minimal. A natural segregation of slow and fast traffic occurs on three- and two-lane roads. On three-lane roads, MVs use the two right

lanes and the kerb-side lane is used almost exclusively by NMVs (traffic in India drives on the left).

Since the MV traffic lane is 3.5 m wide, it can accommodate flow rates of at least 6,000 bicycles per hour (Replogle 1991). On three-lane roads, the MV flow rates are close to or less than 4,000 passenger car units per hour. This is much less than the expected capacity of three-lane roads. The flow for these urban localities can be taken as 2,000 passenger car units per hour, per lane (Indian Road Congress 1990). Though peak volumes do not exceed saturation capacity values, we find average speeds remain in the range of 14 to 39 km/h. On two-lane roads the MV flow rates are close to or less than saturation capacity values. It is only on the one-lane roads that we find flow rates of 726 bicycles/hr and 616 passenger car units/hr. Both these values are approximately one third of their respective saturation capacity values for one lane.

These observations indicate that on two- and three-lane roads, bicycle traffic will naturally segregate itself into the kerb-side lane. Integration of MV and NMV traffic will only take place if the bicycle flow rate exceeds 6,000 bicycles per hour for one MV lane, or if the MV flow rate exceeds one lane capacity on two-lane roads, or two-lane capacity on three-lane roads. Though natural segregation takes place on two- and three-lane roads, the danger to cyclists because of conflicts with MVs is unacceptable. At two- and three-lane locations, it is a waste of resources not to provide a separate bicycle lane, because one whole MV lane gets used by bicycles and other NMVs irrespective of bicycle density.

Since the kerb-side lane is primarily used by bicycles and other NMVs, buses are unable to use the designated bus lanes and are forced to stop in the middle lane at bus stops. In the absence of facilities for NMVs all modes of transport move in suboptimal conditions. This disrupts the smooth flow of traffic in all lanes and makes cycling more hazardous. Therefore, providing a separate bicycle track or lane for NMVs would make more space available for motorized modes and make cycling less hazardous. It is also obvious that in the absence of segregated NMV lanes on arterial roads, it is not possible to provide designated lanes for buses.

III. SEPARATE BICYCLE LANES FOR NMV: ESSENTIAL FOR SUSTAINABLE TRANSPORT SYSTEMS

A sustainable transport system must provide mobility and accessibility to all urban residents with safe and environmentally friendly modes of transport. For example, if a large section of the population can not afford to use motorized transport – either private vehicles or public buses – they either have to walk or cycle to their place of work. If cyclists and pedestrians are to be provided with a safe infrastructure, either road space for them must be physically segregated from motorized traffic, or the speed of the motorized traffic must be reduced. The major arterial roads of the city must be made NMV-friendly. Dedicated NMV routes through parks, green belts and narrow city streets could serve as additional network capacity for cyclists.

Pedestrians, cyclists and non-motorized rickshaws are the most critical elements in mixed traffic. If the infrastructure design does not meet the requirements of these elements, all modes of transport operate in suboptimal conditions. It is possible to redesign existing roads to provide a safe and convenient environment for non-motorized modes, especially if the right of way is 30 m or more (Tiwari 1999), and this can also result in the improved efficiency of public transport vehicles and the enhanced capacity of the corridor when measured in number of passengers per hour, per lane.

A. Bus lanes

Segregated bus lanes are necessary to meet increasing travel demand and to improve public transport. In many cities around the world the kerb-side lane is reserved for buses. This has been attempted in Delhi, but without success. In the absence of segregated cycle lanes, cyclists use the kerb-side lane. This makes it impossible for buses to use the kerb-side lane, in spite of repeated attempts at enforcement by the Delhi Police. If separate lanes were available all cyclists would use them and that would make the curbside lane available for buses. Segregated cycle lanes must be established before dedicated bus lanes can be implemented.

B. Increased capacity

If a separate segregated lane were constructed for bicycles, the kerb-side lane, which is currently used by cyclists, would become available to motorized traffic. This relatively small investment in cycle lanes could increase the road space for motorized traffic by 50 per cent on three-lane roads. Cycle lanes also result in better space utilization. For instance a 3.5 m lane has a carrying capacity of 1,800 cars per hour, but 5,400 bicycles per hour (Replogle 1991). The average car occupancy is 1.15 persons (Indian Road Congress 1990) and a bicycle carries one person. This implies that in order to move the same number of people by car we would need 2.6 times the road area that would be required for cyclists. Given the fact that there is not much space available to expand existing roads, future mobility needs can only be met by increasing the capacity of the existing road network. This can only be achieved by encouraging modes of transport which are more efficient in terms of space utilization.

C. Reduced congestion

Congestion has long been recognized as an environmental problem. Other than causing delays, it causes noise and fumes and increases health risks to road users and residents. Congestion and cycling policies are interconnected in two ways. First, because congestion leads to poor air quality and a poor environment, it may act as a deterrent to cyclists. Second, policies which promote cycling would in themselves help to relieve congestion because cyclists require so much less road space than motorists do, both when travelling and parking.

D. Increased safety

Figures show that even at per capita income levels of US$ 3,000, car ownership levels remain low and the proportion of motorized two-wheelers can be more than 50 per cent (Mohan and Tiwari 1998). Most least motorized countries (LMCs), including India and China, will not reach the income level of US$ 3,000 in the next decade. As incomes increase, the poorest people in countries like India and China will be able to own bicycles, and those who own bicycles today may opt to buy motorcycles when they become richer. As the number of poor and lower middle-class people in these countries is larger than that belonging to the upper class, we are likely to witness greater increases in absolute

numbers of bicycles and motorcycles than cars in the next decade or so. Road safety policies and countermeasures used in societies where cars constitute about 80 per cent of vehicles will not be suitable for most LMCs, where motorized two-wheelers comprise more than 40-50 per cent of the total number of vehicles.

The high rates of pedestrian, bicycle and motorcycle traffic in LMCs (proportions differ from country to country) result in vulnerable road user fatalities constituting 60-80 per cent of all traffic fatalities (Mohan 1992).

Table 3 shows the proportion of road traffic deaths by mode of transport as a percentage of all fatalities in different countries. The data show that vulnerable road users constitute almost 75 per cent or more of fatalities in most LMCs. This flows logically from the fact that this class of road user forms the majority of those using the road space along with fast motorized vehicle, without specific facilities for NMVs. In addition, because vulnerable road users are not protected by metallic or energy-absorbing materials, they sustain relatively serious injuries even at low velocity crashes. A study shows that in LMCs buses and trucks are involved in a greater proportion of crashes than they are in HMCs (Kajzer et al. 1992). The majority of fatal crashes take place

Table 3. Road traffic deaths by mode of transport (Percentage of all fatalities)

	Pedestrians	*Cyclists*	*Motorized Two-wheelers*	*Motorized four-wheelers*	*Others*
Delhi, India (1994)[a]	42	14	27	12	5
Thailand (1987)[a]	47	6	36	12	–
Bandung, Indonesia (1990)[a]	33	7	42	15	3
Colombo, Sri Lanka (1991)[a]	38	8	34	14	6
Malaysia (1994)[a]	15	6	57	19	3
Japan (1992)[b]	27	10	20	42	1
The Netherlands (1990)[b]	10	22	12	55	–
Norway (1990)[b]	16	5	12	64	3
Australia (1990)[b]	18	4	11	65	2
United States of America (1995)[b]	13	2	5	79	1

Source: Mohan, D., and G. Tiwari, 1998. *Reflections on the transfer of traffic safety knowledge to motorizing nations*, Global Traffic Safety Trust.

Note: [a] LMCs [b] HMCs

mid-block. A detailed study done in Delhi shows natural segregation takes place on two- and three-lane roads, with cyclists occuping the kerb-side lane. However, natural segration does not ensure the safety of cyclists.

By creating segregated cycle lanes and ensuring the proper design of intersections, conflicts between motorized traffic and cyclists can be reduced substantially, leading to a sharp decrease in the number of accidents and fatalities for cyclists and motorized two-wheelers.

E. Reduced pollution and energy consumption

Motor vehicles are reported to be the single biggest source of air pollution, causing 70 per cent of the total air pollution in Delhi (Central Pollution Control Board 1993). This is a serious concern to cyclists, pedestrians and motorists, as air quality is worse in or near roads in built-up areas. Cyclists suffer the adverse affects of pollution because of heavier breathing whilst exercising close to the source of exhaust pollution. A dedicated infrastructure can reduce this problem to some extent. While motorized transport is one of the most polluting of all human activities, however, cycling is the least polluting mode of all. Cycling generates no noise pollution or toxic emissions. Therefore, there is a need to make cycling more popular. A better bicycle infrastructure can play an important role in increasing the modal share of bicycles and thus reduce air pollution and health risks.

IV. CONCLUSION

It is clear from the above discussion that non-motorized modes of transport which include bicycles and rickshaws are an integral part of the transport system in all South Asian cities. Existing socio-economic patterns and land-use distribution ensure the presence of NMVs in the whole city and on the complete road network. The densities and modal shares of NMVs in total traffic may differ from one part of the city to the other. However, as long as NMVs are on the road, regardless of their numbers, all vehicles move under suboptimal conditions. Efficient bus systems cannot be designed without taking account of the slow vehicles on the road. Since sustainable transport systems in South Asian cities have to move large numbers of people by bus transport and NMVs, planning for NMVs is indispensable.

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AIR QUALITY IN HO CHI MINH CITY, VIET NAM

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This paper reviews the state of air quality in Ho Chi Minh City as revealed by studies conducted by several organizations in recent years. A comparison is made between the air quality of the Ho Chi Minh City and that of some other cities in the region. It is shown that air quality, both indoor and outdoor (ambient), has been deteriorating in recent years, mainly because of increases in the number of vehicles and industries in and around the city.

Compared with other cities such as Beijing, Tokyo, Bangkok and Manila, the level of sulphur dioxide (SO_2) pollution is lower, while the levels of carbon monoxide (CO) and nitrogen dioxide (NO_2) are approaching the levels of these cities. In the case of particle pollution, the peak particle level at some heavy traffic sites in Ho Chi Minh City is high and exceeds the levels of Bangkok and Manila. The lead pollution is less severe than that of Bangkok, but it is likely to increase if concrete action is not taken.

The experience gained by other cities in the area of environmental management could be used to prevent serious degradation in air quality in the city. Measures that could be incorporated readily into an integrated air quality and transport management plan are discussed.

INTRODUCTION

Ho Chi Minh City is a major city in Viet Nam with a population of 4.7 million (1994) and a natural growth rate of 1.49 per cent, excluding migrants (mainly from the country areas) and temporary residents. It has an area of about 2,056 km^2 and an average population density of 2,282 inhabitants/km^2. The tropical climate has a yearly

* New South Wales Environment Protection Authority, P.O. Box 29, Lidcombe, NSW 2141.

average temperature of 27˚C and relative humidity of 77.8 per cent (Tuan 1996).

As in other bustling and growing cities in the region, the main source of air pollution is motor vehicles. Besides motor vehicles, industrial sources in the city and surrounding areas of Dong Nai Province are also contributing to the air pollution problem, which is particularly acute in the residential areas around these sources.

As currently projected, with an estimated annual population growth rate of 1.63 per cent the population of the city will easily exceed 5 million by the year 2000. This means that the city is in the category of supercities. Although Ho Chi Minh City is not yet in the league of megacities such as with Bangkok, Jakarta, Beijing or Manila, the high economic growth of recent years has been accompanied by a rapid degradation of environmental quality. Frequent visitors to the city are usually struck by the rapidly increasing traffic volume and worsening congestion, which resemble the traffic situation of Bangkok in the 1980s.

With air pollution in the city increasing, a number of organizations in the city have recently conducted some initial studies on air quality and the effects of air pollution on the population. Permanent monitoring stations have not yet been established, but data are collected occasionally, for a number of days, at a number of sites in the city. These sites are mainly near roads with heavy traffic. The collected data are not yet comprehensive enough to provide an overall picture, but do provide some indications of the state of air quality in Ho Chi Minh City.

I. AIR POLLUTION DUE TO MOTOR VEHICLES

Recent data gathered from a number of monitoring stations operated by the Centre for Environmental Technology and Management (CEFINEA) of Ho Chi Minh University of Technology has been published (Tuan 1996; Trung 1996; and Dang 1995). These data show that many air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2) and particles have concentrations exceeding the standard levels. The noise level is also persistently high.

During one particular day, on 25 April 1996, the data measured at the intersection of Dinh Tien Hoang and Dien Bien Phu Streets show

that the maximum hourly concentration of particles was 3.6 mg/m^3, 12 times the current Vietnamese standard (Trung 1996).

The concentration of CO measured on 25 April 1996 was 62.65 mg/m^3, 1.5 times above the standard. Similarly, the NO_2 concentration measured on 23 April 1996 exceeded the standard by 1.5 times. The average noise level was between 76 and 86 dBA, with a peak of 98 dBA while the standard for residential area is 60 dBA (Trung 1996).

The main cause of air pollution in the city is motor vehicles. In 1996, the city had more than 1.1 million motor vehicles, of which motorcycles were more than 1 million. Currently, there are about 1.1 million motorcycles and 101,000 cars. Each month, more than 1,000 vehicles are added to the city traffic. Most of these vehicles currently use leaded petrol. Table 1 shows the breakdown of the different types of vehicle registered in 1997.

Table 1. Vehicles registered in Ho Chi Minh City, 1997

Type	*Number*
Trucks	14 073
Company-operated buses	591
Vans and small trucks	1 082
Small buses	1 601
Cars	194 777
Standard car taxis	2 712
Three-wheeled taxis	1 935
Motorcycles	1 288 754

Approximately 200,000 tons of petrol fuel and 190,000 tons of diesel fuel are consumed each year. The estimated emission into the airshed is about 2,200 tons of SO_2 and 25 tons of lead.

The large increase in the number of vehicles reflects the economic growth in the past ten years. During peak traffic periods on Cach Mang Thang Tam Street, the vehicle density count is now 10,000 per hour, compared to 5,800 per hour in 1990, and only 2,800 per hour in 1985 (Tuan 1996). The growth of traffic however has not been

matched by the upgrading and construction of new roads. The traffic density in some of the congested streets in 1994 is presented in table 2.

Table 2. Traffic density on selected streets, Ho Chi Minh City, 1994

Street	*Traffic density (vehicles/hour)*
Ba Thang Hai	13 000
Tran Hung Dao	12 500
Hung Vuong	10 015
Ly Thuong Kiet	11 306

Source: Tuan, Nguyen Dinh, 1996. Current situation of air pollution in Ho Chi Minh City, Viet Nam. Proceedings of the Asia-Pacific Conference on Sustainable Energy and Environment Technology, held in Singapore, 19-21 June, pp. 242-248.

In 1980 hourly average particle levels in traffic streets were about 3 to 3.1 mg/m^3 during the rainy season and about 3.2 to 3.4 mg/m^3 during the dry season. However, in 1990 at the same locations, hourly average levels increased to 5 to 5.1 mg/m^3 during the rainy season and 7.8 to 8 mg/m^3 during the dry season. The corresponding increase for SO_2 was from 0.8 mg/m^3 in 1980 to 0.97 mg/m^3 in 1990 (Trung 1996).

A recent study by CEFINEA (Tuan 1996) on the daily variations in some air pollutant concentrations due to traffic emissions shows the following results:

(a) For CO, the daily average concentration at important traffic intersections was between 2 and 10 mg/m^3, with a maximum hourly value of up to 23.3 mg/m^3.

(b) The daily average concentration of NO_2 was between 0.05 and 0.25 mg/m^3. The peak hourly value reached 0.726 mg/m^3 at the intersection of Dinh Tien Hoang and Dien Bien Phu Streets, and 0.6 mg/m^3 at Hang Xanh roundabout.

(c) Dust particle concentrations ranged from 0.8 to 15 mg/m^3 at different hours of the day, with a maximum concentration of 37 mg/m^3 measured at the intersection of Dinh Tien Hoang and Dien Bien Phu Streets on 15 March 1995.

(d) Lead concentrations at a number of sites varied between almost nil and 0.41 mg/m^3 at different times of day. The ratio of lead-containing samples to total analysed samples was low.

(e) Air pollutant concentrations varied depending on the month, due to seasonal effects. At the Minh Phung Hau Giang intersection, the average monthly concentration for CO was 0.06 to 4 mg/m^3, for NO_2 0.05 to 0.3 mg/m^3 and for total suspended particulates (TSP) 0.4 to 1 mg/m^3. In the dry season the average concentration was 2-3 times higher than that in the rainy season.

II. AIR POLLUTION FROM INDUSTRIAL SOURCES

Industries also contribute significantly to air pollution, especially in the surrounding areas. Many of these sources of pollution are small factories, and have very high indoor pollutant levels. There are 700 large industrial sources and about 24,000 small-scale factories in and around the city. The large industrial sources are mainly concentrated in the Nha Be and Thu Duc areas. The small factories, mainly family businesses, are scattered across all districts, with the largest concentration in districts 5, 6, 11 and Tan Binh (Tuan 1996).

Almost all of these sources are located in residential areas. Much of the equipment and technology is old and has been in operation for over 10 years. Some is more than 25 years old and not fitted with any pollution-control devices (Tuan 1996). A recently conducted survey showed that many foreign joint ventures operating with outdated imported equipment are causing considerable environmental pollution (Dong 1995).

An investigation conducted by CEFINEA (Tuan 1996) showed that the total dust concentration (TSP) was very high in the indoor environment of almost all industries, especially in the construction materials and metallurgical industries.

Total annual emissions of pollutants to the airshed due to industrial fuel consumption are estimated at 30,000 tons of SO_2, 5,750 tons of NO_2 and 1,650 tons of particulate. In addition, the metallurgical industries produce 2,840 to 4,260 tons of particulate and 994 to 1,420 tons of CO per year (Tuan 1996).

In 1995, of 43 factories on an environmental blacklist, 30 per cent were in Thu Duc, an industrial growth area in the north of Ho Chi Minh City. Two major companies, Posvina and PS (a toothpaste manufacturer), are emitting large quantities of acid gases each day to the surrounding residential areas (Dang et al. 1995). Residents complained about the pollution from these sources and the issue of pollution was also publicized in the media, for example the factory operated by Miliket noodle company was mentioned. In the Ho Chi Minh City suburb of Tan Binh, a steel factory operated by Southern Steel Corporation (Cong ty Thep mien Nam) was also the object of complaints (Dung 1995).

The ambient air pollutant concentrations around several industrial sources are shown in table 3 (Tuan 1996). A number of these sources, for example the Tan Binh Steel Works and the Miliket Noodle Company, exceeded ambient standards for dust, SO_2 and CO.

Since 1996, more industrial parks open each year in the north, in the Thu Duc-Bien Hoa area, in the south, in Nha Be (south Saigon) and recently in the north-east Hoc Mon area. All types of industry are established in these areas and they operate year round. From a meteorological point of view, the location of these industrial parks is not conducive to air pollutants being dispersed quickly from the urban area of Ho Chi Minh City.

As measured at Tan Son Nhat meteorological station from 1952 to 1981, on an average during the dry season, winds come mainly from the north, south and south-east with wind speeds ranging from 2.2 m/s to 3.3 m/s. During the rainy season, however, the winds come mainly from the west and south-west, with wind speeds in the range of 3.3 m/s to 3.7 m/s.

Air quality is much improved by the effect of rain (as shown by measurements at a number of monitoring stations in the city). The location of the industrial areas in the north and the south of the city will have an adverse effect on the air quality in Ho Chi Minh City. It is more appropriate to locate industrial zones in the under developed west and north-west areas of the city, such as Hoc Mon or Cu Chi. Recently, a few industries have been established but no priority has been accorded to infrastructure investment in those areas.

Table 3. Air pollutant concentrations around selected factories in Ho Chi Minh City (mg/m^3)

No.	*Industry and sampling site*	*Dust (TSP)*	*SO_2*	*CO*	*NO_2*	*Others*
1	Chana Textile-Outside factory, distance 25 m	0.18	0.142	0.08		
2	Phuong Dong Detergent-Outside factory, distance of 15 m	0.4	0.42	0.3		
3	Quan Khu 7 Cement Outside factory, distance of 40 m	0.8	0.26	0.055	1.78	
	Outside factory, distance of 120 m	0.4	0.22	0.022	0.66	
4	Tan Binh Metallurgy					
	Outside, distance of 40 m	0.51	0.76	0.4		
	Administrative area	1.3	0.36	0.154		
5	Nha Be Metallurgy					
	Administration area	0.3		0.277		
6	Milipa Instant Noodle					Hydro-carbons:
	Outside	0.7	0.35	0.1	3	15
	Standard (daily average)	0.2	0.3	5	0.1	

Source: Tuan, Nguyen Dinh, 1996. Current situation of air pollution in Ho Chi Minh City, Viet Nam. Proceedings of the Asia-Pacific Conference on Sustainable Energy and Environment Technology, held in Singapore, 19-21 June, pp. 242-248.

III. HEALTH EFFECTS OF AIR POLLUTION

It is known that some primary pollutants such as particles PM_{10} and $PM_{2.5}$ (particulate matter less than 10 and less than 2.5 microns in diameter, respectively) nitrogen oxides, sulphur dioxide and carbon monoxide, and secondary pollutants such as ozone have adverse effects on people's health. These range from respiratory problems to diseases such as sinusitis, bronchitis and asthma. Particles have also been shown to cause an increase in the mortality rate. People with asthma and respiratory diseases are highly susceptible to particles, nitrogen oxides, sulphur dioxide and ozone. In addition, lead particles have serious effects on children's growth and development. Children with high lead

levels are deficient in weight and tend to have a low count of red blood cells. Their IQ levels are also inferior to those with lower lead levels.

There is an extensive literature on studies of the health effects of air pollutants. Most of the studies were conducted in developed countries such as the United States of America and Germany. Recently, the results of these studies have been used to establish revised guidelines and standards for many pollutants such as ozone, carbon monoxide and particles PM_{10} and $PM_{2.5}$. The economic impact of air pollution and the benefits of setting lower level standards for particles are both substantial (Ostro 1998).

In Viet Nam and other countries of the region, the health aspect of air pollution is now acknowledged as an important public health issue. Studies have been conducted and published. The results show that exposure to high levels of pollutants have adverse effects on quality of life.

The health effect of air pollution on traffic police officers was recently studied by the Labour Protection Unit of Ho Chi Minh City (Dang 1995). Due to extended exposure to high levels of air and noise pollution, 2.9 per cent of traffic policemen were infected with tuberculosis, compared to an average infection rate of 0.075 per cent. The rate (presumably using yearly data) of ear, nose, and throat infection was 76 per cent and 32 per cent of traffic policemen had a reduced hearing ability.

There are currently no known studies conducted by the health authorities in Ho Chi Minh City on the effects of gaseous pollutants or particles on asthma or on the death rate. Nor are the levels of lead in blood due to vehicle emissions known.

In Bangkok 40 per cent of traffic policemen have chronic lung ailments. Many of them wrap scarves or white cloths around their mouths and noses. A Public Health Ministry study of 214 people who regularly use buses found that 26 per cent of them suffered ill effects from CO. These people were exposed to a CO level of 67 parts per million (ppm) against the standard of 10 ppm (*Bangkok Post,* 18 March 1996). This does not include the effects of gaseous gases such as the highly toxic and mutagenic polycyclic aromatic hydrocarbons. A comprehensive study (*Bangkok Post,* 18 March 1996) on lead levels in the blood of children has shown that the average lead level was 17

micrograms/decilitre before the introduction of unleaded petrol in 1991, and it came down to 9.23 micrograms/decilitre by 1996. The acceptable level, as specified by the Centers for Disease Control and Prevention of the United States of America, is 10 micrograms/decilitre.

A similar study, called the Urban Air Project, conducted by the Department of Environment and Natural Resources of the Philippines in 1994, showed that out of a sample group of 170,000 people in cities exposed to lead pollution and traffic, 762 (or 0.45 per cent) had varying degrees of coronary disease, and another 91,207 (or more than 50 per cent) suffered from hypertension. This study also showed that at least 39 per cent of the lead pollution came from cars and 58 per cent came from public utility vehicles (APEC 1996). In Jakarta, air pollution in industrial and heavy traffic areas has been identified as a significant contributor to the increased incidence of lung disease (Mangunnegoro 1996).

A study on the effects of particulate pollution in Jakarta, funded by the World Bank, estimated that exposure to particulate concentrations above the World Health Organization (WHO) standard caused an additional 1,200-2,300 deaths, 184,000-541,000 asthma attacks and 5.3-11.8 million lost work days in 1989 (Ostro 1992).

In Kaohsiung, Taiwan, where factories are the major source of air pollution, a study showed that people living within three kilometres of the industrial area have a 6-fold increase in the risk of lung cancer (Ko 1996). It also showed an increase in the incidence of brain tumours of 2-4 times among inhabitants close to a petrochemical plant, a higher rate of leukaemia, and cancers of the lung, kidney, and urinary bladder. Another study (Chen et al. 1998) showed that schoolchildren in urban and industrial areas had significantly more respiratory problems and diseases than to those in rural areas.

The higher level of sulphur dioxide in ambient air has been associated with a higher mortality rate in Seoul, where vulnerable old people have a higher risk of premature death (Lee and Schwartz 1999). In Beijing, the high level of sulphur dioxide in winter was significantly associated with increased mortality. The risk of total mortality was estimated to increase by 11 per cent with each doubling of the sulphur dioxide concentration. The effects of doubling sulphur dioxide levels were significant for chronic obstructive disease (29 per cent), pulmonary

heart disease (19 per cent) and cardiovascular disease (11 per cent) (Xu et al. 1994).

IV. COMPARISON WITH OTHER REGIONAL CITIES

Compared with other cities in the region which have also experienced rapid economic growth in recent decades, the air pollution problem in Ho Chi Minh City is not so serious, but it is likely to become a serious problem unless preventive measures are taken.

As the population is rapidly increasing and vehicle usage continues to grow, the air pollution at some sections of the city, especially near heavy traffic or highly congested roads, will reach the levels of those of the highly polluted cities in the region. In megacities, defined as cities having populations of over 10 million by the year 2000, such as Beijing, Bangkok, Jakarta and Manila, the present situation is already alarming.

In each country the air quality standard is usually defined by the national environment organization and tends to differ from country to country. It is therefore useful to use the WHO recommended standards to compare air quality. The standards of selected countries and the WHO standards are shown in the table in the annex.

It is difficult to compare the air quality of various cities using average values measured at specific locations, as these locations may not be representative of the whole airshed region. The method of measurement can also vary. A reference standard such as that used by the United States Environmental Protection Agency (EPA) is often adopted, but more often the instrumentation and quality assurance protocol are different. For example, during the author's visit to one monitoring location in Ho Chi Minh City, the instrumentation for measuring nitrogen oxides was made in-house by CEFINEA and no calibration was done on a daily basis. Furthermore, the exposure of the population to air pollutants is hard to measure. Nevertheless, it is informative to compare the air quality of some cities using the values of the worst pollution events that happen at specific locations within them.

A. Particles

Total suspended particulate (TSP) pollution is reported to be serious in major cities in Asia, including Bangkok, Manila, Jakarta, Beijing, Seoul, Bombay and Calcutta (WHO UNEP 1992).

The particulate levels in Bangkok and Jakarta were so bad that the World Bank called for "immediate action" to tackle the problem in these two cities (Towprayoon et al. 1996; Gras et al. undated). One in six people in Bangkok now suffer from allergies because of the high level of particles in the air (Towprayoon et al. 1996). The levels of particles at some traffic sites are very high. Measured hourly values have been reported to be as high as 2.18 mg/m^3 at one site (Towprayoon et al. 1996). The average annual level near the commercial centre of Jakarta between 1980 to 1987 was around 0.4-0.5 mg/m^3 (Gras et al. undated), which is 8 times above the annual level recommended by WHO.

In Manila, the daily average concentration of particles is 3 times the standard level of the WHO and the Philippines of 0.15 mg/m^3 (Montesines 1994). The TSP level in Beijing is very high during the winter season due to the use of coal as the main source of heating and power generation. According to the National Environmental Protection Agency of China, the annual consumption of 33 million tons of coal in Beijing frequently reduces visibility in the city to as little as a quarter of a mile (*International Environment Reporter,* 21 January 1998). Ando et al. (1996) reported that the 1991 average monthly value in Beijing was about 0.217 mg/m^3, and the maximum hourly particle level around the residential area approached a level of 0.8 mg/m^3. Even during the summer, as in 1985, the monthly particle level was approaching 0.2 mg/m^3. Statistics recently released by WHO (*International Environment Reporter,* 21 January 1998) show that in some of the larger cities of China, the annual average level of suspended particulate is between 0.3 and 0.4 mg/m^3.

There is little data on particle levels in the residential areas of Ho Chi Minh City. However, data from some heavy traffic sites showed that the average peak hourly value of TSP was of the order of 6 mg/m^3 (Trung 1996). This was very high compared to the peak value of about 0.4 mg/m^3 measured at the main traffic roads in Tokyo (Ando et al. 1996). Away from street level, at one site measured from the top of an eight-storey building, the monthly average ranged from 75 to 150 $\mu g/m^3$

between 1993 and 1994 (Hien et al. 1997). Even at that distance from the street, the annual average already exceeded the annual WHO standard of 60-90 $\mu g/m^3$.

The monthly average level of TSP reached 1 mg/m^3 during the dry season at one street crossing (Tuan 1996). From this average monthly value, the daily average can be assumed to be similar. This is about 6 times the WHO standard. A maximum hourly value of 15 mg/m^3 was recorded at another street. This was much higher than the maximum level reported in Bangkok from traffic sites.

It is clear that particle air pollution from vehicles is a serious problem in Ho Chi Minh City. It is significantly higher than that of some other cities such as Bangkok and Manila, but it is still less than certain cities in China such as Beijing. In addition to vehicular traffic, the recent construction boom at many sites in Ho Chi Minh City has also contributed significantly to the level of particle pollution (Hien et al. 1999).

By contrast, as regards the indoor environment in Ho Chi Minh City, as there has been a recent switch in domestic cooking fuel from oil and wood to cheaper natural gas, particle and carbon monoxide exposure levels have been reduced.

B. Fine particles (PM_{10} and $PM_{2.5}$)

Fine particles are the respirable components of TSP. PM_{10} and $PM_{2.5}$ are particulate matter with aerodynamic diameters of less than 10 µm and 2.5 µm respectively. They are major sources of public health concern. At present, fine particles are not measured in many cities, but we can estimate fine particle levels using the data available for cities which have similar emission characteristics.

As mentioned before, in Ho Chi Minh City, away from the street, at a site on the top of an eight-storey building, the TSP level was about 100 $\mu g/m^3$ as measured by the Dalat Nuclear Research Institute (Hien et al. 1997). At this height, it can be assumed that most TSP came from PM_{10}. If this site can be considered representative of the whole city, then the annual value for PM_{10} was of the order of 0.1 mg/m^3. This is comparable to an annual average of 0.07 mg/m^3 measured in Taipei in 1994 (Ko 1996).

In a recent preliminary study conducted jointly by the Korean Ministry of the Environment and the United States EPA (Report 905-R-95-011), it has been reported that the daily average of ultrafine particulate matter ($PM_{2.5}$) measured at two sites in Seoul were about 74 and 180 $\mu g/m^3$ respectively. Approximately 50 per cent of PM_{10} samples were made up of $PM_{2.5}$. That means that the level of TSP including fine particles PM_{10} and $PM_{2.5}$ can reach up to 1 mg/m^3. The WHO standard for fine particles PM_{10} is 0.07 mg/m^3.

A detailed study of the fine particle level in Jakarta carried out by the Indonesian Environmental Impact Management Agency with AusAID help (J. Gras et al. undated) has shown that the average monthly level of PM_{10} in the centre of Jakarta was between 0.04 mg/m^3 in the wet season and 0.08 mg/m^3 in the dry season. The maximum daily average can reach a value of 0.14 mg/m^3. The average monthly level of fine particle $PM_{2.5}$ was between 0.02 mg/m^3 (wet season) and 0.04 mg/m^3 (dry season).

If this data is extrapolated for other cities (such as Ho Chi Minh City, which, like Jakarta, has a high proportion of motorcycles and 3-wheeled vehicles), it is clear that all major cities in the region, including Ho Chi Minh City, have fine particle levels many times exceeding the WHO standard for PM_{10}. The latest statistics released by WHO in 1998 show that annual mean concentrations of PM_{10} in South-east Asia range from 0.1 to 0.3 mg/m^3 (*International Environment Reporter* 1998).

C. Lead

The daily lead concentrations measured at various sites in Ho Chi Minh City have been reported as being from trace value ~0 up to 0.41 mg/m^3 (Tuan 1996). The daily average at some sites could therefore be very high. It is likely that the yearly averages for a number of sites exceeded the WHO annual standard. However, at one particular site, as measured by Dalat Nuclear Research Institute, for the period of 1993-1994, the average monthly lead concentrations measured in the dry season were 0.199 $\mu g/m^3$ and 0.159 $\mu g/m^3$ in the rainy season (Hien et al. 1997). The annual average at this site was ~0.18 $\mu g/m^3$, which was below the annual WHO standard.

This level is still high but not as bad as those in Bangkok. In the Yaowarat area, the annual lead level was recorded as 0.96 mg/m^3 in

1996 (*Bangkok Post*, March 1996) even long after the introduction of unleaded petrol in 1991. Before 1991 the lead Level was as high as 2.34 mg/m^3. Other cities also recorded high levels of lead concentrations: for example the annual lead level in Manila exceeded the level recommended by WHO (Montesines 1994) and the average annual lead concentrations in Lahore, Pakistan, at traffic sites was 0.004 mg/m^3, which was three times the recommended WHO standard (Smith et al. 1996).

It is expected that the lead pollution in Ho Chi Minh City will worsen unless the Government introduces the use of unleaded petrol.

D. Sulphur dioxide

WHO reports that Beijing and Seoul currently have serious sulphur dioxide (SO_2) pollution. The WHO guidelines are often exceeded by more than a factor of two (WHO and UNEP 1992). In Beijing, coal-fired power stations and the use of coal for domestic heating contribute significantly to SO_2 pollution in the winter. In one study, conducted in December 1991, the measured average monthly ambient SO_2 concentration in a residential area was 0.233 mg/m^3, which was about 5 times that measured around main roads in Tokyo (Ando et al. 1996). The extensive use of coal for energy has produced serious SO_2 and CO_2 pollution in many major cities of China. It also causes an acid rain problem, even in the neighbouring countries of Korea, Japan, Taiwan and the Philippines (Littlefield 1996).

Ho Chi Minh City does not have a SO_2 problem, as the only main SO_2 sources are some large factories located in the Thu Duc area. The main power source is hydroelectricity and most domestic usage is of natural gas or electricity. However, concentration levels near some traffic sites and factories are very high. For example, outside the Tan Binh factory the measured maximum hourly concentration was 0.76 mg/m^3 at 40 m (Tuan 1996), 2 times higher than the WHO guideline standard.

E. Nitrogen oxides

Data measured by CEFINEA revealed that the level of nitrogen oxides at some traffic sites in Ho Chi Minh City was very high (Tuan 1996).

The monthly average NO_2 for December 1991, measured at various main roads in Tokyo was ~0.111 mg/m^3. In Beijing, for the same period, the ambient monthly average concentration recorded in the residential area was about 0.07 mg/m^3 (Ando et al. 1996).

From the range of daily averages measured at a number of sites in Ho Chi Minh City, a monthly average of about 0.15 mg/m^3 can be inferred. This value is of about the same order as that of Tokyo. This suggests that the main causes of this high level was due to some highly congested roads and the poor emission control of vehicle exhaust system.

F. Carbon monoxide

The main source of CO pollution is motor vehicles, especially older vehicles without catalytic converters. The greater the number of motor vehicles, the greater the CO pollution. In Bangkok the daily average concentration of ambient CO measured at a number of roadside stations is between 8.9 and 20.35 mg/m^3. In one public health study conducted recently at a bus station, people were shown to be exposed to an average hourly concentration of 80 mg/m^3 of CO (*Bangkok Post*, March 1996).

In Ho Chi Minh City the hourly value recorded at a number of traffic sites by CEFINEA ranged from 0 to 23.3 mg/m^3 (Tuan 1996). However, on another day (25 April 1996), the maximum hourly value of CO was 62.65 mg/m^3, which was 1.5 times above the standard. It can be said that the level of CO pollution in Ho Chi Minh City is now approaching that of Bangkok.

G. Ozone

Ozone is a secondary pollutant formed, in the presence of strong sunlight, from the reaction of oxygen with nitrogen oxides and hydrocarbon emitted mainly by motor vehicles. Smog, the combination of ozone and nitrogen oxides, is the most frequent gaseous type of air pollution in the summer. In many cities in Asia it is not unusual to have both particle pollution and smog at the same time.

Ozone pollution is frequently recorded as very high in Hong Kong, China and Taipei. Although ozone is not usually measured in Manila, Bangkok or Jakarta, ozone pollution is believed to be very high in these cities. Emissions from motor vehicles without catalytic

converters and the presence of strong sunlight for most hours of the day make it likely that the smog formation and the ozone concentration exceed the WHO standard. It is believed, therefore, that the smog level in Ho Chi Minh City is the same as that of other cities, as the meteorological conditions and the emission characteristics are of a similar nature.

V. CURRENT MEASURES AND RESPONSES

The Government has recognized that the pollution problem is causing a rapid deterioration in the environment. After the Environment Law was adopted in 1994 the Government declared its intention to prosecute all cases of environment violation on 26 April 1995. In July 1995 the People's Committee of Ho Chi Minh City ordered the Office of Science, Technology and Environment (So Cong nghe va Moi truong) to make an inventory of and inspect all industrial air pollution sources in the city. Sources which had serious environmental effects in terms of air, water and noise on surrounding residents were asked to improve or risk having their sites closed down. The names of the 93 worst polluters were published in a blacklist. Some companies were forced to shut down temporarily, including the monosodium glutamate producer Vedan and the processed meat manufacturer Vissan (Levine 1997).

The Committee also started to move factories, especially those in the rubber, plastics, paper and detergent industries, to industrial zones outside the city, mostly in Dong Nai province. This policy is in line with government regulations on industrial, export-processing and high-tech zones. There are currently 10 industrial parks in Dong Nai province.

As regards environmental management, the United Nations Development Programme (UNDP) recently provided US$ 1.12 million funding to a project called "Capacity 21 Trust Fund" to help the Government integrate environmental issues into development policies. Similar programmes have been conducted in China and India. UNDP has estimated that almost US$ 1 billion for clean-up and waste reduction is required to address the growing problem in the Bien Hoa industrial area of the nearby province of Dong Nai, where almost roughly half of the factories have outdated emission controls. Another related UNDP project is to convert some industrial processes (especially in cosmetics) to new processes for the protection of the ozone layer.

In 1995 the Chamber of Commerce and Industry of Viet Nam, with sponsorship from the World Wildlife Fund and UNDP, organized a conference on commercial development and environment. Many environmental specialists reported alarming levels of environmental pollution in many cities in Viet Nam especially in Ho Chi Minh City. Not only air pollution, but also water, ground water and waste pollution are now serious problems that have to be tackled.

In Ho Chi Minh City, the Government also actively pursues a policy of moving houses located near creeks and canals. The policy encourages people to move to new places to protect water and air quality, as well as to promote hygienic city living. Between 30 and 50 per cent of these areas are converted to park land with more tree coverage in order to provide a fresh and clean environment to city residents to enable them to escape the sultry weather and bad air quality. A number of "Green Days" and "Green Weeks" have been initiated, with the participation of youth organizations, to raise environmental awareness (Dang et al. 1995). In 1994 the Government prohibited the production and use of firecrackers during New Year festivities, which has resulted in lower levels of lead and sulfur dioxides in ambient air during the festival months (usually January or February) (Hien et al. 1997).

On the issue of air pollution, a plan to set up a number of permanent air quality monitoring stations in Ho Chi Minh City and in the southern provinces has been actively pursued. More important, the Ho Chi Minh City People's Committee announced an order in March 1996 to enforce the compliance of road vehicles with emission regulations (Trung 1996), which has been enforced by the traffic police department throughout the city since then. In the "Clean and Green" Week of 12 to 19 May 1996, 410 vehicles were booked for emissions offences.

The Ministry of Science, Technology and the Environment currently has a plan to set up some permanent environmental monitoring stations in many cities, including Hanoi, Hai Phong and Da Nang, with the help of other countries. In Ho Chi Minh City the Ho Chi Minh University of Technology has assisted in this effort by providing some technical help and evaluation.

To contain the problem of air pollution, traffic flow and transport management are important. The Office of Transport in Ho Chi Minh City put a proposal to the People's Committee to increase the capacity

of traffic flow at intersections of 12-16 m width by building tunnel at 4.5-5 m depth and 8-8.5 m wide. It is proposed that the first tunnel be built at the intersection of Nam Ky Khoi Nghia and Tran Huy Lieu Streets, which would much improve traffic flows. A feasibility study on the building of a traffic control centre was completed in 1998. This centre will be able to control 48 routes and intersections. Camera systems at 4 intersections and 48 traffic signals in several city districts are also to be installed.

At a seminar organized in 1998 by the People's Committee with the participation of many city organizations and the Overseas Economic Cooperation Fund of Japan, financing for development and planning of urban traffic systems was discussed and proposed. A master plan for transport and communication prepared by the Municipal Department of Communications and Public Works was presented. Under this plan, new main roads linking new urban centres to be developed to the east and south of the city, and a ring road around the city are to be built. Three railway lines are also proposed: from Bien Hoa to Hoa Hung and Phu Lam; from Tan Son Nhat airport to Ben Thanh market (then possibly crossing the Saigon River towards Thu Thiem and the new international airport to be built at Long Thanh, Dong Nai Province); and from Cho Lon to the city centre and Binh Thanh district, then towards the east. This plan is quite ambitious, however. It is not clear how the city can finance this project, even with the help of overseas aid, or keep to the timetable proposed for its implementation.

VI. SOME SUGGESTIONS FOR AN AIR QUALITY MANAGEMENT PLAN IN HO CHI MINH CITY

Ho Chi Minh City can benefit from the experience gained by Asian and other world cities, in dealing with environmental problem in recent years. Many of these cities have similar development patterns resulting from similar strong economic growth. In view of the growing problem in Ho Chi Minh City, the practical measures discussed in the following sections could be considered for incorporation in the air quality management plan.

A. Introduce unleaded petrol and cleaner fuel

Spectacular reductions in lead levels have been achieved in many cities which gradually phased out leaded vehicles. In Bangkok, after

unleaded petrol was introduced in July 1991, a 1996 study of newborn babies showed that blood lead levels were one third of those from before the introduction of unleaded petrol (*Bangkok Post*, March 1996). Even in adults, blood lead levels were found to be lower than in neighbouring cities such as Manila and Kuala Lumpur. This can be attributed to lower lead levels in the atmosphere (Shang et al. 1999). Singapore stopped the distribution and sale of leaded petrol in July 1998.

Of all pollution control measures, the reduction of lead is probably the most important gain in terms of benefits to the health of people living in cities, especially children. However, the use of unleaded petrol increases levels of volatile organic compounds such as benzene and toluene in the air. Newer car models can reduce the emission of these pollutants compared to earlier models using unleaded petrol. The testing of exhaust emissions from used motor vehicles in Bangkok has shown that newer models significantly reduce the emission levels of these pollutants (Muttamara et al. 1999).

Consideration should also be given to reformulated gasoline. Reformulated gasoline, or gasoline blended with ethanol or methanol, significantly reduces volatile organic compound emissions from cars. Volatile organic compounds contain many carcinogenic chemicals such as benzene and toluene. Reformulated gasoline had been introduced and used in many cities in the United States, with significant gains such as the reduction of ozone formation. In 1998, the Central Pollution Control Board of India proposed the introduction of reformulated gasoline (with 3 to 5 per cent ethanol or methanol) on an experimental basis in New Delhi.

SO_2 is not of great concern in Ho Chi Minh City, but consideration should be given to encouraging the use of and gradually introducing low-sulphur diesel fuel. Newly acquired commercial trucks and buses should have engines that are able to use low-sulphur fuel. This would reduce SO_2 emissions from buses and utility vehicles, which are the main sources of high SO_2 levels near traffic sites. Low-sulphur diesel fuel was introduced into Thailand in 1991. Bangkok relies on large power plants for electricity and power-generating plants began to use clean coal technology in 1992.

B. Establish standards for emission control of vehicles

All new vehicles (including motorcycles), whether assembled, manufactured locally or imported, should be required to conform to the emission control regulation. The introduction of catalytic converters for motor vehicles should also be considered.

One example of this measure is that of the Ministry of Science, Technology and the Environment and the Pollution Control Department, of Thailand who together set up emission standards for cars in 1992 and for motorcycles in 1993. Since 1995, all buses, three-wheeled cars (tuk-tuks) and boats have been tested for emission compliance before registration.

In India, in an effort to clean up the polluted air of New Delhi, the Supreme Court ruled in 1999 that new cars sold in and around the capital had to conform to Euro II emission standards from April 2000. Indian car manufacturer such as Maruti have announced that they will produce cars that meet the standards.

According to the Environment Committee of Ho Chi Minh City, up to 85 per cent of road vehicles do not comply with emission regulations. Since the beginning of 1996, traffic police have enforced the emission compliance of road. Some of the difficulties in enforcement are the lack of emission standards and the fine for motorcycles being too low (Trung 1996). A more effective measure would be to check vehicles for emission compliance before registration. The check for emissions should be done before any vehicle can be registered.

As pollution from nitrogen oxides and carbon monoxide is very high in Ho Chi Minh City, the introduction of catalytic converters in the exhaust systems of vehicles would improve the situation. These converters reduce the amount of nitrogen oxides, carbon monoxide and unburnt petrol escaping into the air. In New Delhi consideration is now being given to requiring all engines to be fitted with catalytic converters to reduce unburnt fuel.

Measures, such as the one recently announced by the New Delhi government to ban all taxis, buses and auto rickshaws over 15 years old to combat the daily pollution blanket over the city are too drastic for the situation in Ho Chi Minh City. However, regulations should be introduced to discourage the use older cars and motorcycles.

C. Establish permanent on-line air quality monitoring stations

The monitoring of air quality is the main means of accessing the effectiveness of any air quality management plan, as well as providing information on air quality in the city. The design of the network and the type of pollutants to be measured are considered important factors in assessing the air quality of a particular city. Permanent continuous monitoring stations also provide data on long-term trends in air pollution levels.

Recognizing the importance of air quality monitoring as part of environment management, a number of countries in the region have recently started establishing networks of air quality stations. The largest air quality monitoring network in Asia is in Taiwan, with 66 monitoring stations distributed throughout the large cities of the island, especially in Taipei. In Bangkok the Pollution Control Department started to implement Phase I of a plan to establish permanent monitoring stations in 1993: this involved 8 stations. Phase II will take place over the next few years, and involve 20 more stations.

In Kuala Lumpur air quality monitoring was previously outsourced to private companies, but recently the Government has funded the University of Malaya to set up a few mobile stations to acquire data. This change was made after legal problems arose as the responsibility for data quality assurance was not clarified. As air quality data is essential for successful monitoring of the effects of the implementation of air pollution control strategies, the Government or city authority should always retain responsibility for collecting the information.

In Ho Chi Minh City air quality data is currently measured and collected by different organizations. The Office of Science, Technology and the Environment regularly funds the CEFINEA group at the Ho Chi Minh University of Technology to monitor and evaluate the air data. Due to lack of instruments, only a few pollutants are measured. Some of the instruments are made in-house. The pollutants are measured for a specified period and are manually collected at all sites. The air quality reports are not widely known and available.

D. Develop an information and forecasting service

If an air quality information and forecasting service were established, it could provide timely information to people in the event of high pollution days resulting from particular meteorological conditions. This would also raise general awareness of environmental issues. The air quality reports should be made available publicly.

In China the National Environmental Protection Agency, started to issue weekly comparative air quality reports on major cities in 1998, in a bid to enable the public to supervise the anti-pollution efforts of the Government (*International Environment Reporter* 1998). This is an important step, as it shows the determination of the Government to face the challenge of improving air quality.

As the mass availability of communications and computing technology such as the Internet is expanding rapidly, it would also be effective to make daily information on our quality available on the internet in order to reach a more informed audience. Viet Nam has been linked to the Internet via several fast lines since 1997. Usage of Internet services is increasing in growth centres such as Ho Chi Minh City and Hanoi. Some cities in the region, such as Bangkok and Singapore, already provide this service on a daily basis.

E. Publish names of companies violating environmental standards

The publication of a blacklist, for example, the ten worst companies violating environmental standards would force those companies to improve their images, in addition to having to pay the fines for such violations. This blacklist would also inform the public of the record of these companies in terms of environmental responsibility. The publication of a gold list of companies with the best environment records and practices could be a powerful incentive to companies to strive for better performance.

In Indonesia the environmental protection agency announced such a scheme, called Proper-Prokasih, in 1996. The results suggest that it has had a positive impact on the behaviour of polluters (World Bank 1999). This programme focuses primarily on industrial water pollution, but it could also be extended to air pollution. The following year, the Philippine Department of the Environment and Natural

Resources announced a similar public scheme, called EcoWatch, for both air and water pollution. The EcoWatch programme and its results have been widely reported in the press and have brought a positive public reaction. The success of these case studies has been noted in many countries.

F. Adopt the "polluter-pays" principle and set up a regulatory framework

The adoption of the "polluter pays" principle and the establishment of a regulatory framework would mean that production units, not the State, would be responsible for controlling emissions. To implement this, a strong independent regulatory agency with powers of enforcement would be required. Such a regulatory agency could levy an emission tax for each emission source, based on the amount of emission. The levy could be used partly for monitoring and partly for the improvement of environmental resources or education. Polluters should be penalized to make them less competitive in the market place. Experience shows that such a scheme always benefits the environment because it forces dirty industries to obtain cleaner technology.

The levy based on the emission load could be set up on an annual basis as part of the operating licence requirements. Large manufacturing companies with substantial emissions which could have an impact on air quality in the surrounding areas could be made subject to additional conditions requiring them to monitor air pollutants. Such self-monitoring would be reported to the environmental authority on a regular basis. If any of the air quality guidelines were exceeded, efforts to reduce the load would have to be made. The environmental agency would make its monitoring reports available to the public. This transparent scheme has been adopted by environmental regulatory agencies in many states and countries, including Australia.

Policies giving incentives to industries to reduce emissions are also needed. Industries should be encouraged to implement process changes in order to obtain ISO 14000 or 14001 certification. A number of companies, especially export-oriented ones, have already implemented changes and obtained the ISO environmental standard. Another new approach to speed up the reduction of emission is the emission-trading scheme. Experience of the trading scheme for SO_2 in the United States of America has shown that it has both environmental and economic benefits.

China has recently started a comprehensive reform of the pollution levy system covering all pollution sources including air, water, noise and waste (Bohm et al. 1998). The majority of pollution sources are the state-owned enterprises which have been propped up by the State for many years. The penalizing and treating of state-owned enterprises in the same way as other offending pollution sources are treated, shows the seriousness of the commitment of the government to reducing environmental damages, as well as to economic reform. The lessons of this reform should be very instructive.

G. Introduce transport planning to reduce traffic congestion

The present total road length is about 1,685 km (an average of 820 m of road per square kilometre) or about 4,000 km of traffic lanes. According to the city authority, to provide adequately for traffic flow, city vehicles require at least 9,200 km of traffic lanes. In recent years a number of initiatives have been taken, such as road widening and private build-operate-transfer schemes to reduce congestion and improve traffic flow. However, this has been out of necessity rather than the result of a careful or effective planning process.

Transport planning also involves the diversion of traffic in case of congestion, the management of traffic flows, effective traffic light coordination, and so forth. It is noted that the high level of nitrogen oxides and carbon monoxide pollution at many traffic sites is due mainly to traffic congestion. Unless there are policies to restrict the number of registered vehicles and to encourage other modes of transport, the building of new roads will not solve traffic congestion. The increasing number of vehicles would quickly make the return of congestion highly possible.

The traffic consists mainly of two-wheeled vehicles and almost no roads have clear lanes for different vehicle types, except at a few main roads in the city centre. One practical low-cost suggestion for improving traffic flows on some streets is to designate traffic lanes for different types of vehicle, giving priority to bus lanes. The city authority's proposal is to allow pedestrian and public transport access (and deter other vehicles by charging a high fee) to some quarters in the city centre, as has been done in Singapore. This may not work, since the traffic congestion and high volume of traffic flows are mostly happening outside the city centre.

Traffic congestion is made worse by the numerous traffic accidents in the city. Since the economic reform of the late 1980s, the number of traffic accidents has increased rapidly. From 1990 to 1997, traffic accidents accounted for about 30,000 deaths and 94,000 injuries (Levine 1997). These figures are not surprising as there is no requirement for a motorcycle driver to have a driving licence, nor is there a minimum age limit unless the motorcycle engine capacity is 75 cc or above. In fact, most registered motorcycles in the city are of 50 cc capacity or below. Education on basic traffic rules, as well as regulations stating minimum requirements for driving a motorcycle would improve the situation.

Although heavy-duty trucks and commercial vehicles are restricted to the main arterial roads and are only allowed to travel at certain hours of the day, the inadequacy of alternative road access gives rise to numerous violations. This also provides fertile ground for corrupt practices. Priority should be given to new ring roads, bypassing the city altogether and linking the northern highways to the southern provinces.

H. Increase usage of public transport

At the moment, the provision of public transport, mainly buses, is low. The bus transport system meets less than 5 per cent of transport needs. Consequently, there is an increasing number of taxiing services involving cars, small private buses and even motorcycles. Moreover, with increasing members of tourists coming to the city the demand for convenient transport in the city is increasing. A scheme to expand bus services in many parts of the city, especially along high traffic routes, will ameliorate the traffic and pollution problems. Recent efforts by the city authority to introduce new buses to serve existing and new routes is encouraging, but the uptake of bus transport remains low.

Low-sulphur diesel fuel should be introduced, not only for buses, but also for all trucks and heavy-duty vehicles. As particulates emitted from diesel fuel burning are highly toxic and contain many carcinogenic compounds, it may be appropriate to invest in running part of the bus fleet on compressed natural gases. This technology is now available although the cost is still about double that of diesel-fuel technology. Natural gas vehicle (NGV) bus fleets are running successfully in many cities of the world, such as Sydney, Caracas, Los Angeles and New

York. The Government of the United States of America has a policy of introducing NGVs in government fleets; the United States Postal Service has the world's largest NGV fleet. In 1998 the Government of Malaysia purchased 1,000 NGVs at the time of the Commonwealth Games, and these have now been redeployed as taxis. In Egypt the Government has speeded up plans to set up natural gas fuelling stations outside Cairo.

Another advantage of using NGV is that Viet Nam has abundant supplies of natural gas available from its offshore oil fields, which can be used at a much lower cost than diesel. NGV buses emit 60 per cent less nitrogen oxides, carbon monoxide and harmful particulate than diesel buses. In the long run, the benefits of NGVs outweigh their initial cost, given the lower health and environmental costs due to fewer adverse effects from air pollution.

Consideration should also be given to creating a light rail network in some sections of the city to complement the bus network. The city's transport and communications master plan specifies the future construction of three main railway lines. However, it is not clear whether a feasibility study has been conducted to determine the cost of the project and the time scale of its implementation. A light rail transit (LRT) system was implemented in Kuala Lumpur and is now running successfully. A second light rail system is being built, as well as a rail link to the new airport. Bangkok is also developing a mass transit system based on an elevated LRT system.

Lastly, human-powered, three-wheeled "cyclos" should not be completely banned in the city area, as happened recently. This form of transport is non-polluting and is many people's means of support. Rather than banning its use in the city centre, a limited number of cyclos should be allowed. Many people prefer this mode of transport. In Indonesia the pedicab is also very popular and still in use, although it is officially banned from the streets of Jakarta. The cyclo is popular with both local people and tourists, and contributes to the city's character.

I. Conduct airshed studies and an emission inventory for the city region

Airshed studies involve the detailed understanding of the transport mechanism of air due to meteorology and the emission inventory of both stationary and mobile sources. An airshed model can be made or adapted from well-known urban airshed models publicly

available from organizations such as the United States EPA or the California Institute of Technology. The model can then be used as a tool to portray different scenarios resulting from different control strategies. This computer model can be an invaluable tool in the search for the best way to formulate an appropriate response to the air pollution problem. Particular emphasis should be placed on particles as well as gaseous pollutants.

If time and resources are problems in conducting a detail study, then at least an emission inventory of the amount of different pollutants emitted into the airshed from different sources (factories, domestic sources, cars, motorcycles, and so forth) during each month of the year could be conducted. This would at least provide an overview of the potential air quality problem for the urban area under consideration. The emission inventory might have to be updated (say, once in two years) depending on the rate of industrial and traffic growth in the area.

In addition, more studies on the effects of air pollution on people's health would help to ascertain the economic cost of air pollution. Studies could include the relationship between levels of particles, lead and volatile and reactive organic compounds with people's health. The many studies conducted before in other cities could be referred to in order to gauge the economic benefits of reducing these pollutants in ambient air.

J. Formulate an air quality management plan based on the airshed studies and the economic implications of various control strategies

Due to meteorological conditions and recirculation during the dry season, the highly concentrated new industrial parks in the north, north-east and south of the city can aggravate the air quality problem in the city. Using an the airshed study, a more effective air quality management plan, taking into account transport requirements and industrial development, could be formulated, avoiding serious degradation of the air environment of the city. For example, airshed simulation studies based on current emissions from mobile and stationary sources can predict the daily level of nitrogen oxides, ozone, sulphur dioxide or particles at various places in the city area. Different scenarios can be applied to see the effects of changing the emission input via urban redevelopment, industrial relocation and development, public

transport routing, or reducing current motor vehicle emissions by, for example, 20 per cent.

Levels of pollutants have exceeded national standards at many locations in the city. It is important to identify which pollutants should be targeted for a reduction in their emission levels and to study various control strategies and their economic implications. If particles PM_{10} and $PM_{2.5}$ levels are to be reduced as a policy priority, methods to estimate the health and economic benefits of particle level reduction are available (Ostro 1992 and 1998). The cost of implementation is dependent on the plan, which can be chosen from the best scenario of the simulation study. Costs can be short term, whereas benefits are always long term. Alternatively, if NO_2 is targeted, emissions from motorcycles, which currently contribute, about 70 per cent of total emissions, could be reduced by a plan such as phasing out the old fleet by incentive schemes, limiting total fleet growth and providing more public transport. Currently, the economic benefits of NO_2 reduction are hard to quantify, as the studies looking at its effects on health are not yet as comprehensive as those relating to particles.

CONCLUSION

The air pollution problem in Ho Chi Minh City is rapidly becoming as serious as other larger cities in the region. Levels of sulphur dioxide and lead are low compared to other cities, but they are increasing. Levels of particles, nitrogen oxides and carbon monoxide are similar to, or higher than, those of a number of other cities, such as Bangkok, Tokyo and Manila.

To address the problem of increasing degradation of air quality in many cities in the Asian region, many governments are now actively pursuing plans to contain the problem. For example, the Government of the Philippines has taken initiatives to meet this challenge, one of which was to call for and organize a meeting in 1995 on sustainable development within Asia-Pacific Economic Cooperation countries. The aim of the meeting was to establish a collaborative framework for protecting the environment. A number of initiatives have also recently been taken to contain the air quality problem in Ho Chi Minh City, but a more focused and integrated plan, using the experience gained by other cities that have suffered serious degradations in air quality in the past, is vital to prevent the situation of air pollution in the city from getting worse and becoming harder to contain in the future.

Annex

AIR QUALITY STANDARDS OF SELECTED COUNTRIES AND OF WHO

Pollutant	*Country*	*Annual average*	*Daily average*	*Daily maximum*	*Hourly average*	*3-month average*	*8-hour average*
Total suspended particulates (mg/m^3)	China	0.3	1.0				
	India	0.2					
	Indonesia		0.26				
	Thailand	0.1	0.33				
	Philippines		0.15		0.25		
	Viet Nam		0.2		0.3		
	Japan		0.1	0.2			
	United States	0.075		0.26			
	Australia (NSW)	0.09					
	WHO	0.06-0.09	0.15-0.23				
Particulate matter<10 μm (mg/m^3)	United States	0.05	0.15				
	Australia (NSW)	0.05	0.15				
	European Union		0.07				
	WHO		0.07				

Annex *(continued)*

Pollutant	*Country*	*Annual average*	*Daily average*	*Daily maximum*	*Hourly average*	*3-month average*	*8-hour average*
			0.3				
Sulphur dioxide	Philippines		0.37	0.85			
(mg/m^3)	Viet Nam		0.3		0.5		
	Japan		0.11	0.26			
	United States	0.08		0.365			
	Australia (NSW)	0.06			0.7		
	WHO	0.03	0.09		0.35		
	China	0.12	0.1-0.15	0.15			
	India	0.08	0.0925				
	Indonesia		0.0093				
	Philippines				0.19		
Nitrogen dioxides	Thailand				0.32		
(mg/m^3)	Viet Nam		0.1		0.4		
	Japan		0.04-0.06				
	United States	0.1					
	Australia (NSW)	0.1			0.32		
	WHO		0.16		0.19-0.32		

Annex *(continued)*

Pollutant	*Country*	*Annual average*	*Daily average*	*Daily maximum*	*Hourly average*	*3-month average*	*8-hour average*
	WHO		0.065		0.15-0.2		
Lead (mg/m^3)	Indonesia		6.0				
	Thailand		0.01(7)				
	Viet Nam		0.005				
	European Union	0.002					
	United States					0.0015	
	Australia (NSW)					0.0015	
	WHO	0.0005-0.001					
Carbon monoxide (mg/m^3)	India	2					
	Indonesia						22.6
	Viet Nam				40.0		10.0
	Australia (NSW)				30.0		10.0
	United States				40.0		10.0
	WHO				30.0		10.0

Source: Compiled from different sources.

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