ANATOMY OF A TRAFFIC DISASTER:
TOWARDS A SUSTAINABLE SOLUTION TO BANGKOK'S
TRANSPORT PROBLEMS

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This thesis is presented for the degree of Doctor of Philosophy
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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary educational institution.

Chamlong Poboon
To my parents,
my brother and sisters,
my wife and my son
ABSTRACT

Bangkok's extreme traffic problems have been traditionally explained in terms of a lack of road infrastructure and policy responses for many years have almost exclusively stressed road investment to the exclusion of all other forms of transport infrastructure development. This thesis questions this interpretation of the traffic problem and its chief policy response: building still more roads. It suggests that in order to effectively analyse Bangkok's traffic predicament and to formulate more sustainable responses to the crisis, an understanding is required of Bangkok's land use and transport development, as well as a systematic and detailed perspective on the similarities and differences between Bangkok and many other cities around the world, particularly those in Asia.

This thesis suggests that Bangkok has passed through three key periods: a water-based transport and walking period, a transport modernisation period and a motorisation period. In each period up to motorisation Bangkok appeared to maintain a harmonious relationship between its high density, mixed use urban form, ideally suited to non-motorised modes and to public transport. Even in the motorisation period, high density, mixed use development has mostly followed major road corridors and remains well-suited to much higher public transport and non-motorised mode use than currently exist. However, in this period, rapidly rising motor vehicle ownership and use began to come into conflict with the city's pre-automobile form. Road infrastructure could not be built fast enough to keep pace with traffic growth, despite almost exclusive commitment of resources to roads. High capacity public transport systems, including rail, renewed water transport and busways failed to materialise to help curb the motorisation process and to provide much needed relief on the roads. A basic conflict or mismatch between urban form and transport began to emerge, leaving the city ill-equipped to cope with the automobile and subject to large environmental, social and economic impacts from congestion.

The thesis argues that while Bangkok's per capita road supply is low in an international sense, it is not atypical for an Asian city and road availability per hectare is similar to many other cities around the world. Likewise, common arguments about an inadequate road hierarchy are systematically analysed and are shown to be insufficient in explaining Bangkok's present crisis. The thesis thus suggests that attempting to tackle the traffic problem through an intensification of road building efforts will not provide the relief sought, but will only exacerbate the traffic impacts which are shown to be already at the limits of international experience.
The international comparison of Bangkok with other cities, highlighting basic similarities and differences in land use and transport features, continues to build upon this argument. It shows that Bangkok lies at one extreme in many transport characteristics such as the amount of travel per hectare, and within the Asian cities, it is very high in vehicle ownership and use and energy use, comparatively low in public transport use and very low in non-motorised modes. The thesis suggests that in physical planning terms, Bangkok's traffic crisis appears to stem from a set of mismatches between its transport patterns, urban form and transport infrastructure. These mismatches are between: (1) vehicle use and urban form: higher levels of private vehicle use than can be properly accommodated in its dense, tightly woven urban fabric; (2) vehicle use and road supply: levels of private vehicle use which are incompatible with its road availability and which are uncharacteristically high compared to other Asian cities; (3) transit use, urban form and road supply: lower levels of overall transit use than would be expected in a city of its urban form and road availability; (4) transit infrastructure, urban form and road supply: a public transport infrastructure which is inadequate to meet the demands for transit movement inherent in such a dense city, particularly a lack of rail infrastructure; (5) non-motorised modes and urban form: levels of non-motorised mode use which are uncharacteristically low for such a dense, mixed use urban fabric. These mismatches are mainly the consequence of a long series of inappropriate and ineffective transport policies and investments which are biased towards private transport and which have at least in part arisen from narrow and outdated transport planning processes.

In order for transport planning in Bangkok to address the suggested roots of the crisis, the thesis contends that at least two key constraints would have to be dealt with: the traditional urban transport planning process and the institutional fragmentation in transport policy and implementation. Notwithstanding, there are forces pushing in the direction of change and these are examined in terms of the growing global and local trends towards sustainability, community outrage over traffic and the role of NGOs.

Based on these findings, this thesis provides a case for a series of policies to help deal with Bangkok's traffic disaster. In line with global trends towards sustainability as an organising principle for urban policy development, these policies are offered within a framework of developing a more sustainable transport system in Bangkok. The policies suggested cover priority to public transport infrastructure development, transit-oriented, mixed land use development, transport demand management, improvement of waterway transportation, facilitation of walking and cycling and institutional reform of Bangkok's transport decision making structure. Opportunities for further complementary research are suggested.
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GLOSSARY AND ABBREVIATIONS

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<th>Description</th>
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<tr>
<td>µm</td>
<td>micrometres</td>
</tr>
<tr>
<td>BMA</td>
<td>Bangkok Metropolitan Area, Bangkok Metropolitan Administration</td>
</tr>
<tr>
<td>BMR</td>
<td>Bangkok Metropolitan Region</td>
</tr>
<tr>
<td>BMTA</td>
<td>Bangkok Mass Transit Authority</td>
</tr>
<tr>
<td>CBD</td>
<td>Central Business District</td>
</tr>
<tr>
<td>CFCs</td>
<td>Chlorofluorocarbons</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon monoxide</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>DLT</td>
<td>Department of Land Transport</td>
</tr>
<tr>
<td>DOH</td>
<td>Department of Highways</td>
</tr>
<tr>
<td>DPW</td>
<td>Department of Public Works</td>
</tr>
<tr>
<td>DTCP</td>
<td>Department of Town and Country Planning</td>
</tr>
<tr>
<td>ECMT</td>
<td>European Conference of Ministers of Transport</td>
</tr>
<tr>
<td>ESD</td>
<td>Ecologically Sustainable Development</td>
</tr>
<tr>
<td>ETA</td>
<td>Expressways and Rapid Transit Authority of Thailand</td>
</tr>
<tr>
<td>GBA</td>
<td>Greater Bangkok Area</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>GRP</td>
<td>Gross regional product</td>
</tr>
<tr>
<td>ha</td>
<td>Hectare</td>
</tr>
<tr>
<td>HC</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>ISTP</td>
<td>Institute for Science and Technology Policy</td>
</tr>
<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>klong</td>
<td>Thai word for canal</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre</td>
</tr>
<tr>
<td>km/h</td>
<td>Kilometres per hour</td>
</tr>
<tr>
<td>km²</td>
<td>Square kilometre</td>
</tr>
<tr>
<td>LEQ</td>
<td>Equivalent sound level</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied petroleum gas</td>
</tr>
<tr>
<td>MJ</td>
<td>megajoules</td>
</tr>
<tr>
<td>MRTA</td>
<td>Mass Rapid Transit Authority</td>
</tr>
<tr>
<td>NEA</td>
<td>National Energy Administration</td>
</tr>
<tr>
<td>NEDB</td>
<td>Office of the National Economic Development Board</td>
</tr>
<tr>
<td>NESDB</td>
<td>Office of the National Economic and Social Development Board</td>
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<tr>
<td>NGO</td>
<td>Non-government organisation</td>
</tr>
<tr>
<td>NMV</td>
<td>Non-motorised vehicles</td>
</tr>
<tr>
<td>NO₂</td>
<td>Nitrogen dioxide</td>
</tr>
<tr>
<td>NOₓ</td>
<td>Nitrogen oxides</td>
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<tr>
<td>NSO</td>
<td>National Statistical Office</td>
</tr>
<tr>
<td>OCMRT</td>
<td>Office of the Commission for the Management of Road Traffic</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>ONEB</td>
<td>Office of the National Environment Board</td>
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<tr>
<td>OPM</td>
<td>Office of the Prime Minister</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>Pb</td>
<td>Lead</td>
</tr>
<tr>
<td>PCU</td>
<td>Passenger car unit</td>
</tr>
<tr>
<td>PWD</td>
<td>Public Works Department</td>
</tr>
<tr>
<td>SDR</td>
<td>Special Drawing Right</td>
</tr>
<tr>
<td>SIMR</td>
<td>The Study on Medium to Long Term Improvement/Management Plan of Road and Road Transport in Bangkok</td>
</tr>
<tr>
<td>SO₂</td>
<td>Sulfur dioxide</td>
</tr>
<tr>
<td>SPM</td>
<td>Suspended particulate matter</td>
</tr>
<tr>
<td>SPURT</td>
<td>Seventh Plan Urban and Regional Transport</td>
</tr>
<tr>
<td>SRT</td>
<td>State Railway of Thailand</td>
</tr>
<tr>
<td>TDRI</td>
<td>Thailand Development Research Institute</td>
</tr>
<tr>
<td>TEI</td>
<td>Thailand Environment Institute</td>
</tr>
<tr>
<td>TPD</td>
<td>Traffic Police Division</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Program</td>
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<tr>
<td>URA</td>
<td>Urban Redevelopment Authority, Singapore</td>
</tr>
<tr>
<td>UTP</td>
<td>Urban Transport Planning</td>
</tr>
<tr>
<td>VKT</td>
<td>Vehicle kilometres of travel</td>
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<tr>
<td>VOC</td>
<td>Volatile organic compounds</td>
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<tr>
<td>WCED</td>
<td>World Commission on Environment and Development</td>
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CHAPTER 1

INTRODUCTION

This dissertation explores the various dimensions of Bangkok's traffic crisis, reviews the relevant research literature and reports on an original and wide-ranging data collection and analysis exercise designed to better understand the roots of Bangkok's severe traffic crisis and to clearly portray Bangkok's land-use and transport system in an international and historical context. Flowing from this analysis, the dissertation attempts to formulate a series of appropriate strategies and policies which would appear to be necessary to effectively tackle congestion in Bangkok and to help set the city on path towards a more sustainable transport system. In doing this it also describes a number of key constraints and opportunities involved in this change of direction.

Because of the severity of the city's traffic problems, this introductory chapter provides a brief summary of the problem before proceeding to outline the research design and describing the organisation of the dissertation.

1.1 BANGKOK'S TRAFFIC DISASTER

Earlier this month (October) a policeman assigned to one of the most notorious intersections in Bangkok "snapped" under the pressure of trying to direct the endless streams of crawling vehicles, switched all his lights to green and danced gaily amid the ensuing chaos.

The 25-year-old corporal was eventually hauled out of the traffic jam and off to a psychiatric hospital where he was diagnosed as suffering from an unspecified "mental illness". (Williams, 1993: 12)

This incident involving a traffic police officer in Bangkok, the Thai capital of about 6 million people, captures the essence of the city's disastrous traffic problem. For Bangkoksians, traffic congestion has become a part of everyday life. No one can avoid it. Children need to rise before 5 am, have breakfast in cars en route to school, and are exposed throughout their journey to toxic
air. Bangkok's traffic is the perennial topic of local conversation and comment in Thai newspapers and magazines, as well as in foreign mass media. For example, an article in the "Earth 2000" section of The West Australian, on October 5, 1992 entitled "Congestion City" began with this description of the intimidating impact of Bangkok's traffic.

The IQ of the people of Bangkok is decreasing. Traffic jams pump so much poisonous lead into the air that the average child has lost four intelligence points by the age of seven.

The snarl-up is so appalling that the Thai capital's cars burn 110 million kilograms of petrol each year just waiting for the traffic lights to change....

This foreign newspaper did not exaggerate the seriousness of traffic congestion in Bangkok. Numerous research studies in recent years have come to similar conclusions. For example, recent studies into Bangkok transport have reported that traffic congestion has reached a crisis level on most main roads, especially in the inner area. The average traffic speed in inner Bangkok is now less than 10 kilometres per hour (Halcrow Fox and Associates et al., 1991). The average speed along the roads with the heaviest traffic is only 3 to 5 km per hour. Worse still, traffic speeds on some congested roads in the CBD during peak hours are no more than 1 to 2 km per hour, slower than half walking-pace (Pendakur, 1993). Moreover, it is predicted that by 2006, if no effective measures are taken, the overall average travel speed of all vehicles in Bangkok will drop to only 5 kilometres per hour (JICA, 1990).

The increasing severity of the city's traffic congestion has contributed to a number of other critical issues in Bangkok. The most obvious problems are air and noise pollution, the impact on health, wider ecological impacts, and economic losses. Somewhat paradoxically, despite the persistent decrease in road traffic speeds, traffic accidents have also been increasing, resulting in a substantial number of casualties and reports of property damage.
1.1.1 Air and Noise Pollution and Health Impacts

In line with the substantial increase in vehicular population and worsening traffic congestion, ambient air quality in Bangkok has been deteriorating to very serious levels. For example, it has been estimated that an 8 hour exposure at street level to Bangkok's air is equivalent to smoking nine cigarettes a day (Pendakur, 1992a: 16). Emissions from motor vehicles account for approximately 60 to 70 per cent of all air pollution in Bangkok (Setchell, 1992: 4). The most serious air pollutants are suspended particulate matter (SPM), carbon monoxide (CO) and lead. Moreover, there are increasing levels of other air pollutants such as nitrogen dioxide (NO2), sulfur dioxide (SO2) and ozone (Wangwongwatana, 1992; Department of Pollution Control, 1991; Matichon Weekly, 1996).

Noise pollution is another serious outcome of the traffic situation in Bangkok. According to the Department of Pollution Control, noise levels measured on roadsides at temporary stations along ten roads from 1988 to 1991 were found to exceed standards of internationally accepted levels (e.g. US EPA) of 70 decibels (dB) (Thailand has no community noise level standards). Most sites had equivalent sound levels (LEQ) for 24 hours of 76 to 81 dB (Department of Pollution Control, 1991).

In 1989, Thailand's Office of the National Environment Board reported that air pollution levels in Bangkok throughout the year were harmful to human health. The rate of exposure to air pollution is very high, and the situation is deteriorating. In 1990, more than 1 million inhabitants (more than 10 per cent of Bangkok Metropolitan Region residents) suffered from respiratory illnesses due to air pollution. Moreover, Bangkok's residents suffer from lung cancer at rates of up to three times those of the rest of Thailand (Magistad, 1991; Setchell, 1992). A recent study reported that approximately 186 of 1,000 Bangkok residents suffer from breathing problems (Townsend, 1995: 71). The health of traffic police and street sweepers may be the clearest indicators of the severity of air and noise pollution in Bangkok, as they are regularly exposed for long periods to such pollution. A recent study revealed that out of 1,758 Bangkok traffic police, 753 suffer from a variety of respiratory diseases including asthma, lung cancer etc., 420 of these have been suffering from these diseases for more than five years (Pendakur, 1992a: 16). Furthermore, it was found that 209 out of 3,801 street sweepers
suffered from respiratory disease, and 32 had lost their hearing. By 1994, to protect themselves from severe air pollution, all traffic police wore air filters (Plate 1.1), and portable oxygen sources were provided for police working at major traffic intersections (Townsend, 1995: 71).

Plate 1.1 A traffic police officer in Bangkok

SPM is estimated to cause about 9 to 51 million days per year of restricted activity because of respiratory illnesses and approximately 1,400 deaths annually among Bangkok's inhabitants (Kingsley et al., 1994: 22).

Lead in the air in Bangkok reportedly causes an estimated 200,000 to 500,000 cases of hypertension, 300 to 900 cases of heart attack and stroke, and 200 to 400 deaths annually among adult males in Bangkok (Kingsley et al., 1994: 22). Lead levels in children's blood are also of great concern. It was found that new-born babies in Bangkok have lead levels in their blood about two to five times higher than the level considered dangerous in the United States, due to the long exposure period of mothers during pregnancy. As a result, it is predicted that these children will almost certainly have some mental retardation, lower intelligence and neurological and muscular disorders (Magistad, 1991). Since 1990 there have been large improvements in this area through lead reduction in fuel.

1.1.2 Economic Losses

The severe traffic congestion in Bangkok is estimated to cost up to 40 billion baht (US$1.6 billion) annually in terms of lost time and extra fuel wasted
because of traffic congestion (Suraswadi, 1994). The BMA Deputy Governor in charge of public works recently estimated these losses at about US$8 million per day, or US$2.92 billion per year. Based on this figure, each of the nearly 2 million households in the Bangkok Metropolitan Region in 1990 annually lost approximately US$1,520 or 14 weeks of their average income (Setchell, 1992: 4). This cost, however, does not include external costs triggered by air and noise pollution, such as the damage to human health, and to materials, plants and non-human life in general. Moreover, with respect to foreign investment, which has been a vital part in Thailand's economic growth, it was reported that traffic congestion was the cause of a 40 per cent decrease in applications by foreign investors to the Board of Investment during the first four months of 1989 compared to the same period in 1988 (Padeco, 1990: 3-46).

1.1.3 Traffic Accidents

Traffic accidents are another major adverse outcome of Bangkok's rapidly growing traffic. The 1985 JICA study on road traffic safety in Bangkok found that within the area bounded by the Middle Ring Road, traffic accidents occurred frequently on roads with high traffic volumes where congestion was also severe. Available accident statistics show an increase in road traffic accidents in Bangkok and indicate a steady increase in fatalities and injuries resulting from traffic accidents (Tanaboriboone, 1994: 86-88). The rate of accidents per 100,000 population for Bangkok is around 30 times higher than for the rest of Thailand. The marked difference between the rate of accidents in Bangkok and that of the rest of Thailand cannot simply be explained by the greater number of motor vehicles in Bangkok, because the rate of accidents per 10,000 vehicles in Bangkok is about 10 times higher than that of the rest of the country.1

1.2 RATIONALE FOR THIS STUDY

The severe traffic congestion and its consequences are clearly evident to all Bangkokians and visitors. For example, results from a recent survey revealed that Bangkok residents rated traffic congestion and air pollution as the two worst aspects of living in Bangkok. Those working or living at street

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1Calculation based on data from Research and Planning Division, Police Department, 1993 and the Expressway and Rapid Transit Authority of Thailand, 1992.
level and low-income commuters who travel by bus are the groups most exposed to air pollution (Ross, 1994: 1). In terms of the root of the problem, most relevant agencies, transport studies and planners point out that Bangkok simply does not have enough roads, and that the structure of the existing road system is inadequate (see Chapter 5). One of the key inadequacies of Bangkok's road system suggested in these studies is the proportion of land occupied by roads in Bangkok. Many studies claim that this proportion is particularly low. Figures of 8 to 10 per cent of land occupied by roads are cited for Bangkok compared to 20 to 25 per cent as the norm for most cities (see, for example, Tanaboriboon, 1993; BMA, 1991b; Bardacke, 1995b). Furthermore, several recent transportation studies have identified another major root of traffic congestion in Bangkok as the lack of a proper road hierarchy (see, for example, JICA, 1990; Halcrow Fox and Associates et al., 1991).

The result of the assumption that the main causes of the traffic disaster are Bangkok's low levels of road provision and the lack of a proper road hierarchy, is that a major focus of amelioration activities has been to build massive new roads and expressways to meet growing traffic demand. Evidence of this is found in the solutions and investments proposed by most Bangkok transport studies and development plans, past and present (see Chapter 5).

However, despite these assumptions and interventions, it is clear that in Bangkok during the last three decades the traffic situation has seriously deteriorated. For example, the average traffic speed on Bangkok's roads in 1972 was about 23 kilometres per hour. Today it is only 13 kilometres per hour.\(^2\) Moreover, the impacts of growing traffic and traffic congestion are increasing at an alarming rate, as previously noted.

Adherence to conventional policy approaches is one reason why most Bangkok transport studies have identified similar causes of the traffic crisis: lack of road provision. These studies primarily rely on the conventional transport planning model, which places emphasis on road-based transport. The primary methodology employed in these studies is analysing traffic

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\(^2\)The 1972 traffic speed figure is from F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975: Table B14; the current traffic speed figure is calculated based on data from Kasetsart University and Sindhu Pike Bodell, 1994: 4.1.
volumes and road networks, predicting traffic demand and proposing road supply to meet demand.

1.3 THESIS QUESTIONS

It is clear from the foregoing brief overview that Bangkok suffers serious consequences from its traffic crisis and that there do not appear to be any positive trends in sight to alleviate this situation, despite perseverance with traditional road expansion approaches for many years. This study therefore attempts to go beyond the traditional analysis of the problem which focuses primarily on the issues surrounding what is seen to be an inadequate road system. It attempts rather, to develop a deeper insight into the vexed question of traffic congestion in Bangkok by asking the following key thesis question:

*Can Bangkok’s traffic disaster be analysed and better understood through a detailed investigation into its historical land-use and transport development and through a comprehensive comparison of Bangkok to other cities around the world, especially those in Asia, and can such a new understanding reveal potential sustainable solutions to its traffic crisis?*

In order to answer this overall guiding question, a number of more detailed subordinate questions need to be asked:

(1) What path has Bangkok followed in land-use and transport terms to arrive at its present traffic crisis?

(2) What influence, if any, has this land-use and transport evolution had on the present traffic situation, and does an understanding of this path help to elucidate any causes or potential solutions to the problems?

(3) How does Bangkok compare internationally to a large sample of other cities, especially other Asian cities, in terms of land-use, transport infrastructure, transport use patterns, energy consumption in transport, transport economics and transport externalities, and are there significant interrelations among these factors which help to explain Bangkok’s present transport condition?
(4) What lessons or insights does a detailed international comparison of Bangkok (showing similarities and differences between Bangkok and other cities) provide about the magnitude of the transport problems facing the city and possible root causes of Bangkok's traffic problems and what do such lessons teach about possible solutions to the traffic crisis?

(5) Are the traditional explanations of the major roots of traffic congestion in Bangkok, in terms of an inadequate road system, sufficient to understand Bangkok's traffic situation?

(6) Are solutions derived from this traditional approach effective and suitable for Bangkok?

(7) What are some of the key constraints behind formulation and implementation of effective transport policies within the Bangkok context and conversely, what are some of the key opportunities?

(8) Based on the research in this dissertation, what are the key policies which appear to be necessary to help resolve Bangkok's traffic disaster, incorporating principles of Ecologically Sustainable Development?

Finding answers to these questions should be of benefit, not only to the Thais (particularly the Bangkok community), but also to those in other developing countries who may be moving towards a similar situation with respect to transport and land-use.

Bearing these questions in mind, it is necessary to employ a much broader approach to obtain insights into the real roots of Bangkok's traffic problems. This dissertation aims to provide a better understanding of the roots of Bangkok's traffic crisis by employing a more comprehensive perspective, rather than relying on the perspective derived from the conventional transport planning model. In general terms, the methodology used is primarily to investigate the interrelationship between Bangkok's transport and land-use patterns, through both a historical analysis and a detailed quantitative analysis of the present situation. A primary focus of this study is the international comparative study between Bangkok's transport and land-use factors and those for other cities around the world, especially Asian
cities, which highlights the similarities and differences between Bangkok and other cities.

1.4 METHODOLOGY

Within an interpretive research paradigm, employing both quantitative and qualitative data analyses, this study adopted two methodologies to investigate the roots of Bangkok's traffic crisis and to answer the key research questions in the previous section. It also examined, by way of literature review and a small survey, some of the central constraints and opportunities facing effective transport policy reform in Bangkok.

1.4.1 Bangkok's Transport and Land-Use Evolution Study

The first methodology involves a detailed examination of Bangkok's transport and land-use development since the city's establishment, to reveal an understanding of the interrelationship between the evolution of transport technologies and land-use change, as it unfolded in Bangkok. The historical development prototype of the Western cities developed by Newman et al. (1992) is employed as a guideline and for comparative purposes. The historical development model by Newman et al. has suggested that walking, transit, and the car (the major forms of transport) are key factors affecting city form. The three periods of the development of cities are set out as the traditional walking city, the transit city and the automobile city. This approach, as a basic framework, also helps to illuminate the path Bangkok has followed in arriving at its present traffic crisis.

1.4.2 The International Comparative Study

The second methodology involves placing Bangkok within an international perspective by comparing Bangkok to thirty-six other cities in the United States, Europe, Australia and Asia. This methodology involves an update and extension of the approach used by Newman and Kenworthy (1989) in Cities and Automobile Dependence: An International Sourcebook. This study revealed large differences in the basic land-use and transport characteristics of cities and identified reasons for these differences, as well as proposing a series of policy options for reducing automobile dependence in cities.
This methodology has been selected to provide an understanding of the existing parameters which describe Bangkok's transport and land-use patterns within an international perspective. It aims to provide a primary basis for insights into the roots of Bangkok's traffic problems and directions for potential policy responses.

This international comparative study involve a detailed and systematic data collection, collation and analysis process involving government and non-government organisations and other sources, contributing to a data set of over thirty-eight factors. Quantitative data from secondary sources were collected and organised under the following categories: (1) urban form and land-use; (2) transport infrastructure; (3) transport patterns; (4) transport energy use; (5) transport economics; and (6) transport externalities. Chapter 3 presents this methodology in detail.

1.5 STUDY OUTLINE AND STRUCTURE

This dissertation comprises eight chapters, as set out conceptually in Figure 1.1. Following this Introduction, Chapter 2 attempts to answer questions 1 and 2 by examining the path along which Bangkok has evolved since its foundation as the Thai capital just over 200 years ago. It briefly investigates Bangkok's geographical features and the history of its settlement. Based on the dominant transport features of different periods, the body of the chapter discusses changes in Bangkok's transportation technologies, urban structure and land-use, which are seen as interrelated factors. Reference is made to the historical development of Western cities as a basic framework and for comparative purposes.

Chapter 3 describes in detail the methodology used for the international comparative study, as set out in question 3. It begins by discussing the contribution of the comparative study and demonstrates its objectives. The chapter then provides a general description of the cities which are to be compared to Bangkok and the parameters to be employed for the comparisons. This is followed by a description of the data sources, data collection and data analysis procedures used in the dissertation for the Bangkok data set. Also discussed are the definitions of Bangkok, the study area and Bangkok's zones (CBD, inner area, outer area). Finally, this chapter explains the methods used in obtaining certain specific data, e.g. the
Figure 1.1 The dissertation structure

Note: The information in this diagram does not portray chapter titles, but rather their basic contents.
urbanised area and some transport pattern parameters, together with specific methodological problems associated with deriving such data.

Chapter 4 is a key focus of this study and attempts to provide answers to question 3 of the thesis. It attempts to identify the physical planning roots of Bangkok’s traffic crisis by comparing Bangkok to other cities, particularly Asian cities. The chapter begins by systematically examining the interrelationship among urban form and land-use and transport. It then places Bangkok within an international framework by examining Bangkok’s land-use and transport under five main categories: (1) urban form and land-use in terms of population and employment density and distribution; (2) transport infrastructure, comprising road, railway and waterway networks, and parking provision; (3) transport and energy use patterns, which encompass vehicle ownership, traffic speed, trip characteristics, private and public transport use, and energy consumption; (4) transport economics, such as road expenditure, the costs of private vehicle use, and transit cost recovery; and (5) transport externalities in terms of transport-related deaths, and emissions. Data for all other cities are presented within the same framework.

Chapter 5 highlights the lessons learned in the previous chapters from the study of Bangkok’s transport and land-use by addressing questions 4, 5 and 6 of the thesis. It commences by emphasising the situation of Bangkok traffic congestion and its related problems. Then follows a discussion of the major issues in Bangkok transport, including issues surrounding road provision and road hierarchy. It then discusses factors affecting the rapid growth of motor vehicle population and use in Bangkok. In concluding, this chapter suggests the deeper roots of the traffic crisis in Bangkok, as revealed by the historical study and the international comparative study.

Chapter 6 attempts to answer question 7 of the thesis by looking in detail at some major constraints and opportunities in formulating and implementing transport policies for Bangkok. Attention to this subject is necessary to understand some of the major barriers and positive forces at work within the Bangkok context which will have a bearing on the plausibility and feasibility of the policies outlined in the next chapter. Further constraints, beyond those examined in this thesis, are suggested in Chapter 8 under further studies.
Chapter 7 begins by introducing some criteria and goals which appear to be necessary if Bangkok is to shift towards a more ecologically sustainable transport model. It then addresses question 8 of the thesis by suggesting a set of plausible policies designed to tackle the crisis. They are based on the findings and constraints and opportunities explored in the previous chapters. In addition, lessons from appropriate models from other cities are employed.

Chapter 8 provides the conclusions to the study in terms of a summary of answers to the basic guiding question and detailed questions which lie behind the dissertation, and suggests further possible research efforts.
CHAPTER 2
THE PATH TO TRAFFIC DISASTER:
BANGKOK’S LAND-USE AND TRANSPORT DEVELOPMENT

2.1 INTRODUCTION

To help understand the present traffic disaster in Bangkok, it is necessary to examine the path along which Bangkok has evolved since it was formally founded as the Thai capital just over 200 years ago (though its history dates back some 600 years). This chapter thus first briefly investigates aspects of Bangkok’s geography, which in the early period was a significant factor influencing Bangkok’s urban form and transport patterns. The chapter then provides a brief history of the settlement of Bangkok to show how Bangkok has developed from a small fishing village to the current Bangkok Metropolis. The main part of this chapter discusses changes in Bangkok’s transport technologies, urban structure, and land-use. These are seen as the main factors determining Bangkok’s transformation from the small water-based and walking city to the current mega city which is now notorious around the world for its nightmarish traffic situation.

2.2 GEOGRAPHIC FEATURES

Bangkok, the capital of Thailand, is located in the central part of the country along the Chao Phraya River which flows from north to south into the Gulf of Thailand, at latitude 13° 45' North, and longitude 100° 28’ East (Figure 2.1). Bangkok is situated on an alluvial plain and the whole area is flat and low, on average about 1 metre above mean sea level. The climate is tropical, with high temperatures and humidity levels dominated by the monsoon cycle. There are three main seasons; rainy (May-October), cool (November-January) and hot (February-April). As the city is only 25 km from the Gulf of Thailand, it is also under the influence of the sea tide. In addition, the city always has heavy rainfall in the monsoon season, with the result that there have been a number of floods since the city’s establishment (BMA, 1992b; Mekvichai, 1992; Poungsomlee et al., 1995).
In addition to the Chao Phraya River, which is the major river of Thailand, there are a number of canals in Bangkok, both natural and man-made, which are linked with the river (see Chapter 4 for details). In former times the main mode of transport in Bangkok was waterways. Not until comparatively recently has road transport become the dominant mode.

The entire area of the Bangkok Metropolitan Area is about 1,570 km², with a population of around 6 million in 1990, which is about one-tenth of Thailand’s population. Bangkok is divided into 36 administrative districts under the Bangkok Metropolitan Administration (BMA).

Figure 2.1 Map of the Bangkok Metropolitan Area

2.3 A BRIEF HISTORY OF BANGKOK’S EVOLUTION

The history of Bangkok’s urban development is partly described in a number of Thai studies (see for example: Bhamorabutr, 1982; Bongsadadt, 1973; Buranakit, 1982; Saksri et al., 1989; Jumsai, 1980), though none have systematically linked this history to transport change in the way this thesis has attempted to do. The following account chronologically portrays how Bangkok has developed over a period of six hundred years until it became
the Bangkok Metropolis in 1971. Only those aspects of its history which are central to an understanding of the main thrust of this thesis are included.

About six hundred years ago when Ayuthaya was the capital of the Thai Kingdom, Bangkok was only a small fishing village located south of Ayuthaya. The only way to communicate with the capital, Ayuthaya, was by boat, which took about 4 days.

The present Bangkok Metropolis consists of two parts bisected by the Chao Phraya River. The east bank area is called Bangkok and the west bank is called Thonburi. Bangkok and Thonburi in ancient times were one village situated on the east bank of the Chao Phraya River. Later in the reign of King Chai Raja (1534-1546), the king commanded the excavation of a canal between two bends in the river to shorten the distance between the capital and the gulf. This canal split Bangkok into two parts. As time passed, the tide changed direction, the canal became wider and eventually developed into the present course of the Chao Phraya River, which is now the main waterway route. The old river route was shallow and became a canal, the upper part of which is called Klong Bangkok Noi and the lower part is called Klong Bangkok Yai (Klong in Thai means canal).

The city of Thonburi was established in the reign of King Chakapat (1548-1568) called "Thonburi Srimahasamut". The word "Thonburi" means "the City of Treasures" and the word "Srimahasamut" means "the Magnificence of the Great Ocean". Its name came from the fact that there were plenty of fruit gardens and it was a dwelling place of merchants and the wealthy, as well as being located close to the Gulf of Thailand. The city covered both banks of the Chao Phraya River. Later in the reign of King Narai the Great (1656-1688), the city became very important because fortresses were constructed within the city on both sides of the river's banks to prevent enemy battle ships from invading the capital (Figure 2.2).

After the city of Ayuthaya was destroyed in 1767 by Burmese troops, Thonburi became the capital of Thailand for 15 years from 1767 to 1782, and the Royal Palace was located on the west bank of the river. But when King Rama I became the king of Thailand in 1782 (the first king of the current
Figure 2.2 Bangkok in the Ayuthaya period, circa: 1687

Source: Bastin and Twithchett, 1969

Note: Early European travellers to Ayuthaya misunderstood the name of the Chao Phraya River, calling it "Menam". In Thai "Menam" means river.
Chakri Dynasty), the decision was made to move the capital from the west bank to the east bank of the Chao Phraya River. The king's reason was that more than half of the eastern bank area was surrounded by water, and although the land was low and flooded almost every year, it was a lot easier to protect the capital from the enemy, usually the Burmese, who always came from the west. King Rama I named the new capital "Krung Thep" which means "City of Angels".³

King Rama I undertook the construction of the new Grand Palace on the area bounded by the Chao Phraya River on the west and the existing city moat on the east, where a Chinese community had resided since the Thonburi period. This community was requested to move to a new place, about three km southeast of the new Grand Palace, called Sampeng. The king also commanded the digging of a new city moat called Klong Rob Krung or the canal around the city, paralleling the existing moat, and the construction of city walls to protect the city from invasion. The construction was finished three years later in 1785.

After the move of the seat of government to the east bank, Thonburi on the west bank was left as a small community within Bangkok's territory. In the reign of King Rama VI in 1915 it was declared a city separate from Bangkok. However, in 1971 with the large growth pressures in the region it was incorporated into the Bangkok Metropolitan Area, so Bangkok and Thonburi are now one city.

The following discussion attempts to provide a more detailed outline of the history of Bangkok in terms of land-use and transport, commencing in 1782 when Bangkok became the official capital of the Thai kingdom.

2.4 TRANSPORT AND LAND-USE DEVELOPMENT

To understand the way that transport and land-use are interrelated, a brief overview of the historical pattern of cities in the Western world provides some basic concepts which may be applied to the development of Bangkok. The history of cities has shown that land-use and the form of the city are

³The full name of Bangkok is "Krung Thep Pra-Maha-Nakorn, Amorn-Ratanakosindra, Mahindra-Yudhya, Maha-Dilokpop, Noparatana-Radhani, Burirom, Udom-Rajnivet-Mahasatan, Amorn-Pimarn-Avatarn-Setit, Sakkatuttiya-Vishnukarm-Prasit"
very closely related to the major form of transport: walking, public transport (or "transit"), or the automobile (Bacon, 1967; Hall, 1988). In other words, transport technology is a very important factor in the shaping of cities (Newman and Mouritz, 1992: 21). Newman et al. (1992: 2-6) have demonstrated that there are essentially three different periods in the development of city patterns which can be defined according to the dominant transport technology of the time. They suggest the following archetypal cities through time.

- **The traditional walking city (Figure 2.3)**

This earliest type of city developed around 10,000 years ago and was dominant in the Western world until around 1850. Walking cities still exist today in some places e.g. the medieval core areas of many European cities, the new suburban centres along Stockholm's rail system and many cities in the developing world (e.g. China and Africa where transport is still dominated by non-motorised modes). This type of city is characterised by high-density residential and commercial developments and mixed land-use, and in many places can still be seen to have its old protective walls (e.g. some European, Middle Eastern and North African cities still retain their complete fortifications or parts of them). All destinations in a walking city can be reached on foot in half an hour and so rarely are these cities more than about 5 km across. Typical densities in walking cities were 100 to 200 people per hectare (ha) or more (Newman and Kenworthy, 1996: 2).

- **The transit city (Figure 2.4)**

With the development of train and tram technology in the latter part of the nineteenth century, land-use in cities was shaped to extend along the tracks of trains and trams. However, the new sub-centres which characterised the train systems were created mainly around railway stations within walking distance of approximately 800 metres, while residential and commercial areas which developed along tram routes were linear. The major form of development was medium-density and again the city was characterised by mixed land-use. The city could, however, now spread 20 to 30 km across due to the higher speed of the new transit systems. A Central Business District (CBD) emerged where the rail lines met at the city centre. Transit city densities were lower than in walking cities (50 to 100 people per ha),
Figure 2.3 Traditional walking city

Source: Newman et al., 1992: Figure 1.1

Figure 2.4 Transit city

Source: Newman et al., 1992: Figure 1.2
though still substantially higher than in modern Automobile cities (Newman and Kenworthy, 1996: 3). Most larger European and many east coast American cities were shaped by these technological changes in transport and still retain these characteristics up to the present time (though in many cases the older transit city form is now surrounded by more automobile-based suburbs).

• The automobile city (Figure 2.5)

Automobile technology developed progressively from the late 1800s up to before World War II, and then accelerated rapidly after that. Together with the bus, automobiles soon became the dominant mode of urban transport and significantly shaped the city’s land-use. First they acted as a linkage between train lines, then extended the city out as far as 50 km or more, due to the large increase in travel speeds that became possible. People were now able to reside further from the city centre and the traditional fixed track transit systems, thus low-density housing became the norm in automobile-based cities. In addition, town planning began to separate different land-uses by zoning as a response to the problems of industrial cities. Mixed land-use in automobile cities became restricted mostly to older inner areas. Journey distances naturally increased but could be managed by the faster car technology. Cities became more dispersed and decentralised by these developments. American and Australian cities have rapidly shifted to this type of city and are now heavily dependent on automobiles and extensive road and freeway networks. Densities in Automobile cities are generally less than 20-25 people per ha, with many being less than 10 people per ha (Newman and Kenworthy, 1996: 4).

Based on the dominant transport features or technologies, Bangkok’s development can also be chronologically classified into three main periods. For the purpose of this thesis, these can be defined as follows: (1) the water-based transport and walking period; (2) the transport modernisation period; and (3) the motorisation period. To make it easier to trace the progression in Bangkok’s urban development through these three periods, the names of the Thai kings linked to each period are provided in Figure 2.6. These kings are referred to in the subsequent detailed discussion of each period.
AUTOMOBILE CITY
1940 - Present, US + Australian Cities Mostly
- Low Density
- Separated uses
- Arterial Grid and cul de sac Based
- Decentralised

Figure 2.5 Automobile city
Source: Newman et al., 1992: Figure 1.3
<table>
<thead>
<tr>
<th>YEAR</th>
<th>KING</th>
<th>PERIOD</th>
</tr>
</thead>
</table>
| 1782 | RAMA I  
(1782-1809) | Water-Based Transport and Walking Period |
|      | RAMA II  
(1809-1824) | |
|      | RAMA III  
(1824-1851) | |
|      | RAMA IV  
(1851-1868) | |
| 1868 | RAMA V  
(1868-1910) | Transport Modernisation Period |
|      | RAMA VI  
(1910-1925) | |
|      | RAMA VII  
(1925-1935) | *Political system changed to constitutional monarchy in 1932 |
|      | RAMA VIII  
(1935-1946) | |
| 1946 | RAMA IX  
(1946-) | Motorisation Period |

Figure 2.6 Three characteristic periods in Bangkok's transport and land-use development
2.4.1 Water-Based Transport and Walking Period (1782-1868)

Waterways and walking were the main modes of Thailand's transport and communication for many centuries. Ayuthaya, the former capital of Thailand, was designed as a water and walking-based city. Bangkok also originally followed this pattern, due both to its geographic features (the river and some existing canals), and to its small area which facilitated walking. Waterways and walking were thus the main modes of transport and communication dating from the earliest establishment of the city. After Bangkok became the Thai capital, this stage lasted essentially for 86 years from 1782 to 1868, from the reign of King Rama I to King Rama IV. From about 1868 the city entered what might be termed a transport modernisation period, when roads, trams and railways began to appear and the focus of transport began to shift away from the watercourses. This period is discussed in detail in section 2.4.2.

2.4.1.1 Population and Land-Use

There are various estimates of the population of Bangkok at the time that it became the capital of Thailand, there being no system of collecting statistics at that time. However, summarising from different sources, the most reasonable figure for Bangkok's population in 1782 was approximately 50,000 people (Sternstein, 1982: 93). By the end of the King Rama III period in 1850, 68 years later, the population had doubled to an estimated 100,000 people (Poungsomlee, 1991: 101).

The city was bounded by the city wall which was constructed along the Chao Phraya River on one side and along the new city moat on the other side (Figure 2.7). The area of the city was about 2,200 rai or 3.5 km$^2$ (Suwannamat, 1982: 29). Thus Bangkok at that time was densely populated with a density of around 145 persons per ha.\(^4\) This population density is comparable to the typical walking city density of around 100 to 200 people per ha (Newman and Kenworthy, 1996: 2).

The Grand Palace, which consisted of a number of beautiful edifices, temples, offices, and accommodation for the King's servants and soldiers,

\(^4\)Population density calculated based on 50,000 inhabitants.
was the centre of the built-up area of Bangkok. It was located on land surrounded by the *Chao Phraya River* on the west and the old moat called *Klong Ku Muang* on the east. This area covered around 1.6 km² and is currently called the Inner Rattanakosin Island (see Figure 2.7).

![Bangkok map](image)

**Figure 2.7 Bangkok map during the reigns of King Rama I to King Rama III**

Source: Reproduced from Bunnag, 1985: 165

Typically, most people of Bangkok dwelt along the river or canals. Residential development rarely extended more than one or two hundred metres from the banks of the river or canals (Sternstein, 1982: 16). In this waterway/walking period most residential areas were located inside the area enclosed by the canal around the city. The elite class resided close to the Grand Palace walls while the common people lived further away. The residential areas and commercial areas were mixed or located very close to each other (Bunnag, 1985: 164).

An important feature of Bangkok at that time was the great number of houses built on bamboo rafts floating mainly along the river. These floating houses served both residential and commercial purposes. The estimated number of such floating houses varies from 700 to 7,000 from different
visitors' records (Sternstein, 1982: 13-16). During this water-based transport period a lot of commerce was also carried out on the water in the form of the famous "floating markets" (Plate 2.1).

Plate 2.1 Thai houses along the river and a "floating market"

Source: Sternstein, 1982: 27

During the reign of King Rama IV (1851-1868), the residential areas started to expand further away from the city wall. In 1851, in order to locate the city's new boundary, the king commanded the digging of a new moat called Klong Phadung Krung Kasem, parallel to the two existing moats. As a result, the area of the city extended to about 8.9 km², nearly three times as large as the pre-existing area.5 The residential areas in this reign were still mainly along the river and canals, particularly from the old moat to the newest moat, Klong Phadung Krung Kasem. The commercial area was mainly at Sampeng and Sapan Hun, which were Chinese communities located at the southeast of the Grand Palace outside Klong Rob Krung (the middle city moat) (Figure 2.8). However, after the construction of some roads (e.g. Charoen Krung Road, the first road constructed in 1861), people also started living along these new types of transport corridor (Bunnag, 1985).

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5 Measured from the area inside Klong Phadung Krung Kasem.
Figure 2.8 Bangkok's land-use during the reign of King Rama IV

Source: Reproduced from Bunnag, 1985: 167

2.4.1.2 Transport

Since there were no roads or bridges in Bangkok in the early period from the reign of King Rama I to King Rama III (1782-1851), the main modes of transport in Bangkok were waterways and walking. When Monsignor Pallegoix, French Bishop of Siam, arrived in Bangkok in 1830, he observed that:

There is not a single carriage in the capital; everyone travels by boat; the river and the canals are almost the only busy roads. Only rarely in the middle of the city and in bazaars of markets you find streets paved with large bricks.⁶

(Donner, 1978: 786-787)

⁶The "streets" referred to here were not roads in the true sense of the word, but rather more like footpaths.
The Chao Phraya River was the major artery of both local and foreign transport and communication. Additionally, canals also played an important role, particularly in transport and communication within the city. Due to this unique feature of waterways, Bangkok was given the name The Venice of the East by Europeans who visited at that time.

The first canal dug in Bangkok in this period was Klong Rob Krung or "the canal around the city", but its name varied according to locations. It was dug in 1782 on the east of the city at the time of its establishment, parallel to the existing moat which had been excavated in the Thonburi period. The main purpose was to protect the city from invasion by the Burmese and to serve as communication infrastructure.

After the digging of Klong Rob Krung until the reign of King Rama IV, kings of Thailand commanded the excavation of another five main canals, of which four were dug inside the city. Their respective lengths were approximately 1.5 km, 1.1 km, 0.8 km, and 5.5 km. The other canal was Klong Saen Saep which was dug to connect the city with its suburbs. All of them were dug for the purpose of better communication within Bangkok. Only Klong Phadung Krung Kasem or the new moat was dug both for protecting the city and for communication (Bunnag et al., 1982: 30-33; Bongsadadt and Leelahacheeva, 1984: 5-6). The waterways network in the reign of King Rama IV is shown in Figure 2.9.

Land transport consisted only of small streets - or rather footpaths - that people used for communication or for transporting small amounts of goods, mostly by walking. Most paths were narrow and winding owing to interruption by ditches or canals and buildings. In the rainy season it was difficult to use these paths because they became very muddy. Typically, only a log or plank without a handrail was placed as a bridge across canals and ditches. However, wooden bridges across main canals around the city were bigger, consisting of two or three planks and they were very easy to take down when enemies attacked (Sternstein, 1982: 16; Bhamorabutr, 1982: 67).

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7 The four canals are Klong Maha Nak, Klong Lord Wat Rajanadda, Klong Lord Wat Rajabopit and Klong Phadung Krung Kasem.
The first major land communication route in Bangkok was *Trong Road* (now Rama IV Road) which was constructed in 1857. This road was a by-product of the excavation of a canal from the city moat southeastwards to make a short cut to the *Chao Phraya River*. The dirt dug from the canal was used for constructing the road along the canal. It was approximately 8 km in length linking the city and the *Klong Toey* district (Bongsadadt, 1973: 3; Saksri et al., 1989: 5-13).

The second land communication route, which was more standardised and generally regarded as the first road, was constructed in 1861. According to Thai history, it was built in response to a petition from European consuls in Bangkok who explained that they were accustomed to doing morning exercise by riding horses or carriages in their own countries, but in Bangkok there were no roads available for such activities. As a consequence, they claimed that their health was deteriorating. The king accepted their petition and commanded the construction of what became know as *Charoen Krong Road*, which meant "Prosperous City Road" or to the common folk, the *New Road*. It took four years to build and was completed in 1864, using an old construction technique of paving bricks on the surface without foundation. The road was about 10 km in length (Bhamorabutr, 1982: 59-60).

By the end of King Rama IV's reign, there were five roads constructed, of which three roads with a length of 7 km were confined to the new city moat (*Klong Phadung Krong Kasem*), and two roads, *Trong Road* and *Tok Road*, with a length of 13 km were outside. The total length of roads was therefore only around 20 km, giving the rough figure of 0.15 metres of road length per capita for Bangkok's population at that time. The major roads and other land communication routes in the reign of King Rama IV are shown in Figure 2.10.

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8 Road length is derived from Urban Planning Division, BMA, "Roads, Local Streets and Lanes in Bangkok".
9 Road length per capita is calculated based on an estimated Bangkok population of 130,000 persons.
Figure 2.9 Map of waterways network in the reign of King Rama IV

Source: Reproduced from Saksri et al., 1989: Figure 3.17

Figure 2.10 Major roads and other land communication routes in the reign of King Rama IV

Source: Reproduced from Saksri et al., 1989: Figure 3.20
It should be remembered that during the reign of King Rama IV there were still no automobiles. The first cars appeared in Europe in 1888 (Sachs, 1992). Thus roads were used for horse riding, pedestrians, and horse-drawn carriages. The owners of these horse-drawn carriages were high ranking officials or rich people only (Bhamorabutr, 1982: 74), much the same as in other parts of the world during this pre-automobile period. Ordinary folk walked.

2.4.1.3 Summary of the Water-Based Transport and Walking Period

The first period of Bangkok’s transport and land-use development (1782-1868) was characterised by waterway transport and walking. These major forms of transport suited well the city’s geographical features - a low plain with the river and several canals. There were no roads at the beginning of this period, only in the middle of the city were small streets paved with bricks. The city was confined within the old city wall during the first 70 years, similar to the common walking city of that time. The whole city area was compact, being only about 2 km across, or about a half-hour by walking. The population density was high at about 150 persons per ha and most people lived along the river or canals. The residential areas were close to the Grand Palace which is the centre of the city. Mixed land-use comprising residential and commercial purposes was a major characteristic of Bangkok at that time. After some larger roads and streets were constructed during the end of this period, some residents started to move to reside along these new transport routes and the city boundary was extended. However, the city remained relatively compact, at no more than 4 km across. Waterways remained the main mode of transport, and walking was still the main mode of land transport. There was not a single motor vehicle in Bangkok. This form of city is characteristic of the traditional walking city where the city is densely populated with mixed land-use, and relatively small due to the influence of walking which is the major form of transport (see Figure 2.3).

After this water-based transport and walking period, Bangkok, before the turn of the century, experienced unprecedented changes in transport technology, which also had a significant effect on city form.
2.4.2 The Transport Modernisation Period (1868-1946)

The transport modernisation period began in the reign of King Rama V who ascended the throne in 1868. During his long reign from 1868 to 1910, Thailand was introduced to a number of Western innovations such as electricity, running water, telegraph systems, modern education systems, as well as various modern transport modes. A major reason for this appears to be King Rama V's exposure to Western education, including visits to many developed European countries. Moreover, the king sent a number of members of the Royal family as well as commoners to study in Europe. Consequently, they brought back Western know-how and then applied it to the country's development.

Thailand's period of modernisation lasted from the reign of King Rama V and throughout the reigns of Kings Rama VI to VIII (1868-1945). During that time the land-use patterns and transport systems, both in Bangkok and the rest of the country, experienced significant changes.

2.4.2.1 Population and Land-Use

The population of Bangkok in 1882 in the early period of King Rama V's reign was approximately 169,000 which, based on a built up area of 11.3 km$^2$ or 1130 ha, gave a density of around 150 persons per ha.\textsuperscript{10} From that time the population started to increase noticeably due to the following factors (Sternstein, 1982: 77, 94):

- a great increase in migrants from the countryside that began before the turn of the century and continued throughout the twentieth century;

- increases in overseas immigrants, mainly Chinese;

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\textsuperscript{10} The built up area of Bangkok in 1882 is calculated based on following data:
1) the built-up area of 8.9 km$^2$ in 1851 estimated from the area within Klong Phadung Krung Kasem.
2) the built-up area of 13 km$^2$ in 1900, from Bangkok Metropolitan Administration, 1972.
3) the interpolation for 1882 is based on the following formula:

Exponential growth: $N = N_0 e^{rt}$

Where:
- $N =$ final figure
- $N_0 =$ initial figure
- $r =$ growth rate as a decimal
- $t =$ time period
• a decline in the mortality rate resulting from the introduction of modern medicine; and

• improvements to the city's sanitation system.

The population of Bangkok at the end of King Rama V's reign in 1910 was approximately 440,000. The urbanised area at that time is estimated to be 18.12 km² or 1,812 ha, giving a density of about 243 persons per ha. Nine years later in 1919, during the second half of King Rama VI's reign, the population had increased to 508,800, occupying an estimated built-up area of 24.44 km² or 2,444 ha and giving a density of about 208 persons per ha (Chatchaisittikul in Saksri et al., 1989: 329; see note on calculations). These density figures show that the city had an even higher population density than in the first period of transport development.

The turn of the twentieth century marked the real beginning of the period of transport modernisation in Thailand, and Bangkok in particular. However, the majority of Bangkokians still lived their traditional way of life, which meant dwelling in houses located along the Chao Phraya River and the canals which still provided both water supplies and acted as the major means of communication. Nevertheless, the number of floating houses along the river was beginning to decline.

The majority of inhabitants had traditionally resided within a radius of around 2 km from the Grand Palace or inside the city walls. The population started to spread out through the areas between Klong Rob Krung (the second moat) and Klong Phadung Krung Kasem, the third or new city moat (see Figure 2.11). Residential areas also began expanding further away from only along the banks of the river and the canals. Later, after more roads and other land transport routes were constructed (horse-drawn trams plus electric trams and railway lines), houses and shops began to be located along these new high accessibility corridors (see discussion in this section under "Transport").

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11 The areas of Bangkok in 1910 and 1919 are calculated based on data from the Bangkok Metropolitan Administration, 1972 (Basic Planning Information) which show a built-up area of 13 km² in 1900 and 43 km² in 1936. The same formula as in footnote 8 was used to interpolate the 1910 and 1919 figures for urbanised area.
Overall, the land-use pattern was mixed between residential and commercial purposes. However, the prominent commercial areas were Sampeng, Sapan Hun and Pahurat, where large numbers of Chinese and Indians resided (see Figure 2.11). Starting from the transport modernisation period, the traditional water market or "floating market" began to decline.

King Rama V also initiated the modernisation of the country's administration system and a number of ministries and departments were established. Most government offices were located close to the Grand Palace in the old city core and most of them have remained there up to the present (Bunnag, 1985: 168). As well, King Rama V constructed the Dusit Palace, a complex of princely villas in the area north of the city, immediately beyond Klong Phadung Krung Kasem, the new city moat. He also built some palaces for the Royal Family to the east of the city. Subsequently, the residential area of Bangkok expanded to beyond the new city moat on the north and the east of the city (Saksri et al., 1989: 3-41).

![Map of Bangkok showing land-use patterns](image)

**Figure 2.11 Bangkok's land-use during the reign of King Rama V, 1868-1910**

Source: Reproduced from Bunnag, 1985: 169

Note: Map shows central railway station of Bangkok which is discussed in a following section.
The land-use pattern in the reign of King Rama VI (1910-1925) did not change significantly from the previous reign. However, the residents began to reside more along the new roads and the residential area expanded even further beyond the new city moat. As a result, the population of the area outside the city moat became more densely settled (Saksri et al., 1989: 3-49).

During the reigns of King Rama VII (1925-1935) and King Rama VIII (1935-1946), Bangkok was separated into two cities; Bangkok Metropolitan on the east bank and Thonburi on the west bank. Bangkok Metropolitan grew at an accelerated rate to the north, east and south. By 1936 the built-up area of Bangkok was about 26,900 rai or 43 km² with a population of about 650,000 (Hinshiranan and Pramualratana, 1982; Suwannamat, 1982: 29), giving a density of about 151 persons per ha. Although the built up area of the city noticeably expanded during this period, from only around 11 km² at the beginning of this period to 43 km² at the end of this period, the overall density remained high at approximately 150 persons per ha.

The urbanised area at this time covered the present districts of Samsen, Dusit, Phaya Thai and Bang Sue in the north; Pathum Wan, Phetchaburi Road, Phloenchit Road and Sukhumvit Roads in the east; Si Phraya, Bang Rak, Silom, Sathon, Thung Mahamek and along the Chao Phraya River bank to Yannawa and Bang Kho-la-em in the south (Figure 2.12).

Whilst Bangkok on the east bank became well developed, Thonburi on the west bank remained nearly unchanged throughout most of the transport modernisation period. Most residents lived a traditional way of life along the river and canals without any modern means of transport. Fruit orchards and paddy fields were the main form on land-use of the west bank (Bongsadadt and Rerkyai, 1982: 425-426). It was not until the first road bridge across the Chao Phraya River was constructed in 1932, that Thonburi on the west bank started to experience noticeable growth.
Figure 2.12 Built-up area of Bangkok during the reign of King Rama VII and King Rama VIII

Source: Reproduced from Bunnag, 1985: 171

2.4.2.2 Transport

This period is characterised by Thailand’s emergence into the world of modern transport systems. A number of major new technologies were introduced to the country, particularly in Bangkok, including horse-drawn and then electric tramways, horse-drawn buses, railways, modern road building practice and the faint beginnings of motor vehicles. However, at the beginning of this period some more canals were also excavated. One of the main canals, Klong Prem Prachakorn, was dug for the purpose of better communication between the city and its northern suburbs.
As roads in this period began to provide more convenient transport for Bangkok’s residents, more were constructed during the reign of King Rama V (1868-1910) inside the city area between the old city moat and the new moat (Bongsadadt and Rerkyai, 1982: 425). By the end of the reign of King Rama V, there were approximately fifty roads in Bangkok with a total length of about 70 km (Figure 2.13). In 1910, the last year of King Rama V’s reign, Bangkok’s population had increased considerably to around 440,000, producing a figure of roughly 0.16 metres of road length per capita, which was almost similar to the estimated figure of 0.15 metres per capita in the reign of King Rama IV.

![Map of Bangkok roads in the reign of King Rama V](image)

**Figure 2.13 Major roads in the reign of King Rama V**

Sources: Reproduced from Saksri et al., 1989: Figure 3.22; Bunnag, 1985: 169

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12Road length is derived from Urban Planning Division, BMA, "Roads, Local Streets and Lanes in Bangkok".
Roads in the 42 year reign of King Rama V were available as a means of transport and communication for all classes of people. As there were almost no motor vehicles at that time (251 cars in 1906 or around 0.6 per 1,000 people), the roads were mainly utilised by pedestrians and non-motorised vehicles such as rickshaws, horse cabs, tricycles and animals (Sternstein, 1982: 2).

The following discussion systematically examines the introduction of all the new transport technologies during the modernisation period.

(1) Trams

Tram technology was introduced to Bangkok in 1887 and, as in European cities, it started simply with carriages pulled by four horses. Bangkok was the second city in Asia to have trams, just 10 years after their first appearance in an Asian city, Tokyo (Buranakit, 1982: 270; Kasahara, 1994: 60). Later, in 1901 the trams were converted to electric power (Bhamorabutr, 1982: 75-76; Ankhong, 1986: 80-86). Electric trams rapidly became very popular for residents because they were cheap, efficient and eventually, as the system grew, provided good access to most places in Bangkok (Sternstein, 1982: 32).

Trams were operated by private companies until 1947 when the government took over the business via the Capital Electricity Authority. Trams by that time were operating seven routes along main roads. This constituted a network of some 45 km (Ankhong, 1986: 87).

Trams were the most popular form of land transport during this period because there were only very small numbers of private vehicles. There were only around 3,000 cars in Bangkok before and during World War II, or an ownership rate of approximately 3 per 1,000 people (Ankhong, 1986: 78), and in 1947 there were only around 700 motorcycles, or 0.6 per 1,000 people. In 1947 the number of trams was approximately 200, even higher than the number of buses, which was about 190 (Bongsadadt, 1973: 19).

(2) Buses

The bus was another new transport technology introduced in the transport modernisation period around the early 1880s. Its introduction was made possible by the construction of roads in Bangkok. The early buses were four-
wheeled roofed vehicles with 2 long seats placed opposite each other, and were pulled by two horses. Later in 1913 horse-drawn buses were replaced by motorised buses (Bhamorabutr, 1982: 75). By World War II, the bus routes were expanded to serve more of Bangkok's residential areas (Ankhong, 1986: 67-68). However, the proportion of buses to Bangkok's residents was still very low, at only about 0.16 buses per 1,000 people or 1 bus for 6,200 inhabitants at that time.\textsuperscript{13}

(3) Railways

A steam railway was one of the first modern modes of transport introduced during this period. The first railway was formally opened by King Rama V in 1896, operating for a distance of 71 km between the central station in Bangkok's suburbs and Ayuthaya, the former capital, north of Bangkok. After that, the construction was continued towards the northeast region. In 1900, the 265 km route linking Bangkok and Nakhon Ratchasima, the gateway to northeastern Thailand, was completed (Suratanakavikul, 1982: 390).

Gradually, railways became more popular for goods and passenger transport. More routes were constructed to link Bangkok with other regions. By 1907, Bangkok had three steam railway lines operating through the urban region to the northern, southern, and eastern parts of Thailand. Each line had a number of stations within the Bangkok region, with trains providing some stopping services for passengers wishing to move within the urban area (stations were on average around 2 to 3 km apart in this area) (Jumsai, 1980: 541; State Railway of Thailand, 1995). The areas surrounding these stations within walking distance experienced some extra population growth and development due to better accessibility. However, because of the relatively limited coverage of the lines and the regional nature of services, trains were not major means of transport within Bangkok.

After King Rama V, successive kings also paid close attention to railway development. The Thai railway system was substantially improved, both in terms of network and technology. In 1932 Thailand's political system

\textsuperscript{13}Calculation based on the following data in 1947:
1) number of buses = 190
2) Bangkok's population = 1.178 million
changed from an absolute monarchy to a parliamentary democracy. Thailand at that time suffered from the continuing world depression, later coupled with the impact of World War II. In addition, the Thai government shifted the focus of transport development towards construction of more roads rather than railways, as in other neighbouring countries, to support transport by cars. As a result, the extension of the railway network declined (Suratanakavikul, 1982: 391).

Nevertheless, from the turn of the century until just after the Second World War, railways gradually became the main mode for intercity transport of goods and passengers in Thailand. However, in Bangkok rail development was severely limited from the outset, consisting of a regional rail service with a minimal number of widely-spaced stops within the built-up area.

(4) Non-motorised Mechanised Modes

Another mode of transport which became prevalent during the transport modernisation period was non-motorised mechanised transport, comprising rickshaws, bicycles and tricycles. They were also first introduced into Bangkok in the reign of King Rama V (1868-1910). The following discussion briefly examines their emergence and situation during this period, based on information derived mainly from Bhamorabutr (1982) and Ankhong (1986).

Rickshaws were introduced from China in the early 1870’s. These were two-wheel carts pulled by men, mostly Chinese. They became popular for a long time until they virtually disappeared in the early 1930s under pressure from other forms of transport.

Bicycles were introduced to Bangkok around the late 1880’s. They also became very popular, firstly among high-ranking people including the king. Then they became popular among the common people due to their convenience and low cost.

Tricycles were another non-motorised form of paratransit invented in Bangkok around 1933. Each tricycle could carry two passengers. They were very convenient for travelling short distances and they had the additional advantage of being able to travel along narrow lanes where other modes of transport, especially cars, could not venture. They were widely used at that time.
(5) Taxicabs

In 1918 the first four taxicabs were introduced to Bangkok roads. In 1926, however, there were still only 14 taxis in Bangkok. A few years later the taxi services ceased due to lack of popularity because of their high fares.

(6) Cars

In 1904 after some reasonable standard roads had been constructed in Bangkok, motor cars were introduced to the city, during the period when rickshaws were enjoying widespread popularity. Initially, cars were used only by members of the royal family, high-ranking government officials and wealthier businessmen.

Near the end of King Rama V's reign, in 1906, there were only 251 cars in Bangkok. Six years later in the early period of King Rama VI's reign, the number had increased to 622 (1.4 per 1,000 people). Although this was not a marked difference in absolute terms, it was a large percentage growth, and in a somewhat portentous way, heralded the beginning of Bangkok's acquiescence to the car and the accelerating need for more road space (Bongsadadt and Leelahacheeva, 1984).

Indeed, motor cars have become more and more popular in Bangkok due to their perceived convenience, despite the basic problem of accommodating them within a tight urban form. Prior to World War II, there were approximately 3,000 cars in Bangkok or around 3 cars per 1,000 inhabitants. Although the number was not so high, they gradually suppressed the use of non-motorised paratransit due to their large space requirements within a limited road system shared with other modes of transport.

After the reign of King Rama V, although land transport in Bangkok on the east bank was relatively well-developed, its counterpart, Thonburi on the west bank, was still without any modern land transport. Most people in Thonburi still used traditional boats as means of communication and transport. Not until 1932 was the Rama I Memorial Bridge, the first road bridge across the Chao Phraya River, built to link Bangkok and Thonburi (Bongsadadt, 1973: 4).
While various types of modern land transport technology were introduced into Bangkok and land transport developed appreciably during this period, it is interesting to see how traditional waterway transport changed. The next section will therefore briefly examine waterways over the 80 year transport modernisation period.

(7) Waterways Transport

From the beginning of the transport modernisation period, especially during the first half of King Rama V's reign (1868 to about 1890), the king still paid attention to the extension of the waterways network. More canals were dug to create better links between the city areas and the suburbs and all surrounding towns (Figure 2.14). In addition, some existing canals which had become shallow and dirty were also improved (Policy and Planning Office, 1984: 28-30). After the end of the reign of King Rama V, no further canals were dug inside the city area (Saksri et al., 1989: 3-65).

![Figure 2.14 Major canals dug in the reign of King Rama V](source: Bunnag et al., 1982: Map 4)
Although land transport began to increase in importance within Bangkok as more roads were constructed, water transport still played a dominant role in the beginning of the transport modernisation period, particularly amongst common people. Most goods were still transported along the river. This can be attributed to two factors: first, there was still comparatively little land transport infrastructure compared to the extensive canal network and the river. And second, transport by waterways was at that stage more economical.

However, through the second half of this period (1910 to 1946), land transport became more important while water transport began to decline. More new roads were constructed and a more comprehensive network of trams and buses was developed. A considerable number of people in Bangkok converted from the traditional water-based transport to public land transport modes, while wealthier residents and foreigners were more likely to use motor cars.

As the number of private vehicles steadily increased and more roads were constructed to facilitate cars and other land transport modes, waterways were increasingly neglected and the city began to move towards a motorisation period, which became more and more apparent from the end of the Second World War.

2.4.2.3 Summary of the Transport Modernisation Period

The second period (1868-1946) was a major era of changes for Bangkok. A variety of new transport technologies were introduced to Bangkok including both motorised and non-motorised technologies. Some more roads were built to cater for these land transport vehicles. However, public transport modes, particularly trams played a greater role than private motor vehicles since there were still a very low number of cars and motorcycles. Non-motorised modes such as rickshaws, tricycles and bicycles also played important roles during this period. Waterway transport declined due to the increasing popularity of land transport, particularly in the second half of this period. This major shift in transport technologies had significant effects on urban form and land-use of the city. A number of Bangkok inhabitants moved to live along the new transport routes to avail themselves of faster and more convenient land transport. The city extended northwards and
eastwards where new land transport routes were built. However, the city remained dense with around 150 to 240 persons per ha and the city structure was still relatively compact (around 10 to 12 km across). This is attributable to the "concentrating" characteristics of public transport, particularly trams and the slow speeds of non-motorised transport modes, which were the main modes of land transport.

In comparison to other cities around the world during this era, Bangkok's transport patterns and urban form are somewhat different from the typical transit city in several ways. The transit city is substantially dominated by train and tram technology, whereas Bangkok utilised a variety of modern transport technologies e.g. trams, buses and cars as well as non-motorised transport modes. Trains, however, contributed very little to transport within Bangkok since they were an intercity system. Water transport still played a significant role, though it was not as important as in the first period. As a result, Bangkok's urban form during this period developed in a significantly different way to other transit cities. In short, urban development in transit cities typically emerges along train and tram lines and new suburbs develop around railway stations. New development areas in Bangkok, on the other hand, extended along new roads served by both trams and buses which were typically slower than the train systems built in other cities in the transit era. The built-up areas were still very compact and most of them were confined to within only around 5 to 6 km from the city centre to ensure their accessibility to the city centre and transport facilities, compared to 20 to 30 km in the typical transit city. However, in terms of density and land-use, they were to some extent similar. That is to say, Bangkok had high population density and the land-use was mixed between residential and commercial activities, while the traditional transit city also had mixed land-use with medium density.

2.4.3 The Motorisation Period (1946-Present)

This period started immediately after World War II when the Thai government under the leadership of Field Marshal Plaek Phibulsongkhram (Prime Minister 1949-1957) paid more attention to the development of Bangkok as the centre of the country. Later, Field Marshal Sarit Thanarat's governments (1957-1963) stressed economic development to keep pace with the world economy. The government also implemented a policy of
decentralisation by developing remote areas and establishing regional centres in all regions. In addition, nationwide irrigation, communication, banking, as well as highways and roads were initiated to support the decentralisation process. Nevertheless, Bangkok remained the centre of all activities (Bongsadadt, 1973; Sternstein, 1982).

In 1961 the first national economic development plan was initiated. This plan and its successors focused on nationwide economic growth. Subsequently, there was substantial promotion of industrial investment as well as agricultural production for export markets. Most factories, however, were constructed within Bangkok or its vicinities due to its advantages in transport, since Bangkok was the only international port for both air and water transport. Major highways were gradually built up to link Bangkok with other regions and the road network in Bangkok itself was further developed (Dilokwanich, 1995; Bongsadadt, 1973).

All new state highways constructed during this period for better transport and communication in the country had Bangkok as their origin. The first state highway was constructed to link Bangkok with Khon Kaen, the central city of the Northeastern Region. As this project was financially and technically supported by the United States of America, it was named the Friendship Highway. Subsequently, more highways were constructed to link Bangkok with the other three regions: Phahon Yothin Highway linking the North, Phet Kasem Highway linking the South, and Sukhumvit Highway linking the East.

Not only were major state highways built during Sarit's regime, but also networks of roads in cities and the countryside. In 1960 there were 8,000 km of roads throughout the country. The construction of roads continued through the following governments and by 1978 there were approximately 58,000 km of roads nationwide (Office of the Prime Minister, 1979: 154), which represents more than a seven-fold increase since 1960 or nearly 3,000 km of roads per year. Over this period of 18 years the road length per capita in Thailand increased around 4 times from 0.3 km per 1,000 people in 1960 to about 1.2 km per 1,000 people.14 Transport infrastructure construction was

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14Calculation based on Thailand's population of around 26 million in 1960 and 45 million in 1978.
one of the most important themes in Thailand's development plan, receiving around 10 to 15 per cent of the total development budget (NEDB Report, 1971 quoted in Bongsadadt, 1973: 4).

During the motorisation period from 1946, Bangkok experienced an unprecedented increase in its motor vehicle population. This phenomenon has been dramatically affecting people's lives, their transport patterns, and Bangkok's urban form. Although still a very dense city by international standards, Bangkok has rapidly shifted from a traditional compact city form relying on a variety of transport modes, mainly public transport, water transport and non-motorised modes, towards a much more extended, private vehicle-based city, though with a strong corridor emphasis to its form which is well-suited to high capacity public transport. With these changes has come an increasingly nightmarish traffic situation which has become legendary around the world. This section examines this vital progression in order to understand the possible interrelationships between population, land-use, and transport patterns.

2.4.3.1 Population and Land-Use

(1) Population

During the first decade after the Second World War, from 1947 to 1957, the average annual growth rate of Bangkok's population was approximately 4.3 per cent, which was relatively high when compared with the overall population growth rate of the entire nation, which was about 2.7 per cent (Litchfield Whiting Bowne and Associates and Adams Howard and Greeley, 1960: 32). This marked difference can be attributed to a noticeable decrease in the mortality rate, coupled with a high birth rate in Bangkok, as well as the great number of immigrants to the city from other towns and the countryside (Sternstein, 1982). The 1960 census reported on the classification of the Bangkok-Thonburi inhabitants and showed that according to their place of origin, 66.7 per cent were born in the Bangkok region, 22.8 per cent were born in other provinces, 9.7 per cent immigrated from abroad, and 0.8 per cent were of unknown origin (International Labour Organisation (I.L.O.), 1960: 38).
The average annual population growth in Bangkok during the next two decades remained high. From 1961 to 1970 it was approximately 5 per cent per annum, though it decreased to 3 per cent to 4 per cent during 1971 to 1980. However, the population growth rate was generally much higher than that for the nation which was about 2.5 per cent to 3 per cent annually. This was chiefly because the immigration from the rural areas remained considerable. Most of these migrants moved to Bangkok to find jobs, to do business, to study, or generally to seek a better standard of living. The reason for this is that most factories, government and private offices, schools, universities and service industries tended to cluster primarily in Bangkok and its vicinities. However, the average annual growth rate of Bangkok's population during the 1980's dropped steadily and became lower than the average growth rate of Thailand's population in 1985. The average annual growth rate from 1986 to 1990 was only 0.7 per cent compared to 1.7 per cent for the nation. Bangkok's population growth in comparison with the whole country from 1947 to 1990 is shown in Figure 2.15.

Figure 2.15 Population growth in the BMA (Bangkok and Thonburi), and comparative growth rate for the entire country, 1947 to 1990

Sources: 1. Bangkok's 1947 to 1965 population figures from Pisarnbutr et al., 1983
2. Bangkok's 1970 to 1990 population figures from the Local Administration Department, Ministry of Interior
3. Thailand's 1947 to 1965 population figures from Bongsadadt, 1973: 15
4. Thailand's 1970 to 1990 population figures from the Local Administration Department, Ministry of Interior
5. The average annual growth rate calculation based on data from the above figures
Bangkok's population in 1960 was around 2 million, increasing about 76 per cent to 3.52 million by 1970, and then increasing again by a further 46 per cent to 5.15 million in 1980. The proportion of Thai people residing in the Bangkok metropolitan area increased steadily from below 7 per cent in 1947 to 8 per cent in 1960, to nearly 10 per cent in 1970, and to over 10 per cent in 1980. However, during 1980 to 1990, the rate of population growth in the official Bangkok Metropolitan Area was markedly lower than in the previous decades, due partly to a shortage of affordable land. Bangkok's population increased only 10.6 per cent during this decade to 5.7 million. Consequently, the proportion of Thai people residing in the official Bangkok metropolis has steadily declined from the high point in 1980, to be below 10 per cent in 1990. On the other hand, the population growth rate of the five provinces around Bangkok rose significantly in the period 1980 to 1990 (Table 2.1 and Figure 2.16). This is because most immigrants now find jobs or reside in these provinces, where a number of new factories have been built and the land prices are still affordable. However, many inhabitants of these five provinces regularly commute to work in Bangkok, adding an extra burden on the traffic system.

Table 2.1 Population growth of the BMA and surrounding provinces, 1970 to 1989

<table>
<thead>
<tr>
<th>Province</th>
<th>Population (thousand)</th>
<th>Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMA</td>
<td>3,185</td>
<td>4,852</td>
</tr>
<tr>
<td>Samut Prakan</td>
<td>341</td>
<td>503</td>
</tr>
<tr>
<td>Nonthaburi</td>
<td>278</td>
<td>383</td>
</tr>
<tr>
<td>Pathum Thani</td>
<td>242</td>
<td>332</td>
</tr>
<tr>
<td>Nakhon Pathom</td>
<td>434</td>
<td>545</td>
</tr>
<tr>
<td>Samut Sakhon</td>
<td>207</td>
<td>256</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,687</strong></td>
<td><strong>6,871</strong></td>
</tr>
</tbody>
</table>

Source: JICA, 1990: Table 1.1.1

Figure 2.16 Percentage of the Thai population residing in the Bangkok Metropolitan Area (BMA), 1947 to 1990
(2) Land-Use

It can be seen from the previous brief discussion, that from the beginning of the motorisation period the successive governments have given high priority to investment in road and highway construction linking Bangkok with the other regions. In addition, the government's policy that focused on economic growth has resulted in the substantial promotion of industrial investment. The emergence of thousands of factories in Bangkok and its vicinities has led to an unprecedented growth of population in Bangkok and in the surrounding provinces. Ever since this policy was adopted, Bangkok has grown rapidly, expanding out into surrounding areas. Initially, most industrial, commercial and residential development took place along the main road transport corridors to ensure adequate accessibility and to take advantage of the cheaper land in fringe areas. Later, networks of other main roads and small lanes were built to facilitate access to land further away from the major road corridors, but without any systematic planning. This has led to haphazard development and left many other parcels of land almost inaccessible (NESDB et al., 1991; Mekvichai, 1990).

Most urbanisation has taken place in the southeastern, northern and the western corridors of the Bangkok region. The dominant factor determining urban development in each case has been the development of major roads (NESDB et al., 1991; Pongsosomlee and Ross, 1992). In the southeast, development has followed Phetchaburi Road and Sukhumvit Road from Bangkok to the east coast, where industrial and residential land-use is clustered. To the north along Phahon Yothin Road, industrial and residential estates, coupled with new university campuses, have contributed to large scale urban extension. In the west, along Phet Kasem Road, residential estates and factory sites are flourishing (Mekvichai, 1992). JICA (1990) described the essential character of Bangkok's urban development in the following way:

One of the prominent features of the Bangkok urban area is the narrow strips of built-up areas along the arterial roads radiating from the central area of Bangkok, with vacant tracts being left between the strips within the city (p. 33, see Figure 2.17)

The built-up area of Bangkok now extends about 30 km from the city core, and has expanded not only to Bangkok's fringe, which was once agricultural
land, but also into the neighbouring provinces of Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon and Nakhon Pathom. These provinces are now considered to be parts of the Bangkok Metropolitan Region (BMR), as shown in the land-use map in Figure 2.18.

![Bangkok's urban form based on major road corridors](image)

**Figure 2.17 Bangkok's urban form based on major road corridors**

Source: Reproduced from JICA, 1990: Figure 6.2.1
Figure 2.18 Bangkok Metropolitan Region (BMR) built-up area, showing surrounding five provinces

Source: Reproduced from NESDB et al., 1991: Figure 3.8
During the motorisation period, the built-up or urbanised area of Bangkok expanded rapidly. In 1958 the built-up area was only 96 km². In 1971 it had almost doubled to 184 km² and in the next ten years it almost doubled again to 344 km² in 1980. By 1984 it had expanded to 547 km² and then to 637 km² by 1988 (Department of Town and Country Planning, 1973; BMA, 1972; Setchell, 1992).

This type of development has led to some reduction of Bangkok's population density, particularly in the new development areas on the fringes of Bangkok. However, over the last three decades the overall urban density of the region has only slightly decreased due partly to the offsetting effect of the very high density inner area (Figure 2.19). The current density of Bangkok is about 149 persons per ha, slightly lower than those of some other Southeast Asian cities, e.g. Jakarta has an urban density of 171 persons per ha, Manila has 198, while Surabaya has a density of 177 persons per ha. However, Bangkok's urban density is still very high in international terms (Barter and Kenworthy, 1996: Table 2). Chapter 4 discusses this issue in more detail.

![Bangkok's population density from 1958 to 1990](image)

**Figure 2.19 Bangkok's population density from 1958 to 1990**

Notes: 1. Areas used in the calculation are built-up areas only.
   2. The 1990 area is the built-up area within the Outer Ring Road.

In line with the substantial population growth in Bangkok during the motorisation period, the transport system in Bangkok experienced a major change and has significantly affected the pattern of land-use and urban form. The next section explores this phenomenon in detail.
2.4.3.2 Transport

In 1958 the Thai government employed American consultant firms, Litchfield Whiting Bowne and Associates and Adams Howard and Greeley, to carry out Bangkok's area planning. In 1960, they submitted the first Bangkok urban plan, The Greater Bangkok Plan 2533 (1990), to the Thai Government. Based on the American paradigm, the company mainly designed the plan around dependence on cars and road infrastructure, as they summarised in their main recommendations. The plan stated that it would:

...facilitate this future land development in a "finger" type growth to most economically provide needed utilities and traffic routes...

Further on it stressed:

...the development of integrated loop and arterial roads with adequate parking facilities, to provide easy movement of traffic within and around the Metropolitan Area, and strengthening connections to other cities.

(p. 9)

This emphasis is not surprising considering the cultural context of the consultants, but more particularly the time period, which was the height of America's headlong pursuit of planning around the automobile (see for example Kenworthy, 1990a and b). For example, traditional computer-based land-use/transport modelling came into being with the Detroit and Chicago Area Transport Studies of the late 1950s. Thereafter, this form of transport planning based on extrapolating trends and supplying roads to meet demand became the norm in North America and other developed parts of the world. That American consultants would apply it overseas is perhaps to be expected, though with some sensitivity to local realities, particularly the very different land-use patterns, one might have expected the approach to be modified (see Chapter 6).

In more detail, the Bangkok plan proposed the construction of three ring roads around Bangkok and two expressways. The first expressway was a through north-southwest route, the second was a through west-east route. Both were proposed to pass through Bangkok's inner area, connecting
Bangkok with cities located around 60 to 100 km from Bangkok. Moreover, thirty-eight new main roads were proposed to support this road network. Bangkok was being designed as the centre of transport and exporting in Thailand, with the local implications of the transport plans taking second place (Litchfield Whiting Bowne and Associates and Adams Howard and Greeley, 1960).

Likewise, the successor to the Greater Bangkok Plan, The First Revision of the Plan for the Metropolitan Area, prepared by the Department of Town and Country Planning in 1971 also promoted road-based transport to cope with the city's worsening traffic problems. This plan confirmed the construction of three circumferential roads, a number of radial and cross-city roads and several minor roads. In addition, it proposed the construction of several new bridges across the Chao Phraya River and a riverside drive. Alternatively, with the awareness of the uncertainty of the riverside drive construction, two elevated expressways were proposed as an urgent solution to traffic congestion. One expressway was designed to run above main canals for much of its length, and the other was to be built above an existing major road (Department of Town and Country Planning, 1973).

Although none of the Bangkok plans have been officially adopted, transport infrastructure developments in Bangkok have tended to follow those which were designed in these plans. More and more roads were built to supply land transport demand. More canals were filled in and replaced by roads. Consequently, the role of water transport has declined rapidly, although some paratransit forms have emerged and have been playing an increasingly significant role. Figure 2.20 illustrates the whole system of transport in Bangkok as it has emerged during the motorisation period.
Figure 2.20 Structure of the transport system in Bangkok

Notes: 1. A pick-up is a light truck which is mostly used as a private car in Bangkok due to its cost-competitiveness over cars.
2. Tuk-tuk is a motor tricycle.
3. Silor-lek is a four-wheel small van.

As shown in Figure 2.20, the transport system in Bangkok consists of two main systems, land transport and water transport. The following section examines in detail the changes to each transport mode in Bangkok during the motorisation period and looks at their current situations.

(1) Land Transport

Transport studies in Bangkok have traditionally classified land transport in Bangkok into only two main systems: private transport and public transport. Yet, in common with other cities around the world, there is another mode of transport which is always ignored and regarded as insignificant. This is the non-motorised mode (see, for example, JICA, 1990; Halcrow Fox and Associates et al., 1991). The other mode that has different operational characteristics to traditional public transport is paratransit and will be discussed separately. This section examines the land transport system in Bangkok under four headings: private transport, public transport, paratransit and non-motorised transport.
(1.1) Private Transport

In 1947 when Bangkok's population was around 1.2 million there were only 5,700 motor vehicles in the city, of which only 3,260 were private cars. This vehicle ownership equated to just 4.8 motor vehicles per 1,000 people and only 2.7 cars per 1,000 people. In other words, in 1947 Bangkok had to function primarily on non-motorised modes, water transport and other modes of public transport. From that time the population of motor vehicles grew steadily to around 1980, at which point there was a dramatic escalation in the rate of growth of motor vehicles.

In 1960 there were 71,300 motor vehicles registered in Bangkok, of which 20,200 were cars. By 1970 the vehicular numbers had increased by about four-fold to 275,400 with 197,700 cars and 41,600 pick-ups. Ten years later, in 1980 the figures had doubled to 571,300 of which 299,100 were cars and 55,400 were pick-ups. By 1990, 2,031,600 motor vehicles were registered in Bangkok including 899,200 cars and 268,600 pick-ups. In 1993 the total figure reached 2,656,000 of which 1,092,000 were cars and 272,000 were pick-ups (Figure 2.21). These data represent annual increases in motor vehicles of 13.5 per cent from 1960 to 1970, 7 per cent from 1970 to 1980, 13 per cent from 1980 to 1990 and 10 per cent from 1990 to 1993, far in excess of population growth rates in each period.

![Figure 2.21 Number of motor vehicles in the BMA (Bangkok and Thonburi), 1947 to 1993](image)

**Figure 2.21 Number of motor vehicles in the BMA (Bangkok and Thonburi), 1947 to 1993**

Sources: 1. 1947, 1950 data from Bongsadadt, 1973: 19
2. 1960 to 1993 data from Department of Land Transport

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\(^{15}\)In Bangkok, most pick-ups (light-trucks) are used as private cars.
The total number of vehicles per 1,000 people in Bangkok was 33 in 1960 compared with 90 in 1970 and 122 in 1980, while by 1990 it had leapt to 366 and to 429 in 1993. The number of cars per 1,000 inhabitants also rose considerably from just 3 in 1947 to 14 in 1960, 54 in 1970, 71 in 1980, 199 in 1990 and 220 in 1993 (Figure 2.22). As shown in Figure 2.23, this rate of growth is far higher than in any other city in Southeast Asia, except Kuala Lumpur where the rate of growth is as high as that of Bangkok.

This trend shows that in spite of the continually deteriorating traffic situation in the city, its inhabitants still decide to own their own cars. The number of cars in Bangkok has been increasing steadily from 1960 to 1980, with the number increasing markedly from 1980 to 1993.

As also shown in Figure 2.21 and Figure 2.22, another mode of private transport which has been noticeably increasing is the motorcycle. Immediately after World War II in 1947 there were only around 700 motorcycles in Bangkok. Over the next 13 years this number had increased to 13,000 in 1960 and then to 59,500 in 1970, 172,000 in 1980, 728,700 in 1990 and 1,105,100 in 1993. This figure was only slightly less than the number of cars in 1993. The average annual growth rates were approximately 23 per cent from 1947 to 1960, 15 per cent from 1960 to 1970, 11 per cent from 1970 to 1980 and 15 per cent from 1980 to 1993. These growth rates are the highest of all classes of vehicles. The number of motorcycles per 1,000 people has of course also been rapidly increasing from only 3 in 1947 to 6 in 1960, 17 in 1970, 35 in 1980, then almost a quadrupling to 124 in 1990 and to 178 in 1993.

As also shown in Figure 2.23, the substantial increase in motorcycle numbers in Bangkok during this period is in common with other Southeast Asian cities except Manila.16

Bangkok started to be aware of a developing traffic problem along some roads in the mid-1950s when there were only about 40,000 motor vehicles, of which 21,000 were cars. These problems continued and according to the traffic survey reported by the Thai Government, between 1964 and 1972 the

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16 According to Guia (1996) the unusually low level of motorcycle ownership in Manila is due to three factors: (1) the ratio of income of an average earning person to the high price of a motorcycle; (2) the climatic condition of high annual rainfall and a number of typhoons annually; and (3) the high levels of service offered by the jeepneys and the motorised tricycles.
Figure 2.22 Vehicle ownership by vehicle type in Bangkok, 1947 to 1993

Sources: Calculation based on the following data sources:
1. Number of vehicles in 1947 from Bongsadadt, 1973
2. Number of vehicles from 1960 to 1993 from Department of Land Transport

Note: Car numbers from 1970 include cars and pick-ups.

Figure 2.23 Vehicle ownership by vehicle type in Southeast Asian cities, 1960 to 1993

Sources: 1. Bangkok’s data from Figure 2.22

Note: Bangkok’s car numbers include cars and pick-ups.
daily traffic volume on the arterial roads increased by 3 to 4 times (Donner, 1978: 835).

In order to keep pace with this substantial growth in traffic volume, successive governments have given emphasis to the construction of roads. Since roads were needed to access existing residential areas, and canals already served as transport routes, a number of canals were filled in and converted to roads (Bongsadadt, 1984: 54; Bunnag, 1982: 127). Notwithstanding, this policy has never been demonstrated to be able to cope with the traffic problems in Bangkok. Traffic volumes have kept on increasing rapidly and have exceeded the capacity of many roads, particularly in the inner area (JICA, 1990).

As a consequence of mostly growing traffic volumes, traffic conditions in Bangkok have been steadily deteriorating. The overall average traffic speed in the inner area is less than 10 km/h, and goes down to 3 to 5 km/h during peak hours. Worse still, on some roads in the city centre, traffic becomes nearly gridlocked during peak periods (JICA, 1990; Pendakur, 1992a).

In summary, it is apparent that private transport has rapidly become popular in Bangkok during the post-war period (much more so than in other similar Southeast Asian cities, as show in more detail in Chapter 4). The considerable increase in the number of private vehicles has quickly saturated Bangkok’s roads, particularly roads in the inner area. Severe traffic congestion is therefore a common but nonetheless, very intimidating situation for Bangkok residents. The next section explores the trends in public transport, another major form of transport in Bangkok during the motorisation period.

(1.2) Public Transport

As a result of rapid development in the road network since the end of World War II, people in Bangkok began to turn more to the use of road-based transport, not only cars but also buses. On the other hand, there was no development of the tram system at all during the post-World War II period. The number of trams remained the same at about 200 throughout the decade following the end of the Second World War, while the number of buses increased noticeably from only 191 in 1947 to 2,000 in 1959 (Bongsadadt,
1973: 19). Worse still, as road traffic substantially increased, trams were
considered an obstacle to other modes of road transport. A similar attitude
prevailed in Western cities during the same period and many tram systems
had disappeared by the early sixties in Britain, Australia, the United States
and other places (see Bayliss, 1989; Barry, 1991). Litchfield Whiting Bowne
and Associates and Adams Howard and Greeley (1960) recommended in
their Greater Bangkok Plan 2533 that:

The old single track system blocks traffic and the cars are out-moded,
slow and inconvenient....The Nakorn Luang Electric works has for some
time desired to abandon trams and substitute trolley buses whenever
funds are available. The lack of flexibility of trolley buses as far as
routing is concerned, and the greater interference with free moving
traffic are not desirable from the standpoint of facilitating movement and
convenience. We therefore concur with the recommendation contained in
the special report on urban transport facilities prepared by Transport
Consultants Incorporated for the Ministry of Communications, that
trams be abandoned on a planned program coordinated with street
improvements and their operations absorbed by bus service. (p. 92-93)

Eventually, the government in 1961 decided to gradually abolish the system,
route-by-route. The last tram route was removed in 1968 (The Technical
Section, Thai Farmer Bank, 1992: 8). As already mentioned, the
abandonment of the tram did not take place only in Bangkok. Among the
exceptions around the world were in some cities of Switzerland, Austria,
West Germany, Italy, Belgium, Netherlands, cities in the former USSR, and
other countries of the Eastern Bloc which had low car ownership, as well as
some scattered systems such as in Melbourne, Australia and Blackpool,

After the abolition of trams, the main means of land public transport for
Bangkokians was the bus. The next section examines in detail the
development of buses during the motorisation period, as well as their role in
Bangkok's transport system and their problems.
(1.2.1) Buses

The number of buses in service in Bangkok has been continuously increasing since the end of World War II. For example, the number of buses more than tripled from 191 in 1947 to 667 in 1950, and then increased a further threefold to nearly 2,000 in 1960. In 1970 the figure again more than doubled to 4,200. The number then increased to 7,900 in 1980 and to 11,100 in 1990 (Figure 2.24).

![Graph showing the number of buses and proportion of buses to population in Bangkok, 1947 to 1990](image)

**Figure 2.24 Number of buses and proportion of buses to population in Bangkok, 1947 to 1990**

Sources: 1. Number of buses in 1947 and 1960, from Bongsadadt, 1973  
2. Number of buses in the other years, from Department of Land Transport, 1990 and Bangkok Mass Transit Authority, 1990a, 1990b  

Note: 1990 population is the BMR population.

Despite the noticeable increase in the number of buses during this period, the service fell far short of demand due to the huge population and settlement density of people in Bangkok. The proportion of buses to Bangkok's inhabitants remained very low. As shown in Figure 2.24, in 1947 there were around 0.19 buses per 1,000 people, while in 1960 this had increased to 0.9 buses per 1,000 people, and remained at this same level in 1970. The proportion only marginally increased to 1.2 per 1,000 people in 1980 and to 1.3 per 1,000 people in 1990.
Partly as a result of this low ratio of buses to population, in the early 1970s a new type of public transport, the minibus, was introduced to Bangkok. The minibus is a small private commercial truck which is converted into a passenger carrier. These mini-buses were initially operated illegally along small distributor roads (sois) in suburbs serving residential areas and main roads. Minibuses became popular and necessary to poor and middle class people who lived in suburbs, since regular buses were scarcely available and could not easily service the tight urban fabric of the sois (Bongsadadt, 1973: 18).

Since there were a number of bus companies at the beginning of the 1970s who operated their services individually, conflicts, high competition, and route overlapping arose. This led to unsatisfactory services and traffic problems. In addition, from 1973 many of these companies suffered considerably from the oil price crisis and inflation. They asked the government permission to raise fares and took direct action in an effort to force the government. Consequently, in 1975 the government decided to combine all bus companies, of which there were twenty-four private and two government owned companies, into a single state-enterprise called The Metropolitan Company Limited. Then, in 1976 it was renamed the Bangkok Mass Transit Authority (BMTA) which has been running the bus service in the Bangkok metropolis and the five surrounding provinces up to the present day. However, as there were still a number of illegal minibuses operating in Bangkok, the government forced them to join with the Bangkok Mass Transit Authority in order to be able to control their service quality (BMTA, 1990b: 1).

Currently, bus services are mainly operated by the Bangkok Metropolitan Transit Authority (BMTA). In addition, BMTA also oversees privately-owned buses and minibuses. In 1993, there were approximately 11,200 buses catering for Bangkok commuters. Basically, buses operating in Bangkok are categorised into three types: regular buses, air-conditioned buses and minibuses. In addition, in order to try to take part in the easing of severe traffic congestion in Bangkok, in 1993, BMTA, in cooperation with a private firm, initiated the micro-bus service, a twenty-seat, small, air-conditioned bus, in certain business areas. This service has become very popular among Bangkok residents because of its superior quality (BMTA, 1992, 1993).
In summary, bus services in Bangkok, which have become the dominant mode of public transport during the post-war period, are unable to provide adequate and satisfactory services for Bangkok residents due partly to the inadequate number of buses. Overall though, it is probably worth concluding that buses simply do not have the capacity to move the number of passengers required in Bangkok. Even if more buses were to be purchased, there is not the road space to accommodate them (see Chapters 4 and 5). In addition, due to the fact that buses are caught in the traffic along with other road-based vehicles, they are unable to offer a competitive service in terms of speed and reliability. This is developed more in Chapter 5. The following section discusses another mode of public transport in Bangkok, the railway, although it presently has a very tiny role in Bangkok.

(1.2.2) Railways

During the first two decades of the motorisation period, there were some improvements to train infrastructure in Thailand. In 1947 there were approximately 3,300 km of route length throughout the country, in 1957 the length had increased to 3,500 km, and in 1967 it increased again modestly to 3,800 km (State Railway of Thailand, 1970: 363). Due however to the government's policy shift to high investment in roads and highways, the role of the railway has been rapidly declining and there has been only little improvement in railway facilities (State Railway of Thailand, 1970: 239). In 1993 there were approximately 4,000 km of railway tracks in Thailand which means that only around 200 km of railway tracks have been added in the 26 years since 1967 (State Railway of Thailand, 1993: 21).

At present, the railway system in Thailand is solely operated by the State Railway of Thailand (SRT) which is the largest state enterprise in Thailand (TDRI, 1993: 4). As the railway system is mainly inter-regional it has contributed very little to passenger movement within Bangkok. For example, in 1972, only 7,000 trips (which was 0.15 per cent of the total internal trips in the Greater Bangkok Area) were made by trains daily, compared with 2.64 million trips by buses. Even ferry trips were about twenty times higher than rail trips in 1972 (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975). In 1989 train travel in Bangkok also had a very low share of total trips. The average number of daily passengers in the urban area is
around 20,000, which is only 0.13 per cent of Bangkok's 15.6 million daily trips (JICA, 1990: 4-3).

Despite this very minor contribution for overall travel, the train passenger volumes inside the Bangkok area always exceed the train capacity during rush hours (TDRI, 1993: 43-55). Passengers hanging from the train doors are a common scene, indicating relatively high demand but inadequate supply of train services.

(1.3) Paratransit

The term "paratransit" was first used in the US by the Federal Department of Transport in 1972 (Kirby, 1979: 37). In general, paratransit is an unconventional form of public transport which provides supplementary services to conventional public transport. However, in a broader perspective, paratransit is not only supplementary to conventional public transport, but is also a high potential activity in its own right that can contribute much more to urban transport. It represents a more decentralised, informal approach to urban transport. In many ways, it becomes a kind of grass-roots movement (Roos, cited in Commonwealth of Australia, 1980: 7).

Since buses in Bangkok are unable to provide a reliable and viable service, both in terms of quantity and quality, various paratransit modes have become alternatives for Bangkokians, despite their higher fares and lower safety. Taxis and tuk-tuks are the most common paratransit modes, while less common modes are silor-leks and hired-motorcycles (Poboon et al., 1994: 16; Tanaboriboon, 1993: 19).

Taxis have become more popular since the beginning of the motorisation period due to their advantages of convenience, safety and faster movement compared to tricycles and motor tricycles (Ankhong, 1986: 69). As shown in Figure 2.25, taxi numbers have increased noticeably since the end of World War II from only 110 in 1947 to 360 in 1955, to a massive 7,200 in 1960 and then 8,900 in 1970. During the 1970s the government imposed a quota to limit the number of taxis, since because of their low capacity, they were also considered to be a cause of traffic problems. Therefore, the number of taxis in 1980 and 1990 remained stable at around 13,500. However, after the
government lifted the quota in 1991, the number of taxis soared considerably. In 1993 there were approximately 36,000 taxis in Bangkok, nearly triple the 1990 figure (Department of Land Transport, 1993).

![Graph showing the number of taxis and tuk-tuks in Bangkok (and Thonburi), 1947 to 1993](image)

**Figure 2.25 Number of taxis and tuk-tuks in Bangkok (and Thonburi), 1947 to 1993**

Sources: 1. 1947 to 1970 data from Bongsadadt, 1973: 19, 20
2. 1980, 1990 and 1993 data from Department of Land Transport

Another common mode of paratransit is the *tuk-tuk* or *samlor* or motor tricycle. It is a three-wheel taxi with a three-seat capacity. They were first introduced onto Bangkok’s roads in 1955 (Bongsadadt, 1973: 19). From 1955 to 1959 the number of *tuk-tuks* was about 2,000. Then in 1960 the government banned tricycles from Bangkok’s roads and replaced them with *tuk-tuks*, with the result that the *tuk-tuk* number leapt to 7,000. After that the government issued regulations to limit the number of *tuk-tuks*, so the numbers have remained almost stable at around 7,000 to 7,500 through to the 1990s (Bongsadadt, 1973; Department of Land Transport, 1990, 1993).

A more recent mode of paratransit is the *silor-lek*, which is a small 4-wheel vehicle of 6 passenger capacity converted from a light truck. The number of *silor-leks* has increased noticeably during the last decade as Bangkok has expanded further to the surrounding area and many *sois* are not served by buses. In 1985 there were about 3,400 *silor-leks* in Bangkok, but by 1990 the number had more than doubled to approximately 8,200. However, due to the competition from another recent mode of paratransit, hired motorcycles, which also serve along *sois*, the number of *silor-leks* has only moderately
increased to around 8,500 in 1993 (JICA, 1990; Department of Land Transport, 1990, 1993).

Hired motorcycles generally cater for commuter trips in sois which are not accessible to public transport, particularly buses and minibuses. They are also used for transporting children to school. As hired motorcycles can zig-zag through traffic when other vehicles are caught up, they have become very popular among Bangkok residents.

Prior to 1981 there were less than 100 hired motorcycles in Bangkok and they were, strictly speaking, illegal. The turning point was in 1982 when hired motorcycles were officially approved by the Metropolitan Police Division and the Department of Land Transport. Consequently, they have rapidly become very popular as traffic congestion has grown. By 1988 the number of hired motorcycles had increased more than 160 times the 1981 numbers to 16,000. Currently, there are approximately 37,500 hired motorcycles operating in Bangkok (Poapongsakorn, 1994: 3).

(1.4) Non-motorised transport

During the transport modernisation period a variety of non-motorised modes were introduced to Bangkok e.g. tricycles, bicycles, rickshaws. They played an important role in moving people and their operational characteristics were consistent with the city structure and infrastructure provided. However, when the number of motor vehicles increased, the number of non-motorised trips fell, due to people's concern about road danger and their preference for faster and more convenient motor vehicles. For example, rickshaws nearly disappeared from Bangkok streets before World War II, but returned for a short time during the war due to the shortage in fuel for motor vehicles (Ankhong, 1986: 42).

Tricycles became popular among Bangkok residents after World War II. In 1950 there were about 13,000 tricycles in Bangkok. However, as traffic volume grew rapidly, they too were considered an obstacle to road traffic. Thus, the government in 1950 issued a regulation to limit the number of tricycles and also aimed to gradually eliminate tricycles. However, the regulation failed to diminish the number of tricycles. Field Marshall Sarit Thanarat, the Prime Minister at that time, therefore, commanded the
abandonment of the registration of tricycles in Bangkok as of 1960. His main reason was related to the growing traffic problem:

_Due to the substantial development of Bangkok and Thonburi, there are many more vehicles, particularly motor vehicles which are popular among residents because they are convenient and fast. However, tricycles which are slow moving vehicles are still popularly used. These tricycles are the obstacles of free traffic, triggering worse and confusing traffic, unnecessarily hampering other people..._

(Rujirawong, 1964: 61)

The services of tricycles were replaced by motor tricycles. The elimination of tricycles in Bangkok was saluted by Rujirawong (1964) as follows:

_Nowadays, there are no tricycles in Bangkok and Thonburi. They are replaced by motor tricycles. The elimination of tricycles relieves a number of problems such as traffic congestion, passenger dangers, city dirtiness, criminals, and tricycle drivers' health problems. This is due mainly to the prime minister's initiation and fore-sight._ (p. 65)

The most common type of non-motorised vehicle is the bicycle. The bicycle was very popular in Bangkok until the beginning of the motorisation period when motorised traffic was limited (Ankhong, 1986: 51). However, due to the substantially growing volume of traffic in Bangkok, the number of bicycles rapidly diminished. The main obstacles facing cyclists are the traffic dangers, severe air and noise pollution and the lack of infrastructure for cycling (Poboon et al., 1994). In 1989 Bangkok residents used bicycles for less than 1 per cent of total daily trips (TT Planning and Design Co. Ltd. and Transport Research Unit, 1995: Table 4.4). Chapters 4 and 5 discuss this issue in detail.

(2) Waterway Transport

Water transport declined from World War II, but still played a significant role during the first decade of the motorisation period, as described by Litchfield Whiting Bowne and Associates and Adams Howard and Greeley in 1960 in the _Greater Bangkok Plan 2533:_

67
The inland waterways—the rivers and klongs—have been and will continue to be an essential part of the transportation system of Thailand, particularly in the Central Plain. The larger klongs, if at all navigable, are lined with housing both singly and in clusters; and the waterways in the rural areas serve as main transportation routes, as well as a water supply source. (p. 112)

As already mentioned, from 1960 government planning and development efforts have focused mainly on road-based transport and a number of canals have been filled in and replaced by roads. For example, some of the significant roads in the Bangkok central area which used to be canals are Silom Road, Witthayu Road, Rama IV Road and Sri Ayuthaya Road. Moreover, the other canals were left without adequate maintenance. A number of canals became places for disposing of litter and waste water and were encroached upon by people who lived along their banks. As a consequence, they have become dirty, shallow and narrow. As flood protection has become one of the priorities of the BMA, a number of water gates and locks have been constructed for flood control along many canals, making them useless as fast, efficient channels for transport in Bangkok (Bunnag et al., 1982; F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975).

The diminishing role of water transport in Bangkok is statistically evident when comparing the proportion of its passengers to the total passengers over the last two decades. In 1989 waterway transport in Bangkok served about 260,000 passengers daily, which was only about 2 per cent of Bangkok's daily passenger trips (JICA, 1990). The number of passengers is still comparatively low, only around 4 per cent of the total public transport ridership. By comparison, there were around 180,000 boat passengers daily in 1972, which accounted for about 3.8 per cent of total passenger trips in Bangkok and around 7 per cent of the total public transport passengers at that time. Although the number of boat passengers marginally increased over these two decades, the share of water transport in the whole transport system and in the public transport system, decreased considerably to be only about half of what it was.

Despite the rapidly diminishing role of water transport in Bangkok in the post-war period, the Chao Phraya River and a number of canals in Bangkok which provide a comprehensive waterway network still play a role in urban transport. Bangkok residents who live along the banks of the Chao Phraya River and the main canals still use this mode of transport as it provides a faster trip than any other mode with a reasonable fare. Furthermore, as the traffic in Bangkok has become very severe, more Bangkok residents have turned to use boats as a better alternative during recent years.

Currently, waterway passenger transport in Bangkok can be classified into four services; express boats along the Chao Phraya River, ferries across the Chao Phraya River, fixed route long-tail boats along canals, and flexible route long-tail boats. Beside these commuter services, there are also tour boats providing services for tourists, mostly foreigners, to some specific points, e.g. floating markets at Wat Sai and Damnoensaduak. All of them are operated by private operators.

In addition to the above boat services, as traffic congestion in Bangkok became worse, the BMA in 1990 initiated the experimental boat service projects along four canals on the east bank of the river. The total length of these services is around 53 km (Poo Jad Karn, 1994: 5). There are about 210 boats altogether involved in these services, both long tail boats and in-board engine boats. Some boats have a capacity of up to 100 passengers.

This initiative received a positive response from Bangkok commuters as a better alternative to land transport and their passenger volumes have been appreciably increasing ever since. In 1993, only the third year of the services, there were about 70,000 passengers daily (Traffic Engineering Department, 1992: 51), which was approximately one-quarter of total daily boat passengers in Bangkok.

The demand for boat transport is even higher than the supply. The Bangkok Governor recently stated that “more and more people are contacting city administrators complaining about the inadequate boat services and urging that more routes be opened” (Phanchampee, 1993: A1). This excess demand has prompted the BMA to consider extending the project to another four routes, of which three routes are on the west bank and one route is on the east bank of the Chao Phraya River (BMA, 1994).
It would appear that the recent appreciable increases in boat patronage are a consequence of the chronic and severe traffic congestion in Bangkok. Boat transport provides a more viable and faster service compared to buses and boats are somewhat removed from the air pollution along the roads and provide relief from the heat. The service has thus become popular with Bangkok commuters who live not so far from the waterway network. It is possible that waterway transport in Bangkok can play a more important role in Bangkok’s transport system. Nevertheless, there are some constraints such as the passenger carrying capacity of the vessels and the dangers presently involved in this mode. Chapter 5 discusses this issue in more detail.

2.4.3.4 Summary of the Motorisation Period

After the Second World War, Bangkok entered a period of rapidly increasing numbers of motor vehicles. The governments at this time directed transport policy towards road and highway development which resulted in huge investments in road infrastructure, both in Bangkok and throughout Thailand. Main highways were constructed to link Bangkok with all regions. By contrast, non road-based public transport modes (i.e. trains and waterways transport) as well as the on-road tram system, received very little attention. As a result, their roles substantially declined. Trams were eliminated from Bangkok for the sake of free traffic and were replaced by buses. Buses and private vehicles have rapidly become the dominant modes, as graphically depicted in Plate 2.2. New developments took place mostly along main road corridors, radiating from Bangkok to other regions as road transport became almost the only means available for travel. The city structure considerably changed from a compact city form to finger type or ribbon development in the outer areas.

Bangkok's residents now have to travel much longer to their workplaces or to schools. Although the density of the city has declined somewhat due to this type of settlement, particularly in the outer area, the overall density of the city remains relatively high due to the high density of the inner area and the fact that most residents in the outer areas live very close to these transport corridors.
Compared to what is termed the automobile city, where most people depend largely on cars and live sparsely along the comprehensive road networks, as occurs in American and Australian cities, Bangkok is still far from being able to be labelled as such. Bangkok does not have the comprehensive road network of the automobile city. Bangkok’s density is still relatively high due to the different paths of development from the previous period as described earlier. The city’s structure is much more suited to the development of public transport services. However, Bangkok has been moving towards the automobile city in terms of its motor vehicle population growth and huge investment in roads and freeways to facilitate private vehicles. Unfortunately, as the city’s structure and transport infrastructure provision do not suit the high level of car use, traffic congestion in Bangkok has thus become a huge problem.
Plate 2.2 Bangkok road scenes in 1960 and at the present time

2. Bangkok at the present from the Feature Magazine, 1990: 10
2.5 CONCLUSIONS

In order to explain the full horror of Bangkok's traffic congestion, this chapter has attempted to show the path along which Bangkok has evolved, particularly in terms of transport and land-use, widely recognised as interrelated factors. A brief comparison with the historical pattern of Western cities has been employed to put the development of Bangkok in context. The history of cities has shown that walking, transit, or the car (the major forms of transport) are key factors affecting city form. The three periods of the development of cities are the traditional walking city, the transit city and the automobile city. Based on the transport features, the development of Bangkok can also be classified into three main periods: (1) the water-based transport and walking city; (2) the transport modernisation period; and (3) the motorisation period. During each period, Bangkok has seen major changes in transport technologies which strongly influenced the city's structure and land-use. This is summarised in Figure 2.26. This finding is consistent with the theory outlined earlier in this chapter by Bacon (1967), Hall (1988), Newman and Mouritz (1992) and Newman et al. (1992).

During the first period (1782-1868), Bangkok was characterised by water-based transport and walking, modes which were very compatible both with the city landscape and its small area. These modes of transport allowed the city to be very compact, with a dense population and a mixed land-use, again features which are central to the traditional walking city. Then, during the transport modernisation period (1868-1946), Bangkok experienced the introduction of a variety of new transport technologies in the form of trams, railways, buses, modern roads and cars, as well as a variety of non-motorised transport modes. Water transport, on the other hand, declined. However, public transport, particularly trams, coupled with non-motorised modes, played a major role, because of the still very low numbers of motor vehicles. The city was, therefore, still dense, with mixed land-use, and only slight expansion. In this respect, Bangkok differed from the more typical transit city. The transit city was more typically characterised by train and tram technology, the former of which enabled new development to emerge further away along train lines and new suburbs to develop around railway stations. Nevertheless, both are similar in terms of mixed land-use and dense population.
Figure 2.26 The relationship between transport technologies and Bangkok's urban structure and land-use
After the Second World War, Bangkok entered the motorisation period. As a consequence of the rapidly growing motor vehicle population and government policies emphasising road construction and giving priority to road traffic, trams and non-motorised transport modes were eliminated from Bangkok's roads (trams completely, with only bicycles remaining of the non-motorised modes, and in small numbers). Private vehicles (cars, pick-ups and motorcycles) rapidly began to dominate roads, and buses became the dominant means of public transport. Water transport rapidly declined to the point where it now plays a minor role. This major change in transport technologies has significantly affected the city's structure. Most new development has taken place along main road corridors, as ribbon development in the outer areas of Bangkok, and now extends approximately 30 km from the city centre. Development has also scattered away from the main road corridors along smaller roads. However, despite this linear dispersal, city density has only slightly declined and mixed land-use still strongly characterises Bangkok's development. Hence, in land-use terms Bangkok has not yet become an automobile city, where people primarily live in scattered, low density, single use settlement patterns along a comprehensive road network. However, there has been a rapidly growing trend for people to rely on cars for an increasing proportion of their travel needs. In the more extreme outer reaches of the city, residential and commercial development is becoming increasingly separate from the main road corridors, with only very basic roads linking these new concentrations of people and jobs to the main roads. These areas, despite still having reasonable densities compared to Western cities, have almost no transit service and are heavily automobile dependent. Each month they add an increasingly unsustainable traffic burden to the greater road network.

The evolution of transport and land-use development in Bangkok through the three key periods described in this chapter can be summarised in quantitative terms in Table 2.2. This table sets out some key land-use and transport characteristics for the various years which provide a summary perspective on how rapidly and significantly Bangkok has changed from 1782 to the present time.
Table 2.2 The evolution of transport and land-use in Bangkok from its establishment to the present time as depicted by some factors

<table>
<thead>
<tr>
<th>Land-use/Transport Period</th>
<th>Water-Based Transport (1782-1868)</th>
<th>Transport Modernisation Period (1868-1946)</th>
<th>Motorisation Period (1946-present)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First half (Rama I - Rama III)</td>
<td>First half (Rama V)</td>
<td>First half (1946-1980)</td>
</tr>
<tr>
<td></td>
<td>Second half (Rama IV)</td>
<td>Second half (Rama VI - Rama VIII)</td>
<td>Second half (1981-present)</td>
</tr>
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<td>(1910)</td>
<td>(1970)</td>
</tr>
<tr>
<td></td>
<td>(1860s)</td>
<td>(1930s)</td>
<td>(1990)</td>
</tr>
<tr>
<td>Population</td>
<td>About 50,000</td>
<td>440,000</td>
<td>3.6 million</td>
</tr>
<tr>
<td></td>
<td>About 130,000</td>
<td>650,000</td>
<td>6.4 million</td>
</tr>
<tr>
<td>Built-up area (ha)</td>
<td>350</td>
<td>1,812</td>
<td>18,400</td>
</tr>
<tr>
<td></td>
<td>890</td>
<td>4,300</td>
<td>42,580</td>
</tr>
<tr>
<td>Density (persons/ha)</td>
<td>145</td>
<td>243</td>
<td>201</td>
</tr>
<tr>
<td></td>
<td>146</td>
<td>151</td>
<td>149</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td>(1780s)</td>
<td>(1910)</td>
<td>(1970)</td>
</tr>
<tr>
<td></td>
<td>(1860s)</td>
<td>(1940s)</td>
<td>(1990)</td>
</tr>
<tr>
<td>Canal length changes (km)</td>
<td>+71</td>
<td>+129</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1,640</td>
<td>na (many canals were filled in and many have become shallow and narrow)</td>
</tr>
<tr>
<td>Road length (km)</td>
<td>no road (only small streets)</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>na</td>
<td>2,190</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,803</td>
</tr>
<tr>
<td>Road length per capita (m)</td>
<td>–</td>
<td>0.15</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Road route length (km)</td>
<td>–</td>
<td>13.3</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>112</td>
</tr>
<tr>
<td>Rail route length (km)</td>
<td>–</td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>Rail route length/1,000 (m)</td>
<td>–</td>
<td></td>
<td>30.2</td>
</tr>
<tr>
<td>people (m)</td>
<td>–</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>Rail route length/1,000 (m)</td>
<td>–</td>
<td></td>
<td>44.6</td>
</tr>
<tr>
<td>people (m)</td>
<td>–</td>
<td></td>
<td>26.1</td>
</tr>
<tr>
<td>Rail route length/1,000 (m)</td>
<td>–</td>
<td></td>
<td>15.7</td>
</tr>
<tr>
<td>people (ha (m)</td>
<td>–</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Cars/1,000 people</td>
<td>–</td>
<td>negligible</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Motorcycles/1,000 people</td>
<td>–</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Buses/1,000 people</td>
<td>–</td>
<td>–</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>Trams/1,000 people</td>
<td>–</td>
<td>na</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
</tbody>
</table>

Notes: 1. Canal lengths include all canals in Bangkok and its suburbs (see Bunnag et al., 1982).
2. Rail route lengths for 1910 and 1930s estimated from Figures 2.11 and 2.12.
3. na = not available.
The findings of this chapter provide the foundation for an understanding of Bangkok's transport and land-use patterns as one root of Bangkok's traffic problems. The picture can be sharpened, however, to obtain a clearer insight into Bangkok's current traffic situation by comparing Bangkok with other global cities. Thus Chapters 3 and 4 place Bangkok in an international perspective by comparing the city's urban form, transport infrastructure, transport patterns, transport economics and transport externalities with global cities, particularly other Asian cities.
CHAPTER 3

UNDERSTANDING BANGKOK IN AN INTERNATIONAL CONTEXT:
METHODOLOGY

3.1 INTRODUCTION

Chapter 2 investigated the development of Bangkok's transport and land-use. It proposed that the major forms of transport technology in each period of the city's history were central factors affecting city structure and land-use. During the "motorisation era", which began with the end of World War II, Bangkok started moving towards a more car-dependent city, in terms of rapidly growing vehicle numbers and massive construction of road infrastructure. Private vehicles and buses have now become the dominant means of transport with waterway transport cast in a very minor role. Furthermore, the existing railway system, which is inter-regional, has not been developed for urban commuting and represents only a small fraction of the city's transport. Thus, an increasing trend towards automobile-dependence has significantly shaped the city's form, particularly in outer areas, where new developments have grown during the motorisation era. Traffic congestion has become a critical problem in Bangkok, with enormous adverse effects on people's lives, as well as on the environment and the local and national economy.

In order to address what some see as Bangkok's "nightmarish" traffic problem, it is essential to understand the root of the problems. This requires an examination not only of Bangkok's transport infrastructure and transport system but also its urban form as closely interrelated factors. As Cervero (1986: 396) asserted, "Any lasting solution to mobility problems must begin with land use considerations." One effective way to gain such insight into this complicated issue is to compare Bangkok's land-use and transport system to other cities around the world. Newman and Kenworthy (1989), through their Cities and Automobile Dependence: An International Sourcebook, have shown the value of such a comparative methodology. Their work has contributed to an international understanding of the relationships among urban form, transport patterns and energy use. In the case of this study, findings from such a comprehensive approach will be used to help suggest a
set of efficient and consistent policies and strategies designed to address Bangkok's severe traffic problems.

This chapter is therefore the first of two chapters devoted to a comparative study between Bangkok's land-use and transport patterns and those of other global cities. It describes in detail the methods used in the comparative study. It commences with the rationale for the comparative study by referring to other significant global cities studies and then demonstrating the objectives of the present comparative study. Following this are a general description of cities to be compared to Bangkok and parameters to be employed for the comparisons. It then depicts in detail the various data sources, the approaches used for data collection and the data analysis. Also discussed in this chapter are the definitions of Bangkok, study area and Bangkok's zones which require a clear explanation for the comparisons to have any significance. Finally, this chapter explains in detail the methods used to obtain some specific data e.g. urbanised area and some transport pattern, transport economic and transport emissions parameters, together with specific problems associated with deriving such data. One of the aims of this chapter is to attempt to show the uniqueness of the work undertaken in this thesis, since no other such broad and systematic efforts have been previously made to examine Bangkok's transport and land-use in relation to other cities. The complexity of this approach and the obstacles that had to be overcome in order to derive the required data, need to be understood.

3.2 RATIONALE FOR THE COMPARATIVE STUDY

3.2.1 Previous comparative studies of global cities

Very few reliable and detailed comparative land-use and transport studies have been conducted on global cities, despite the acknowledgement of their potentially large benefit to the development of transport policy and planning. This is mainly due to the time-consuming and difficult nature of accurate and comparable data collection. For example, two well-known studies of this kind were Hall's *The World Cities* (Hall, 1977), and Thomson's *Great Cities and Their Traffic* (Thomson, 1977), though even in these studies there was a paucity of comparative data on the cities examined. Perhaps lesser known comparative works were Hall and Hass-Klau's *Can Rail Save The City?* (Hall and Hass-Klau, 1985) and Goldberg and Mercer's *The Myth of
the North American City: Continentalism Challenged (Goldberg and Mercer, 1986). Hall examined patterns of urban growth in eight large world cities: London, Paris, Randstad Holland, Moscow, New York, Tokyo, Hong Kong and Mexico City, in terms of population, land-use, transport and urban plans. He concluded that the general tendency was for all great urban areas to spread outwards. Planners, therefore, have power to influence the course of urban change by means of land-use control, provision of infrastructure and, very importantly, the shape and mode of transport networks.

Thomson examined the transport problems, policies and plans of thirty large cities around the world. He found that, despite differences in size, wealth and age, all cities, with few exceptions, suffered from the same problems, i.e. traffic congestion, parking frustration, financial losses in public transport, accidents, poor conditions for pedestrians, and environmental degradation. Thomson classified sample cities into five archetypal groups and recommended different strategies for tackling the problems (see Chapter 4). He accentuated three important elements in a city transport strategy: the land-use disposition and the network structure, population densities, and the geographical shape of the city.

A possible weakness of the work in these studies was that they tended to study each city in isolation and drew general conclusions without many detailed quantitative comparisons between cities. The main reason was unavailability of reliable, comparable data. Thomson (1977) admitted that the main obstacle to clear insights into what was happening in cities was a lack of statistics and the ambiguous nature of the data obtained. He concluded his book by saying:

Finally, is it not time that an effort was made by some international body, such as the United Nations, to establish a foundation for the collection of important statistics about cities on a comparable basis? Without such, it is impossible to conduct scientific research into the organisation and functioning of cities... (p. 324)

Hall and Hass Klau's work examined the role of new rail systems in helping to revitalise cities, particularly their centres. They compared thirteen cities: seven in Germany and six in Great Britain, in some aspects of transport and land-use with some very good but patchy standardised data. They were
ultimately inconclusive about the extent to which rail benefited cities due to too many other factors which seemed to be at work and these were difficult to separate from the rail factor alone. However, they concluded that transit systems, with complementary measures, e.g. a careful blend of new and old developments in cities, improvement of the environment, particularly pedestrian spaces, and the encouragement of the right mix of activities, had a role to play in raising the potential of city centres. Hall and Hass Klaau also highlighted the problems of good comparative urban data on which to base conclusions (there own questionnaire-based data collection work suffering partly from this problem).

In 1986, Goldberg and Mercer (1986) conducted a comparative study of Canadian and American cities examining their cultural context, social and demographic structures, economy and political institutions. Over three-hundred North American metropolitan areas were examined in over 30 dimensions, including density, transport, household change and structure, income and fiscal disparities, and economic structure. Contrary to the prevalent myth of the continent similarity between cities in these two countries, the study revealed many salient differences. One of the major differences was that Canadians seem to have a strong sense of the need for public intervention in social and economic matters, whereas the Americans are more committed to individualism. Canadians expect more livable cities with a compact form and which are better served by public transport and public transport is utilised at significantly higher levels. American cities, on the other hand, are much more devoted to private transport, in terms of vehicle ownership and use and Americans commute by car much more than Canadians. The spread-out form of American cities and their extensive road and freeway systems supported by federal funds are the major reasons for this (Canada does not have a federal mechanism such as the US Highway Trust Fund for building freeway systems in cities). Whilst American central cities have declined in population over the last decade, Canadian central cities have been on average growing, while maintaining high-quality shopping and other services for the residents and workers. In terms of safety, although several American cities are as safe as the Canadian ones, on average the American cities have a substantially higher rate of violent crime.

Goldberg and Mercer's study drew heavily on readily available, centrally collected data such as that provided by the respective national censuses. No
effort was made to collect more difficult comparative data. The work in this study of Bangkok draws on both these kinds of data.

By 1996 the serious issue of availability of comparable and reliable data for global cities comparative studies had been at least partly addressed through a major joint effort between the UN Centre for Human Settlements and the World Bank which collected, through a series of consultants in each country, a large data base on cities called *Indicators Programme: Monitoring the City* (Urban Indicators Review). The work commenced as early as 1993 and some of the results were presented at Habitat II (City Summit) in Istanbul in June 1996. The study involved collection of 74 "key indicators" and 75 "extensive indicators" in each city. The indicators were classified into seven groups: Background Data Module (24 key indicators); Poverty, Employment and Productivity (6 key, 17 extensive indicators); Social Development (12 key, 10 extensive indicators); Infrastructure (7 key, 13 extensive indicators); Transport (9 key, 9 extensive indicators); Environmental Management (8 key, 20 extensive indicators); Local Government (8 key, 6 extensive indicators). The fact that this very extensive and costly exercise was undertaken appears to provide some recognition of the value of comparative urban assessments. Unfortunately, at the time of writing, detailed data from this study were not freely available. Notwithstanding, a preliminary examination of some of the data and discussion with the director of the study reveal many problems and gaps in the material collected (perhaps understandably given its huge scope) (personal communication, Jeff Kenworthy).

The need for and value of sound international comparative transport data is also being acknowledged by other major organisations around the world. The UITP (International Union for Public Transport) in Brussels, in conjunction with the US Department of Transport and the World Bank, is mounting a major exercise in April this year to try to establish uniform standards for international data collection on transport and to forge commitments by major agencies around the world to collect and maintain transport data based on a regular basis. The UITP is also currently undertaking its own large data collection on public transport in some 300 cities world-wide.
These efforts stress the value of comparative approaches to understanding and analysing urban transport issues and lend support to the methodology adopted in this thesis.

Acknowledging the intimidating task of collecting reliable data for global cities comparisons, Newman and Kenworthy (1989) pursued their global cities study, which took nearly a decade to collect and assemble the required data. On a uniform, standardised basis, they collected, analysed and compared data on land-use and transport patterns in thirty-two major world cities for 1960, 1970 and 1980. The selected cities encompassed cities in the USA and Canada, Australia, Europe and three Asian cities - Singapore, Hong Kong and Tokyo. Data collected were mainly in two groups: land-use pattern and transport pattern data. The data were presented in raw and standardised formats and were then extensively compared and statistically correlated. A highly summarised picture of the main findings of this study, which have contributed substantially to urban and transport policy and planning debate worldwide, are as follows:

(1) Land-use intensity, degree of centralisation, level of traffic restraint, public transport performance and orientation to non-auto modes exhibit a very significant relationship with gasoline use and overall transport patterns, in other words, with levels of automobile dependence.

(2) Sample cities can be classified into five major groups according to their land-use and transport characteristics, as show in Table 3.1.
Table 3.1 Transport patterns and energy use characteristics of major world cities, 1980

<table>
<thead>
<tr>
<th>Class</th>
<th>Transport and energy use patterns</th>
<th>Cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Very high automobile dependence almost no role for public transport, walking or cycling, very high gasoline use.</td>
<td>Phoenix, Houston, Denver, Detroit, Perth, Adelaide, Los Angeles, and Brisbane</td>
</tr>
<tr>
<td>II</td>
<td>High automobile dependence, minor though significant role for public transport, walking and cycling, high gasoline use.</td>
<td>Washington, Melbourne, Boston, Chicago, San Francisco, and Sydney</td>
</tr>
<tr>
<td>III</td>
<td>Moderate automobile dependence, important role for public transport, walking, and cycling, moderate gasoline use.</td>
<td>Toronto, New York, Copenhagen, Hamburg, Zurich, and Brussels</td>
</tr>
<tr>
<td>IV</td>
<td>Low automobile dependence, public transport, walking and cycling equal with, cars, low energy use.</td>
<td>Amsterdam, Frankfurt, West Berlin, Vienna, London, and Stockholm</td>
</tr>
<tr>
<td>V</td>
<td>Very low automobile dependence, public transport, walking and cycling more important than cars, very low gasoline use</td>
<td>Munich, Singapore, Paris, Hong Kong, and Tokyo</td>
</tr>
</tbody>
</table>

Source: Newman and Kenworthy, 1989: Table 5.5

From Table 3.1 above, we can see that the level of gasoline use per capita diminishes from Class I to Class V, while the transport system becomes less oriented to private vehicles and more oriented to public transport, walking and cycling. Urban density increases from Class I to Class V, while road provision per capita and CBD parking supply declines substantially. These findings tend to contradict the conventional transport paradigm, which gives priority to tackling traffic congestion by proposing the construction of more roads and freeways and their ancillary facilities such as more parking. The results provide empirical evidence that land-use and commitment of transport resources to public transport and non-motorised modes are very significant, though not the only factors, in creating futures for cities which are less automobile dependent and require lower levels of energy use.

3.2.2 Relevance of a comparative approach to Bangkok

Bangkok's traffic problems have been rapidly deteriorating. They have enormous impacts on the environment, human health, and the economy, as briefly discussed in Chapter 1 and further elaborated in Chapter 4. A number of studies have been conducted to examine these phenomena and several plans have been initiated in Bangkok to address these chronic symptoms. Nevertheless, none of these studies and plans has attempted to
contextualise and identify the roots of the problems by examining Bangkok in an international context. This can at least be partly attributed to difficulties in obtaining data from other cities on the same basis to permit comparisons with Bangkok. Moreover, there are significant difficulties in locating and analysing Bangkok data.

As discussed above, the comparative studies, particularly that by Newman and Kenworthy (1989), have demonstrated their value in providing a useful basis for studying transport (and land-use) characteristics, which can lead to effective policy-making and planning. This thesis applies a somewhat expanded version of Newman and Kenworthy's methodology to Bangkok's land-use and transport systems, by comparing relevant Bangkok characteristics with those of other cities, particularly other developing cities in Southeast Asia, which are generally more comparable to Bangkok in terms of social, cultural and environmental conditions. The data used are not-yet-published 1990 data for all cities (see section 3.6.1). This methodology is aimed at providing a deeper understanding of Bangkok's land-use and transport system, and helping to disclose the roots of the city's traffic problems. This approach provides a perspective on the city which has never been previously achieved. Figure 3.1 illustrates the conceptual basis of this comparative study.

3.3 OBJECTIVES OF THE COMPARATIVE STUDY

The objectives of the comparative study between Bangkok and other cities using 1990 data are as follows:

1) To examine Bangkok's urban form and land-use patterns to identify differences/similarities with other cities;
2) To examine Bangkok's transport infrastructure to compare levels of provision with those in other cities;
3) To examine Bangkok's transport patterns to see to what degree they are oriented to private or public transport, as well as to examine the role of non-motorised transport;
4) To examine the energy use characteristics of Bangkok's transport and compare to other cities;
5) To examine some transport economic indicators in Bangkok and how these compare with cities around the world;
Figure 3.1 Conceptual basis of the comparative study of Bangkok
6) To examine key transport externalities in Bangkok and how they compare in cities world-wide;
7) To suggest what are the roots of Bangkok's traffic problems by examining and analysing the whole array of international comparative urban data; and
8) To apply the lessons from these comparisons to further transport policy and planning which may help direct Bangkok towards a sustainable future.

3.4 CITIES TO BE COMPARED TO BANGKOK

In *Cities and Automobile Dependence*, Newman and Kenworthy (1989) selected thirty-two major cities around the world on the basis of variety in terms of location, climate, population sizes, density and transport patterns, in order to determine international implications from the comparisons. Their sample cities included five Australian cities, ten American cities, one Canadian city, thirteen European cities and three of the wealthier Asian cities. Cities in the developing world were not included because the vastly different transport patterns which result from their poverty make comparisons difficult with more affluent, developed cities. The availability and complexity of collecting data in cities in the developing world was also a factor which mitigated against their inclusion at the time. However, Newman and Kenworthy suggested that a future study of the developing world cities could reveal some useful lessons for Western cities.

For the Bangkok comparative study, cities selected are mainly based on those included by Newman and Kenworthy (1989), though with a few subtractions and additions (West Berlin and Moscow have been eliminated because of obvious changes and difficulties attached to data collection, Toronto has not been included as it is only one Canadian city and not really representative of other Canadian cities, whereas four cities in the developing world - Kuala Lumpur, Jakarta, Manila and Surabaya - have been added). The factors considered for the comparisons were a wide range of land-use and transport patterns, as well as some transport economics and externalities data. The cities vary from highly automobile dependent American and Australian cities to highly public transport-oriented wealthy Asian cities. In addition, the four cities in less developed Southeast Asian countries are likely to have many things in common with, or similar to Bangkok, such as culture and climate, as well as social, economic and environmental conditions, offering potentially useful lessons to Bangkok.
As a result, in this study Bangkok will be compared to another thirty-three major cities around the world, as shown in Table 3.2. These cities consist of ten American cities, five Australian cities, eleven European cities, three richer Asian cities and four Southeast Asian cities. Their populations vary from slightly over 600,000 for Frankfurt to over 18 million for New York. Most however have populations between 1 and 4 million.

3.5 PARAMETERS FOR COMPARISON

Data collected for the comparative study are mainly concerned with land-use and transport factors. Parameters for comparisons are based primarily on Newman and Kenworthy (1989), the most comprehensive approach to a study of this type. In addition, The Institute for Science and Technology Policy (ISTP), Murdoch University, Western Australia has been involved in a World Bank funded project to collect data on ten key urban transport indicators for essentially the same cities as in the present study, including Bangkok (Kenworthy et al., 1997). The indicators are:

(1) Modal split for the journey-to-work
(2) Journey-to-work trip length
(3) Journey-to-work trip time
(4) Expenditure on journey-to-work
(5) Modal energy efficiency
(6) Transport related deaths
(7) Public transport operating cost recovery
(8) Expenditure on all roads
(9) Emissions from the transport sector
(10) Condition of road infrastructure

These extra data were developed for Bangkok as part of this doctoral thesis, and compared with the other global cities. The list of ten parameters belies a much larger list of fourteen extra data items which had to be collected in order to derive these ten items. The additional items were:

- Private transport capital cost per km
- Private transport variable cost per km
- Average private transport occupancy for the journey-to-work
### Table 3.2 Cities in the comparative study and their 1990 population

<table>
<thead>
<tr>
<th>Cities</th>
<th>1990 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>US Cities</strong></td>
<td></td>
</tr>
<tr>
<td>Houston</td>
<td>3,462,529</td>
</tr>
<tr>
<td>Phoenix</td>
<td>2,122,101</td>
</tr>
<tr>
<td>Detroit</td>
<td>3,912,679</td>
</tr>
<tr>
<td>Denver</td>
<td>1,787,928</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>8,863,164</td>
</tr>
<tr>
<td>San Francisco</td>
<td>3,686,592</td>
</tr>
<tr>
<td>Boston</td>
<td>2,793,701</td>
</tr>
<tr>
<td>Washington</td>
<td>3,559,604</td>
</tr>
<tr>
<td>Chicago</td>
<td>7,261,166</td>
</tr>
<tr>
<td>New York</td>
<td>18,409,019</td>
</tr>
<tr>
<td><strong>Australian Cities</strong></td>
<td></td>
</tr>
<tr>
<td>Perth</td>
<td>1,142,646</td>
</tr>
<tr>
<td>Brisbane</td>
<td>1,333,773</td>
</tr>
<tr>
<td>Melbourne</td>
<td>3,022,910</td>
</tr>
<tr>
<td>Adelaide</td>
<td>1,023,278</td>
</tr>
<tr>
<td>Sydney</td>
<td>3,539,035</td>
</tr>
<tr>
<td><strong>European Cities</strong></td>
<td></td>
</tr>
<tr>
<td>Hamburg</td>
<td>1,652,363*</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>634,357*</td>
</tr>
<tr>
<td>Zürich</td>
<td>788,740*</td>
</tr>
<tr>
<td>Stockholm</td>
<td>674,452*</td>
</tr>
<tr>
<td>Brussels</td>
<td>964,385</td>
</tr>
<tr>
<td>Paris</td>
<td>10,661,937</td>
</tr>
<tr>
<td>London</td>
<td>6,679,699</td>
</tr>
<tr>
<td>Munich</td>
<td>1,277,576*</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>1,711,254</td>
</tr>
<tr>
<td>Vienna</td>
<td>1,539,948</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>702,731*</td>
</tr>
<tr>
<td><strong>Richer Asian Cities</strong></td>
<td></td>
</tr>
<tr>
<td>Tokyo</td>
<td>11,618,287*</td>
</tr>
<tr>
<td>Singapore</td>
<td>2,705,115</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>5,522,281</td>
</tr>
<tr>
<td><strong>Southeast Asian Cities</strong></td>
<td></td>
</tr>
<tr>
<td>Bangkok</td>
<td>6,556,685</td>
</tr>
<tr>
<td>Jakarta</td>
<td>8,222,515</td>
</tr>
<tr>
<td>Kuala Lumpur</td>
<td>3,024,750</td>
</tr>
<tr>
<td>Manila</td>
<td>7,948,392</td>
</tr>
<tr>
<td>Surabaya</td>
<td>2,473,272</td>
</tr>
</tbody>
</table>

Sources: 1. Bangkok’s population data from JICA, 1990

Note: The cities marked with an asterisk have larger functional urban regions which were considered for some key transport data. The 1990 populations of these larger regions were:

- Hamburg: 2,470,000
- Stockholm: 1,641,669
- Amsterdam: 804,711
- Frankfurt: 2,502,816
- Munich: 2,296,870
- Tokyo: 31,796,702
- Zurich: 1,211,339
- Boston: 4,056,907
• Transit fare per passenger kilometres
• Transit operating revenues and operating costs
• Travel time cost per hour
• Capital cost of a bicycle
• Per capita gross regional product (GRP)
• Number of working days per year
• Transport deaths
• Total deaths
• Emissions of CO₂, NOₓ, SO₂, CO, VHC, SPM from private and public transport

The parameters for the comparative study are classified into five main groups: urban form and land-use, transport infrastructure, transport patterns and energy use, transport economics and transport externalities (Table 3.3).

3.5.1 Urban Form and Land-Use

These parameters comprise data on population density and employment density in different parts of each city (CBD, inner area, outer area and the whole city), as well as the proportions of population and jobs found in different parts of each city. These parameters provide measures of how dispersed or centralised cities are, a very important factor in determining transport patterns such as trip length and modal split. In addition, the densities of population, jobs, and total activities in the inner area are used as some indication (though far from perfect) of the extent of mixed land-use in inner areas. This is significant, as many studies have shown that mixed land-uses have a substantial influence on modal split and trip length, enabling more walking and cycling, as well as shorter trip lengths (see for example Cervero, 1986: 392; Cervero and Radisch, 1995: 26; Owens and Rickaby, 1992: 249; Newman and Kenworthy, 1989: 13-14).

3.5.2 Transport Infrastructure

Provision of transport infrastructure is believed to have a significant relationship with transport patterns (Newman and Kenworthy, 1988b, 1989; Shoup and Willson, 1991; Topp, 1995). For example, cities with high provision of roads and parking tend to rely more on private vehicle use. On
Table 3.3 Parameters employed for the international comparison

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>URBAN FORM AND LAND-USE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Population density</td>
<td>Number of people per ha of urbanised area</td>
</tr>
<tr>
<td>1.1 Whole city density</td>
<td>Number of people per ha for the whole city</td>
</tr>
<tr>
<td>1.2 Central city density</td>
<td>Number of people per ha for the central city</td>
</tr>
<tr>
<td>1.3 Inner area density</td>
<td>Number of people per ha for the inner area</td>
</tr>
<tr>
<td>1.4 Outer area density</td>
<td>Number of people per ha for the outer area</td>
</tr>
<tr>
<td>2. Employment density</td>
<td>Number of jobs per ha of urbanised area</td>
</tr>
<tr>
<td>2.1 Whole city density</td>
<td>Number of jobs per ha for the whole city</td>
</tr>
<tr>
<td>2.2 Central city density</td>
<td>Number of jobs per ha for the central city</td>
</tr>
<tr>
<td>2.3 Inner area density</td>
<td>Number of jobs per ha for the inner area</td>
</tr>
<tr>
<td>2.4 Outer area density</td>
<td>Number of jobs per ha for the outer area</td>
</tr>
<tr>
<td>3. Degree of centralisation</td>
<td>Proportion of people and jobs in the CBD and inner area</td>
</tr>
<tr>
<td>3.1 Proportion of population in CBD</td>
<td>% of city's population living in CBD</td>
</tr>
<tr>
<td>3.2 Proportion of jobs in CBD</td>
<td>% of jobs located in CBD</td>
</tr>
<tr>
<td>3.3 Proportion of population in inner area</td>
<td>% of city's population living in inner area</td>
</tr>
<tr>
<td>3.4 Proportion of jobs in inner area</td>
<td>% of jobs located in inner area</td>
</tr>
<tr>
<td><strong>TRANSPORT INFRASTRUCTURE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Road supply</td>
<td>Road length (metres) per capita</td>
</tr>
<tr>
<td>2. Road density</td>
<td>Road length (metres) per 1000 ha of urbanised area</td>
</tr>
<tr>
<td>3. Rail route supply</td>
<td>Rail route length (metres) per 1,000 inhabitants</td>
</tr>
<tr>
<td>4. Rail route density</td>
<td>Rail route length (metres) per 1,000 ha of urbanised area</td>
</tr>
<tr>
<td>5. Parking spaces</td>
<td>Number of parking spaces in CBD per 1,000 CBD workers</td>
</tr>
<tr>
<td>6. On-street parking</td>
<td>% of on-street parking spaces in CBD</td>
</tr>
<tr>
<td><strong>TRANSPORT PATTERNS AND ENERGY USE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Energy use in private passenger transport</td>
<td>Petrol, diesel and LPG use in private passenger vehicles (MJ per capita)</td>
</tr>
<tr>
<td>2. Total vehicles on register</td>
<td>Number of all types of motor vehicles per 1,000 inhabitants</td>
</tr>
<tr>
<td>3. Car ownership</td>
<td>Number of private cars per 1,000 inhabitants</td>
</tr>
<tr>
<td>4. Average speed of traffic</td>
<td>Overall 24 hour/7 day per week average speed of all types of road-based motor vehicles for the whole city</td>
</tr>
<tr>
<td>5. Average speed of public transport</td>
<td>Weighted average speed of different types of public transport for the whole city (weighted by relative usage of each mode)</td>
</tr>
<tr>
<td>Parameters</td>
<td>Definitions</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>6. Private vehicle kilometres per capita</td>
<td>Annual kilometres of travel by private passenger vehicles per capita</td>
</tr>
<tr>
<td>7. Private vehicle passenger kilometres per capita</td>
<td>Annual kilometres of travel by car passengers per capita (VKT by vehicle occupancy)</td>
</tr>
<tr>
<td>8. Public transport passenger kilometres per capita</td>
<td>Annual kilometres of travel by public transport passengers per capita (passenger trips by average trip length)</td>
</tr>
<tr>
<td>9. Private transport/public transport balance</td>
<td>% of total motorised passenger kilometres in public transport</td>
</tr>
<tr>
<td>10. Proportion of public transport passenger kilometres on rail</td>
<td>% of public transport passenger kilometres on trains and trains</td>
</tr>
<tr>
<td>11. Rail service kilometres per hectare</td>
<td>Annual car (wagon) kilometres of rail per hectare</td>
</tr>
<tr>
<td>12. Proportion of workers using public transport</td>
<td>% of workers using public transport to work</td>
</tr>
<tr>
<td>13. Proportion of workers using private transport</td>
<td>% of workers using private transport to work</td>
</tr>
<tr>
<td>14. Proportion of workers using foot or bicycle</td>
<td>% of workers walking or cycling to work</td>
</tr>
</tbody>
</table>

**TRANSPORT ECONOMIC FACTORS**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Expenditure on roads</td>
<td>Three year average expenditure for construction and maintenance of all roads by all tiers of government per capita and per US$1,000 GRP</td>
</tr>
<tr>
<td>2. Cost of private transport use</td>
<td>Per kilometre cost of private transport use comprising capital cost, variable cost and total cost</td>
</tr>
<tr>
<td>3. Cost recovery by public transport</td>
<td>Operating revenues divided by operating costs of all public transport operators (capital expenses excluded)</td>
</tr>
<tr>
<td>4. Transit fare</td>
<td>Transit fare per passenger kilometre</td>
</tr>
</tbody>
</table>

**TRANSPORT EXTERNALITIES**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transport related deaths as a proportion of number of residents</td>
<td>Number of transport related deaths per 100,000 people</td>
</tr>
<tr>
<td>2. Transport related deaths as a proportion of passenger kilometres</td>
<td>Number of transport related deaths per million passenger kilometres (public and private)</td>
</tr>
<tr>
<td>3. Transport related deaths as a proportion of total deaths</td>
<td>% of transport related deaths for total deaths in city</td>
</tr>
<tr>
<td>4. Transport emissions of CO</td>
<td>Per capita transport emissions of carbon monoxide (kg)</td>
</tr>
<tr>
<td>5. Transport emissions of HC (VOC)</td>
<td>Per capita transport emissions of volatile hydrocarbons (kg)</td>
</tr>
<tr>
<td>6. Transport emissions of NOX</td>
<td>Per capita transport emissions of nitrogen oxides (kg)</td>
</tr>
<tr>
<td>7. Transport emissions of SOX</td>
<td>Per capita transport emissions of sulphur oxides (kg)</td>
</tr>
<tr>
<td>8. Transport emissions of SPM</td>
<td>Per capita transport emissions of suspended particulate matter (kg)</td>
</tr>
<tr>
<td>9. Transport emissions of CO2</td>
<td>Per capita transport emissions of carbon dioxide (kg)</td>
</tr>
</tbody>
</table>

---

**All financial data are expressed in 1990 US dollars.**
the other hand, cities with high provision of public transport infrastructure, particularly rail systems, are likely to rely more on public transport use.

Therefore, it is necessary to collect data at least on three main parameters: road provision in terms of road length per capita and per ha; number of route lengths of rail services per 1,000 inhabitants and per 1,000 ha; and parking spaces in the CBD. These data can then be compared to provide some insight into the extent to which Bangkok's infrastructure encourages private or public transport use.

3.5.3 Transport Patterns and Energy Use

Transport patterns are the main parameters indicating whether cities depend on private or public transport. Thus it is necessary to study such factors as the amount of energy used in private passenger transport which tends to be an overall barometer of automobile dependence, total vehicle ownership, car ownership, average speed of traffic and public transport, private vehicle kilometres and passenger kilometres per capita, public transport passenger kilometres per capita, the percentage of total passenger kilometres carried on public transport, the percentage of public transport passenger kilometres on rail, rail service kilometres per capita, and the modal split of travel to work. Though not exhaustive, these parameters when taken together, provide a substantial insight into the overall characteristics of transport in any city.

3.5.4 Transport Economics

Transport is a significant part of the economic system. Thus, it is useful to examine the degree to which governments at all levels and relevant agencies invest in providing and maintaining transport infrastructure, particularly roads, which can give some idea of the relative focus of government transport policy in different cities. This parameter is standardised by population and gross regional product (GRP). Another potentially useful parameter is the cost of private transport use which provides some idea of the economic dimension underlying Bangkok's transport patterns in comparative terms (i.e. the capital cost, variable cost and total cost of driving per kilometre in different cities). The third parameter is the operating cost recovery of public transport. This parameter enables some understanding of the financial situation of public transport in each city, and a comparative
insight into what is often a very vexed transport policy issue (i.e. the societal "subsidy" of transit operations). In addition, the transit fare per passenger kilometre in each city is compared, as it is one of the key factors affecting the financial situation of public transport.

3.5.5 Transport Externalities

To see clearly how severe the adverse effects of transport in Bangkok are, it is productive to examine some international comparisons of certain key externalities. Two parameters, which are considered to be major transport externalities (see for example Barde and Button, 1990; Quinnet, 1990), are employed: (1) transport related deaths and (2) transport emissions. For comparative purposes, transport related deaths were standardised by population, passenger kilometres, and as a percentage of total deaths. Transport emissions encompass six major air pollutants: carbon monoxide (CO), hydrocarbons (HC) or volatile organic compounds (VOC), nitrogen oxides (NOx), sulphur oxides (SOx), suspended particulate matter (SPM), and carbon dioxide (CO2). All of these emissions parameters were standardised by population.

3.6 DATA SOURCES

The comparative study has two main sources of data: world cities data sources and Bangkok data sources.

3.6.1 World Cities Data Sources

Without data and analysis undertaken by other researchers, the international comparisons in this thesis would be impossible, due to the difficulties and time involved in obtaining extensive comparable data from global cities. Fortunately, data for other global cities used in the present study have been being collected and analysed during the period of this research by four researchers at the Institute for Science and Technology Policy (ISTP), Murdoch University, Western Australia. Data collection and analysis by Dr. Jeff Kenworthy and Felix Laube focuses on cities originally included in Cities and Automobile Dependence: An International Sourcebook. They also include some additional cities (e.g. in Canada) in their forthcoming book, Cities and Automobile Dependence II: An International Databook which are not included in
the present study due to lack of final data. Paul Barter has been collecting and analysing data on Asian cities, mainly in Southeast Asia, for his PhD thesis, and Benedicto Jun Guia, another PhD student, has collected and analysed data on Manila for his PhD thesis.

3.6.2 Bangkok Data Sources

Many agencies (mostly governmental offices) hold data on Bangkok’s transport, land-use, energy consumption, transport economic factors and transport externalities. All had to be visited and contacted for data for this comparative study. These are listed in Table 3.4.

In addition to the data compiled and held by the above agencies, data for Bangkok are derived from the following key studies:

(1) The 1990 Study on Medium to Long-Term Improvement/Management Plan of Road and Road Transport in Bangkok conducted by the Japan International Cooperation Agency (JICA).
(2) The 1991 Seventh Plan Urban and Regional Transport -SPURT by the Office of the National Economic and Social Development Board.
(4) The 1994 Revision of the Traffic and Transport Master Plan by Faculty of Engineering, Kasetsart University and Sindhu Pike Bodell.
(5) The 1995 Mass Rapid Transit Master Plan by Faculty of Engineering, Kasetsart University and Sindhu Pike Bodell.
(6) The 1993 State Railway of Thailand’s Master Plan by the Thailand Development Research Institute (TDRI).
(8) The 1990 Survey of Urban Transport Costs and Fares in the SEATAC Region by Padeco co., Ltd.

Many personal contacts have also yielded useful data. For example, academics in Chulalongkorn University, the Asian Institute of Technology, Mahidol University and those who work for non-government organisations
Table 3.4 Agencies holding data on Bangkok's transport, land-use and energy consumption, transport economic factors and transport externalities

<table>
<thead>
<tr>
<th>Agencies</th>
<th>Relevant data held</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bangkok Metropolitan Administration (BMA)</strong></td>
<td></td>
</tr>
<tr>
<td>1. Department of Policy and Planning</td>
<td>General statistics on Bangkok's population and transport, budget for road constructions, traffic accidents, traffic deaths, total deaths</td>
</tr>
<tr>
<td>2. Department of Public Works</td>
<td>Transport infrastructure construction plans, road expenditures</td>
</tr>
<tr>
<td>3. Department of Permanent Secretary</td>
<td>Maps, land-use data</td>
</tr>
<tr>
<td>3.1 City Planning Division</td>
<td>Traffic statistics</td>
</tr>
<tr>
<td>3.2 Traffic Engineering Division</td>
<td></td>
</tr>
<tr>
<td>4. Department of Drainage and Sewage</td>
<td>Canal network in Bangkok</td>
</tr>
<tr>
<td><strong>Ministry of Transport and Communication</strong></td>
<td></td>
</tr>
<tr>
<td>1. Department of Highways</td>
<td>Highways in Bangkok, road expenditures</td>
</tr>
<tr>
<td>2. Harbour Department</td>
<td>Waterways traffic statistics, number of boats</td>
</tr>
<tr>
<td>3. Department of Land Transport</td>
<td>Number of vehicles registered</td>
</tr>
<tr>
<td>4. State Railway of Thailand</td>
<td>Railway routes, railway service statistics, plans</td>
</tr>
<tr>
<td>5. Bangkok Mass Transit Authority</td>
<td>Bus services statistics, number of buses, plans, revenue and expenditures on bus operation</td>
</tr>
<tr>
<td><strong>Ministry of Interior</strong></td>
<td></td>
</tr>
<tr>
<td>1. Expressway and Rapid Transit Authority of Thailand</td>
<td>Expressway infrastructure, user characteristics, plans, revenues and expenditures</td>
</tr>
<tr>
<td>2. Department of Town and Country Planning</td>
<td>Bangkok's land-use, physical plans, maps</td>
</tr>
<tr>
<td>3. Police Department</td>
<td>Accident statistics</td>
</tr>
<tr>
<td>4. Department of Labour</td>
<td>Number of jobs</td>
</tr>
<tr>
<td><strong>Office of the Prime Minister</strong></td>
<td></td>
</tr>
<tr>
<td>1. Office of the National Economic and Social Development Board (NESDB)</td>
<td>National plans and Bangkok's plans and statistics on transport, GDP data</td>
</tr>
<tr>
<td>2. Office of the Commission for the Management of Road Transport (OCMRT)</td>
<td>Plans and statistics for Bangkok's transport, mass rapid transit plans</td>
</tr>
<tr>
<td>5. Petroleum Authority of Thailand</td>
<td>Energy use in transport</td>
</tr>
<tr>
<td>6. National Safety Council</td>
<td>Traffic accidents, traffic deaths</td>
</tr>
<tr>
<td><strong>Ministry of Science, Technology and Environment</strong></td>
<td></td>
</tr>
<tr>
<td>1. Department of Energy Development and Promotion</td>
<td>Energy use in Thailand and Bangkok, energy use in land transport and waterways transport</td>
</tr>
<tr>
<td>2. Department of Pollution Control</td>
<td>Air pollution data, air quality and noise standards</td>
</tr>
<tr>
<td>3. Office of Environmental Policy and Planning</td>
<td>National Environment Plan</td>
</tr>
<tr>
<td><strong>Non-government organisations</strong></td>
<td></td>
</tr>
<tr>
<td>1. Thailand Development Research Institute (TDRi)</td>
<td>BMA development plans, railway master plan, energy use in transport, emissions data</td>
</tr>
<tr>
<td>2. Thailand Environment Institute (TEI)</td>
<td>VKT data for road transport, emissions data</td>
</tr>
<tr>
<td><strong>International organisations</strong></td>
<td></td>
</tr>
<tr>
<td>1. Japan International Cooperation Agency (JICA)</td>
<td>Bangkok traffic data from various JICA studies</td>
</tr>
<tr>
<td>2. United Nations Development Program (UNDP)</td>
<td>General data on transport in Bangkok, Thailand and Asia Pacific countries</td>
</tr>
</tbody>
</table>

**Note:** Some data items are mentioned as being sourced from more than one authority. In this study, conflicting data on similar items abounds, and part of the original contribution of this work is to sift through these data and determine which is the most accurate and which conforms to the comparative requirements of the approach. This is a time consuming and difficult task.
have provided data and assistance. Their names are provided in the Acknowledgements.

3.7 DATA COLLECTION ON BANGKOK

As many agencies are involved in Bangkok's land-use, transport and energy policy, planning and implementation, the work involved in contacting, visiting and gathering data from these agencies was extremely time-consuming, requiring a great deal of personal contact to secure data. To obtain reliable and sufficient data, two periods of data collection were undertaken in Bangkok. The first was from December 1992 to February 1993, and the second was from October 1994 to March 1995. Figure 3.2 below shows the stages in the data collection process from designing the parameters, to remote contacts for missing or incomplete data after analysis of data derived from the second data collection visit.

3.8 DATA ASSEMBLY AND ANALYSIS

Data for Bangkok were standardised for comparison with data for other cities (see Appendix A). For example, data on population and the extent of urbanised areas were employed for calculation of population density; numbers of jobs and urbanised area data were used for calculation of employment density; road length and population were used for getting road length per capita; and vehicle kilometres of travel and average occupancy rate were used for calculation of occupant or passenger kilometres.

The data analysis process involved two key stages, as will be seen in Chapter 4. First, standardised data on key indicators for Bangkok and the other cities were employed for correlation analysis, to examine basic relationships among land-use, transport infrastructure and transport patterns. Second, all standardised data were used for comparison between Bangkok and other cities (these are presented mainly by means of column graphs). Standardised data from the Western cities were averaged to form a representative picture for each group of cities from a particular region, i.e. American cities, Australian cities and European cities. This approach of using representative statistics for different groupings of cities was designed to simplify interpretation of comparative data.
<table>
<thead>
<tr>
<th>Time</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 1992</td>
<td>Designed parameters and identified data to be collected</td>
</tr>
<tr>
<td>October 1992</td>
<td>Examined agencies and individuals holding relevant data</td>
</tr>
<tr>
<td>November 1992</td>
<td>Contacted agencies and individuals by letters and faxes</td>
</tr>
<tr>
<td>December 1992 to February 1993</td>
<td>First data collection in Bangkok Visits to agencies and individuals</td>
</tr>
<tr>
<td>March 1993</td>
<td>Analysed the data derived from the first trip</td>
</tr>
<tr>
<td></td>
<td>Identified further data required and problems with data</td>
</tr>
<tr>
<td>July 1994</td>
<td>Contacted agencies and individuals</td>
</tr>
<tr>
<td>October 1994 to March 1995</td>
<td>Second data collection in Bangkok</td>
</tr>
<tr>
<td>April 1995</td>
<td>Analysed data derived from the second trip</td>
</tr>
<tr>
<td>June 1995</td>
<td>Remote contact for missing, incomplete data or problematic data</td>
</tr>
</tbody>
</table>

Figure 3.2 Bangkok data collection process
Because of the significant problems and variability encountered in collecting and assembling reliable and comparable data for Bangkok, this issue requires some explanation. Thus, the next section describes these problems and the methodologies employed, beginning with an explanation of definition of the Bangkok area, a key factor in both data collection and for the comparative study as a whole.

3.9 DEFINITIONS OF BANGKOK

Three main terms are generally used to define or delineate Bangkok in most urban and transport studies: the Bangkok Metropolitan Area (BMA), the Greater Bangkok Area (GBA) and the Bangkok Metropolitan Region (BMR). These three "Bangkoks" differ both in area and in population. To avoid confusion, therefore, each must be clearly explained.

- The Bangkok Metropolitan Area (BMA)

The Bangkok Metropolitan Area is the area under the administration of the Bangkok Metropolitan Administration. It is the capital of Thailand and commonly known among Thai people as "the real Bangkok". Its boundary covers both sides of the Chao Phraya River. The total area is 1,565 km²; the total population in 1990 from the national census was 5.882 million (JICA, 1990; NSO, 1990a).

- The Greater Bangkok Area (GBA)

The Greater Bangkok Area consists of the Bangkok Metropolitan Area (BMA) and the surrounding three provinces: Nonthaburi, Pathum Thani and Samut Prakan. This area covers all of the built-up area which has continuously extended beyond the boundary of the BMA, particularly to Nonthaburi and Pathum Thani in the north and to Samut Prakan in the south. The total area covered is 4,717 km²; the total population in 1990 was 7.639 million (JICA, 1990; NSO, 1990a).

- The Bangkok Metropolitan Region (BMR)

This is the largest area of the three. In recent time, as urbanisation of the provinces around the BMA has rapidly extended with close links to the
BMA land-use and transport patterns, the term "Bangkok Metropolitan Region (BMR)" has been adopted to cover the whole urban area. The BMR consists of the BMA and the five adjacent provinces: Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon and Nakhon Pathom. The total area of the BMR is 7,758 km²; the total population in 1990 was approximately 8.654 million (JICA, 1990; NSO, 1990a; BMA, 1992a).

The three Bangkok areas are illustrated in Figure 3.3 and the details on land-use and population are shown in Table 3.5.

Table 3.5 Area and population of the Bangkok Metropolitan Area (BMA), the Greater Bangkok Area (GBA) and the Bangkok Metropolitan Region (BMR), 1990

<table>
<thead>
<tr>
<th>Province</th>
<th>Area (km²)</th>
<th>Population 1990 (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMA</td>
<td>1,556.22</td>
<td>5.882</td>
</tr>
<tr>
<td>Nonthaburi</td>
<td>622.30</td>
<td>0.575</td>
</tr>
<tr>
<td>Samut Prakan</td>
<td>1,004.09</td>
<td>0.770</td>
</tr>
<tr>
<td>Pathum Thani</td>
<td>1,525.86</td>
<td>0.412</td>
</tr>
<tr>
<td>GBA</td>
<td>4,217.37</td>
<td>7.633</td>
</tr>
<tr>
<td>Samut Sakhon</td>
<td>872.35</td>
<td>0.358</td>
</tr>
<tr>
<td>Nakhon Pathom</td>
<td>2,168.33</td>
<td>0.657</td>
</tr>
<tr>
<td>BMR</td>
<td>7,758.15</td>
<td>8.654</td>
</tr>
</tbody>
</table>

Sources: 1. Areas from JICA, 1990
          2. Population for BMA, Nonthaburi, Samut Prakan and Pathum Thani from the 1990 national census
Figure 3.3 Map of the Bangkok Metropolitan Area (BMA), the Greater Bangkok Area (GBA) and the Bangkok Metropolitan Region (BMR)
3.10 THE STUDY AREA

The comparative study between Bangkok and the other cities requires the definition of a relevant and comparable metropolitan area, fundamental to the collection of raw and standardised data on transport and land-use.\(^\text{20}\) As Newman and Kenworthy (1989) observed:

*The most appropriate and meaningful way of defining a metropolitan area is to take what may be termed the full functional urban region. This is usually a large, fairly contiguous built up area which may transcend any number of political of administrative boundaries such as those of Cities and States, but which functionally acts as a single, unified region.*

(p. 17)

For Bangkok, the built-up area has extended beyond the boundary of the Bangkok Metropolitan Area (BMA) to neighbouring provinces, as discussed in Chapter 2. This urbanised area functions mostly as a unified urban region from the perspective of transport. Thus, it is necessary to encompass the whole built-up area as representative of Bangkok for the international study. In addition, some key raw data on transport patterns used in the comparative study are obtained from the 1990 Study on Medium to Long-Term Improvement/Management Plan of Road and Road Transport in Bangkok, conducted by JICA. The JICA study area is bounded by the Outer Ring Road; the main part is the built-up area of Bangkok. Thus, the area bounded by the Outer Ring Road is adopted as the Bangkok study area for the comparative study. This area covers 1,640 km\(^2\). It is the centre of the Bangkok Metropolitan Region and comprises the main built-up areas of the Bangkok Metropolitan Area (BMA), Nonthaburi, Pathum Thani and Samut Prakan. For the purposes of the transport study, this area is divided into 19 zones (Figure 3.4). There were approximately 1.7 million households and about 6.357 million people in this area in 1989.

The population of this study area is employed mainly to permit calculations of standardised land-use and transport data. However, for the energy use data, it was necessary to select a different area since most energy use data were obtained from studies on energy consumption by the Petroleum Authority of Thailand, the Office of the National Energy Policy and the

\(^{20}\text{Metropolitan area definitions for other cities contained in the international comparison are presented in Appendix D.}\)
Figure 3.4 The Bangkok study area

Source: Reproduced from JICA, 1990: Figure 1.2.1 and 1.2.2
Department of Energy Development and Promotion, all of which used the Greater Bangkok Area (GBA) as their study area. The population of the GBA, which is larger than the population of the JICA study area, was thus used for calculation of per capita figures on energy use to ensure comparability with relevant previous research.

3.11 BANGKOK'S ZONES

Obtaining comparable figures on the three major zones of Bangkok (the central business district (CBD), the inner area, and the outer area) was a significant data-collection challenge. Many different definitions of Bangkok's zones are used by different authorities and in various Bangkok studies (Figure 3.5). For example, the Bangkok Metropolitan Administration (Department of Policy and Planning, 1987) divided the BMA into three zones - inner, middle and outer - for the purpose of administration, based on land-use by districts. Pongsosomlee and Ross (1992) also applied this definition for their study: *Impacts of Modernisation and Urbanisation in Bangkok: An Integrative Ecological and Biosocial Study*. Halcrow Fox and Associates et al. (1991) in the *Seventh Plan Urban and Regional Transport (SPURT)* used the Greater Bangkok (GBA) as the study area, and divided it into four zones, (using transport routes as the boundaries - central, inner, area inside the Outer Ring Road and the area outside the Outer Ring Road). The Office of National Economic and Social Development Board (1987), in the *Sixth National Economic and Social Development Plan (1987-1991)*, classified the Bangkok Metropolitan Region into four zones on the basis of land-use (the Central Business Area, Rapidly Growing Suburban Area, Industrial Area and the Outer BMR Area). JICA (1990) considered that, in terms of traffic speed, the area within the Middle Ring Road is "Inner Bangkok".

For the purpose of the international comparison, Bangkok is divided into three zones - the central business district (CBD), the inner area and the outer area, based on the land-use characteristics and the district boundaries (Figure 3.6). This selection also partly reflects availability of data on population, employment and land-use and is in keeping with the methodology adopted by Newman and Kenworthy (1989) in their comparative urban research.

After Halcrow Fox and Associates et al., 1991: The Seventh Plan Urban and Regional Transport (SPURT)

Figure 3.5 Different definitions of Bangkok's zones
After the National Economic and Social Development Board (NESDB): The Sixth National Economic and Social Development Plan (1987-1991)

Figure 3.5 (cont.)

After JICA, 1990: Study on Medium to Long-Term Improvement/Management Plan of Road and Road Transport in Bangkok
Figure 3.6 Bangkok’s three zones, as adopted in this study
3.11.1 Definition of the Central City or Central Business District (CBD)

Traditionally, the CBD is defined as the largest single concentration of employment, as it is the hub of commercial and business activities in cities (Short, 1991: 108). However, Newman and Kenworthy (1989: 21) defined the CBD for their comparative study according to the consensus view of government authorities in each city, largely on the basis of one or more small administrative or traffic planning zones for which comparable data were available. In practice, this mostly corresponded to "the largest single concentration of employment".

For Bangkok, the centre of business activities is not as clearly defined as it is in most Western cities. Rather, Bangkok seems to have an extended business centre. This is also seen in other developing Southeast Asian cities which have developed rapidly from the walking city through motorisation, mainly based upon bus transport (Barter and Kenworthy, 1995: 5). A key reason for this pattern is the problem of accessibility. Without a high capacity system it is difficult to concentrate a CBD at very high densities. Nevertheless, the tendency towards centralisation in rapidly developing cities still exists, so the response is to spread the central area over a wider area to maintain access by lower capacity buses as well as non-motorised modes. This is reflected, as will be seen in Chapter 4, in generally low job densities in the CBD, but high proportions of total metropolitan jobs contained in the centre.

Several definitions of "central" are used by different authorities, as mentioned earlier. However, based on the three reasons: historical development, level of concentration of activities, and the availability of comparable data, the central area of Bangkok adopted for the comparative study can be delineated as shown in Figure 3.6.

This area covers the old city centre, which is bounded by the river and Klong Phadung Krung Kasem, and the new central business district containing a number of commercial offices and shopping centres. Five districts are within this CBD: Phra Nakhon, Pom Prap Sattru Phai, Samphanthawong, Pathum Wan and Bang Rak. In terms of concentration of business activities, this area also has a high share of floor area permitted for office and commercial-type
development, as well as a number of head offices of private companies and shopping centres (Kidokoro and Hanh, 1993: 9).

For the purpose of the comparative study, parking supply data obtained relate only to the old city centre area. Therefore, the old city centre (comprised of three districts: Phra Nakhon, Pom Prap Sattru Phai and Samphanthawong), is used as the CBD for the analysis of parking provision. Data on parking for the wider CBD area are not available.

3.11.2 Definition of the Inner Area

The inner area in cities is often defined as that part of the urban region that was developed prior to the Second World War and which generally has higher density, mixed land-uses and was developed around public transport, i.e. the pre-automobile part of the city (Newman and Kenworthy, 1989: 20). In the case of Bangkok, although there are several definitions of the inner area from different authorities and studies, as mentioned earlier, these definitions reveal only slight differences. Thus, to define Bangkok's Inner Area is not as difficult as it is to define the CBD. Based on these existing definitions, as well as population density, location, and the availability of comparable data, Bangkok's inner area is defined as the groups of districts located within or served by the Middle Ring Road, including the CBD, as shown in Figure 3.6. The inner area consists of five districts of the CBD and the surrounding fifteen districts.21 This definition is consistent with the definitions from the following sources: (1) the Department of Policy and Planning, BMA (1987) (based on administrative purposes); (2) the Impacts of Modernisation and Urbanisation in Bangkok: An Integrative Ecological and Biosocial Study (Poungsomlee and Ross, 1992), based on an integrative environmental study; and (3) the Revision of the Traffic and Transport Master Plan (Bangkok Master Plan), prepared by the Faculty of Engineering, Kasetsart University and Sindhu Pike Bodell (1994b), and based on transport planning considerations.

3.12 Defining Urban Land and Land-Use data

Comparing Bangkok to other cities necessitates consistent and comparable data on the urbanised area as the basis for calculating the major land-use parameters such as population density and employment density. For this study, the urbanised area was defined as "all land presently developed for residential, commercial, industrial and special urban purposes (schools etc), including all streets and roads" (Newman and Kenworthy, 1989: 28). Obtaining reliable data on Bangkok's urbanised area was predicted to be easy before the start of data collection. In fact, it was one of the most difficult data collection tasks of this research enterprise. This was because Bangkok's area and density statistics collected by all relevant agencies and urban and transport studies on Bangkok refer only to the whole land area of the Bangkok Metropolitan Area, the Greater Bangkok Area or the Bangkok Metropolitan Region. None has adopted the definition of the "real" urbanised area. In addition, as the study area for this research embraces not only parts of BMA but also some parts of the other three neighbouring provinces, it is very difficult to obtain land-use data for the whole study area, particularly for these adjacent provinces.

For the part of the area covered by the BMA, the research was aided by a land-use map produced by the Department of City Planning, BMA in 1986. This represents the most current available BMA land-use data. This map provided good detail on all types of land-use by district, and was very useful for calculating urbanised areas by zone, particularly the CBD and the Inner Area, which are located within the BMA. Nevertheless, two major problems were encountered in acquiring urbanised area data for the BMA districts:

(1) The first problem resulted from a redefinition of BMA districts in 1990. In attempting to calculate the urbanised area of the inner area (whose boundary was delineated by the boundaries of the present districts), it was revealed that in 1990 the Bangkok Metropolitan Administration redivided the BMA into 36 districts from 24 districts. Some districts (included in the inner area by this study) were divided into two or three districts. Some of these newly divided districts were located in the inner area, while others are beyond its limits. As a result, to obtain urbanised area figures for these districts, it has been necessary to apply the previous proportion of urbanised area of the original district, as shown in Table 3.6.
Table 3.6 Urbanised areas of the BMA districts established in 1990

<table>
<thead>
<tr>
<th>Original districts</th>
<th>% urbanised area</th>
<th>New districts</th>
<th>Total area of new districts (ha)</th>
<th>Urbanised area of new districts (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phra Khanong</td>
<td>24.1</td>
<td>1. Khlong Toei</td>
<td>2,280</td>
<td>550</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Pravet and Phra Khanong</td>
<td>12,070</td>
<td>2,912</td>
</tr>
<tr>
<td>Bang Khen</td>
<td>30.9</td>
<td>1. Chatuchak</td>
<td>3,290</td>
<td>1,017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Don Muang and Bang Khen</td>
<td>13,640</td>
<td>4,215</td>
</tr>
</tbody>
</table>

Sources: 1. Per cent of urbanised area is calculated based on land-use data from BMA, 1986: *Bangkok Land Use Map by Districts*  
2. Total area of new districts data from the JICA, 1990: Table 1.2.1

Notes: 1. *Pravet* and *Phra Khanong* constitute Zone 13 in the 1990 JICA Study.  
2. *Don Muang* and *Bang Khen* constitute Zone 11 in the 1990 JICA Study.  
3. Urbanised area of new districts derived from applying the original per cent of urbanised area.

(2) The second problem occurred after determining the boundary of the study area. Parts of four of Bangkok's districts were excluded. This necessitated calculation of the urbanised area of the remaining part of such districts to be included in the figure for the Bangkok urbanised area. The process began with estimating parts of the districts to be excluded, and then calculating the urbanised area of the districts within the study area as shown in Table 3.7.

It was necessary to calculate figures for the urbanised land of the three neighbouring provinces (Samut Prakan, Nonthaburi and Pathum Thani) which fell within the study area, as no land-use data are available by districts for these provinces. Furthermore, only some parts of these provinces are included in the study area. In Zone 16, the whole area of *Phra Pradaeng district* and an estimated one quarter of *Muang Samut Prakan district* are included. In Zone 17 and Zone 18, *Muang Nonthaburi district*, *Pak Kret district*, and an estimated three-fifths of *Bang Kruai district* are included. In Zone 19, *Muang Pathum Thani district*, three quarters of *Sam Khok district*, half of *Klong Luang district*, one-third of *Than yaburi district* and one-third of *Lam Luk Ka district* are included. As there are no exact data available on the urbanised area of these districts which are within the study area, the average
percentages of urbanised area of each province were adopted for the calculation as shown in Table 3.8.

Table 3.7 The urbanised area of the four Bangkok's districts of which some parts are excluded from the study area

<table>
<thead>
<tr>
<th>Zone/district</th>
<th>Total urbanised area (ha)</th>
<th>Estimated urbanised area to be excluded</th>
<th>Urbanised area remaining within the study area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bang Khun Thian and Chom Thong</td>
<td>2,338</td>
<td>Three-fifths (1,403 ha)</td>
<td>935</td>
</tr>
<tr>
<td>Rat Burana</td>
<td>753</td>
<td>One-fifth (150 ha)</td>
<td>603</td>
</tr>
<tr>
<td>Zone 15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phasi Charoen</td>
<td>1,472</td>
<td>One-third (491 ha)</td>
<td>981</td>
</tr>
<tr>
<td>Taling Chan</td>
<td>1,262</td>
<td>One half (631 ha)</td>
<td>631</td>
</tr>
</tbody>
</table>

Source: Total urbanised areas of the districts are calculated based on land-use data from BMA, 1986: Bangkok Land Use Map by Districts.

Table 3.8 Urbanised areas of Samut Prakan, Nonthaburi and Pathum Thani falling within the study area

<table>
<thead>
<tr>
<th>Zone/provinces</th>
<th>Total area within the study area (ha)</th>
<th>% urbanised</th>
<th>Urbanised area within the study area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samut Prakan</td>
<td>12,120</td>
<td>22.4</td>
<td>2,715</td>
</tr>
<tr>
<td>Zone 17,18 Nonthaburi</td>
<td>20,430</td>
<td>24.1</td>
<td>4,923</td>
</tr>
<tr>
<td>Zone 19 Pathum Thani</td>
<td>50,520</td>
<td>16.9</td>
<td>8,537</td>
</tr>
<tr>
<td>Total</td>
<td>83,070</td>
<td>19.5</td>
<td>16,175</td>
</tr>
</tbody>
</table>

Sources: 1. Total area from JICA, 1990: Table 1.2.1
2. Percentages of urbanised area are calculated based on data from NESDB et al., 1991: Table 2-1.
3.13 DATA ON TRANSPORT PATTERNS

One of the major difficulties with collection of Bangkok data involves obtaining reliable and comparable transport data. While a number of agencies are involved with Bangkok's transport, no specific agency holds all or even a major part of the required data. Fortunately, several transport studies have been conducted recently. Nevertheless, not all of the data from these different sources are compatible. This necessitates comparison and double checking to select the best reliable data for the international comparative study. None of the required items are amenable to primary data collection by the author because of the scale and cost of the required collection exercises. Transport studies from which travel data are obtained are multi-million dollar exercises. Section 3.13.1 to 3.13.3 describe the data and the data-collection procedures employed in this study using the best available sources.

3.13.1 Passenger Kilometres

As passenger kilometre figures were not provided directly by relevant agencies and studies, the process of obtaining them requires some calculations. In the case of private transport modes, it is the total number of passenger or occupants (including driver) multiplied by the average trip length. The other method of obtaining passenger kilometres by private modes is to multiply the annual vehicle kilometres of travel (VKT) by a genuine average vehicle occupancy (24 hour, 7 days-per-week figure). This method is used in a majority of the other cities, but was not possible for Bangkok. In the case of public transport, the passenger kilometres are derived by multiplying the annual passengers carried by an average passenger trip length for each specific mode. Data needed for calculations of passenger kilometres for both public and private transport were available from the relevant transport studies.

3.13.1.1 Road-Based Transport Passenger Kilometres

Data on passenger kilometres for road-based transport were derived mainly from the JICA (1990) data. In this JICA study daily bus and taxi passenger kilometres were already provided, as a result of the transport model used. However, car and motorcycle passenger kilometres required calculation.
This required using numbers of person trips by cars and motorcycles per day and multiplying them by average trip lengths to obtain daily passenger kilometres for each mode. These daily passenger kilometres were then multiplied by 339 days to obtain annual figures. The factor of 339 days is derived from the assumption that, on average, one weekend (Saturday and Sunday) is equal to 1.5 weekdays, in terms of traffic volume (personal communication R. Lloyd, Main Road Department, Western Australia). This assumption is reasonable in Bangkok because two main types of trip - journey-to-work and journey-to-school - which account for about 30 per cent of total trips on weekdays, decrease substantially on weekends.

3.13.1.2 Train Passenger Kilometres

It was also necessary to calculate train passenger kilometres as no direct figures were available. Daily passenger kilometres were derived by multiplying the numbers of passengers per day by the average trip length, as provided in JICA (1990). The characteristics of person trip numbers by trains during weekdays and weekends are similar to those for road-based transport. Thus, the 339 days factor was then applied to obtain the annual figure. This assumption is supported by the fact that the distribution of trip purposes on train is not significantly different from that for the road-based transport (see TT Planning and Design Co. Ltd. and Transportation Research Unit, 1995: Table 4.4).

3.13.1.3 Boat Passenger Kilometres

Annual boat passenger kilometres were calculated by multiplying two factors: numbers of passengers per year and the average passenger trip length by boat. The two main sources of the raw data are: (1) numbers of passengers per year from the Department of Energy Development and Promotion (1993): Study on Energy Consumption in Water Transport; and (2) average boat trip length from JICA (1990).

3.13.2 Data on Vehicle Kilometres of Travel (VKT)

Figures for vehicle kilometres of travel (VKT) for both private and public transport in Bangkok are perhaps the most problematic data to acquire. First, there are very few studies providing these data mainly because of the
sophisticated, time-consuming and costly nature of processes required to obtain reliable VKT figures. For example, designing and running a transport model, which is one common process for acquiring VKT data, requires, in simple terms, comprehensive data on socio-economic factors, vehicle numbers, trip numbers and characteristics from known origins to known destinations, and traffic volumes across selected screen lines to check that the model is predicting traffic levels with a sufficient degree of accuracy. This process involves a large number of home interviews or personal travel diaries, and systematic road surveys. The second problem is that available studies often provide only the total VKT figure; data are often not desegregated by type of vehicle. The third problem is inconsistency among VKT figures from different studies. Finally, for Bangkok, though most studies have data on service levels provided by buses and other road-based public transport, no single study provides the vehicle or wagon kilometres of service for trains.

The following sections address in detail the specific problems with data collection and the methods used in this study to obtain VKT figures for each main mode of transport in Bangkok.

3.13.2.1 Road-Based Transport Vehicle Kilometres of Travel

Two main studies provide data on VKT for Bangkok's road-based transport: (1) the 1987 *Energy Use in Road Transport Study* conducted by Chulalongkorn University for the National Energy Administration (NEA); and (2) the 1990 *Study on Medium to Long-Term Improvement/ Management Plan of Road and Road Transport in Bangkok (SIMR)* by JICA. The former provides daily and annual VKT figures for all types of road-based vehicles for the GBA, while the latter provides total daily VKT figures, as well as bus and taxi VKT figures for the area bounded by the Outer Ring Road. In addition, another study addresses Bangkok's road-based transport VKT: the 1994 *Traffic Crisis and Air Pollution*, by the Thailand Environment Institute et al. (TEI). This study, however, did not define the study area and provided VKT figures only for some types of vehicles.

Although the 1990 JICA study did not provide VKT figures for all types of vehicles, it did provide information on numbers of trips, trip lengths and occupancy rates for each type of vehicle. These data can be effectively used
for estimating VKT. Thus, these data were employed to obtain the VKT for all types of vehicles in the area within the Outer Ring Road. The figures obtained were then compared to those from the two other studies to assess the most accurate figure for the international comparative study, as shown in Table 3.9. The process of checking involved calculation of daily VKT per vehicle and some logical judgements to determine the reliability and validity of the final data set.

After comparing and checking the reliability and consistency of the VKT data from these three sources, which vary considerably, as shown in Table 3.9, the following conclusions were arrived at:

- VKT data from the Thailand Environment Institute et al. (1994) are unlikely to be consistent or useable for five reasons. First, the 1994 study failed to provide sources and the methodology used to calculate VKT. Second, the study employed no definition of "Bangkok", triggering problems in standardising VKT data for comparative purposes (requiring a clearly defined population and geographical area). Third, VKT data from this study do not apply to all major transport modes and particularly exclude motorcycles. Fourth, definitions of some modes of transport are ambiguous. For example, the term "utility vehicle" was not clearly defined. Finally, this study gave such extraordinarily high VKT (about double that of the other two sources). Although several contacts were made, there was no clarification of what appears to be a clear problem in relation to the other two studies which give comparable and much lower VKT figures for Bangkok.

- VKT data from the National Energy Administration (1987a,b,c) appear on first sight to be consistent and reliable, as this study provided VKT detail for virtually all modes of transport, both on a daily and an annual basis. This study also provided evidence of a systematic methodology used to obtain VKT data. For example, a conventional sequential land-use/transport model comprised of four submodels was used: Trip Generation, Trip Distribution, Modal Split and Traffic Assignment. The process involved collection of both primary data such as home interviews, roadside interviews, traffic volume counts and secondary data such as socio-economic data and vehicle numbers. However, two inconsistencies were revealed
### Table 3.9 Bangkok's vehicle kilometres of travel, vehicle numbers and travel per vehicle from different sources

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual VKT (million km)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars</td>
<td>9,621.29</td>
<td>7,547.60</td>
<td>15,438.00</td>
</tr>
<tr>
<td>Taxis</td>
<td>3,321.52</td>
<td>1,404.60</td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td>3,991.17</td>
<td>4,523.10</td>
<td></td>
</tr>
<tr>
<td>Motor tricycles (tuk-tuks)</td>
<td>669.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small buses</td>
<td></td>
<td>395.20</td>
<td></td>
</tr>
<tr>
<td>Medium Buses</td>
<td>168.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Buses</td>
<td></td>
<td>2,692.60</td>
<td></td>
</tr>
<tr>
<td>Buses (Total)</td>
<td>687.15</td>
<td>4,649.40</td>
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</tr>
<tr>
<td>Light Trucks</td>
<td>1,603.61</td>
<td>3,749.00</td>
<td>3,749.00</td>
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<tr>
<td>Medium Trucks</td>
<td>1,603.64</td>
<td></td>
<td></td>
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<tr>
<td>Heavy Trucks</td>
<td>2,138.17</td>
<td>2,682.00</td>
<td>2,682.00</td>
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<tr>
<td>Trucks (Total)</td>
<td>3,360.38</td>
<td>3,090.80</td>
<td>6,431.00</td>
</tr>
<tr>
<td>Utility Vehicles</td>
<td></td>
<td></td>
<td>23,900.00</td>
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<tr>
<td>Others</td>
<td>36.45</td>
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<tr>
<td><strong>Total annual VKT</strong></td>
<td>21,018.00</td>
<td>21,885.20</td>
<td>45,769.00</td>
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<tr>
<td><strong>Daily VKT (million km)</strong></td>
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<tr>
<td>Cars</td>
<td>28.38</td>
<td>32.82</td>
<td>45.54</td>
</tr>
<tr>
<td>Taxis</td>
<td>9.80</td>
<td>6.62</td>
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<tr>
<td>Motorcycles</td>
<td>11.77</td>
<td>19.67</td>
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<tr>
<td>Motor tricycles (tuk-tuks)</td>
<td></td>
<td>2.91</td>
<td></td>
</tr>
<tr>
<td>Small buses</td>
<td></td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>Medium Buses</td>
<td></td>
<td>8.68</td>
<td></td>
</tr>
<tr>
<td>Large Buses</td>
<td></td>
<td>14.96</td>
<td></td>
</tr>
<tr>
<td>Buses (Total)</td>
<td>2.03</td>
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<tr>
<td>Light Trucks</td>
<td></td>
<td>5.80</td>
<td>11.06</td>
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<tr>
<td>Medium Trucks</td>
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<td>5.80</td>
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<td>Heavy Trucks</td>
<td></td>
<td>7.73</td>
<td>7.91</td>
</tr>
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<td>Trucks (Total)</td>
<td>9.91</td>
<td>19.33</td>
<td>18.97</td>
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<tr>
<td>Utility Vehicles</td>
<td></td>
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<td>70.50</td>
</tr>
<tr>
<td>Others</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total daily VKT</strong></td>
<td>62.00</td>
<td>107.19</td>
<td>135.01</td>
</tr>
<tr>
<td><strong>Number of Vehicles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars</td>
<td>972,100</td>
<td>708,532</td>
<td>940,195</td>
</tr>
<tr>
<td>Taxis</td>
<td>13,493</td>
<td>17,691</td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td>821,500</td>
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</tr>
<tr>
<td>Motor tricycles (tuk-tuks)</td>
<td>7,406</td>
<td>7,901</td>
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</tr>
<tr>
<td>Small buses</td>
<td></td>
<td>440</td>
<td></td>
</tr>
<tr>
<td>Medium Buses</td>
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<td>4,369</td>
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</tr>
<tr>
<td>Large Buses</td>
<td></td>
<td>31,597</td>
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<tr>
<td>Buses (Total)</td>
<td>8,182</td>
<td>36,406</td>
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</tr>
<tr>
<td>Light Trucks</td>
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<td>53,695</td>
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<tr>
<td>Medium Trucks</td>
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<td>53,699</td>
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</tr>
<tr>
<td>Heavy Trucks</td>
<td></td>
<td>71,598</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.9 (cont.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucks (Total)</td>
<td>61,561</td>
<td>178,995</td>
<td>88,654</td>
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<td>Utility Vehicles</td>
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<td>275,506</td>
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<td>Total</td>
<td>1,884,242</td>
<td>1,569,787</td>
<td>1,304,355</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Daily VKT per vehicle</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>29.20</td>
<td>46.32</td>
<td>47.71</td>
</tr>
<tr>
<td>Taxis</td>
<td>468.83</td>
<td>374.20</td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td>14.33</td>
<td>31.71</td>
<td></td>
</tr>
<tr>
<td>Motor tricycles (tuk-tuks)</td>
<td>368.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small buses (pick-ups)</td>
<td>5000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Buses (6 wheels)</td>
<td>1986.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Buses</td>
<td>473.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buses (Total)</td>
<td>247.74</td>
<td>709.77</td>
<td></td>
</tr>
<tr>
<td>Light Trucks (pick-ups)</td>
<td></td>
<td>108.01</td>
<td></td>
</tr>
<tr>
<td>Medium Trucks (6-wheels)</td>
<td></td>
<td>108.01</td>
<td></td>
</tr>
<tr>
<td>Heavy Trucks (10-wheels)</td>
<td></td>
<td>107.96</td>
<td></td>
</tr>
<tr>
<td>Trucks (Total)</td>
<td>161.03</td>
<td>107.99</td>
<td>213.98</td>
</tr>
<tr>
<td>Utility Vehicles</td>
<td></td>
<td></td>
<td>255.90</td>
</tr>
<tr>
<td>Total</td>
<td>32.91</td>
<td>68.28</td>
<td>103.51</td>
</tr>
</tbody>
</table>

Sources: 1. VKT sources:
1.1 JICA's daily VKT for buses from JICA, 1990: Table 10.4.1. VKT for taxis from JICA, 1990: Table 10.4.3. Daily VKT for cars and motorcycles are calculated based on number of trips, average trip lengths, average occupancy rate for each modes from JICA, 1990. Total daily VKT from JICA, 1989: Table 1.24. Daily VKT for trucks is derived from applying the difference between the total daily VKT and the VKT for all other modes. JICA’s annual VKT are derived from multiplying the daily VKT by 339 days (by assumption, 1 weekend = 1.5 weekdays, which is common in land-use/transport models (personal communication R. Lloyd, Main Roads Department, Western Australia).
1.2 NEA’s annual VKT from NEA, 1987b: Table 4.22. Daily VKT from NEA, 1987a: Table 2
1.3 TEI’s VKT from TEI et al., 1994: Table 2.7
2. Number of vehicle sources:
2.1 JICA’s vehicles figures from JICA, 1990: Bus, taxi, motor tricycle from Table 4.1.1 and Table 4.4.1. Car, motorcycle from Table 7.2.2
2.2 NEA’s vehicle figures from NEA, 1987c: Table 4.22
2.3 TEI’s vehicle figures from Department of Land Transport, 1990: number of vehicles registered in the GBA

Notes: 1. Description of study areas:
1.1 JICA study area is the area within the Outer Ring Road.
1.2 NEA study area is the GBA which comprises BMA, Nonthaburi, Pathum Thani, Samut Prakan.
1.3 TEI’s study did not give a definition of the Bangkok area. However, to obtain daily VKT per vehicle, number of vehicles registered in the GBA are adopted for the calculation.
2. JICA’s car VKT and number of vehicles include pick-ups which are heavily used for passenger purposes.
3. JICA’s taxi VKT and number of vehicles include motor tricycles (tuk-tuks).
after examining data for consistency by comparing daily and annual figures, and checking daily VKT per vehicle by applying the number of vehicles reported in the same study, as shown in Table 3.9. These were: (1) Inconsistencies between daily and annual VKT figures which appear to make annual VKT figures the product of only 230 days of daily VKT figures; this appears to be an unacceptably low annualisation factor - most cities use between about 320 and 345 days. However, there simply may be an error in the daily figures which appears to give a low annualisation factor. As explained under the JICA figures, the NEA total VKT is actually close to the JICA figures, but there are other problems with the detail in the data which make use of its component parts doubtful; (2) Daily VKT per vehicle figures for some modes are so high as to appear unrealistic. For example, the average daily VKT per bus is approximately 710 km. In comparison, the Bangkok Mass Transit Authority (BMTA)'s annual report (1990a: 22) revealed that on average one bus operated for 9.5 trips a day, travelled approximately 208 km. JICA (1990: 137) reported that in 1988 the average length of a Bangkok bus route was 23 km. Given the average of 9.5 trips a day per bus, 1 bus would travel 219 km a day, which is consistent with BMTA's figure but inconsistent with the NEA figures. It is very difficult to imagine any bus being able to travel such a long daily distance as reported by the NEA, simply because of the congestion and restricted movement in their area of operation.

- The JICA VKT figures are likely to be the most reliable for five reasons. First, the study used a comprehensive and systematic methodology to obtain data for calculation of VKT figures. For example, person trip data were derived from comprehensive home interviews (about 50,000 samples). A vehicle origin-destination survey was conducted by interviewing approximately 10 per cent of total vehicle owners to clarify the status of vehicle use and to correct the person trip survey results. In addition, a cordon line survey and a screen line survey were also conducted to supplement and improve the accuracy of the first two surveys. Second, VKT figures for each mode derived from the calculations are compatible with other relevant study data, such as number of vehicles. Third, daily VKT per vehicle figures appear to be consistent with trip lengths and Bangkok's urban structure, in which the majority of residents still live in relatively high density. Fourth, the JICA total VKT figure is almost the same as that of NEA, though the internal breakdown between modes is different. It would
appear that this total VKT has some reliability. Finally, the JICA study results have been widely acknowledged and adopted for most major urban and transport studies on Bangkok (see for example TDRI, 1990; Padeco, 1990; Halcrow Fox and Associates et al., 1991). As a result, the JICA VKT figures were adopted for the international comparative study reported in this dissertation.

3.13.2.2 Train Vehicle Kilometres of Travel

No single study provides train vehicle or wagon kilometre data for Bangkok because, as discussed previously, most Bangkok transport studies focus on road transport. However, such data is required to obtain a fair and complete picture of transport in Bangkok, hence, calculations were required to obtain train VKT. The method used involved calculations from three available factors: (1) passenger kilometres on trains; (2) capacity per wagon or number of seats per bogie; and (3) load factor -the average percentage of passengers travelling in each bogie as a proportion of its capacity. The formula for obtaining the train VKT is as follows:

\[
\text{Train VKT} = \frac{\text{Passenger kilometres}}{\text{Wagon capacity} \times \text{Load factor}}
\]

The passenger kilometres data for train travel are derived from the calculation based on the number of passengers and the average trip length described previously. The wagon capacity and load factor are derived from the ESCAP’s *Railway Statistics and Information for Asia and the Pacific, 1987* (ESCAP, 1991: 432,438).

3.13.2.3 Boat Vehicle Kilometres of Travel

Obtaining boat VKT or "ferry" kilometres of service is a less complicated process than for the previous two transport modes. A recent comprehensive study by the Department of Energy Development and Promotion (1993), *Study on Energy Consumption in Water Transport*, provides detailed data on vehicle kilometres of travel by each mode of water transport (fixed-route long-tail boats, express boats, ferries across the river and non-fixed-route boats). After checking reliability of the data using the methodology
demonstrated in the study, VKT figures for each mode were summed to yield the total VKT for all boats.

3.13.3 Energy Use

Energy use in private passenger transport in Newman and Kenworthy (1989) was defined as gasoline use per capita, since in the cities in their study, most private passenger vehicles used gasoline. Where there was a significant quantity of other fuel such as diesel or LPG used in private passenger transport, they added this to the gasoline figure. In the present study, however, this energy is referred to as "private passenger transport energy use", rather than just gasoline use. It is measured in terms of "megajoules (MJ)" (1 megajoule = 1,000,000 joules). This is because in Bangkok there are three main fuel types used in private passenger transport (gasoline, diesel, and LPG [Liquid Petroleum Gas]), and it is therefore somewhat misleading to refer to these as simply "gasoline use". The conversion factors applied for each fuel type to obtain the energy figures are as follows (Bosch, 1976):

- 1 litre of gasoline = 34.69 MJ
- 1 litre of diesel = 38.29 MJ
- 1 litre of LPG = 26.26 MJ

In addition, energy use in public transport (buses, trains and boats) was also examined and compared to private energy use to calculate the balance of energy use in transport within Bangkok. Energy use by the main transport modes (private transport, buses, trains, and boats) was also standardised by passenger kilometres to compare the energy efficiency of each mode, as will be shown in Chapter 4.

Obtaining data on Bangkok's transport energy use for this study was one of the problematic data collection processes and requires some clarification, as described below:

- The definition of "Bangkok" used by relevant agencies and studies for energy use in transport is the Greater Bangkok Area (GBA), which is larger than the area used for transport data. Thus, to standardise energy use data for this comparative study, the population of the GBA was adopted.
No agency or study was able to provide data on energy use in trains in Bangkok. The only data available from the State Railway of Thailand was the total fuel use in trains for the whole of Thailand. Hence, calculations were required to obtain an estimate of fuel use by passenger trains in Bangkok. As shown in Table 3.10, the train kilometres for suburban trains in Bangkok and for the whole Thai train system were applied to calculate the proportion of service within the GBA. This proportion was then utilised to obtain the amount of fuel used in suburban trains in Bangkok. Although this does not necessarily take into account differences in efficiency of energy use in different train types and areas, it was the best possible estimate under the circumstances.

Table 3.10 Method for obtaining fuel use data for Bangkok's trains, 1989

<table>
<thead>
<tr>
<th>Trains</th>
<th>Train kilometres</th>
<th>Proportion of train kilometres (%)</th>
<th>Fuel use (diesel - litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Thai trains</td>
<td>42,085,130</td>
<td>100.00</td>
<td>117,497,000</td>
</tr>
<tr>
<td>Suburban trains in Bangkok</td>
<td>290,959</td>
<td>0.69</td>
<td>812,320</td>
</tr>
</tbody>
</table>

Source: Train VKT and fuel use data for all Thai passenger trains from the State Railway of Thailand, Annual Report 1990

Note: Proportions of train kilometres and fuel use in suburban trains are from calculations undertaken for this study.

3.14 DATA FOR TRANSPORT ECONOMIC FACTORS

Obtaining the data for road expenditure and private transport costs is a very complicated task as it involves several sets of data. The methodologies used are as follows:

3.14.1 Road Expenditure

Road expenditure comprises all monies spent for road construction and maintenance by governments at all levels and through all relevant agencies. This data item is not an easy one to obtain as expenditures on roads occur at many different levels and are frequently very difficult to trace. This is unlike the situation in public transport where expenditures are generally much more transparent. The data obtained have originated through rigorous investigations to ensure all expenditures have been unearthed and
included. Bangkok in particular involves expenditures through four different sources: (1) the Bangkok Metropolitan Administration; (2) the Department of Highways; (3) the Expressways and Rapid Transit Authority of Thailand; and (4) the Public Works Department. The final data shown are a three year average for each city around the 1990/91 year and converted to 1990 US dollars. Taking any one particular year may skew the picture for a particular city due to construction projects at any one time. A three year average evens this out to some extent.

3.14.2 Private Transport Costs

The private transport cost comprises two items: capital cost and variable cost. The capital cost is basically the purchase prices of private vehicles. For Bangkok, as well as in other Southeast Asian cities, there are two main types of private vehicle: cars and motorcycles. In particular, in Bangkok "cars" comprises private cars and the cheaper pick-ups. Thus, weighting is required for the calculation, as shown in the following formula:

\[
Capital \ cost = \frac{\left(\frac{(C_cW_c + P_cW_p)W_{cw}}{K_c}\right) + \frac{M_cW_{mw}}{K_m}}{L}
\]

Where:
- \(C_c\) = car capital cost
- \(P_c\) = pick-up capital cost
- \(W_c\) = weighted factor for car numbers
- \(W_p\) = weighted factor for pick-up numbers
- \(M_c\) = motorcycle capital cost
- \(W_{cw}\) = weighted factor for modal share by cars/pick ups to work
- \(W_{mw}\) = weighted factor for modal share by motorcycles to work
- \(K_c\) = average annual VKT for a car
- \(K_m\) = average annual VKT for a motorcycle
- \(L\) = assumed life of vehicles

Capital cost for "cars" is derived by weighting prices for private cars and pick-ups by their numbers. Average private transport capital cost is derived by weighting capital costs for "cars" and motorcycles by their modal shares for the journey-to-work. In addition, obtaining the overall average annual capital cost per km requires the weighting between two main modes: cars and motorcycles by the average annual vehicle kilometres travelled by each type of vehicle. It is also assumes that the life of a private vehicle, as for private vehicles in other cities under study, is about 10 years. The annual
capital cost for private vehicles is derived simply by dividing the average capital cost per km by 10 years.

The variable cost for private vehicles in Bangkok is also derived by weighting the variable cost per km for private cars and pick-ups by their numbers and weighting variable costs per km between "cars" and motorcycles by their modal share for the journey-to-work as shown in the following formula:

\[
\text{Variable cost} = ((V_C W_c + V_p W_p)W_{cw}) + V_m W_{mw}
\]

Where:
- \( V_C \) = car variable cost/km
- \( V_p \) = pick-up variable cost/km
- \( W_C \) = weighted factor for car numbers
- \( W_p \) = weighted factor for pick-up numbers
- \( V_m \) = motorcycle variable cost/km
- \( W_{cw} \) = weighted factor for modal share by cars/pick ups to work
- \( W_{mw} \) = weighted factor for modal share by motorcycles to work

Most basic data required for calculation of the capital costs and variable costs for Bangkok's vehicles are available from the JICA 1990 study. For an international comparison, Thai currency is converted to American dollars based on the 1990 Special Drawing Right (SDR) used by the International Monetary Fund as the international unit of account to reduce the effects of floating exchange rates in international transactions (International Road Federation, 1993: 7). This SDR has also been adopted for all other cities in this study. The conversion to US dollars involves dividing the local currency (baht) by the SDR of 35.29 and then multiplying by the US SDR of 1.39 to convert to 1990 US dollars.

3.15 TRANSPORT EMISSIONS

The transport related emissions being examined are CO, HC, NO\textsubscript{X}, SO\textsubscript{X}, SPM and CO\textsubscript{2}. Emissions of CO\textsubscript{2} were calculated directly from fuel use by public and private modes of transport using standard rates of CO\textsubscript{2} emissions per MJ of fuel burned. The standard rates, which are derived from River and Kenworthy (1993: 32), are as follows:

- 72 grams of CO\textsubscript{2} per MJ of gasoline and diesel used
• 65 grams of CO₂ per MJ of LPG used

Energy use by all modes of transport was collected and calculated from three main agencies: the Petroleum Authority of Thailand, the Department of Energy Development and Promotion, and the State Railway of Thailand, as described earlier.

For all other emissions, the data is derived from TDRI (1990): *Energy and Environment: Choosing the Right Mix*. However, after comparing and double checking with other cities, these emission figures appeared to be too high. For example, the emissions per capita for CO, HC and SO₂ in Bangkok are about two to three times as high as those for all other cities. Moreover, SPM emissions are about 5 to 10 times as high as other cities. The reason for these unusually high emission levels are attributable to the fact that the TDRI study used the figures for the number of trips from the 1990 JICA study, but adjusted the numbers of trips by a factor of two to get the VKT figures (see TDRI, 1990: 49). As these VKT figures are the basis for the calculation of the emissions inventory, this simply means that the emission figures are also double what they should be. Given these facts, this study has adjusted the emission data from TDRI by halving them. The results still show comparably high emissions rates in Bangkok as might be expected.

3.16 CONCLUSIONS

Global cities comparative studies have demonstrated their significant contribution to urban and transport policy and planning over the last few decades (e.g. Hall, 1977; Thomson, 1977; Hall and Hass-Klau, 1985; Goldberg and Mercer, 1986; Newman and Kenworthy, 1989 plus the recent United Nations, World Bank and UITP exercises, as described). This approach, particularly the quantitative comparative study conducted by Newman and Kenworthy (1989), has been applied and adapted to this study of Bangkok. In total, thirty-four global cities are incorporated into this study, including four neighbouring Southeast Asian cities. The main parameters to be compared are urban form and land-use, transport infrastructure, and transport patterns (including energy use), plus some additional selected comparative data on transport economics and transport externalities.
The data for Bangkok were collected from a considerable number of relevant agencies and studies over an extended period of time. These data were difficult to collate and it was not easy to resolve differences between the various sources and different study areas. Raw data had to be standardised for comparison with that of other cities. Data collection necessitated clarification of definitions of Bangkok and the study area to ensure consistency for the comparative study. Specific methods were used to obtain some problematic data, such as data for urbanised areas, passenger kilometres, vehicle kilometres of travel, energy use, transport costs, and transport emissions. As a result of these calculations, it is now possible to compare Bangkok to other cities. No previous research has ever attempted to bring together such a disparate array of data items from so many studies which often conflict in their basic output. The results of this research mean that for the first time it is possible to see how Bangkok fits into the broad international patterns of urban transport and land-use and how its land-use and transport characteristics may offer new knowledge about the roots of its traffic crisis.

Chapter 4 thus places Bangkok in the international context, by means of a comprehensive investigation of Bangkok’s land-use, and transport patterns, as well as some transport economics factors and selected transport externalities. This comparative study provides a unique insight into Bangkok’s traffic situation in the early 1990s and an important window on the roots of its chronic transport problems. The results of these comparisons provide guidance for developing effective solutions for Bangkok’s serious traffic problems, as outlined in subsequent chapters.
CHAPTER 4

UNDERSTANDING BANGKOK IN AN INTERNATIONAL CONTEXT: URBAN FORM, TRANSPORT AND TRAFFIC COMPARISONS

4.1 INTRODUCTION

This chapter examines Bangkok's transport and land-use, as well as additional factors of transport economics and transport externalities, in comparison with other cities around the world, particularly Asian cities. The international comparative study attempts to reveal the roots of Bangkok's traffic disaster and also to clarify its impact in terms of energy use, transport-related deaths and the level of transport emissions.

This chapter starts by demonstrating the interrelationship between urban form, land-use and transport. It then places Bangkok into an international framework to examine Bangkok's land-use, transport and the impact of transport, in the following five sections:

(1) The urban form and land-use of Bangkok in terms of population and employment density;
(2) The transport infrastructure, comprising the road, railway and waterway networks, and parking provision;
(3) Transport and energy use patterns, which encompass vehicle ownership, traffic speed, trip characteristics, private and public transport use, and energy consumption;
(4) Transport economics, comprising road expenditure, costs of private transport use and transit cost recovery; and
(5) Transport externalities, in terms of transport-related deaths and transport emissions.

4.2 THE RELATIONSHIP BETWEEN URBAN FORM AND TRANSPORT

One of the most well known studies on the relationship between urban form and transport strategies was conducted by Thomson (1977). In his global
cities study, he argued that to tackle transport problems, it is vital to consider city structure as a major determinant:

The important elements in a city transport strategy are the land-use disposition and the network structure. The land-use disposition requires clear objectives concerning first the volume of employment to be concentrated in the city centre and the location of other employment in sub-centres or in a dispersed pattern, secondly the densities of population, and thirdly the geographical shape of the city. (p. 320)

Thomson proposed five city archetypes, based on different city structures and private and public transport systems (Figure 4.1). They can be envisaged as running along a continuum. At one end is Archetype A, which has fully accommodated car use by a comprehensive network of freeways and roads, and has a dispersed urban form, such as found in Los Angeles, Detroit, Denver and Salt Lake City. This is called the Full Motorization archetype. At the other end is Archetype E, based on traffic limitation, i.e. low parking availability, prohibitions in certain streets and extensive priorities for buses, cyclists and pedestrians. Archetype E is well served by public transport, including rail or some other segregated system. The structure and close integration of land-use and transport is designed to lead to relatively little demand for travel, particularly by private transport. Cities in this archetype, according to Thomson, are London, Singapore, Hong Kong, Stockholm, Vienna, Bremen and Gothenburg. In between are Archetype B (Weak Centre Strategy) and Archetype C (Strong Centre Strategy; D is described later) which have different degrees of centralisation, that is the size and density of population and employment concentrated in the city centre. Archetype B cities have weaker city centres, due to the suburbanising influence of the automobile. However, the radial road network is also supported by a reasonably strong radial public transport system, in particular rail. Thomson suggests that Archetype B cities are caught between the different pulls of Archetype A and Archetype C cities and in some sense are finding it difficult to decide which way they want to head. As a result, he suggests that they tend to have a less stable land-use and transport interrelationship. Cities of this type are Melbourne, Copenhagen, San Francisco, Chicago and Boston. Archetype C cities have stronger centres served by both radial roads and in particular good, high capacity radial public transport systems, often incorporating underground
rail services. Ring roads are provided only to divert through-traffic around the centre. Cities in this model are typically the "great cities" of the world, namely Paris, Tokyo, New York, Athens, Toronto, Sydney and Hamburg. In addition, Archetype D or Low Cost Strategy, is a special case of the strong-centred city and consists of cities in developing countries. They tend to utilise low-cost transport strategies, due to a lack of capital to build high-capacity transport networks. They generally have high densities with a major centre served by numerous bus corridors, in which non-residential activities are concentrated. These cities have a variety of sub-centres and sub-urban centres, located along these main corridors which maximise local accessibility in what are typically very mobility-constrained environments. Examples of these cities, according to Thomson, are Bogota, Lagos, Calcutta, Istanbul, Karachi, Manila and Teheran.

Figure 4.1 Thomson's five city archetypes

Source: Thomson, 1977: Figure 9, 10, 14, 15 and 16

The global cities study conducted by Newman and Kenworthy (1989) confirms that urban form, transport infrastructure, and transport patterns are significantly interrelated and that they vitally affect energy consumption in transport (energy use in transport being a reasonable surrogate for the overall level of automobile dependence). These researchers found that the five most significant factors affecting the amount of gasoline used in urban transport are: land-use intensity, orientation to non-automobile modes, level
of traffic restraint, degree of centralisation, and public transport performance (Figure 4.2).

![Diagram showing interrelationship between gasoline use and transport/land-use parameters]

**Figure 4.2 The interrelationship between gasoline use and transport/land-use parameters**

Source: Adapted from Newman and Kenworthy, 1989: Figure 4.1

Supporting their findings in a study of the effect of infill development in existing parts of Australian cities, McGlynn et al. (1990) also argued that:

> A comprehensive approach to urban consolidation\(^{22}\) must fully and explicitly recognise the ability of transport systems to shape the form of cities. Systems built around public transport (especially rail-based transport), walking and cycling, will encourage more compact development. Car-based systems, on the other hand, will dissipate the city into the sprawling suburbia so common in America, and increasingly familiar in Australia. (p. 1)

---

\(^{22}\) Urban consolidation is the term used in Australia to describe the policy approach to urban development which stresses the utilisation of land within existing built-up areas in Australian cities in preference to development on new land at the urban fringe. This can consist of redevelopment of low-grade uses, infilling of bypassed land and dual occupancy construction.
Walmsley and Perrett (1991: 6-7), also pointed out that urban form and the character of land-use have an effect on public transport use.

The actual form of the cities has effect on the patronage. In French cities and in Toronto, land-use densities are high. This favours public transport; more people live within walking distance of a station and the city itself tends to be more compact so that a given length of line serves a higher population. Road traffic tends to be more congested which also favours a rail mode. Sacramento, by contrast, has a low density of population, and the correspondingly lower patronage [of transit] per kilometre reflects this. (p. 6)

They demonstrate further that cities with high densities also have different lifestyles, leading to mixed land-use, which positively affects the use of the rail system:

The mixture of land-uses can also have a marked effect on the use made of a rail system. For example, Toronto is a well-established city with a traditional centre offering a wide range of shops and leisure facilities which are open well into the evening; as a result, the streets are crowded late at night and the Metro is extensively used for long periods of the day. Washington, on the other hand, is a city of office workers and the centre is very quiet at night. If a Metro system is little used at night it can become an undesirable place to live, which can itself further discourage patronage; Marseille also tends to suffer in this respect. (p. 7)

Cervero (1996) and Cervero and Radisch (1995) have also demonstrated the importance of mixed land-use in reducing automobile use through a positive effect on public transport, walking and cycling. This view was supported by the European Conference of Ministers of Transport (ECMT) (1990), who highlighted the importance of land-use on transport demand and as a factor influencing the form of transport. They argued that:

Different land-use configurations can have important implications for transport demand and the ability of the different forms of transport to carry it. In compact, public-transport-oriented cities, public transport ridership can exceed 400 trips per capita per year. At the other extreme
in low density “new world” type cities, public transport trip rates can be below 50 trips per capita per year. (p. 77-78)

These researchers are among many who have identified the critical problems with automobile-dependent cities and the linkages between urban form and transport. Thus it is important here that we also examine all of these factors to understand the transport situation in large metropolises such as Bangkok. These relationships are illustrated in Figure 4.3 below.

![Figure 4.3 The interrelation among urban form, transport infrastructure, transport patterns and their relations to energy consumption](image)

Source: Adapted from Newman and Kenworthy, 1989: Figure 4.1

To begin to obtain a more concrete perspective on the interrelationships between urban form, land-use and different transport parameters, correlation analysis is one simple method which can be employed, as Newman and Kenworthy (1989) showed in their global cities study (though it is important to recognise that more sophisticated statistical analysis is required to untwine the myriad of intercorrelations between the variety of variables). The objective of correlation analysis in this case is to provide a quick statistical perspective on how strongly the main transport and land-use factors are related to three key indicators of automobile dependence: gasoline use as an indicator of the level of private vehicle use; proportion of
passenger kilometres on public transport as an indicator of the relative importance of transit in the transport system; and proportion of workers using foot or bicycle to work as an indicator of the orientation to non-motorised modes. The main transport and land-use factors to be examined encompass urban form, transport infrastructure, and transport patterns as described in Table 4.1. Utilising available 1990 data from a large sample of global cities as described in Chapter 3, these main transport and land-use factors are correlated with the chosen three key indicators of automobile dependence. Table 4.2 demonstrates the results of this analysis in terms of the percentage of variance explained by each variable ($r^2$ value) and correlation coefficient ($r$ value).

4.2.1 Correlations between Gasoline Use and Transport/Land-Use Factors

In terms of the relationship between gasoline use and the transport/land-use variables, it is clearly seen from the $r^2$ and $r$ values in Table 4.2 above that population density has a very significant negative relationship with gasoline use. That is cities with higher population density are likely to consume less gasoline. This finding is consistent with what Newman and Kenworthy (1989) found in their original thirty-two global cities study using 1980 data. In addition, gasoline use also has a significant negative relationship with inner area population density and a significant negative relationship with the proportion of jobs located in the inner area. These results suggest that cities with a higher degree of centralisation of work also use less gasoline, and by implication, travel less in private vehicles. This finding concerning centralisation of work is consistent with Cervero and Landis (1992) who showed that when jobs transferred from the central city of San Francisco to the suburbs, transit use was decimated.

Table 4.2 also shows a strong positive relationship between gasoline use and road supply, and indicates some positive relationship with parking provision in CBD. It can be suggested from this that cities which provide more roads and parking tend to have higher levels of private vehicle use and energy consumption.

Regarding the relationship between gasoline use and broad transport factors the results of the analysis suggest that overall levels of vehicle ownership are strongly associated with the level of gasoline or car use (which is not
### Table 4.1 Main transport and land-use factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>Main indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban form</td>
<td>1. Whole city population density (persons/ha)</td>
</tr>
<tr>
<td></td>
<td>2. Inner area population density (persons/ha)</td>
</tr>
<tr>
<td></td>
<td>3. Proportion of jobs in inner area</td>
</tr>
<tr>
<td>Transport infrastructure</td>
<td>1. Road supply (metres of road per person)</td>
</tr>
<tr>
<td></td>
<td>2. Parking provision (number of parking spaces per 1000 CBD jobs)</td>
</tr>
<tr>
<td>Transport patterns</td>
<td>1. Total vehicles per 1,000 people</td>
</tr>
<tr>
<td></td>
<td>2. Car ownership per 1,000 people</td>
</tr>
<tr>
<td></td>
<td>3. Car passenger kilometres per capita</td>
</tr>
<tr>
<td></td>
<td>4. % of total passenger kms on public transport</td>
</tr>
<tr>
<td></td>
<td>5. % of workers using foot or bicycle</td>
</tr>
</tbody>
</table>

### Table 4.2 Results of statistical correlations between main transport and land-use factors and key indicators of automobile dependence in thirty-four cities around the world, 1990

<table>
<thead>
<tr>
<th>Factors</th>
<th>Gasoline use</th>
<th>% Transit use</th>
<th>% Walking/cycling to work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>r^2</td>
<td>r</td>
</tr>
<tr>
<td>Urban form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population density</td>
<td>-0.872</td>
<td>0.760</td>
<td>0.881</td>
</tr>
<tr>
<td>Inner area density</td>
<td>-0.780</td>
<td>0.608</td>
<td>0.918</td>
</tr>
<tr>
<td>% of jobs in inner area</td>
<td>-0.709</td>
<td>0.502</td>
<td>0.661</td>
</tr>
<tr>
<td>Infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road supply</td>
<td>0.811</td>
<td>0.658</td>
<td>-0.797</td>
</tr>
<tr>
<td>Parking spaces</td>
<td>0.594</td>
<td>0.353</td>
<td>-0.754</td>
</tr>
<tr>
<td>Transport patterns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total vehicles</td>
<td>0.933</td>
<td>0.871</td>
<td>-0.843</td>
</tr>
<tr>
<td>Car ownership</td>
<td>0.939</td>
<td>0.882</td>
<td>-0.815</td>
</tr>
<tr>
<td>Car passenger kms</td>
<td>0.961</td>
<td>0.923</td>
<td>-0.927</td>
</tr>
<tr>
<td>% pass. kms on public transport</td>
<td>-0.888</td>
<td>0.789</td>
<td>1.000</td>
</tr>
<tr>
<td>% walking/cycling</td>
<td>-0.854</td>
<td>0.729</td>
<td>0.808</td>
</tr>
</tbody>
</table>


Note: All correlations are statistically significant at ≤ 0.0005.
unexpected), and that lower use of both public transport and non-motorised modes are strongly associated with higher gasoline and car use.

4.2.2 Correlations between the Relative Use of Transit and Transport/Land-Use Factors

As also shown in Table 4.2, the proportion of total passenger kms on transit is strongly correlated to urban density, inner area population density and proportion of jobs in the inner area i.e. cities with higher density and a higher degree of centralisation of jobs seem to have a higher use of public transport (e.g. see also Cervero and Landis 1992). The significant negative correlations between the level of transit use and provision of road and parking spaces in the CBD, number of total vehicles and cars, and car use suggest that the more cities are built for the private vehicle and the more cities turn to private vehicles, the lower is the public transport performance. On the other hand, the significant relationship with the level of walking and cycling to work indicates to some degree that public transport and non-motorised transport use tend to be mutually supportive (i.e. environments with higher levels of walking and cycling tend to be associated with higher transit use where a reasonable transit service is provided. A short walk or bicycle ride is often the most convenient way of getting to a transit system).

4.2.3 Correlations between Level of Walking and Cycling to Work and Transport/Land-Use Factors

Although the correlation values between the proportion of workers using foot or bicycle to work and transport/land-use factors derived from this analysis are not generally quite as high as in previous variables, they suggest that the level of non-motorised mode use in cities is related to urban form, transport infrastructure provision and other broader transport patterns. First, they show that cities with higher density and a higher degree of centralisation seem to have a higher level of non-motorised mode use (at least to work). Second, cities with more road supply and parking provision tend to have a lower level of walking and cycling. Finally, the negative correlations between the level of walking and cycling to work and the magnitude of vehicle ownership and level of car use, plus the positive correlation between the level of walking and cycling and level of transit use, suggest that cities with higher walking and cycling can to some extent keep
the level of private transport use at a lower level and encourage healthy public transport performance.

In summary, the literature and the correlation analysis results presented here using a large sample of global city data, suggest strongly that urban form, transport infrastructure and transport patterns have a very close interrelationship with the level of gasoline consumption (or private transport use), the magnitude of transit use and the extent of walking and cycling in cities. Cities with higher density, a higher degree of centralisation and lower road and parking provision are likely to rely more on public transport and non-motorised modes and tend to consume less energy. This argument provides a useful starting point for further investigation of Bangkok's transport problems and the solutions to be suggested.

4.3 URBAN FORM AND LAND-USE

As seen in the above argument, urban form and land-use have a substantial influence on transport patterns and vice versa. In addition, density, the main parameter describing the urban form of a city, has very significant effects on travel distance and modal split (Pushkarev and Zupan, 1977). Not only does population density affect transport patterns, but job densities and their areas of concentration have significant effects on transport patterns (Newman and Kenworthy, 1991). In particular, transport patterns can be affected by whether jobs are located in central, inner or outer areas and whether they are found in strong, concentrated modes in these areas, or dotted randomly across the landscape (Alexander, 1980: 249-275; Cervero and Landis, 1992). Thomson (1977) found in his global cities study that the most important factor controlling the transport characteristics of the city is the degree of centralisation. That is, cities with concentrated urban activity in the centre have shorter journey distances, whereas cities with dispersed activity have longer journeys and depend more on private transport.

Bearing these considerations in mind, this section examines Bangkok’s population density and job density in each of four areas: the whole city, the central business district, the inner area, and the outer area (as defined in Chapter 3, see Figure 3.6). The next step is then to compare Bangkok’s density with that of other large cities, paying particular attention to Bangkok's urban form. Table 4.3 provides data on Bangkok's urban form in
<table>
<thead>
<tr>
<th>City</th>
<th>Whole city density</th>
<th>Central city density</th>
<th>Inner area density</th>
<th>Proportion of population in CBD(%)</th>
<th>Proportion of population in inner area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston</td>
<td>9.5</td>
<td>5.7</td>
<td>17.9</td>
<td>303.3</td>
<td>18.4</td>
</tr>
<tr>
<td>Phoenix</td>
<td>10.5</td>
<td>5.1</td>
<td>16.6</td>
<td>89.7</td>
<td>16.4</td>
</tr>
<tr>
<td>Detroit</td>
<td>12.8</td>
<td>6.1</td>
<td>16.5</td>
<td>306.0</td>
<td>28.6</td>
</tr>
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<td>Denver</td>
<td>12.8</td>
<td>8.7</td>
<td>18.7</td>
<td>175.9</td>
<td>16.3</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>12.9</td>
<td>12.4</td>
<td>28.2</td>
<td>506.7</td>
<td>28.7</td>
</tr>
<tr>
<td>San Francisco</td>
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<td>111.1</td>
<td>794.3</td>
<td>59.8</td>
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<td>7.1</td>
<td>71.2</td>
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<td>43.1</td>
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<td>9.5</td>
<td>27.3</td>
<td>688.5</td>
<td>38.1</td>
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<tr>
<td>Chicago</td>
<td>16.6</td>
<td>8.7</td>
<td>30.3</td>
<td>921.0</td>
<td>47.3</td>
</tr>
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<td>New York</td>
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<td>11.0</td>
<td>226.6</td>
<td>799.1</td>
<td>91.5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>14.7</td>
<td>8.3</td>
<td>56.2</td>
<td>502.1</td>
<td>39.8</td>
</tr>
<tr>
<td>Australian Cities</td>
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<td></td>
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<tr>
<td>Perth</td>
<td>10.6</td>
<td>4.3</td>
<td>9.5</td>
<td>131.5</td>
<td>15.3</td>
</tr>
<tr>
<td>Brisbane</td>
<td>9.8</td>
<td>4.0</td>
<td>11.8</td>
<td>528.6</td>
<td>20.3</td>
</tr>
<tr>
<td>Melbourne</td>
<td>14.9</td>
<td>5.9</td>
<td>27.1</td>
<td>530.6</td>
<td>27.2</td>
</tr>
<tr>
<td>Adelaide</td>
<td>11.8</td>
<td>5.1</td>
<td>19.1</td>
<td>408.1</td>
<td>16.7</td>
</tr>
<tr>
<td>Sydney</td>
<td>16.8</td>
<td>7.2</td>
<td>20.8</td>
<td>422.2</td>
<td>39.2</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>12.5</td>
<td>5.5</td>
<td>15.9</td>
<td>404.3</td>
<td>24.8</td>
</tr>
<tr>
<td>European Cities</td>
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<td>39.8</td>
<td>23.6</td>
<td>29.9</td>
<td>331.7</td>
<td>85.7</td>
</tr>
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<td>Frankfurt</td>
<td>46.6</td>
<td>43.5</td>
<td>65.5</td>
<td>498.9</td>
<td>61.0</td>
</tr>
<tr>
<td>Zürich</td>
<td>47.1</td>
<td>35.3</td>
<td>37.3</td>
<td>417.3</td>
<td>72.6</td>
</tr>
<tr>
<td>Stockholm</td>
<td>53.1</td>
<td>39.3</td>
<td>101.4</td>
<td>262.3</td>
<td>91.7</td>
</tr>
<tr>
<td>Brussels</td>
<td>79.9</td>
<td>46.8</td>
<td>50.3</td>
<td>470.5</td>
<td>91.7</td>
</tr>
<tr>
<td>Paris</td>
<td>46.1</td>
<td>22.1</td>
<td>179.7</td>
<td>369.6</td>
<td>96.7</td>
</tr>
<tr>
<td>London</td>
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<td>23.6</td>
<td>63.0</td>
<td>423.7</td>
<td>78.1</td>
</tr>
<tr>
<td>Madrid</td>
<td>35.5</td>
<td>37.2</td>
<td>96.6</td>
<td>276.1</td>
<td>106.9</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>41.9</td>
<td>31.6</td>
<td>77.5</td>
<td>350.1</td>
<td>86.9</td>
</tr>
<tr>
<td>Richer Asian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tokyo</td>
<td>71.0</td>
<td>73.1</td>
<td>63.2</td>
<td>546.7</td>
<td>132.1</td>
</tr>
<tr>
<td>Singapore</td>
<td>86.8</td>
<td>49.3</td>
<td>82.8</td>
<td>366.2</td>
<td>124.2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>300.5</td>
<td>149.0</td>
<td>113.6</td>
<td>1712.6</td>
<td>803.9</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>182.8</td>
<td>90.1</td>
<td>86.6</td>
<td>841.8</td>
<td>353.4</td>
</tr>
<tr>
<td>Southeast Asian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangkok</td>
<td>18.3</td>
<td>42.4</td>
<td>324.8</td>
<td>132.3</td>
<td>288.6</td>
</tr>
<tr>
<td>Jakarta</td>
<td>190.8</td>
<td>58.8</td>
<td>205.1</td>
<td>203.5</td>
<td>264.7</td>
</tr>
<tr>
<td>Kuala Lumpur</td>
<td>58.7</td>
<td>22.4</td>
<td>123.1</td>
<td>178.4</td>
<td>68.8</td>
</tr>
<tr>
<td>Manila</td>
<td>198.0</td>
<td>67.7</td>
<td>444.8</td>
<td>228.5</td>
<td>372.4</td>
</tr>
<tr>
<td>Surabaya</td>
<td>176.9</td>
<td>77.9</td>
<td>360.2</td>
<td>309.6</td>
<td>265.1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>150.7</td>
<td>57.8</td>
<td>256.5</td>
<td>216.1</td>
<td>252.3</td>
</tr>
</tbody>
</table>

Sources: 1. Bangkok data from Appendix A

Note: Tokyo’s whole city job density is for the Tokyo metropolis, whereas population density is for the whole Tokyo Metropolitan Area.
comparison to thirty-three other global cities showing data for the four distinct geographic areas of CBD, inner area, outer area and the whole city. This information is used for further discussion throughout this section.

4.3.1 Bangkok's Population Density

The Bangkok Metropolitan Area (BMA) in 1990 had a population of about 6 million people. The entire Bangkok Metropolitan Region (BMR), which includes the five surrounding provinces (Nonthaburi, Pathumthani, Samut Sakhon, Samut Prakan and Nakhon Pathom), had a population in 1990 of approximately 9 million. The entire area of the BMR is about 7,800 square kilometres (NESDB et al., 1991). However, as most of the transport data used in this study refer to the area bounded by the Outer Ring Road (for reasons of availability), population and land-use data therefore refer to the same area. The area contained within the Outer Ring Road is approximately 1,640 square kilometres, with a population of 6.357 million in 1989 (JICA, 1990) (see Figure 3.4).

Overall, in 1989 Bangkok had a total urbanised area of approximately 426 square kilometres (42,600 ha), and the population was about 6.4 million in that year. The density of Bangkok was therefore about 149 persons per ha. This density is quite typical of Asian cities. The five cities in developing Southeast Asian countries analysed in this study have on average an overall density of about 151 people per ha, ranging from the lowest, Kuala Lumpur (59) to Jakarta (171), Surabaya (177), and to the highest, Manila (198). Bangkok's density is much higher than that of Singapore (87) and Tokyo (71), but much lower than Hong Kong (301). In the wider international perspective, Bangkok's density is very high, about ten times higher than Australian and American cities, and about triple that of European cities (Figure 4.4).
Figure 4.4 Bangkok's urban density compared to other global cities, 1990

Source: Table 4.3

With regard to its development pattern and for the purposes of international comparison, Bangkok can be categorised into three areas: the Central Business District (CBD); the Inner Area, including the CBD; and the Outer Area (see Chapter 3). Figure 4.5 shows the population and urban density of these three zones in Bangkok in 1989.

Figure 4.5 Bangkok's population and density in three areas, 1989

Sources: 1. Population and area data from Appendix A
2. Density figures from Table 4.3

Note: The city is not circular. This diagram serves only as a conceptual guide to its density profile (see Figure 4.6).
4.3.1.1 The Central Business District (CBD)

This area covers the old city centre and the new Central Business District containing a number of business/commercial buildings and shopping centres. It is fully developed with a built-up area of around 21 square km (2,100 ha) (see Figure 3.6 in Chapter 3). Its population was approximately 668,000 in 1989. This means that slightly over 10 per cent of the Bangkok population was living within the Central Business District of the city. This area is very dense containing about 325 persons per ha. It is almost the densest of all CBDs in the cities being studied, except central Manila and central Surabaya, which have densities of 445 and 360 persons per ha respectively. For example, by comparison the Manhattan area or CBD of New York was 227 per ha in 1990 and Paris only 180 per ha.

However, most cities in Asia also have a relatively dense CBD. For example, central Jakarta has 235, central Kuala Lumpur has 123, and central Hong Kong has 114. Of the Asian cities, only central Singapore and central Tokyo have relatively low population density CBDs of about 83 and 63 persons per ha respectively (nevertheless, this is still relatively high by international standards).

Central Bangkok's population density is about 20 times higher than the CBD density of Australian cities (16 persons per ha). It is nearly six times higher than the American cities (56 persons per ha), more than four times higher than the European cities (78) and much higher than that of the wealthier Asian cities (87). From the perspective of transport, central Bangkok's density is ideal for walking, and other non-motorised modes according to the assumption that the density in historical "walking cities" is between 100 and 200 people per ha (see Chapter 2). This is even lower than the current density in central Bangkok.

4.3.1.2 The Inner Area

This area covers the Central Business District (CBD) and the surrounding districts, largely located within the Middle Ring Road (see Figure 3.6). The land-use of this zone is mostly mixed residential and commercial. Beyond the CBD, commercial buildings are located mostly along main roads, while houses are located along small streets (sois). The entire area of this zone is
approximately 221 square kilometres (22,100 ha), of which approximately 128 square kilometres (12,800 ha) is built-up area. The population of this zone was approximately 3.7 million in 1989, or nearly 60 per cent of Bangkok's entire population in the study area. The inner area has a density of approximately 289 persons per ha, which is also typical for Asian cities. For example, the average inner-area density of the five Southeast Asian cities is 252 persons per ha. On the other hand, this density is very high compared to inner areas of Australian, American and European cities, which have average densities of 24, 39 and 87 people per ha respectively. Furthermore, Bangkok's inner area density is even higher than the density of the CBDs of the two densest central cities of the North, New York (227) and Paris (180), and is even comparatively higher than the density of the historical "walking cities" in the pre-motorised period. It can be suggested from this that Bangkok in density terms has what might be called an "extended" walking city as shown in Figure 4.6 where walking and non-motorised modes are highly suited to the relatively compact land-use patterns.

4.3.1.3 The Outer Area

This zone is also shown in Figure 3.6. Most land in this zone is not yet urbanised. Paddy fields, fruit orchards and vegetable farms are common. The residential areas have developed as ribbon development mainly along major roads. Most of them have been developed during the motorisation period. However, large areas behind the developed strips are vacant and waiting for development, regarded by current landowners as more profitable than farming. The entire area of the Outer Area is approximately 1,149 square kilometres (114,900 ha), of which only 29,700 hectares or approximately 26 per cent has been urbanised. The population of the outer zone in 1989 was about 2.6 million. As a result, the density of this zone was only 89 persons per ha. This is fairly typical of new Asian city suburbs, which have mostly developed during the 1980s. The density is approximately seven times the density of new suburbs in US and Australian cities and is more typical of older European "transit cities" densities of about 50 to 100 persons per ha. Also, because development is mostly in a linear form, it is ideally suited to transit systems, because all activities are rarely far from the main spine.
The structure of Bangkok is not as depicted earlier in Figure 4.5 - a series of rings of development. Rather, the outer area is quite distinct and contains dense corridors similar to transit-oriented corridors in European cities, as suggested above. Figure 4.6 provides a conceptual outline of Bangkok’s urban form showing the high density walking city CBD, the extended walking city inner area and the medium density, transit-oriented outer area corridors. The concentration of mixed uses along the main road spine of these corridors is also shown.

![Bangkok urban form diagram]

**Figure 4.6 Bangkok's conceptual urban form**

### 4.3.2 Employment

The total number of people employed in the study area (i.e. number of jobs) is about 2.7 million. Job density for the whole area is 62 per ha. The CBD has approximately 272,000 jobs (10.2 per cent), giving a density of 132 jobs per ha. The inner area (including CBD) has 1.5 million jobs at a density of 120 jobs per ha and accounts for nearly 60 per cent of total jobs in Bangkok. The outer area has approximately 1.1 million jobs, which amounts to about 40 per cent of total jobs with a density of 38 jobs per ha (Table 4.4). Although the city centre has the highest job density, it is not much higher than the job density of the whole inner area. These data suggest that jobs in Bangkok do not concentrate only in the CBD, but rather distribute throughout the inner area. In addition, Bangkok's job densities maintain a proportion of approximately 40 per cent of population densities throughout the three zones.
Table 4.4 Employment in Bangkok by zone, 1989

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of jobs</th>
<th>Jobs/ha</th>
<th>% Total jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBD</td>
<td>271,944</td>
<td>132.2</td>
<td>10.2</td>
</tr>
<tr>
<td>Inner Area (including CBD)</td>
<td>1,535,247</td>
<td>119.5</td>
<td>57.8</td>
</tr>
<tr>
<td>Outer Area</td>
<td>1,121,885</td>
<td>37.7</td>
<td>42.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,657,132</strong></td>
<td><strong>62.4</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Sources: Calculations based on the following sources
1. Employment data from JICA, 1990
2. Urbanised area data from Appendix A

4.3.2.1 Job Density Compared to Global Cities

Bangkok's job density is typical for Asian cities. For example, the five Southeast Asian cities in Table 4.3 have on average 58 jobs per ha, ranging from 22 in Kuala Lumpur to 78 in Surabaya. Bangkok's job density is higher than for Singapore (49), but lower than for Tokyo (73),\(^{23}\) and much lower than for Hong Kong (148). Taking a broader perspective, Bangkok's job density is much higher than job densities in cities of the North. For instance, it is about twelve times as high as job densities in Australian cities (5 jobs per ha), more than seven times as high as that for American cities (8 jobs per ha) and nearly double that for European cities (32 jobs per ha). These relationships are illustrated in Figure 4.7.

![Figure 4.7 Bangkok's employment density compared to other global cities, 1990](image)

Figure 4.7 Bangkok's employment density compared to other global cities, 1990

Source: Table 4.3

\(^{23}\)This is the job density of the Tokyo metropolis of 11.6 million people, not the wider Tokyo Metropolitan Area of 31.8 million for which job data are not available.
4.3.2.2 Job Density in the CBD and the Inner Area

With respect to job density by area, the concentration of jobs in Bangkok's CBD is much lower than that of the Northern cities. For example, job density in Bangkok's CBD is about 132 per ha, or nearly one-fourth of American cities (502), and about one-third of the Australian and European cities (404 and 350). Furthermore, it is much less than richer Asian cities such as Singapore (386), Tokyo (547) and Hong Kong (1,713). However, this level of job density is not so different from those for cities in developing Southeast Asian countries, although it is considerably below the average of 210 in these cities. Job densities in the CBDs of Southeast Asian cities range from 178 per ha for Kuala Lumpur, to 203 for Jakarta, to 227 for Manila and to 310 for Surabaya. The reason for lower CBD job densities in developing cities was discussed in Chapter 3, section 3.11.1, in terms of the need to maintain accessibility in mobility constrained environments. This factor seems to be particularly accentuated in Bangkok's extremely congested conditions. The discussion later in this section expands on this point.

However, in terms of inner area job densities, Bangkok maintains a level significantly in excess of most other cities. At 120 jobs per ha it is about four times higher than US and Australia cities and about 40 per cent higher than in European cities. It is similar to Singapore and Tokyo and is only significantly eclipsed by Hong Kong at 775 jobs per ha.

In terms of the proportion of metropolitan jobs located in each area, Bangkok's CBD is quite low (10.2 per cent), compared to European cities (19.7 per cent), Singapore (18.2 per cent), Tokyo (27.7 per cent), Australian cities (14.3 per cent), and even compared to Southeast Asian cities such as Jakarta (31 per cent), Kuala Lumpur (24 per cent), Surabaya (46 per cent). Only the American cities have nearly the same proportion of jobs in the CBD as Bangkok (10.8 per cent). However, in terms of the proportion of metropolitan jobs in the inner area, 57.8 per cent of Bangkok's jobs are located in this area, a situation close to that of the other Asian cities in the study. For example, Jakarta has 59 per cent of jobs in the inner area, Kuala Lumpur has 53 per cent, and Hong Kong has 43 per cent. From the wider perspective, the proportion of Bangkok's jobs in the inner area is almost identical to the average for European cities (58.1 per cent), a little higher than
its wealthier Asian neighbours (54.2 per cent) and much higher than the American cities (31.5 per cent) and Australian cities (37.2 per cent).

The data presented above indicate that a high proportion of Bangkok's population lives in dense conditions in the city centre and in the inner area, as is the case in other Southeast Asian cities. European cities and richer Asian cities also have moderately dense populations in the CBD. By contrast, Australian and American cities have very low population densities in their central cities. In terms of job density, Bangkok and Southeast Asian cities also have moderately high densities in their CBD, but especially in their inner areas. This density reflects the traditional way of life of people in Asian cities, where they live and do business in the same buildings in mixed-use neighbourhoods. However, many offices and shopping centres in the CBD of these cities have recently emerged and have been utilised in the same way as those in Western cities. People now come to work during the daytime and leave for their homes in other areas at the end of the work day.

Thus, one common characteristic of Southeast Asian city CBDs is the mix between traditional shophouses and modern high-rise buildings. On the other hand, the central areas of most American and Australian cities have very low population densities but very high employment densities. This means that their CBDs are characterised by modern offices where workers come to work during business hours and live elsewhere. European cities and richer Asian cities' CBDs also have some similar characteristics to those of American and Australian cities. However, they have much higher population densities, which simply means that there are more people living in their central cities with potential to access the concentration of jobs found in the CBD.

Bangkok, in common with other Southeast Asian cities, also has high population and job densities in the inner area, only slightly lower than population and job densities in the CBD. By contrast, American and Australian cities have much higher population densities in the inner areas than in the CBD (the "doughnut" effect), but their inner job density is much lower than the job density in the CBD (about one-twentieth). This phenomenon is also seen in Europe and richer Asian cities, but the contrast is not as strong as in the American and Australian cities.
These data suggest that Bangkok and Southeast Asian cities exhibit mixed land-use characteristics for residential and commercial/business purposes without such a strong and distinct central business district (CBD) as in Western cities. This finding is compatible with findings by Rimmer (1986, cited in Barter and Kenworthy 1995: 5), who argues that developing Southeast Asian cities appear to have weak centres of business activity, as they have been developed from the "walking city" through motorisation, mainly based upon bus transport, compared with most cities of the North which grew around radial rail systems which assisted in strongly focussing jobs in one centre. Lower capacity and slower bus systems are not nearly as effective at concentrating jobs. In general, mixed land-use is seen to be preferable as it enriches working and living environments, reduces vehicular trip-making, and offers more opportunities for walking and cycling to work (Cervero, 1986: 392).

Next to Bangkok and Southeast Asian cities are the richer Asian cities. Then come the European cities, with stronger centres of business activities but weaker mixed land-use. The American and Australian cities are located at the other end of the spectrum. They generally exhibit clear CBD areas, mainly for commercial and business activities, but with very low population densities. These relatively low population densities continue into the inner areas, with a dramatic drop in job densities as well. The land-use patterns of Australian and American cities seem to induce higher levels of vehicular trip-making to work, thus requiring longer commuting distances.

4.3.3 Summary of Bangkok's Urban Form and Land-Use

Bangkok's urban form and land-use compared to other cities are summarised in a qualitative form as shown in Table 4.5.
### Table 4.5 A summary comparison of urban form and land-use of Bangkok with other cities

<table>
<thead>
<tr>
<th>City</th>
<th>Whole city density</th>
<th>Job density profile</th>
<th>Central and Inner area land use</th>
<th>Transport modes most facilitated by urban form and land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangkok</td>
<td>high</td>
<td>moderately steep</td>
<td>highly mixed</td>
<td>Walking, cycling, transit</td>
</tr>
<tr>
<td>Southeast Asian cities</td>
<td>high</td>
<td>highly mixed</td>
<td></td>
<td>Walking, cycling, transit</td>
</tr>
<tr>
<td>Richer Asian Cities</td>
<td>high</td>
<td>weakly mixed for the most part</td>
<td></td>
<td>Transit with moderate walking and cycling</td>
</tr>
<tr>
<td>European Cities</td>
<td>medium</td>
<td>steep</td>
<td>highly mixed</td>
<td>Transit with moderate walking and cycling</td>
</tr>
<tr>
<td>Australian Cities</td>
<td>very low</td>
<td>steep</td>
<td>weakly mixed for the most part</td>
<td>Private vehicles with transit for selected trips</td>
</tr>
<tr>
<td>American Cities</td>
<td>very low</td>
<td>steep</td>
<td>weakly mixed for the most part</td>
<td>Private vehicles with limited transit opportunities for the most part</td>
</tr>
</tbody>
</table>

In terms of urban form, Bangkok has retained its high-density, mixed use urban structure, especially in the CBD and inner area, despite the impact of the era of intense motorisation. It has a substantial walking city core, an extended walking density inner area, which can also be served effectively by transit, and is surrounded by corridors of relatively high density, mixed use, transit city urban structure. Few parts of Bangkok are really yet built exclusively for cars, apart from some of the exceptionally far-flung new residential estates, but these are still at densities far in excess of suburban, auto-based densities in Australian and US cities. Bangkok’s central and inner areas are characterised by mixed land-use (commercial/business and residential), which offers greater opportunity for walking and cycling. However, as noted in Chapter 2, in the outer zone, the built-up area is extending very quickly (as far as 30 km or more), and, increasingly, most residents have to travel long distances to workplaces which are located mainly in the inner area. Of even greater concern is the fact that many newly developed outer areas are not served by public transport, even though densities would support a reasonable transit service. This requires Bangkok’s residents who live in the outer area to rely even more heavily on private vehicles, and to place escalating pressure on an already heavily burdened road system, especially in the central and inner areas.

On the whole, land-use and urban form in Bangkok are inherently supportive of high levels of public transport, walking and cycling, though as
discussed in detail in the remainder of this chapter, there are many factors mitigating against the exploitation of this land-use advantage.

4.4 TRANSPORT INFRASTRUCTURE

Transport in Bangkok, in common with most other big cities around the world, relies mainly on a network of land transport, particularly roads. However, as Bangkok is located on the banks of the Chao Phraya River and its tributaries, and it was originally built primarily around a comprehensive waterway system, this waterway network still has a role to play in Bangkok transport.

This section provides a comprehensive examination of present transport infrastructure in Bangkok covering the road network, railway system, waterway network and the essential ancillary to the road network, the parking infrastructure in Bangkok. It also puts Bangkok into the international comparison to obtain a better perspective of Bangkok's infrastructure by employing data on global cities as shown in Table 4.6.

4.4.1 Road Network

As Bangkok is the centre of the whole country's activities, the road system serves not only transport and communication within the city, but also intercity transport. The main intercity routes are the north, the northeast and the southwest corridors (JICA, 1990).

4.4.1.1 An Overview of Bangkok's Road Network

Bangkok's road network is a combination of a radial/circumferential system and a grid system. In terms of the circumferential system, there are two major roads: the Middle Ring Road and the Outer Ring Road. The middle ring road is comprised of Ratchada Phisek Road in the east and Charan Sanitwong Road in the west. The outer ring road has so far been built only in sections, as shown in Figure 4.8. The radial road system consists of nine main roads: Vibhawadi Rangsit/Phahon Yothin and Pracha Chuen in the north, Phetchaburi/New Phetchaburi, Sukhumvit and Rama IV in the east, Suksawat, Thonburi-Pak Tho, Phet Kasem and Bangkok Noi-Nakhon Chaisri in the west. The
Table 4.6 Bangkok’s transport infrastructure data compared to other cities, 1990

<table>
<thead>
<tr>
<th>City</th>
<th>Road supply (m/person)</th>
<th>Road density (m/ha)</th>
<th>Rail route supply (m/1000persons)</th>
<th>Rail route density (m/1000ha)</th>
<th>Parking spaces per 1000 CBD workers</th>
<th>% on-street parking</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston</td>
<td>11.7</td>
<td>111.2</td>
<td>0.0</td>
<td>0</td>
<td>612</td>
<td>7.1</td>
</tr>
<tr>
<td>Phoenix</td>
<td>9.6</td>
<td>100.8</td>
<td>0.0</td>
<td>0</td>
<td>906</td>
<td>6.2</td>
</tr>
<tr>
<td>Detroit</td>
<td>6.0</td>
<td>76.8</td>
<td>0.0</td>
<td>0</td>
<td>706</td>
<td>?</td>
</tr>
<tr>
<td>Denver</td>
<td>7.6</td>
<td>97.3</td>
<td>0.0</td>
<td>0</td>
<td>606</td>
<td>4.6</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>3.8</td>
<td>90.8</td>
<td>4.1</td>
<td>97</td>
<td>520</td>
<td>?</td>
</tr>
<tr>
<td>San Francisco</td>
<td>4.6</td>
<td>73.6</td>
<td>64.4</td>
<td>1,049</td>
<td>137</td>
<td>2.3</td>
</tr>
<tr>
<td>Boston</td>
<td>6.7</td>
<td>80.4</td>
<td>135.6</td>
<td>1,521</td>
<td>285</td>
<td>20.0</td>
</tr>
<tr>
<td>Washington</td>
<td>5.2</td>
<td>75.3</td>
<td>104.7</td>
<td>1,508</td>
<td>253</td>
<td>?</td>
</tr>
<tr>
<td>Chicago</td>
<td>5.2</td>
<td>86.5</td>
<td>135.1</td>
<td>2,390</td>
<td>128</td>
<td>4.6</td>
</tr>
<tr>
<td>New York</td>
<td>4.6</td>
<td>88.5</td>
<td>81.9</td>
<td>1,573</td>
<td>60</td>
<td>18.1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>6.5</td>
<td>88.1</td>
<td>52.6</td>
<td>814</td>
<td>421.3</td>
<td>9.0</td>
</tr>
<tr>
<td>Australian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perth</td>
<td>10.7</td>
<td>113.4</td>
<td>55.1</td>
<td>586</td>
<td>631</td>
<td>9.8</td>
</tr>
<tr>
<td>Brisbane</td>
<td>8.2</td>
<td>80.4</td>
<td>147.0</td>
<td>1,438</td>
<td>322</td>
<td>?</td>
</tr>
<tr>
<td>Melbourne</td>
<td>7.7</td>
<td>114.7</td>
<td>224.3</td>
<td>3,345</td>
<td>337</td>
<td>5.9</td>
</tr>
<tr>
<td>Adelaide</td>
<td>8.0</td>
<td>94.4</td>
<td>136.2</td>
<td>1,601</td>
<td>380</td>
<td>23.5</td>
</tr>
<tr>
<td>Sydney</td>
<td>6.2</td>
<td>104.2</td>
<td>241.2</td>
<td>4,057</td>
<td>222</td>
<td>9.1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>8.2</td>
<td>101.4</td>
<td>160.8</td>
<td>2,208</td>
<td>418</td>
<td>12.1</td>
</tr>
<tr>
<td>European Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamburg</td>
<td>2.6</td>
<td>103.5</td>
<td>117.7</td>
<td>3,742</td>
<td>177</td>
<td>?</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>2.0</td>
<td>93.2</td>
<td>208.1</td>
<td>5,117</td>
<td>246</td>
<td>17.7</td>
</tr>
<tr>
<td>Zürich</td>
<td>4.0</td>
<td>188.4</td>
<td>694.6</td>
<td>32,706</td>
<td>137</td>
<td>41.1</td>
</tr>
<tr>
<td>Stockholm</td>
<td>2.2</td>
<td>116.8</td>
<td>178.9</td>
<td>6,536</td>
<td>193</td>
<td>15.7</td>
</tr>
<tr>
<td>Brussels</td>
<td>2.1</td>
<td>157.3</td>
<td>237.5</td>
<td>17,791</td>
<td>314</td>
<td>23.0</td>
</tr>
<tr>
<td>Paris</td>
<td>0.9</td>
<td>41.5</td>
<td>171.9</td>
<td>7,933</td>
<td>199</td>
<td>?</td>
</tr>
<tr>
<td>London</td>
<td>2.0</td>
<td>84.6</td>
<td>247.1</td>
<td>6,221</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Munich</td>
<td>1.8</td>
<td>96.5</td>
<td>285.7</td>
<td>8,571</td>
<td>266</td>
<td>21.1</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>4.6</td>
<td>131.6</td>
<td>166.0</td>
<td>4,739</td>
<td>223</td>
<td>50.7</td>
</tr>
<tr>
<td>Vienna</td>
<td>1.8</td>
<td>122.9</td>
<td>323.0</td>
<td>22,087</td>
<td>186</td>
<td>54.7</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>2.6</td>
<td>126.9</td>
<td>234.7</td>
<td>11,458</td>
<td>354</td>
<td>66.4</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>2.4</td>
<td>114.8</td>
<td>261.3</td>
<td>11,536</td>
<td>230</td>
<td>36.3</td>
</tr>
<tr>
<td>Richer Asian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tokyo</td>
<td>3.9</td>
<td>273.4</td>
<td>67.9</td>
<td>4,820</td>
<td>43</td>
<td>7.5</td>
</tr>
<tr>
<td>Singapore</td>
<td>1.1</td>
<td>95.5</td>
<td>24.8</td>
<td>2,150</td>
<td>164</td>
<td>5.5</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.3</td>
<td>84.1</td>
<td>21.2</td>
<td>6,362</td>
<td>33</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>1.8</td>
<td>151.0</td>
<td>38.0</td>
<td>4,451</td>
<td>80</td>
<td>6.0</td>
</tr>
<tr>
<td>Southeast Asian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangkok</td>
<td>0.6</td>
<td>89.6</td>
<td>15.7</td>
<td>1,238</td>
<td>397</td>
<td>62.9</td>
</tr>
<tr>
<td>Jakarta</td>
<td>0.5</td>
<td>85.4</td>
<td>5.9</td>
<td>1,143</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Kuala Lumpur</td>
<td>1.5</td>
<td>88.1</td>
<td>15.0</td>
<td>2,662</td>
<td>297</td>
<td>?</td>
</tr>
<tr>
<td>Manila</td>
<td>0.6</td>
<td>118.8</td>
<td>9.7</td>
<td>1,919</td>
<td>27</td>
<td>?</td>
</tr>
<tr>
<td>Surabaya</td>
<td>0.3</td>
<td>53.1</td>
<td>0.0</td>
<td>0</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>0.7</td>
<td>87.0</td>
<td>9.3</td>
<td>1,392</td>
<td>240</td>
<td>62.9</td>
</tr>
</tbody>
</table>

Sources: 1. Rail route data from Appendix B
2. The other data for Bangkok from Appendix A
grid system in Bangkok consists of a series of roads located mostly in the old city centre and CBD.

Figure 4.8 shows this basic structure of Bangkok's road network including the main intercity routes. This road network is bounded by the Outer Ring Road which encompasses the main part of the Bangkok Metropolitan Administration (BMA), and the urbanised area of three satellite towns surrounding the BMA namely Nonthaburi, Pathum Thani and Samut Prakan.

In terms of the basic road network structure in Bangkok, several studies suggest that Bangkok's road system is generally not a satisfactory one. The network is coarse and poor in both the quantity and quality of road provided. There is, according to a number of studies, a lack of coordination between expressways, main roads and access roads which results in a poor and inefficient road hierarchy. There are also inadequacies in the level of provision of secondary and distributor roads. Moreover, there are a number of missing links. According to the studies, these missing links and other factors lead to excessively long trip distances and innumerable traffic bottlenecks (JICA, 1990: 80; Halcrow Fox and Associates et al., 1991: 6-26, 6-27). These claims are examined in more detail later.

It is clear from these reports that many commentators see Bangkok's traffic crisis stemming primarily from an inadequate road system. However, these studies have, by and large, judged Bangkok on the basis of much more developed cities in the western world. They have never gone further to examine the broader roots of Bangkok's traffic crisis and appear to have never systematically compared Bangkok to other cities in developing countries to see how similar or different Bangkok is in terms of road infrastructure. The next section will systematically examine Bangkok's road network issue by comparing it to other cities around the world, particularly cities in developing Southeast Asian countries.
Figure 4.8 The road network in Bangkok

Source: Reproduced from JICA, 1990: Figure 3.2.2

Notes: 1. Expressways are updated to June 1996 by information from ETA.
2. Main roads and highways are updated by information from Department of Highways.
4.4.1.2 Bangkok’s Road Network in an International Comparison

Table 4.7 shows that currently in Bangkok there are around 980 km of major roads, comprised of primary and secondary routes and distributors, and 2,800 km of small local access streets (sois). In addition, there are three expressways. The first route, Chalerm Mahanakorn Expressway, has been in operation since 1987, and is around 27 km long. The second stage expressway, which is 20.4 km long and runs from Jang Wattana Road to Rama IX Road, was opened for users in 1993. The third expressway is the 15.4 km Don Muang Tollway linking Bangkok International airport with the Chalerm Mahanakorn Expressway (Prachachart Thurakit (Special Issue), 1993: 26-43; Townsend, 1995: 86-90).

Table 4.7 Existing Road Network Length in Bangkok

<table>
<thead>
<tr>
<th>Road Length (km)</th>
<th>Inside Ring Road</th>
<th>Middle Ring Road</th>
<th>Outside Ring Road</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Roads</td>
<td>304</td>
<td>674</td>
<td></td>
<td>978</td>
</tr>
<tr>
<td>Sois</td>
<td>825</td>
<td>2,000</td>
<td></td>
<td>2,825</td>
</tr>
<tr>
<td>Total</td>
<td>1,129</td>
<td>2,674</td>
<td></td>
<td>3,803</td>
</tr>
</tbody>
</table>

Source: JICA, 1990: 84; Table 3.2.2

Data on road length in Bangkok show that it has 0.6 metres of road per capita. As shown in Figure 4.9, in an international perspective, this is very low as it is only one-tenth or less the level found in Australian and American cities, and one-fourth the average for European cities. However, it is not much lower than for the richer Asian city of Singapore (1.1). In fact, it doubles that for Hong Kong (0.3). Moreover, when we compare Bangkok’s per capita road length to other large cities in developing Asian countries, Bangkok is not so unusually low. For example, Surabaya has only 0.3 metres per capita, Jakarta only 0.5 metres, Manila 0.6 metres and Kuala Lumpur has 1.5 metres per person.
Figure 4.9 Urban roads per capita in Bangkok compared to other international cities, 1990

Source: Table 4.6

Thus the land-use picture suggested earlier, consisting of a "walking city" inner zone and a "transit city" outer zone is borne out by the physical reality of very low road availability per capita, as is usually found in such concentrated cities, particularly Asian cities. It begins to highlight how just a relatively small number of cars can fill the available road space very quickly if there are no policy constraints to limit car ownership and use.

Furthermore, as shown in Figure 4.10, the data from the international comparison reveals that Bangkok's road density, which is about 90 metres per ha, is in common with other cities around the world. This level is even slightly higher than that for the American cities (88 metres per ha), and not a lot lower than that found in Australian cities (101 metres per ha) and European cities (115 metres per ha). Thus, in this respect, Bangkok and other Asian cities already have what might be called normal levels of road infrastructure provision, as found in cities of the North. It also begins to indicate that any attempts to match Bangkok's road provision per capita with cities of the North (at least a fourfold increase to match that found in European cities), are unlikely to be feasible given the city's dense, tightly woven urban fabric. This is because its density of roads per ha would also need to increase by a similar proportion, giving the city an extraordinarily high length of road per urban ha. Chapter 5 discusses this issue in more detail.
Figure 4.10 Urban road density in Bangkok compared to other world cities, 1990

Source: Table 4.6
Note: Tokyo's road length includes all small lane ways

4.4.2 Railway Network

The railway system in Thailand is solely operated by the state enterprise, the State Railway of Thailand (SRT). The system is an inter-regional, not an urban system, linking Bangkok as the centre with the rest of the country. Currently, there are four main lines; the northern, the northeastern, the eastern and the southern lines. In addition, there is a minor line linking Bangkok and Mae Klong, a district located around 60 kilometres southwest of Bangkok. The total length of the national railways in Thailand is around 4,000 kilometres. Most of the tracks are single. Only from Bangkok to Phachi, which is about 90 kilometres in length, is there a double track (State Railway of Thailand, 1993).

However, the national railway network also caters to urban commuters to a limited extent within a radius of 30 kilometres from the Bangkok city centre, except the northern line which serves up to 50 kilometres. There are altogether only 30 stations within the Bangkok urban area; 8 stations along the northern line, 6 stations on the eastern line, 8 stations on the southern line, and 7 stations along the minor Mae Klong line, plus the centre station at Hua Lamphong (Figure 4.11).

The current route length of railways in the greater Bangkok Area is 120 km serving the 30 stations shown in Figure 4.11. In 1972, the route length in the
Figure 4.11 Railway network in Bangkok

Source: Reproduced from JICA, 1990: Figure 4.5.1
GBA was 112 km. In the core area at that time, there was only 27 km of rail routes, and only the Northern line and part of the Eastern Line (between Yommarat Junction and Makkasan) had double tracks (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975). These infrastructure are almost the same as that of the present time, demonstrating only very minor improvements in the railway system.

In contrast, a number of Asian cities have been rapidly implementing new urban rail systems. For example, Singapore's Mass Rapid Transit (MRT), which has been operating since 1987, consists of two double-tracked lines with a total length of 67 kilometres of which 19 km is underground and 44.8 km elevated. The system services 42 stations (Bushell, 1993: 332). Plans are for a much more extensive radial and circumferential system of both heavy and light rail consisting of 160 km of double track service.\(^{24}\) Hong Kong in 1987 had 116.1 km of urban rail line which consisted of 34.4 km of MTR underground, 7.6 km of elevated MTR track, 23.3 km of light rail track, 16.8 km of tramway and a 34 km line from Kowloon to Canton (KCR line), servicing a total of 190 stations (Bushell, 1993: 133-136). Tokyo has been continuously developing its railway network for nearly 120 years. In 1877 Tokyo introduced trams for the first time, only a short time before Bangkok. In 1991 there were more than 1,800 km of at-grade railway track and 241 km of underground network in the Tokyo metropolitan area, much of which has been developed in the last 30 years (Kasahara, 1994: 60). Tokyo's underground system alone covers 207 stations (Bushell, 1993: 350-357). Like Bangkok, Tokyo removed virtually all of its old tram system, but in contrast to Bangkok, Tokyo progressively implemented a vast network of commuter and underground rail.

Other cities in the developing world are also implementing new rail systems. For example, Manila has been operating an elevated light rail system since 1984 with a length of 14 km (Bushell, 1993). Kuala Lumpur is also working on a rail system consisting of surface electric trains and light rail (elevated through the city centre) (Muhummad, 1995: 22). The surface electric system consists of two double-tracked lines with a length of 48 km and 105 km,

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serving 39 stations and was opened in 1995.\textsuperscript{25} The first phase of the urban elevated/at-grade light rail network with a length of 12 km serving 13 stations has been operating since the middle of 1996. In addition, there are three more rail projects to be constructed and by the year 2000 Kuala Lumpur is expected to have 280 km of electric passenger rail (personal communication, Paul Barter, January 1997).

Mexico City, a city of nearly 20 million inhabitants and also very notorious for traffic congestion, inaugurated its Metro system in 1969 with one line of 12.7 km and 16 stations. At present, it consists of a network of 9 lines with a length of 141 kilometres and 125 stations (Bauer and Quintanilla, 1991: 52).

Bangkok is still therefore one of a rapidly diminishing number of large world cities without a quality rail system. Although there are currently three mass rapid transit projects proposed, only one elevated train project with a length of 23 km is under construction, while the other two are unlikely to eventuate in the near future. Chapters 5 and 6 examine this policy issue in more detail.

A quantitative examination of Bangkok’s rail network compared to other cities around the world begins to reveal the paucity of rail service available. In terms of railway route length, Bangkok has a very low level of infrastructure provision and these existing tracks are, as mentioned previously, mainly used for regional transport purposes. Bangkok with only 120 km of tracks, has a per capita provision of only 16 metres per 1,000 inhabitants. In comparison, in 1990, the eleven European cities in Table 4.6 on average have 261 metres per 1,000 persons, the five Australian cities have 161 metres, the ten American cities have 53 metres, and the richer Asian cities of Tokyo, Singapore and Hong Kong have 68, 25 and 21 metres of high quality urban rail network respectively (Figure 4.12).

\textsuperscript{25}The 105 km line runs from Rawang (32 km from the CBD) via the city centre to nearby city of Seremban (73 km from the CBD).
Figure 4.12 Railway route length per 1,000 urban inhabitants, 1990

Source: Table 4.6

With regard to railway route length density, Bangkok has 1,238 metres of railway tracks per 1,000 ha of urbanised area. This figure is also very low when compared to European cities which average 11,536 metres per 1,000 ha ranging up to 32,700 metres per 1,000 ha of urbanised area in Zurich. The three richer Asian cities have on average 4,451 metres, or nearly four times as much as Bangkok. Even the low density Australian cities with their high dependence on cars, have on average 2,205 metres of rail per 1,000 ha of urbanised land. Furthermore, the developing Southeast Asian cities of Kuala Lumpur and Manila have much higher rail network density than Bangkok. On the other hand, the sprawling American cities have only 814 metres of tracks per 1,000 ha, though this is genuine urban rail network, not inter-regional systems used for some urban commuting as in Bangkok (Figure 4.13). The low US figure is primarily due to the four cities without any rail service at all, and Los Angeles which is only just beginning to develop one. For the cities with established rail networks, the route length density is higher at 1,608 metres per 1,000 ha, or 30 per cent more than in Bangkok.
The data presented above reveal the very low level of railway infrastructure in Bangkok in an international perspective. It begins to highlight the inconsistency between Bangkok's urban form which is, as mentioned earlier, ideal for transit, particularly rail along already established high density corridors. This issue is discussed in detail in Chapter 5.

4.4.3 Waterway Network

As described in Chapter 2, Bangkok once depended heavily on water transport. The land is low and flat around the Chao Phraya River estuary. It is only 1 to 1.5 metres above mean sea level. The Chao Phraya River and a comprehensive network of canals served for many years as the main mode of transport and communication both within the city and for inter-city transport. Although a number of canals have been filled in or have become shallow, as noted in Chapter 2, the waterway network in Bangkok is still comprehensive, and is unique among all cities in the study.

According to the 1941 Canal Maintenance Act, which is still currently enforced, there were altogether ninety-two canals in Bangkok of which sixty-three were on the east bank and twenty-nine on the west bank (Bongsadadt and Leelahacheeva, 1984). Figure 4.14 shows the network of existing waterways in Bangkok.
Figure 4.14 River and canal network in the Greater Bangkok Area (GBA)

Sources: Reproduced from Bunnag et al., 1982: Map 1; Bongsadad and Leelahacheeva, 1984; and JICA, 1990: Figure 4.6.1
Canals in Bangkok can be classified into three groups by their functions and their width (Bongsadadt and Leelahacheeva, 1984):

(1) The primary canals

This group consists of five canals namely Klong Bangkok Noi, Klong Maha Savat, Klong Tawee Wattana, Klong Phasi Charoen and Klong Bangkok Yai. They have widths of at least 30 metres and serve as transport routes, people’s daily household water supply, water supply for farms and orchards and other uses. Most of these are on the west bank of the Chao Phraya River.

(2) The secondary canals

This group consists of smaller canals but which are still in good condition and provide a high level of utility for people who live along them. Their widths are from 10-30 metres. There are thirty-eight canals classified in this group located on both sides of the Chao Phraya River.\(^{26}\)

On the west bank of the river there are fewer secondary canals than on the east bank but they have generally remained as more active transport routes than on the east bank. The main west bank canals are Klong Bang Sai Kai and Klong Bang Sakae.

(3) The distributor canals

This group consists of canals of less than 10 metres in width. They constitute an interlinking network on both banks and on the east bank most of them are located in Bangkok’s outer area.

The Chao Phraya River and canals in the BMA occupy a significant area. While roads amount to 3,845 ha, the waterway area amounts to 5,436 ha. If waterways are considered part of the urbanised area, then they would be constitute 14 per cent of the BMA and roads would occupy 10 per cent of the

BMA. Assuming that the waterways still fulfilled an active transport role as they did in earlier periods in Bangkok, then it could be suggested that Bangkok Metropolitan Area already has some 24 per cent of its urban area devoted to movement purposes, a figure more typical of Western cities. Whilst however the canals remain neglected, little advantage is being exploited.

The whole waterway system of the BMA which consists of the Chao Phraya river and canals, constitutes a length of nearly 1,000 kilometres. The waterway network in inner Bangkok has altogether a length of more than 350 km while the waterways in outer Bangkok constitute a network of more than 600 km (Khaoprasert, 1977 quoted in Bunnag et al., 1982: 156-157). There are approximately 640 km of canals with a width of around 8 metres or more. It is these canals which have potential to fulfil quite a significant mass transport function. If the length of potentially useful, navigable waterways is added to the length of the road network, the per capita provision of "roads" in Bangkok increases from 0.6 metres per person to 0.72 metres per person, or a 20 per cent increase in movement facilities per person.

4.4.4 Parking Provision

Parking provision is another factor significantly affecting transport patterns in cities around the world, especially the amount provided in the city centre (Newman and Kenworthy, 1988, 1989). Parking is classified into on-street and off-street spaces. In Bangkok on-street parking is very restricted on most major roads, particularly during peak period, but it is available on most minor roads and sois. Off-street parking is available in most big private and government offices and in large new department stores. Most older parking facilities are surface lots, but due to the very high price of central city land, most new parking facilities are likely to be multi-storeyed. There is almost no control of the off-street parking supply apart from along main roads (JICA, 1990: 115; Pboon et al., 1994: 11).

The only data available on parking in Bangkok is from the JICA survey, in The Study on Medium to Long-Term Improvement/Management Plan of Road and

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28Calculation based on canal data from BMA
Road Transport in Bangkok, 1990. This study surveyed both on-street parking and off-street parking in Bangkok's old CBD which is the area surrounded by the Chao Phraya River and Krung Kasem Road. The survey area is approximately 9 square kilometres and was divided into 6 zones (Figure 4.15).

![Image of parking survey area]

Figure 4.15 Parking survey area

Source: Reproduced from JICA, 1990: Figure 3.3.11

4.4.4.1 On-Street Parking

Calculated from the length of legal parking sections along roads and streets in the old CBD area, the total on-street parking capacity estimated by JICA is around 32,000 spaces (Passenger Car Units or PCU). This is by far the biggest parking resource in central Bangkok, unlike in virtually every other city examined where on-street parking is mostly small compared to off-street supply (see later). Zones 2-1, 4-1 and 4-3 have comparatively high levels of parking density throughout the day as they are in busy business areas. In zones 1, 3, 5 and 6 the parking densities are relatively high during the
daytime, but sharply decrease in the late afternoon as parking in these zones is mainly for work and business, but in zone 3 the parking density increases again in the evening as people come to drink or eat around this area. In zones 2 and 4 the parking densities remain almost constant over the whole day because people who live in these zones use the streets as their garages.

4.4.4.2 Off-Street Parking

As shown in Table 4.8, off-street parking capacity in the old CBD of Bangkok is 18,848 spaces (PCU) of which 12,096 spaces are in surface lots and the rest are in parking buildings. Multi-storeyed parking lots account for 5,160 spaces or 76 per cent of indoor parking spaces as the land price is extremely high in the area where indoor parking is prevalent.

The number of off-street parking spaces is very high in zone 4 because this zone contains very active businesses, shopping centres and hotels which provide many multi-storeyed parking facilities.

Table 4.8 Off-street parking in Bangkok's old CBD

<table>
<thead>
<tr>
<th>Zone No.</th>
<th>Open Space</th>
<th>Type of Parking Lot Building</th>
<th>Free and Toll</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1-Storey</td>
<td>Multi-Storeyed</td>
</tr>
<tr>
<td>1</td>
<td>1250</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1067</td>
<td>190</td>
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<tr>
<td>3</td>
<td>2366</td>
<td>705</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>5158</td>
<td>259</td>
<td>2786</td>
</tr>
<tr>
<td>5</td>
<td>1567</td>
<td>297</td>
<td>360</td>
</tr>
<tr>
<td>6</td>
<td>688</td>
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<td>1440</td>
</tr>
<tr>
<td></td>
<td>12096</td>
<td>1646</td>
<td>5160</td>
</tr>
</tbody>
</table>

Source: JICA, 1990: Table 3.3.7

In terms of parking charges, 14,507 spaces or 77 per cent of total off-street parking spaces are free. This is a very open and easy parking policy which encourages high car use. On-street parking spaces are likewise free. There are no parking meters installed on any road in Bangkok.
Total parking supply in Bangkok’s CBD amounts to 50,848 spaces of which 63 per cent is on-street. By contrast, for all the other cities in this comparison where off-street and on-street spaces are available, the proportion of on-street spaces to total spaces is only some 18 per cent. The European cities on average have about 36 per cent on-street parking, while, the Australian, the American and the richer Asian cities have only 12 per cent, 9 per cent and 6 per cent on-street parking spaces respectively (Figure 4.16).

![Bar chart showing percentage of on-street parking in the CBD of Bangkok and other world cities, 1990](image)

**Figure 4.16 Comparative percentage of on-street parking in the CBD of Bangkok and other world cities, 1990**

Source: Table 4.6

Based on the Bangkok CBD parking data and employment numbers, the ratio of parking spaces to the number of jobs in the city centre is 397 spaces per 1,000 workers. As shown in Figure 4.17 this proportion is very high compared with the richer Asian cities of Singapore (164), Tokyo (43) and Hong Kong (33), and much higher than for European cities (230), Kuala Lumpur (297) and Manila (27). Interestingly, Bangkok’s CBD parking supply is only slightly lower than for Australian cities (418) and American cities (421), which are generally heavily car-oriented in their city centres (Figure 4.17).
Despite having an urban environment which in land-use and road infrastructure terms is structured against car use, Bangkok provides parking more like an average American or Australian city. Parking provision in Bangkok in 1990 was even higher than a number of American and Australian cities. For example, New York has 60 parking spaces per 1,000 CBD jobs, Chicago has 128, Boston has 285, Sydney has 222, and Melbourne has 337.

It can be argued that high levels of parking provision coupled with free or very cheap parking have, to some extent, been contributing to Bangkok’s burgeoning private car use and the increasingly hostile condition of the public environment. This issue is discussed in detail in Chapter 5.

4.5. TRANSPORT AND ENERGY USE PATTERNS

Transport patterns in cities provide the important indicators to show whether cities are based mainly on public transport or private transport. They also demonstrate how strongly non-motorised modes are playing a role in urban transport. This section explores Bangkok’s transport patterns in terms of vehicle ownership, traffic speed, trip characteristics, private and public transport use and energy consumption in transport. Similar to the previous sections, data on global cities, as shown in Table 4.9 are used to
<table>
<thead>
<tr>
<th>City</th>
<th>Gasoline use (MJ per capita)</th>
<th>Total vehicles per 1000 people</th>
<th>Car ownership per 1000 people</th>
<th>Average speed of traffic (km/h)</th>
<th>Average speed of public transport (km/h)</th>
<th>Total private vehicle kms per capita</th>
</tr>
</thead>
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<td></td>
<td></td>
<td></td>
<td>Bus Train Tram Ferry Total system</td>
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<td></td>
</tr>
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<td>644</td>
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<td>24.5 -</td>
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<td>693</td>
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<td>753</td>
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<td>690</td>
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<td>19.9 -</td>
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Table 4.9 (cont.)

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Sources: 1. Bangkok's data from Appendix A
compare Bangkok with other cities, particularly Asian cities, to see where
Bangkok's transport patterns lie in an international perspective.

4.5.1 Vehicle Ownership

Despite road space limitations, the motor vehicle population in Bangkok has
been soaring dramatically. As mentioned in Chapter 2, the number of motor
vehicles began to increase noticeably after the end of World War II but
increased especially sharply from 1980 onwards.

In 1980 there were in round figures 610,000 motor vehicles registered in the
Bangkok Metropolitan Area (BMA), of which 299,000 were cars, 55,000 were
pick-ups and 172,000 were motorcycles. In 1990 the number had markedly
increased to 2,046,000 of which about 899,000 were cars, 269,000 were pick-
ups and 729,000 were motorcycles (Figure 4.18).

![Figure 4.18 Number of motor vehicles registered in the Bangkok Metropolitan Area (BMA) in 1980 and 1990](image)

Source: Department of Land Transport, 1980, 1990

In Bangkok most pick-ups (private small trucks) are utilised for the same
activities as cars and as shown in the data, the pick-up population, along
with motorcycles and cars, has been growing very rapidly (Figure 4.18). This
phenomenon is the result of two major factors; first, the price of a pick-up is
about half of the price of a car, and second, most pick-ups consume diesel,
which is much cheaper than gasoline. For example, in 1989 the price of a
Toyota Corona, a reasonably representative private car in Bangkok, was
around 500,000 baht (US$20,000), whereas the price of a Toyota Hilux, a representative pick-up, was only about 265,300 baht (US$10,600). In the same year, the retail price of super gasoline was 8.45 baht (US$0.34) per litre, and the retail price of regular gasoline was 7.75 baht (US$0.31), compared to the retail price of diesel which was 6.10 baht (US$0.24), or about 28 per cent cheaper than super gasoline and 16 per cent cheaper than regular gasoline (JICA, 1990: 346, 349).

In spite of a rapidly worsening traffic situation in Bangkok, a large number of private motor vehicles continue to be introduced onto Bangkok's roads everyday. For the 11 months from September 1993 to July 1994 there were 131,102 new private cars, 64,534 new pick-ups and 215,125 new motorcycles registered in Bangkok. This represents an estimated daily increase on Bangkok roads of 400 cars, 200 pick-ups and 600 motorcycles (Department of Land Transport, 1993, 1994). Assuming an average length of 5 metres per vehicle, this number of extra cars and pick-ups equates roughly to an additional 3 km of bumper-to-bumper traffic added to Bangkok's roads each day, or 1,100 km per year. Considering Bangkok's road network is 3,780 km, this means that in less than only 4 years enough cars and pick-ups are added to fill the entire 1990 road system with one lane of traffic. In practice, some vehicles are leaving the vehicle fleet as these new vehicles are being added, but it is clear from the rapid growth in registered vehicles that new vehicles are far outstripping the wastage rate.

To obtain a clearer understanding of the situation surrounding Bangkok's vehicle ownership, this section looks systematically at the vehicle ownership rates in Bangkok for various vehicle types compared to other Asian cities.

4.5.1.1 Total Vehicle Ownership

The total vehicles in Bangkok in 1990 was about 2,046,000, giving Bangkok a total vehicle ownership of about 348 per 1,000 people. As shown in Figure 4.19, compared to other Asian cities, this level of motor vehicle ownership is very high, only slightly less than that in Tokyo (374) and Kuala Lumpur (403) which are richer than Bangkok. Bangkok's motor vehicle ownership is much higher than all the other Asian cities. For example, it is more than fourfold that in Hong Kong (78) and Manila (86), and between 1.6 and 1.7 times as high as that in Singapore (200), Jakarta (201) and Surabaya (209).
Figure 4.19 Bangkok's total vehicle ownership compared to other Asian cities, 1990

Source: Table 4.9

Furthermore, as motor vehicle population in Bangkok has been soaring, by 1993 the total vehicle ownership per 1,000 residents had substantially increased to 429. This exceeded that for Tokyo in the same year (397), and was second only to Kuala Lumpur (480).\(^{29}\)

4.5.1.2 Cars and Pick-ups

Further examination of vehicle ownership in Bangkok by type of vehicle reveals similar patterns. In particular, Bangkok has a high level of car ownership. In 1990 car ownership was 153 per 1000 inhabitants and if pick-ups are included because they are used primarily for private passenger travel, that figure increases to 199.\(^{30}\) As shown in Figure 4.20, this level of car ownership is higher than all the other Asian cities in this study except Tokyo, including much richer cities like Singapore with only 101 cars per 1,000 in 1990 and Hong Kong with a mere 43 per 1,000 in 1990. Even if all goods vehicles in Hong Kong, some of which are used partly for private

\(^{29}\)See Chapter 2 for Bangkok and Southeast Asian cities' figures. Figure for Tokyo is estimated based on 1990 data and data from Secretariat to the Summit Conference of Major Cities of the World, 1994.

\(^{30}\)Calculated based on data from Department of Land Transport, 1990. Number of cars = 899,161; number of pick-ups = 268,598. 1990 Bangkok population census = 5,882,411.
travel are included, the Hong Kong "car" ownership rate is still only 67 per 1,000 people.

![Comparative car ownership in Asian cities, 1990](image)

**Figure 4.20** Comparative car ownership in Asian cities, 1990

Source: Table 4.9

Note: Bangkok's car ownership includes pick-ups.

In 1993 the number of cars (including pick-ups) in Bangkok rose to about 1,354,000 giving 220 per 1,000 inhabitants which is very high in relation to other Asian cities. This level already exceeds that for Kuala Lumpur (206) and is only marginally lower than that for Tokyo (236).31

### 4.5.1.3 Motorcycles

The other popular mode of private transport in Bangkok is the motorcycle. In 1990 there were nearly 729,000 motorcycles in Bangkok, which was more than four times the 1980 figure. The dramatic increase in the motorcycle population is associated with the rapidly deteriorating traffic conditions in Bangkok. Motorcycle are relatively easy to manoeuvre through long traffic queues on main roads and are particularly effective in negotiating congested and narrow major sois leading to the main roads. They are also comparatively easy to park in the congested city conditions. On top of these advantages, motorcycles are an advantage in the new sprawling areas

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31 Data for Bangkok are from Department of Land Transport and estimated BMA population of about 6.2 million. Data for other cities are from Barter, 1996b and Guia, 1996 (PhD thesis in preparation).
around Bangkok which have grown so rapidly without any public transport system to connect them with the rest of the city. These advantages seem to outweigh the obvious increased dangers associated with riding motorcycles, and of course, motorcycles are much cheaper to purchase than cars.

In motorcycles per 1,000 people, Bangkok is also very high compared to many other cities. In 1990 Bangkok had 124 motorcycles per 1,000 people, compared to only 4 in Hong Kong, 6 in Manila, 36 in Tokyo, 45 in Singapore and 98 in Jakarta. Nevertheless, it is slightly lower than Surabaya (147 per 1,000) and much lower than Kuala Lumpur (180) (Figure 4.21).

![Figure 4.21 Comparative motorcycle ownership in Asian cities, 1990](image)

**Figure 4.21 Comparative motorcycle ownership in Asian cities, 1990**

Sources: 1. Bangkok's figure calculated based on data from Department of Land Transport, 1990 and Bangkok 1990 population census
2. Other cities are from Barter and Kenworthy, 1995; and unpublished data from Barter, 1996d and Guia, 1996 (PhD thesis in preparation)

It would appear from these data that most cities in the developing Southeast Asian region do, like Bangkok, favour the motorcycle. Only Manila is an exception, due to the existence of an extensive and popular Jeepney system which is much cheaper than motorcycles and gives better weather protection in a very wet climate. Manila also has high motorcycle prices relative to the residents' income, as noted in Chapter 2. In most of the other cities, motorcycles provide a relatively affordable means to rapidly increase ones personal mobility and to allow families to move into rapidly growing new areas which are predicated on motorised transport, but which mostly lack a good public transport system.

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4.5.1.4 Combined Car and Motorcycle Ownership

Because cars and motorcycles are the principal means of independent private mobility and the motorcycle component is so significant in many Asian cities, it is useful to combine these data to see how the Asian cities compare with each other.

In this respect, Figure 4.22 shows that Bangkok has a higher number of cars and motorcycles per capita than the three richer Asian cities (Singapore, Tokyo and Hong Kong) and is second only to Kuala Lumpur in the developing Southeast Asian cities (due mostly to Kuala Lumpur's high motorcycle ownership). In 1990 Hong Kong had a combined car and motorcycle ownership of 47 per 1,000, Manila had only 72 per 1,000, Singapore had 146 per 1,000, while Bangkok had 323 per 1,000 persons. Bangkok's car and motorcycle ownership was even higher than Tokyo's (261 per 1,000 people in 1990) which, in a small twist of irony, is the capital of the biggest car and motorcycle manufacturing country in the world.

![Bar chart showing car and motorcycle ownership per capita in various cities, with values for HK, Man, Sing, Jak, Sura, Tokyo, Bkk, and KL.

Figure 4.22 Comparative car and motorcycle ownership in Asian cities, 1990

Sources: 1. Bangkok’s figure calculated based on data from Department of Land Transport, 1990 and Bangkok 1990 population census

Note: Bangkok’s car figure includes pick-ups

In summary, the data and discussion in this section has highlighted the exceptionally high level of vehicle ownership in Bangkok compared to other
Asian cities. Although some studies have labelled this phenomenon as an inevitable consequence of increasing income (see JICA, 1990), it is worthwhile to examine in more detail whether this explanation alone is adequate in international perspective. Chapter 5 examines the factors affecting the high level of vehicle population in Bangkok in detail.

4.5.2 Traffic Speed and Public Transport Speed

Traffic speed in Bangkok is notoriously slow and congestion is widespread throughout the day, not just in peak periods. The 'Earth 2000' column in the West Australian of October 5, 1992 is representative of international perceptions of Bangkok's traffic problems:

Morning jams are so bad that suburban mothers leave home before dawn with their sleeping children, who they wake, wash, dress and feed in their cars during the four-hour crawl to schools in town.

The evening "rush" is no better. One night in late July a monsoon downpour knocked out a handful of old cars at strategically inconvenient intersections, where they jammed the other 2.3 million vehicles on the city's thoroughfares until four in the morning. The evening crawl home took many drivers 11 hours. Radio stations warned people not to set out on the roads without meals, water - and even a chamber pot.

Slow traffic speeds on Bangkok roads have been commonplace and systematically recognised since at least 1972. In that year, average speeds of trips by private vehicles were 22.7 km/h, whereas trips by public transport averaged 12 km/h, only half the speed of trips by private vehicles (F.H. Kocks KG and Genieurges.-MHB, 1975: B23). Such dramatic difference in speeds of travel undoubtedly influenced Bangkok commuters' decisions about choices between private and public transport during that period.

Compared to those reported by the more recent 1991 SPURT study, traffic speeds measured periodically by the BMA vary significantly from each other. However, average traffic speeds during peak hours in the area bounded by the Middle Ring Road (including on the Middle Ring Road, but excluding on the expressway), which comprises the central area and inner suburbs, are generally less than 10 km/h. In other large cities, average
speeds are typically around 16 km/h in the central areas and 25-35 km/h in inner suburbs (Halcrow Fox and Associates et al., 1991: 3-6). Similar findings were reported by JICA: in 1989 average speeds on at-grade roads of all vehicles in the area bounded by the Outer Ring Road was only 8.1 km/h; average speeds on the expressway were only 11.4 km/h (JICA, 1990: 265). This report highlighted the rapidly deteriorating traffic congestion problems in terms of travel speeds.

In addition, according to the Office of the Commission for the Management of Road Traffic (Suraswadi, 1994), the overall average speed during peak hours in 1990 was only 10.4 km/h. Traffic movement along arterial roads was even slower: only about 8.5 km/h. Worse still, the average speed in Bangkok’s central area was reported to be as low as 6.5 km/h. Furthermore, the traffic speeds were predicted to still be substantially decreasing (Table 4.10).

Table 4.10 Average traffic speed by road in Bangkok during rush hour by type of road, including future projections

<table>
<thead>
<tr>
<th>Road type</th>
<th>1990</th>
<th>2000a</th>
<th>2000b</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads in CBD</td>
<td>6.5</td>
<td>5.0</td>
<td>5.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Arterial Roads</td>
<td>8.0</td>
<td>7.6</td>
<td>8.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Suburban Roads</td>
<td>19.6</td>
<td>12.7</td>
<td>13.8</td>
<td>7.7</td>
</tr>
<tr>
<td>Toll Road</td>
<td>17.3</td>
<td>26.6</td>
<td>31.0</td>
<td>13.1</td>
</tr>
<tr>
<td><strong>All Roads</strong></td>
<td>10.4</td>
<td>10.6</td>
<td>11.9</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Source: Suraswadi, 1994: Figure 4.2

Notes: 1. "2000a" refers to average traffic speeds in the year 2000 if the "Base Transport Plan" is implemented.
         2. "2000b" refers to average traffic speeds in the year 2000 if the "Full Transport Plan" is implemented.

More recently, the Revision of the Traffic and Transport Master Plan 1994 reported that in 1993, overall traffic speed in Bangkok’s inner area was only 9.2 km/h. The average speed for surrounding areas varied from less than 10 km/h to 15 km/h. This study predicted that by 2001, the traffic speed in all areas would be substantially worse (Kasetsart University and Sindhu Pike Bodell, 1994b: 64).

Moreover, the speed of traffic on some of the most congested roads in the CBD during peak hours is almost at gridlock. On some roads, for example
Rama 9 Road and Asoke-Din Daeng Road, the traffic speed is only at 1-2 km/h (Pendakur, 1993: 56), even slower than walking pace.

Although the traffic speed figures from these different recent studies vary slightly, they show the sharp deterioration in traffic conditions during the last two decades. Users of private transport, who enjoyed markedly faster speeds in 1972, are now experiencing critical traffic congestion problems. The same applies to public transport. The rapid growth in private vehicle numbers, as mentioned previously, is of course one of the main reasons.

There are two points which can be made about this picture of deteriorating speeds: (1) Generally speaking it would be faster to either walk or at least ride a bicycle if this were feasible; typically walking can achieve an average speed of 3 to 5 km/h and cycling 10 to 20 km/h, depending on environmental conditions and other factors. It is now rare for average speeds on arterial roads in Bangkok to reach cycling speeds, and in terms of overall speeds, traffic is moving at a slow bike speed. (2) In many cities around the world average road speeds in central areas have remained essentially constant for many years (e.g. London and New York), despite predictions that they were descending into total gridlock. Mogridge (1989, 1990) has suggested that the reason for this is that new equilibriums have been constantly formed between private and public transport especially rail, as traffic has pushed towards potentially worse conditions. This has led him to suggest that the only way to improve road speeds in central London is actually not to widen roads or build more roads (which just fill with more traffic), but to improve rail speeds in order to effect a net transfer of people onto that mode. It would appear that Bangkok’s central area speed has reached no such equilibrium, but continues to deteriorate, and that perhaps the reason for this, according to Mogridge’s proposition, is the lack of a rail system.

In comparison to other cities, overall traffic speed on Bangkok roads is noticeably slow, at approximately 13 km/h. Most cities in Southeast Asia have much higher road traffic speeds (around double Bangkok’s speed). For example, in 1990 Surabaya’s average traffic speed was around 27 km/h. The traffic speed in Manila in 1990 was 26 km/h, while overall traffic speed in Kuala Lumpur in 1991 was about 26 km/h, and it was about 24 km/h in Jakarta. Compared to richer Asian cities, European, Australian and
American cities, Bangkok's traffic speed is noteworthy for being the lowest of all global cities (Figure 4.23).

![Bar chart showing average speed of road traffic (km/h) for various cities including Bkk, Jak, Tokyo, KL, Man, HK, Sura, Sing, Euro, Aus, and US, with values ranging from 13 to 49.]

Figure 4.23 Bangkok's traffic speed compared to global cities, 1990

Sources: Table 4.9

Note: Bangkok's traffic speed is for the Greater Bangkok Area.

The above overall average traffic speed figures reveal that, without question, traffic congestion in Bangkok is amongst the worst in the world. Traffic congestion does not occur only during peak hours and is not confined within the city centre and the inner area. Rather, it is unpredictable both in terms of time and location. For example, Bangkok commuters currently get caught in severe traffic congestion on a regular basis, even in Bangkok's outer areas (Halcrow Fox and Associates et al., 1991). There appears no longer to be any discernible "rush hour" in Bangkok. It is abundantly clear, therefore, from the foregoing data, that effective and feasible solutions are desperately needed for Bangkok.

In addition, the overall average public transport speed in Bangkok in the early 1990s was only around 9.2 km/h which is the lowest among all cities in the study (see Table 4.9). For example, the other four developing cities in Southeast Asia have average public transport speeds of 15 to 17.5 km/h, which is almost double the public transport speed in Bangkok. Furthermore, the public transport speed in Bangkok is about three to four times lower than those in richer Asian cities and in cities of the North. Worse still, compared to the overall traffic speed in Bangkok of 13 km/h, it is also much lower.
The extremely low speed of public transport appears to be one of the major factors contributing to the low use of this mode and, consequently, to the high use of private transport, as will be discussed in the next section.

However, when we examine each mode of public transport in Bangkok, the extremely low overall public transport speed is attributable to the bus speed, given that buses are the dominant mode of public transport in Bangkok. As buses in Bangkok often get caught in traffic jams, the average bus speed is only around 9 km/h, compared to the average boat speed of 16 km/h, and train speed of 34 km/h (see Table 4.9). Clearly, boats and trains provide much faster transport services for Bangkok's residents. Unfortunately, these two modes have a very low share of Bangkok's public transport, despite their considerable advantages. This issue is discussed in detail in Chapter 5.

4.5.3 Trips Characteristics

The trip referred to in this study is the "linked trip", which means that one trip is counted for one purpose. For instance, someone may drop into a market for shopping on the way from the office to home, and then proceed home. The journey from the office to the market is counted as a private-purpose trip, and the journey from the market to home is counted as a home-coming trip. Thus, the complete office-to-home journey is counted as two trips (JICA, 1990).

4.5.3.1 Trip Generation

In 1989, a total of 15.6 million trips were made daily in Bangkok, of which 13.4 million were trips other than walking and cycling. Bangkok residents made 12.55 million trips, or around 94 per cent (i.e. internal trips). The remaining 850,000 trips, or about 6 per cent, were made by non-residents (i.e. external trips) (JICA, 1990: 51). Over the 17 years from 1972 to 1989, trips in Bangkok increased nearly threefold. In 1972 only about 4.678 million internal trips and 138,000 external trips were made per day in the Greater Bangkok Area (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975: B22).

The current trip production rate of Bangkok residents is estimated to be 2.22 per person per day. Males generate on average 2.71 trips each, compared to only 1.77 by females. It is noteworthy that vehicle-owning households made
more than twice as many trips as the non-vehicle-owning households. On average, each vehicle-owning household produced 3.21 trips, whereas each non-vehicle-owning household made only 1.57 trips daily (JICA, 1990: 54, 56).

In 1972, Bangkok residents made on average 1.15 trips per inhabitant daily, with a low proportion of these being trips to work. Two reasons account for the difference between the 1972 and 1989 trip generation rates. First, in 1972, a large number of Bangkok residents lived and worked at the same place. Thus they did not need to travel to work (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975: B22). Second, the rate of vehicle ownership at present is much higher than that of 1972. In 1972 there were only 43 vehicles per 1,000 Bangkok inhabitants (or around 1 vehicle per 26 persons), compared to 348 vehicles per 1,000 people (or 1 vehicle per 3 people) in 1990 (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975: B21; Department of Land Transport, 1990). As revealed above, those who have vehicles tend to make many more trips than those who do not.

### 4.5.3.2 Trip Composition By Mode

![Trip Composition By Mode](image)

**Figure 4.24 Trip mode composition, 1989**

Source: JICA, 1990: Figure 2.2.4 and Figure 2.2.5

As shown in Figure 4.24, in 1989 about 33 per cent of the total trips in Bangkok were made by bus, 27 per cent by car, 16 per cent by motorcycle, 8 per cent by taxi and only 15 per cent were made on foot or by bicycle. This represents an extraordinarily low proportion of trips by foot or bicycling for such a dense city. By comparison (Figure 4.25), in the Tokyo metropolitan
area, which has less than half Bangkok's density (Bangkok has a population density of 149 people per ha, Tokyo has 71 people per ha), about 42 per cent of all daily trips are on foot and bicycle. All other cities in Figure 4.25 also have much higher levels of trips by non-motorised modes. In addition, as we can also see in Figure 4.24 above, with respect to trips by motor vehicles only, Bangkok residents made about 38 per cent of trips by bus, 33 per cent by car, 19 per cent by motorcycle and 10 per cent by taxi. Trips by private vehicles are a high proportion of the total trips in Bangkok, cars and motorcycles being responsible for more than half of the total trips by motor vehicles. Furthermore, when we include trips made by taxis, which are basically operated as private cars in terms of capacity, road space use and energy use, the private trips account for more than 60 per cent of Bangkok's total trips by motor vehicles.

![Modal split for total trips in Bangkok compared to other Asian cities, 1990](image)

**Figure 4.25 Modal split for total trips in Bangkok compared to other Asian cities, 1990**

**Sources:** 1. Bangkok data from JICA, 1990  
2. Other cities data from Barter, 1996d (PhD thesis in preparation)

### 4.5.4.3 Bangkok's Trips to Work Compared to Other Cities

Generally, journeys to and from work are regarded as the most important trips in an urban transport study because they mainly take place during rush hours and, consequently, they are the major contributor to traffic congestion. In Bangkok, to-work trips in 1989 accounted for around 20 per cent of all trips or around 3 million trips daily. Bangkokians made about 90 per cent of their work trips by motorised modes in 1989, only 10 per cent were made on foot or by bicycle (Figure 4.26). This is unlikely to have improved in favour
of non-motorised modes in the intervening period, because of deteriorating circumstances in the street environment.

![Modal split for the journey-to-work in Bangkok, 1989](image)

Figure 4.26 Modal split for the journey-to-work in Bangkok, 1989

Source: After JICA, 1990: Figure 2.5.1

As Figure 4.27 shows, the proportion of walking and cycling to work in Bangkok is very low, compared to wealthy Asian cities, European cities and the other Southeast Asian cities. For example, in 1990 Singapore and Tokyo have 22 per cent of people going to work on foot or by bicycles, Hong Kong has 17 per cent, European cities on average have 18 per cent, Surabaya has 24 per cent, Jakarta has 22 per cent, Manila has 18 per cent and Kuala Lumpur has 17 per cent. Considering that the inner zone of Bangkok is structured as a "walking city" with an intense concentration of both residents and workplaces, it is an indication of a serious problem to find so few people walking or cycling. With such a small available road space being totally dominated by cars and motorcycles, and with hazardous air pollution, it is little wonder that few will risk walking or cycling in such chaotic traffic, even if distances are reasonable (Chapter 5 discusses this issue in greater detail).
Figure 4.27 Journey-to-work by foot and bicycle in a sample of global cities, 1990 (%)

Figure 4.28 Journey-to-work by public transport in a sample of global cities, 1990 (%)

Figure 4.29 Journey-to-work by private transport in a sample of global cities, 1990 (%)

Source: Table 4.9
Figures 4.28 and 4.29 show that trips by private vehicles account for approximately 60 per cent of total trips to work in Bangkok, while public transport carries only 30 per cent of work trips. This is very low public transport use to work for such a large, dense city. For example, Hong Kong, Singapore and Tokyo had a very large 74 per cent, 56 per cent and 49 per cent of workers respectively using public transport in 1990, while Manila had 54 per cent and European cities averaged 39 per cent. These figures further reveal the critical situation with respect to traffic in Bangkok. Here we have a high-density, mixed land-use city with limited road space, as is the case in other Asian cities, but with generally much lower transit and much higher private transport use. This finding also underpins the need for appropriate initiatives to relieve Bangkok’s serious traffic problems.

4.5.4 Private and Public Transport Use

The balance between private and public transport travel is another important factor indicating the level of automobile dependence of a particular city. This section therefore examines Bangkok’s transport use by means of some standardised and comparable parameters such as per capita vehicle kilometres of travel (VKT) and per capita passenger kilometres by private and public modes. Bangkok's private and public transport use is then compared to those of other cities.

4.5.4.1 Private Transport Use

Bangkok residents use private vehicles, mainly cars, pick-ups and motorcycles, at a relatively high rate for an Asian city. On average, car and pick-up vehicle kilometres per capita is about 1,514 km per annum and motorcycle kilometres per capita per year is around 630 kms, a total of 3,198 kms per capita in private passenger modes (including other private passenger transport modes) (see Appendix A). In 1972, by contrast, car use per capita per annum was only 365 kms (or 24 per cent of the 1989 figure), and the motorcycle use was only 188 kms per capita per annum (30 per cent of the 1989 figures) (see Appendix A). Overall, private vehicle kilometres per person has increased more than three times in the period from 1972 to 1989. The proportion of motorcycle use in Bangkok is quite high and rapidly accelerating.
As shown in Figure 4.30, total private vehicle kilometres per capita (i.e. passenger plus commercial/freight traffic in Bangkok) is much higher than that for other Southeast Asian cities, except Kuala Lumpur, and also much higher than that in Hong Kong. However, this level is slightly lower than that in Singapore and Tokyo and much lower than that in European cities and automobile-based American and Australian cities.

![Bar chart showing annual private VKT per capita for various cities in 1990](chart.png)

**Figure 4.30 Total private vehicle kilometres per capita in Bangkok compared to other global cities, 1990**

Source: Table 4.9

Although the level of private vehicle use in Bangkok (passenger kms per capita in passenger vehicles per year), is still relatively low compared to that in the American and Australian cities, it is much higher than that in other developing Southeast Asian cities, except Kuala Lumpur. The Bangkok levels are even higher than all richer Asian cities (Figure 4.31). In 1990, the average passenger kilometres per capita in private passenger vehicles in Bangkok was nearly twice the average for the wealthy Asian cities of Hong Kong, Tokyo and Singapore (4,634 compared to 2,386). It was also between two and three times higher than most of the other developing Asian cities.
4.5.4.2 Public Transport Use

With respect to public transport use in Bangkok, bus is the dominant mode of public transport. Other modes are boats and railway, which play a very minor role (see Table 4.11). Buses carry approximately 96 per cent of total public transport passengers annually, whereas boats and trains carry only about 4 per cent and 0.24 per cent respectively. In addition, total annual public transport passenger kilometres are approximately 14,700 million kms, or about 33 per cent of the private and public combined total of 44,240 million passenger kilometres. This indicates the dominant role of private transport in Bangkok. Of total public transport passenger kilometres, buses accounted for 14,400 million kilometres or 98 per cent, whereas boats and trains accounted for only 206 million kilometres and 66 million kilometres (1.4 per cent and 0.45 per cent respectively).
Table 4.11 Performance of public transport modes in Bangkok, 1989

<table>
<thead>
<tr>
<th>Public transport modes</th>
<th>Annual passengers carried (million)</th>
<th>% passengers carried</th>
<th>Annual passenger kms (million)</th>
<th>% passenger kms</th>
<th>Annual vehicle kms (million)</th>
<th>% vehicle kms</th>
<th>Average trip length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buses</td>
<td>2,571.93</td>
<td>95.73</td>
<td>14,428.50</td>
<td>98.15</td>
<td>687.15</td>
<td>97.99</td>
<td>5.6</td>
</tr>
<tr>
<td>Boats</td>
<td>108.38</td>
<td>4.03</td>
<td>205.92</td>
<td>1.40</td>
<td>13.22</td>
<td>1.88</td>
<td>1.9</td>
</tr>
<tr>
<td>Trains</td>
<td>6.44</td>
<td>0.24</td>
<td>65.70</td>
<td>0.45</td>
<td>0.90</td>
<td>0.13</td>
<td>10.2</td>
</tr>
<tr>
<td>Total</td>
<td>2,686.75</td>
<td>100.00</td>
<td>14,700.12</td>
<td>100.00</td>
<td>701.27</td>
<td>100.00</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Sources: 1. Train vehicle kilometres are calculated based on train passenger kilometres (see Chapter 3 for methodology and Appendix A for data)
2. Boat vehicle kilometres and passenger kilometres calculations based on data from Department of Energy Development and Promotion, 1993 (see Appendix A)
3. The rest are calculated based on data from JICA, 1990 (see Appendix A)

Although private transport is playing the dominant role in Bangkok, as Table 4.9 and Figure 4.32 show, the per capita passenger kilometres and the percentage of total annual passenger kms on public transport reveal that Bangkok's public transport is more significant in the overall urban transport picture than in American, Australian and European cities and even some developing Asian cities. Nevertheless, Bangkok's public transport use (33 per cent) is only about two-fifths of that of Hong Kong (82 per cent), only about half of that of Tokyo (63 per cent), and much less than that for Singapore (47 per cent), Jakarta (46 per cent) and Manila (45 per cent).

In summary, Bangkok's relative use of transit is by no means a disaster in an international comparative sense, though it is much lower than would appear to be required for a city of its density, mixture of land-uses and limited road space. Furthermore, the comparison of 1972 data and 1989 data on modal split also reveals the substantial decrease in public transport share in Bangkok. In 1972, about 57 per cent of total trips by motor vehicles in Bangkok were made by public transport compared to only 38 per cent in 1989 (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975; JICA, 1990).
Figure 4.32 Public transport use in Bangkok as a percentage of total motorised passenger kilometres of travel, compared to other cities, 1990

Source: Table 4.9

This becomes clear in considering the situation of the developed Asian cities. By and large these cities appear to have avoided the traffic disaster of Bangkok through an extraordinary commitment to public transit, especially effective rail systems. Rail is a very effective fast and reliable mode of public transport due to segregated routes which avoid traffic congestion. However, Bangkok has an extremely low level of rail service and use of rail. As shown in Table 4.9, Bangkok has only 21 km of rail service per hectare, which is only a fraction of levels of rail service in other cities, particularly richer Asian cities (4,914 km per hectare) and European cities (3,651 km per hectare). In terms of rail use, Bangkok has a mere 0.45 per cent of total public transport passenger kilometres on rail. By contrast, other cities around the world, particularly richer Asian cities and European cities, have demonstrated their commitment to rail system development and use and have between 30 per cent and 96 per cent of total public transport passenger kms on rail (Figure 4.33). Of course, Bangkok is not the only city, or even the only Asian city, not to have developed a rail system yet. By 1990, Surabaya and Kuala Lumpur, and to a slightly lesser extent, Jakarta and Manila are all in similar situations with respect to low rail development (Figure 4.33). However, as demonstrated previously in this chapter, since that time Kuala Lumpur has intensively developed its rail system. Bangkok would appear to need to address the potential of rail use for passenger travel, if it is to effectively address its current traffic crisis.
Figure 4.33 Proportion of public transport passenger kilometres on rail in Bangkok compared to other cities, 1990

Source: Table 4.9

In summary, based on the data presented above, it can be said that Bangkok relies much more heavily on private vehicle transport than most other cities in developing Asian countries, as well as richer Asian cities. Furthermore, there is the worrisome trend in the continued decline in the relative role of public transport. This has been the trend for at least the last two decades. This pattern is clearly inconsistent with Bangkok's urban structure and land-use, which is ideal for walking, cycling and transit. To gain a deeper understanding of the degree to which Bangkok depends on private transport, the next section explores the issue of energy consumption, which is regarded as one of the main indicators of automobile dependence in cities.

4.5.5 Energy Consumption in Transport

Measurements of transport energy use are key indicators of the level of commitment to the automobile and to motor vehicles in general. Thus, this section begins by examining energy consumption in Bangkok. Bangkok is then compared with other global cities to put Bangkok's transport energy consumption in perspective.

4.5.5.1 Energy Consumption in Bangkok's Transport

This section explores in detail the energy consumption in Bangkok's transport, which can be divided into three main sectors: road transport,
water transport and trains. Obviously, road transport is the major consumer of energy in Bangkok. However, it is worthwhile to explore other sectors to determine their energy use and efficiency, compared to road transport.

(1) Energy Consumption in Road Transport

Bangkok accounts for 50 per cent of Thailand's consumption of petroleum products and 40 per cent of total road transport energy use (Sayeg, 1992: 43). In terms of road transport energy consumption in Bangkok, gasoline is responsible for 41 per cent, diesel 54 per cent and liquid petroleum gas (LPG), 5 per cent. In total, cars and motorcycles account for around 94 per cent of gasoline use. Trucks, pick-ups and buses consume almost all of the diesel, while tuk-tuks account for most of the LPG (Figure 4.34).

![Figure 4.34 Energy consumption in road transport in Bangkok by fuel type and mode, 1990](image)

Source: Interpolation from the Petroleum Authority of Thailand, 1990 data (see Appendix C)

Overall, of the total 138,500 million MJ of energy consumed in road transport in Bangkok, private transport consumes approximately 115,700 million MJ or 84 per cent, whereas public transport consumes only around 22,700 million MJ, or 16 per cent.

In terms of energy use per capita in road transport, one Bangkokian consumes on average approximately 18,000 MJ per year. Energy use in cars, pick-ups and trucks and motorcycles is responsible for almost all of private transport energy use per capita (or approximately 15,000 MJ per person). If we examine this situation in greater detail, we can see that together, cars and pick-ups account for around 9,300 MJ, or well over half of the total energy
consumed per capita. Motorcycles are responsible for about 1,800 MJ, while taxis and tuk-tuks have very low shares of 470 MJ and 100 MJ respectively. Bus energy use per capita is only about 3,000 MJ, or only one-sixth of the total energy use in road transport in Bangkok (Figure 4.35).

![Figure 4.35 Energy consumption in road transport per capita in Bangkok, 1990](image)

Out of the total 18,000 MJ of energy use in road transport per capita in Bangkok, diesel has the highest share of around 10,400 MJ or 57.3 per cent. Gasoline use is about 7,100 MJ or 39.4 per cent, while LPG has the lowest share of 600 MJ, or 3.3 per cent.

(2) Energy Consumption in Water Transport

In total, the various modes of waterway transport in Bangkok, comprised of fixed-route long-tail boats, express boats, ferries, and non-fixed-route boats, consumed about 9 million litres of diesel and 0.2 million litres of gasoline in 1990. This was only around 0.4 per cent that of the energy consumed by road transport, whereas waterway transport caters for the equivalent of approximately 2 per cent of total road transport ridership. This unbalanced situation is probably due to road based transport in Bangkok being dominated by private vehicles which waste enormous amounts of energy while idling in serious traffic jams, as demonstrated earlier (see Chapter 1), as well as high loadings in boats. The data presented above suggest that, in
terms of energy use, water transport in the Bangkok context is much more efficient than road transport. However, due to the rapidly increasing popularity in water transport over the recent years, energy consumption in water transport in Bangkok has also been increasing (Figure 4.36).

Figure 4.36 Energy consumption in waterway transport in Bangkok, 1989 to 1992

Source: Calculation based on data from Department of Energy Development and Promotion, 1993

The major increase in energy consumption in recent years is in consumption by fixed-route boats. This has been brought about by the new boat routes along the canals and increase in passengers numbers along existing routes. The result has been an increase in the number of in-service boats and trips, thus accounting for this increase in energy consumption.

(3) Energy Consumption in Trains

Trains in Bangkok account for only a minuscule share of energy use, as train transport represents only about 0.45 per cent of passenger movement in public transport and 0.15 per cent of total passenger movement in Bangkok. In 1990, the suburban train system consumed approximately 812,320 litres of diesel, which accounted for about 0.69 per cent of total energy use by trains in Thailand.\(^{32}\) Energy use by trains amounts to only about 0.13 per cent of the amount of energy used in public passenger transport, and less than 0.03 per cent of total energy use in total passenger transport in Bangkok. As

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\(^{32}\)Calculation based on data from State Railway of Thailand, 1990 Annual Report (see Chapter 3).
shown in Figure 4.37, in terms of energy efficiency (energy use per passenger kilometre), trains are apparently the most efficient mode of passenger transport in Bangkok. They used less than one-third of energy used by buses, nearly one quarter of that used by boats, nearly one-seventh of that used by private road-based transport and nearly one-sixth of the average energy used per passenger km for the total road-based passenger transport (buses and private passenger vehicles). In this respect, it seems clear that trains are the favoured mode if energy use in passenger transport in Bangkok is to be kept at a minimum. Unfortunately, to date, and for the foreseeable future, trains have and will play only a very tiny role in Bangkok's transport.

![Energy Efficiency Chart](image)

Figure 4.37 Energy efficiency in different transport modes in Bangkok, 1990

Source: Appendix A

4.5.5.2 Energy Consumption in Bangkok's Transport Compared to Global Cities

Gasoline use in Bangkok, almost entirely consumed by private cars and motorcycles, is about 1.6 thousand millions litres or 7,800 MJ per capita, per year. Furthermore, when we include energy consumed by pick-ups (mainly used as private cars) and other private transport modes, energy consumption per capita in Bangkok’s private passenger transport is about 11,760 MJ. Although this level is not high compared to the car-based American and Australian cities, it is the highest among Asian cities,
including richer Asian cities (Singapore, Tokyo and Hong Kong), and is approaching levels in the much wealthier European cities. Bangkok's private transport energy consumption is extremely high, compared to other cities in developing Asian countries. For example, it is more than double that of Jakarta, and more than four times that of Surabaya and Manila (Figure 4.38).

![Bar chart showing comparative annual gasoline use per capita in global cities, 1990](chart)

**Figure 4.38** Comparative annual gasoline use per capita in global cities, 1990

**Source:** Table 4.9

**Note:** Bangkok energy use includes diesel used by pick-ups.

In addition, the proportion of gasoline use compared to the total energy use in Bangkok transport is the highest amongst Asian cities. As shown in Figure 4.39, Bangkok’s gasoline consumption per capita is nearly 65 per cent of the total energy use per capita in transport, compared to only 25 per cent in Hong Kong, and 44 per cent in Tokyo. It is also higher than for the three cities (Jakarta, Surabaya, Manila) in developing Southeast Asian countries, with per capita gasoline consumption ratios from 40 per cent to 53 per cent and slightly higher than those for Singapore and Kuala Lumpur. This high rate of gasoline use in Bangkok is indicative of the somewhat disproportionate use of cars for a typical Asian urban environment.
Figure 4.39 Gasoline use as a proportion of total transport energy use in Asian cities, 1990

Sources: 1. Bangkok calculation based on data from Petroleum Authority of Thailand, 1990 (see appendix C)

Note: Bangkok energy use includes diesel used by pick-ups.

In summary, energy use in transport in Bangkok is dominated by the private transport modes. Compared with global cities, it is clear that Bangkok is located at one extreme within the Asian city sample because of its commitment to private vehicle use. The next section examines another factor - transport economics - which also seems to be one of the significant factors affecting Bangkok's transport patterns.
4.6 TRANSPORT ECONOMICS

Transport is commonly regarded as an important factor in fostering economic growth (Australian Automobile Association, 1993). There is, however, no evidence that investment in transport infrastructure in cities and expenditure on travelling have a positive impact on the overall economy (Berechman, 1995). To develop some understanding of particular economic aspects of passenger transport in Bangkok, this section examines a range of key transport economic data. Findings are then compared with other cities, focusing on three major issues: 1) road expenditure (investment by all levels of government and relevant agencies in road construction and road maintenance); 2) costs of private transport use; and 3) public transport cost-recovery. Table 4.12 provides a summary of the findings on these three aspects of the economics of transport in Bangkok compared to other cities. The specific data behind these three summary parameters are examined in the sections which follow.

4.6.1 Road Expenditure

This parameter provides an insight into the emphasis of the government's transport spending policy, particularly after comparing the figure for Bangkok with those for other cities (see Table 4.13). Southeast Asian countries and Thailand in particular have been shown in some studies to spend a low proportion of income on roads, despite their rapid economic growth. For example, Padeco's overview of the basic transport problems in Southeast Asian countries, particularly Thailand, concluded that:

Many Southeast Asian countries have experienced rapid economic growth in recent years, with the case of Thailand most extraordinary. However, at least until very recently, the portion of national and local tax revenues devoted to roads has not increased significantly.

(Padeco, 1990: 1-1)
Table 4.12 Bangkok's transport economic factors compared to other cities, 1990

<table>
<thead>
<tr>
<th>City</th>
<th>Road expenditure per capita ($US)</th>
<th>Road expenditure per US$1000 GRP</th>
<th>Private transport capital cost/km ($US)</th>
<th>Private transport variable cost/km ($US)</th>
<th>Total costs per km ($US)</th>
<th>Transit cost recovery (%)</th>
<th>Transit fare /pass./km ($US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Houston</td>
<td>230</td>
<td>8.79</td>
<td>0.176</td>
<td>0.076</td>
<td>0.252</td>
<td>28</td>
<td>0.053</td>
</tr>
<tr>
<td>Phoenix</td>
<td>309</td>
<td>19.41</td>
<td>0.207</td>
<td>0.079</td>
<td>0.286</td>
<td>28</td>
<td>0.048</td>
</tr>
<tr>
<td>Detroit</td>
<td>198</td>
<td>8.79</td>
<td>0.232</td>
<td>0.074</td>
<td>0.307</td>
<td>23</td>
<td>0.060</td>
</tr>
<tr>
<td>Denver</td>
<td>291</td>
<td>11.86</td>
<td>0.281</td>
<td>0.084</td>
<td>0.365</td>
<td>19</td>
<td>0.062</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>175</td>
<td>7.03</td>
<td>0.180</td>
<td>0.071</td>
<td>0.251</td>
<td>43</td>
<td>0.090</td>
</tr>
<tr>
<td>San Francisco</td>
<td>198</td>
<td>6.36</td>
<td>0.194</td>
<td>0.080</td>
<td>0.275</td>
<td>45</td>
<td>0.072</td>
</tr>
<tr>
<td>Boston</td>
<td>284</td>
<td>10.22</td>
<td>0.190</td>
<td>0.076</td>
<td>0.266</td>
<td>24</td>
<td>0.086</td>
</tr>
<tr>
<td>Washington</td>
<td>262</td>
<td>7.30</td>
<td>0.208</td>
<td>0.089</td>
<td>0.297</td>
<td>50</td>
<td>0.102</td>
</tr>
<tr>
<td>Chicago</td>
<td>315</td>
<td>12.10</td>
<td>0.217</td>
<td>0.078</td>
<td>0.295</td>
<td>46</td>
<td>0.089</td>
</tr>
<tr>
<td>New York</td>
<td>286</td>
<td>9.96</td>
<td>0.218</td>
<td>0.088</td>
<td>0.306</td>
<td>47</td>
<td>0.111</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>264</strong></td>
<td><strong>10.18</strong></td>
<td><strong>0.210</strong></td>
<td><strong>0.089</strong></td>
<td><strong>0.290</strong></td>
<td><strong>35</strong></td>
<td><strong>0.077</strong></td>
</tr>
<tr>
<td>Australian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perth</td>
<td>133</td>
<td>7.51</td>
<td>0.289</td>
<td>0.111</td>
<td>0.400</td>
<td>28</td>
<td>0.066</td>
</tr>
<tr>
<td>Brisbane</td>
<td>167</td>
<td>8.89</td>
<td>0.215</td>
<td>0.095</td>
<td>0.309</td>
<td>54</td>
<td>0.059</td>
</tr>
<tr>
<td>Melbourne</td>
<td>89</td>
<td>4.22</td>
<td>0.295</td>
<td>0.088</td>
<td>0.383</td>
<td>24</td>
<td>0.065</td>
</tr>
<tr>
<td>Adelaide</td>
<td>133</td>
<td>6.70</td>
<td>0.303</td>
<td>0.108</td>
<td>0.411</td>
<td>40</td>
<td>0.121</td>
</tr>
<tr>
<td>Sydney</td>
<td>188</td>
<td>8.74</td>
<td>0.244</td>
<td>0.108</td>
<td>0.382</td>
<td>55</td>
<td>0.062</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>142</strong></td>
<td><strong>7.21</strong></td>
<td><strong>0.269</strong></td>
<td><strong>0.102</strong></td>
<td><strong>0.371</strong></td>
<td><strong>40</strong></td>
<td><strong>0.070</strong></td>
</tr>
<tr>
<td>European Cities</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamburg</td>
<td>97</td>
<td>3.20</td>
<td>0.470</td>
<td>0.000</td>
<td>0.470</td>
<td>62</td>
<td>0.100</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>172</td>
<td>4.89</td>
<td>0.480</td>
<td>0.000</td>
<td>0.480</td>
<td>45</td>
<td>0.111</td>
</tr>
<tr>
<td>Zürich</td>
<td>185</td>
<td>4.13</td>
<td>0.460</td>
<td>0.000</td>
<td>0.460</td>
<td>60</td>
<td>0.091</td>
</tr>
<tr>
<td>Stockholm</td>
<td>174</td>
<td>5.22</td>
<td>0.570</td>
<td>0.228</td>
<td>0.796</td>
<td>33</td>
<td>0.077</td>
</tr>
<tr>
<td>Brussels</td>
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<td>3.39</td>
<td>0.410</td>
<td>0.103</td>
<td>0.513</td>
<td>27</td>
<td>0.106</td>
</tr>
<tr>
<td>Paris</td>
<td>166</td>
<td>4.94</td>
<td>0.424</td>
<td>0.000</td>
<td>0.424</td>
<td>61</td>
<td>0.061</td>
</tr>
<tr>
<td>London</td>
<td>113</td>
<td>5.10</td>
<td>0.358</td>
<td>0.000</td>
<td>0.358</td>
<td>93</td>
<td>0.133</td>
</tr>
<tr>
<td>Munich</td>
<td>100</td>
<td>2.76</td>
<td>0.590</td>
<td>0.000</td>
<td>0.590</td>
<td>54</td>
<td>0.071</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>166</td>
<td>5.54</td>
<td>0.314</td>
<td>0.136</td>
<td>0.450</td>
<td>66</td>
<td>0.124</td>
</tr>
<tr>
<td>Vienna</td>
<td>72</td>
<td>5.56</td>
<td>0.272</td>
<td>0.121</td>
<td>0.393</td>
<td>59</td>
<td>0.069</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>?</td>
<td>?</td>
<td>0.311</td>
<td>0.089</td>
<td>0.400</td>
<td>40</td>
<td>0.074</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>135</strong></td>
<td><strong>4.17</strong></td>
<td><strong>0.423</strong></td>
<td><strong>0.135</strong></td>
<td><strong>0.485</strong></td>
<td><strong>55</strong></td>
<td><strong>0.092</strong></td>
</tr>
<tr>
<td>Richer Asian Cities</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tokyo</td>
<td>109</td>
<td>2.94</td>
<td>0.200</td>
<td>0.090</td>
<td>0.290</td>
<td>?</td>
<td>0.110</td>
</tr>
<tr>
<td>Singapore</td>
<td>63</td>
<td>4.83</td>
<td>0.295</td>
<td>0.148</td>
<td>0.443</td>
<td>115</td>
<td>0.041</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>94</td>
<td>6.64</td>
<td>0.524</td>
<td>0.271</td>
<td>0.796</td>
<td>156</td>
<td>0.072</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>89</strong></td>
<td><strong>4.81</strong></td>
<td><strong>0.340</strong></td>
<td><strong>0.170</strong></td>
<td><strong>0.510</strong></td>
<td><strong>126</strong></td>
<td><strong>0.074</strong></td>
</tr>
<tr>
<td>Southeast Asian Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangkok</td>
<td>71</td>
<td>18.46</td>
<td>0.122</td>
<td>0.111</td>
<td>0.233</td>
<td>93</td>
<td>0.018</td>
</tr>
<tr>
<td>Jakarta</td>
<td>15</td>
<td>9.96</td>
<td>0.130</td>
<td>0.053</td>
<td>0.183</td>
<td>101</td>
<td>0.023</td>
</tr>
<tr>
<td>Kuala Lumpur</td>
<td>18</td>
<td>4.50</td>
<td>0.098</td>
<td>0.083</td>
<td>0.181</td>
<td>135</td>
<td>0.025</td>
</tr>
<tr>
<td>Manila</td>
<td>23</td>
<td>21.10</td>
<td>0.170</td>
<td>0.154</td>
<td>0.307</td>
<td>122</td>
<td>0.016</td>
</tr>
<tr>
<td>Surabaya</td>
<td>10</td>
<td>13.79</td>
<td>0.070</td>
<td>0.032</td>
<td>0.102</td>
<td>127</td>
<td>0.038</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>27</strong></td>
<td><strong>13.56</strong></td>
<td><strong>0.19</strong></td>
<td><strong>0.083</strong></td>
<td><strong>0.291</strong></td>
<td><strong>116</strong></td>
<td><strong>0.024</strong></td>
</tr>
</tbody>
</table>

Sources: 1. Bangkok road expenditure calculations based on data from Table 4.13 and JICA, 1990
2. Bangkok’s private transport costs calculations based on cost data from JICA, 1990; BMTA, 1990a and VKT data from Appendix A
3. Bangkok’s transit costs calculations based on transit cost data from BMTA, 1990a; Padeco, 1990 and passenger kilometre data from Appendix A

Note: See Chapter 3 for methodology
There are four main government agencies responsible for road construction and road maintenance in Bangkok:

1) The BMA: responsible for the majority of roads in Bangkok, particularly those which are not highways and expressways;
2) The Department of Highways (DOH): responsible for all highways in the Bangkok area;
3) The Expressways and Rapid Transit Authority of Thailand (ETA): responsible for all expressways; and
4) The Public Works Department (PWD): responsible for bridges and roads connecting bridges to other existing roads.

Table 4.13 shows expenditure on road construction and maintenance by these four authorities in Bangkok from 1989 to 1991.

**Table 4.13 Road expenditure in Bangkok by different government agencies, 1989 to 1991**

<table>
<thead>
<tr>
<th>Agency</th>
<th>Road expenditure (millions of baht)</th>
<th>Average (US$ million, 1990)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1989</td>
<td>1990</td>
</tr>
<tr>
<td>BMA</td>
<td>2,335</td>
<td>2,397</td>
</tr>
<tr>
<td>DOH</td>
<td>3,100</td>
<td>3,100</td>
</tr>
<tr>
<td>ETA</td>
<td>2,511</td>
<td>7,917</td>
</tr>
<tr>
<td>PWD</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,156</strong></td>
<td><strong>13,714</strong></td>
</tr>
</tbody>
</table>

Sources: 1. BMA expenditure from BMA, 1990: 22
2. DOH expenditure estimation based on data from Halcrow Fox and Associates et al. (1991) Table 5.1
3. ETA expenditure from Padeco, 1990: Table 2-48
4. PWD expenditure from Padeco, 1990: 2-76

Notes: 1. PWD 1989 expenditure is an estimated figure.
2. Conversion from Thai baht to US$ using the Special Drawing Right (SDR).

Given an average figure of annual road expenditure in Bangkok of US$446 million, the annual road expenditure per capita for Bangkok for the period 1989 to 1991 by all levels of government agencies is US$71. Figure 4.40 and Figure 4.41 compare Bangkok's road expenditure per capita and per US$1,000 GRP with those for other cities calculated using the same standardised methodology. They refer to road expenditure in 1990, even though the expenditure is a three year average for 1989 to 1991.
As shown in Figure 4.40, per capita expenditure on road construction and maintenance in Bangkok in 1990 is much higher than for all Southeast Asian cities. For example, Kuala Lumpur spent US$18 per capita, Jakarta spent US$15, Manila spent US$23, and Surabaya spent only US$10. In addition, the level of road expenditure in Bangkok exceeds that of richer Singapore (US$63) and approaches levels of Hong Kong (US$94), and Tokyo (US$109), although it is much lower than the average for American cities (US$264), European cities (US$135), and Australian cities (US$142), which are all much wealthier than Bangkok. Moreover, as shown in Figure 4.41, Bangkok’s road
expenditure as a proportion of GRP is one of the highest among all cities. In 1990 it was about US$18.50 per US$1,000 GRP compared to only US$4.20 for European cities, US$4.80 for richer Asian cities, US$7.20 for Australian cities, US$10.20 for American cities and US$13.60 for average Southeast Asian cities.

The comparative study clearly indicates a relatively high level of road expenditure in Bangkok, at least in this recent period. Both Thai national and local governments have emphasised road and expressway construction to cope with Bangkok's deteriorating traffic situation. Several road and expressway projects have been proposed, particularly in recent years. For example, during the five-year Sixth National Social and Economic Development Plan (1987-1991), total investment in road projects amounted to US$1,670 million. This accounted for approximately 97 per cent of the total investment in transport in Bangkok (Kasetsart University and Sindhu Pike Bodell, 1994: 3).

4.6.2 Costs of Private Vehicle Use

A detailed examination of costs of private vehicle use, reveals useful insights. For example, where the costs of driving are low people are likely to drive more. The costs of driving in Bangkok are presented and compared with those for other cities in Figure 4.42.

![Figure 4.42 Car cost per kilometre of travel in Bangkok compared to other cities, 1990](image)

*Source: Table 4.12*
Despite relatively low kilometres of travel per private vehicle in Bangkok (less than 10,000 km per year for a car compared to a common 12,000-13,000 km for a car in other cities), which is partly due to the difficulty of moving about in congested traffic, the per km costs of driving in Bangkok are relatively low. From Figure 4.42, we can see that the total cost of driving in Bangkok in 1990 was approximately US$0.233 per km. This is less than one-third of the cost for Hong Kong (US$0.796 per km), about half of that for European cities (US$0.485 per km) and Singapore (US$0.443 per km), and considerably lower than that for Australian cities (US$0.371 per km) and American cities and Tokyo (US$0.290 per km). However, the total cost of driving per km in Bangkok is not much different from those for other Southeast Asian cities.

The capital costs of private vehicle use (private vehicle prices) on average are also much cheaper than those for richer Asian cities, European cities, Australian cities and American cities. For example, prior to 1991, the average price for a 1,600 cc car in Bangkok was about 500,000 baht (US$20,000) (JICA, 1990: Table 13.2.2). After the government reduced import and surcharge tax in 1991, the price decreased to about 450,000 baht (US$16,000), compared to US$41,000 for a car of the same size in Singapore (Phang, 1993). This comparatively low price could be seen as encouraging more Bangkokians to buy cars.

The variable costs for using a private vehicle (fuel, oil, tyres, maintenance, insurance, depreciation etc.) per km in Bangkok (US$0.111 per km) are relatively low, as shown in Figure 4.42. They are much lower than those for the richer Asian cities (only a quarter of that for Singapore and less than half of that for Hong Kong) and much lower than that for European cities. However, they are slightly higher than those for Australian, American and Southeast Asian cities. Some variable costs of using private vehicles in Bangkok are extremely low, particularly road taxes. For example, an owner of a Mercedes Benz 230E, which costs about 2.6 million baht (US$104,000), pays only 4,096 baht (US$164) for the annual road tax (only about 0.15 per cent of purchase price), whereas the owner of the same vehicle in Singapore has to pay up to ten times higher. Moreover, motorcyclists in Bangkok also pay very low annual road tax of only 100 bahts (US$4) irrespective of their engine sizes (Tanaboriboon, 1993: 18). Thus, we can see that the relatively
low cost of private vehicle use is also likely to contribute to high levels of private vehicle ownership and use in Bangkok.

4.6.3 Transit Cost Recovery

Analysis of cost recovery for public transport is a valuable parameter in understanding public transport in cities. The data here refer only to operating costs and operating revenues and do not consider interest on capital debt. High cost recovery is generally associated with a high degree of popularity of public transport among city residents and workers and high levels of use. Cost recovery data provides insights into levels of "societal subsidy" to public transport. That is, when public transport is operated at a loss, the government must subsidise the shortfall in order to maintain services. There are of course a whole range of debated topics surrounding the way that the issue of "subsidy" is dealt with. For example, the balance sheets of public transport operators never show a credit for the benefits to non-users of their operations, yet these exist (Willeke et al., 1989). Some cities may make a conscious decision to subsidise public transport in recognition of its importance and the fact that cars are also subsidised. It is not possible to go into these issues in detail here, but the simple presentation of cost recovery figures can mask a range of issues concerning the value and importance of public transport in cities.

For Bangkok, only the cost recovery of buses is taken into consideration owing to two main reasons: 1) there are no data available on the cost recovery for boat and train services within Bangkok. Data on the cost and revenue for trains available from the SRT are provided only for the whole country; 2) as demonstrated previously, bus is the dominant mode of public transport in Bangkok. It accounts for approximately 98 per cent of total passenger kilometres in public transport, whereas boats account for only 1.4 per cent and trains account for only 0.5 per cent. Thus buses can be seen as representative of Bangkok's public transport for this comparative study of cost recovery.

Bus services in Bangkok can be classified into three types: 1) BMTA's buses; 2) private buses; and 3) minibuses. In terms of cost recovery, BMTA buses recover 82 per cent of their operating costs, the lowest rate amongst the three. Private buses recover, on average, 110 per cent, and minibuses
recover 120 per cent. Overall, bus operation in Bangkok achieves an operating cost recovery of 93 per cent (Table 4.14).

Table 4.14 Operating cost recovery for buses in Bangkok, 1990

<table>
<thead>
<tr>
<th>Bus types</th>
<th>Passengers/day (thousand)</th>
<th>Average trip length (km)</th>
<th>Pass-km/day (thousand)</th>
<th>Cost recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMTA</td>
<td>3,605</td>
<td>6.0</td>
<td>21,630</td>
<td>82</td>
</tr>
<tr>
<td>Private</td>
<td>1,368</td>
<td>6.0</td>
<td>8,208</td>
<td>110</td>
</tr>
<tr>
<td>Minibus</td>
<td>1,120</td>
<td>3.3</td>
<td>3,696</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,093</strong></td>
<td><strong>5.7</strong></td>
<td><strong>33,534</strong></td>
<td><strong>93</strong></td>
</tr>
</tbody>
</table>

Sources: 1. Passengers per day calculation based on data from JICA, 1990: Table 4.1.1 and BMTA, 1990a: 23.
2. Average trip length data from JICA, 1990: Figure 4.2.5.
3. Passenger kilometres are calculated by multiplying passengers per day and average trip length.
5. Cost recovery for private buses and minibuses are averages of data from Padeco, 1990: 2-99.
6. Cost recovery for all buses calculated by weighting cost recovery of each mode by passenger kilometres.

Note: Data on public transport usage in this table differ a little from those used in the international comparisons but were used here because they show the indicative split between BMTA, Private and Minibuses which is needed for the weighted cost recovery figure. They are understatements of total bus use in Bangkok, according to more reliable data.

When data on cost recovery of buses in Bangkok are compared to transit cost recovery ratios for other cities, the situation of bus operations in Bangkok is clarified, as shown in Figure 4.43.

![Figure 4.43 Bangkok's transit cost recovery compared to other cities, 1990](image)

Sources: Table 4.12

203
Figure 4.43 shows that Bangkok’s transit cost recovery was approximately 93 per cent. This rate is much higher than rates for American cities (35 per cent), Australian cities (40 per cent) and European cities (55 per cent). This is partly due to the relatively higher transit patronage in Bangkok, e.g. in 1990 approximately 33 per cent of Bangkok’s total passenger travel was by public transport, compared to only 4 per cent in American cities, 8 per cent in Australian cities and 23 per cent in European cities (see section 4.5.4.2 in this chapter). Thus, despite its relatively low transit levels compared to wealthy Asian cities (64 per cent of passenger travel by transit), Bangkok still has a relatively high use of public transport in an international sense and this is reflected in a comparatively high cost recovery in a global perspective. In addition, costs of transit operation in Bangkok, particularly private buses, are much lower than those for such richer cities, due to relatively low wages for drivers and other employees, and relatively low maintenance costs for fleets in Bangkok. Maintenance is often not carried out to the degree that it should be to keep buses in good operating order, particularly from an emissions perspective.

However, when compared to other Asian cities, the rate of transit cost recovery in Bangkok is relatively lower, e.g. Hong Kong (136 per cent), Kuala Lumpur (135 per cent), Surabaya (127 per cent), Manila (122 per cent), Singapore (115 per cent) and Jakarta (101 per cent). The lower rate of transit cost recovery in Bangkok in the Asian context is attributable to three reasons:

1) Lower transit fares

As shown in Table 4.12, transit fares per passenger kilometre in Bangkok (US$0.018) are almost the lowest among all cities in the study, second only to those for Manila (US$0.016). Bangkok’s transit fares are about 4 to 5 times cheaper than those for cities of the North and the richer Asian cities. They are also considerably lower than those for other Southeast Asian cities, e.g. Surabaya (US$0.036), Kuala Lumpur (US$0.025) and Jakarta (US$0.023).

2) Inefficient operations of BMTA

In Bangkok, the state-owned enterprise, BMTA, is the largest bus operating body responsible for about 65 per cent of all bus passengers, while the private sector has only a 35 per cent share. As commonly seen in developing
countries, public transport operated by governmental agencies is often faced with financial problems. For example, buses in Beijing only recover 20 per cent of their costs due to a while range of inefficiencies (Hu and Kenworthy, 1996). While privately-owned bus enterprises are able to make a profit from their operation, i.e. their cost recovery ranges from 110 per cent to 130 per cent (Padeco, 1990: 2-99), BMTA has continuously suffered from substantial financial losses. BMTA's low rate of cost recovery is attributable to inefficiency in personnel management, substantial overhead expenditures, lack of proper scheduling and poorly planned bus networks (Tanaboriboon, 1994: 20). In addition, accumulated debts from previous companies (transferred to the BMTA since it was established about two decades ago), have also aggravated BMTA's financial situation.

3) Traffic congestion

Severe traffic congestion in Bangkok also contributes significantly to the inefficiency in bus operations. Buses in Bangkok are often caught in severe traffic and experience many more delays than those in other cities. This means that buses are operated at lower numbers of trips per day than the optimal situation; they carry fewer passengers and therefore generate less revenue. In addition, large amounts of energy are wasted by buses idling in traffic, triggering higher costs of bus operation.

From this comparative study it can be seen overall, however, that the financial situation of public transport in Bangkok, although it has a slight deficit, compares relatively well to that in cities of the North. In addition, privately-owned enterprises in Bangkok have shown that they can make a profit from their operations. A number of Asian cities, both the wealthier cities such as Hong Kong and Singapore, and less wealthy Southeast Asian cities, demonstrate that public transport can make profits and serve a large number of city residents, requiring a lower societal subsidy for public transport. These examples provide hope for Bangkok's public transport, particularly the state-owned enterprises, to improve their operational efficiency and overcome their financial problems, though this must be seen in the overall context of an improvement in the general traffic situation.
4.7 TRANSPORT EXTERNALITIES

The rapidly growing number of motor vehicles and traffic volume in Bangkok during the motorisation period has contributed to several adverse effects such as air and noise pollution, congestion-related energy losses, traffic accidents and so forth, as outlined in Chapter 1. Among the serious consequences of such effects are negative health impacts and concerns for the safety of Bangkok's residents. Although the costs of these transport externalities are difficult to measure in monetary terms, they are estimated to be very high. For example, Quinnet (1990) found that transport accident costs amount to approximately 2 per cent of GDP and air and noise pollution account for about 0.5 per cent. Given Bangkok's GDP in 1990 of around US$23,000 million (JICA, 1990: 359), the social cost of accidents, air pollution and noise in Bangkok would amount to approximately US$575 million per annum.

To obtain a clearer perspective on the seriousness of transport externalities in Bangkok, two major indicators were selected for the comparative study: (1) transport-related deaths; and (2) transport emissions. Transport-related deaths were standardised by the number of city residents, total deaths, and total passenger kilometres in private and public transport. Transport emissions comprise five main air pollutants: CO, HC, NOx, SO2, SPM, and CO2 (see Table 4.15).

4.7.1 Transport-Related Deaths

As outlined in Chapter 1, traffic accidents in Bangkok have been increasing steadily, resulting in a steady increase in fatalities and injuries. The rate of accidents in Bangkok is substantially higher than for the rest of the country, both in proportion to population and to the number of vehicles. In addition, the proportion of number of deaths from transport accidents related to total deaths in Bangkok, has been steadily increasing. In 1990, 949 people were killed in transport accidents in Bangkok, which accounted for over 60 per cent of total accidental deaths and approximately 5 per cent

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33Calculation based on data from Research and Planning Division, Police Department and the Expressway and Rapid Transit Authority of Thailand, 1992.
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2. Bangkok's CO2 emissions data are calculated by the factors shown in Chapter 3. The other Bangkok emissions data are adjusted from TDRI, 1990 data as demonstrated in Chapter 3.
4. Bangkok's passenger kilometre data from Appendix A

Notes: 1. The average SO2 for European cities excludes Hamburg as it is suspected that the figure represents inclusion of non-urban transport sources.
2. The average CO for European cities excludes Stockholm for the same reason as above.
of total deaths.\textsuperscript{35} In comparison to other cities, Bangkok’s transport-related deaths are relatively high in relation to population, total deaths, and passenger kilometres of travel (Figure 4.44, Figure 4.45 and Figure 4.46).

![Figure 4.44 Bangkok's transport deaths per 100,000 people compared to other cities, 1990](image)

*Source: Table 4.15*

![Figure 4.45 Bangkok's transport deaths as a percentage of total deaths compared to other cities, 1990](image)

*Source: Table 4.15*

\textsuperscript{35}Calculation based on data from the Police Department, 1993 and BMA, 1990.
Figure 4.46 Bangkok's transport deaths per 1,000 million passenger kilometres compared to other cities, 1990

Source: Table 4.13

As shown in Figure 4.44, transport-related deaths per 100,000 people in Bangkok in 1990 was about 16. This is a high figure, second only to Kuala Lumpur (22.7 deaths). In comparison, the figure was only 5.3 in Tokyo, 5.7 in Hong Kong, 8.7 in Singapore and 8.8 in European cities. There were 12 to 15 transport-related deaths per 100,000 in the more road-based Australian and American cities respectively. For the other Southeast Asian cities, deaths ranged from only 4.5 in Jakarta to 7.8 in Surabaya, and to 13.8 in Manila.

In terms of the transport-related deaths as a percentage of total deaths, as shown in Figure 4.45, Bangkok also had a very high rate (at 4.9 per cent), only slightly lower than that for Kuala Lumpur (5.3 per cent) and Manila (6 per cent), which had the highest percentage of transport deaths among all cities. The other cities had noticeably lower transport-related deaths as a percentage of total deaths. For example, Jakarta had only 0.8 per cent, European cities had 0.8 per cent, Hong Kong had 1.1 per cent, Singapore had 1.7 per cent, Australian cities had 1.7 per cent and the American cities had 2 per cent. Of course, transport deaths as a percentage of total deaths is influenced by the level of deaths in total and the importance of other causes in different environments. For example, in an "old" population deaths will tend to be higher than in "young" population.
Figure 4.46 also demonstrates the relatively high proportion of transport-related deaths in Bangkok per passenger kilometre as well as in other developing Southeast Asian cities. In 1990 Bangkok had 23.2 deaths per 1,000 million passenger kilometres, Jakarta had 15.7, Kuala Lumpur had 28.8, Manila had 35.6 and Surabaya had 36.7. The level of transport-related deaths per 1,000 million passenger kilometres in Bangkok is however very high, compared to only about 6 in Tokyo, 9 in US cities, 10 in Australian cities, 11 in European cities, 12 in Hong Kong, and 15 in Singapore.

Overall, Figure 4.44 to 4.46 demonstrate that although Bangkok has severe traffic congestion and slow speeds overall, it has a relatively high transport death rate, by whatever measure is chosen. While this could be seen as a surprising, or even paradoxical finding, this noticeably high rate of transport-related deaths might be attributed to three causes:

1) **Dangerous driving**: Drivers in Bangkok are frequently reported to have violated traffic regulations leading to serious traffic accidents. For example, only 16 per cent of drivers in Bangkok stop for pedestrians at pedestrian crossings and about 6 per cent of drivers keep driving through intersections even after red lights have indicated for 5 seconds (Punyahotra, 1993: 40). In addition, due to frustration with traffic congestion and weak law enforcement, drivers in Bangkok often exceed speed limits whenever and wherever they can, even for a short distance. As a consequence, when accidents occur, they are often quite serious. JICA (1987) revealed that the main cause of accidents in Bangkok is improper driving speed, accounting for 41 per cent of total accidents. Alcohol is also a significant factor affecting driving behaviour and contributing to the high accident rate in Bangkok. According to the Police Department, about 80 per cent of people involved in traffic accidents in Bangkok had relatively high blood alcohol concentrations (Office of the National Safety Council of Thailand, 1995: 7).

2) **Motorcycle accidents**: One of the most popular modes of transport in Bangkok is the motorcycle, both private and hired. Motorcycle use accounts for approximately 16 per cent of all trips, carrying nearly 2.5 million people daily (JICA, 1990). Travelling by motorcycle is dangerous; when accidents occur they are often serious. This disadvantage is exacerbated by reckless drivers, speeding and weaving through traffic. From the report of the Bangkok Police Department (1994), out of 34,326 traffic accidents in Bangkok
during the first half of 1994, 13,201 cases or nearly 40 per cent involved motorcycles. The significance of motor cycle deaths is also seen in the high transport death rate in Kuala Lumpur. Kuala Lumpur has some 180 motor cycles per thousand people in 1990 (the highest in the sample) and has a very high rate of motor cycle deaths (nearly six times as high as that for cars in total numbers, about seventeen times as high as that for cars in proportion to vehicle numbers) (Umar, 1994).

3) Pedestrian accidents: As noted in Chapter 1, Bangkok pedestrians are particularly vulnerable to accidents. In 1985, approximately 20 per cent of total accidents involved pedestrians (JICA, 1985). Pedestrians are often seriously injured or killed when they are run over by motor vehicles. Unfortunately, there are no separate statistics on pedestrian deaths available for Bangkok. Due to a general lack of concern for pedestrians, the design of road infrastructure does not provide protection to pedestrians. For example, there are inadequate facilities such as bridges across roads, pedestrian underpasses and pedestrian crossings, particularly along main roads in the outer area where traffic speeds and traffic volumes are relatively high. Although some roads do have pedestrian bridges, the temptation to cross at grade in dangerous situations is high due to infrequent protected crossing points. Moreover, there are hardly any footpaths or pedestrian crossings along most sois. These hostile environments create high risks for pedestrians. JICA (1985) reported that approximately 11 per cent of vehicle-to-pedestrian accidents occurred when pedestrians were crossing roads with no pedestrian crossing.

4.7.2 Transport Emissions

Air pollution is one of the most serious and growing problems in both developed and developing cities around the world. The main source of urban air pollution is fossil fuel combustion, particularly vehicular emissions, which has been increasing in line with growing numbers of vehicles. The other main sources are industrial activities and power generation. In urban areas, the major airborne pollutants emitted by motor vehicles are carbon monoxide (CO), hydrocarbons (HC) or volatile organic compounds (VOC), nitrogen oxides (NOx), sulphur oxides (SOx), suspended particulate matter (SPM), carbon dioxide (CO2), and lead (Pb) (OECD, 1988b: 47; UNEP, 1991: 7).
In Bangkok, motor vehicles are the major sources of air pollution. Emissions from motor vehicles account for approximately 60-70 per cent of all air pollution in Bangkok (Satchell, 1992: 4; Pendakur, 1992a: 17). Private cars, constituting over 40 per cent of Bangkok's vehicle fleet, are major contributors of carbon monoxide (CO), hydrocarbons (HC), and lead. Pick-ups, buses, and trucks with diesel engines contribute large amounts of sulphur, nitrogen oxides (NOx) and particulates. In addition, two-stroke engine motorcycles, which account for around 82 per cent of all motorcycles in Bangkok, are a major source of hydrocarbons, as they emit considerable amounts of unburnt hydrocarbons in both visible and invisible form (Sayeg, 1992: 62). The high level of emissions from the transport sector in Bangkok is related not only to the quantity but also to the quality of motor vehicles. Many vehicles have very poor engines due to age and insufficient maintenance. Moreover, enforcement of emissions regulations is quite weak. The main roads, where traffic congestion is most serious, are the major sources of air pollution (Kidokoro and Hanh, 1993: 11; Thailand Environment Institute et al., 1994: 1-3,1-4). As discussed in the following sections (4.7.2.1 to 4.7.2.6), when compared to other cities Bangkok has relatively high levels of road-based transport emissions for its level of per capita vehicle use. Some emissions, such as SPM, HC and SO2, are the highest among all cities currently under study.

4.7.2.1 Suspended Particulate Matter (SPM)

Particulate matter is the term used to describe a broad array of finely divided solids or liquids that may be dispersed into the air by combustion processes, industrial activities, or natural events. These particulates can range in diameter from less than 0.1 micrometres (μm) to 1,000 μm. Particulates smaller than 10 μm are called "suspended inhalable particulates"; particulates 2.5 μm or smaller in size are known as "fine particulates". Particulates 10 microns or less in size remain in the atmosphere longer than larger particles and they can penetrate deep into the respiratory system. Respirable particulates in urban areas often contain lead, other metals, organic compounds, sulfuric acid, and other sulfates which are harmful to humans. Combustion of diesel fuel from trucks and buses, particularly those with poorly maintained engines, is a major source of inhalable and fine particulates (Wijetilleke and Karunaratne, 1995: 3, 33). In addition, non-tailpipe emissions, such as wear and tear on brakes and tyres, are also
sources of hazardous particulates such as asbestos, a well-known carcinogen (Barde and Button, 1990: 3). As noted in Chapter 1, SPM is the most serious air pollution problem in Bangkok. The results of the comparative study on SPM emissions shown in Figure 4.47 clearly underpin the fact.

![Figure 4.47: Bangkok's transport emissions of SPM compared to other cities, 1990](image)

**Figure 4.47 Bangkok's transport emissions of SPM compared to other cities, 1990**

*Source: Table 4.15*

The SPM emission level in Bangkok was about 9.1 kg per capita in 1990, the highest amongst all cities being studied. It is more than double that for Surabaya (4.3 kg per capita), the second highest; almost three times higher than that for Jakarta (3.4 kg per capita); six times higher than that for Manila (1.5 kg per capita); and nine times higher than that for Kuala Lumpur (1 kg per capita). It is much higher than for all developed Australian, American, and European cities and richer Asian cities.

It is noteworthy that nearly all Southeast Asian cities, except Kuala Lumpur, had relatively high levels of SPM emissions. As diesel engines have long been recognised as the main sources of SPM, particularly fine particulates (Barter, 1996c), the relatively high levels of SPM emissions are mainly attributable to the greater popularity of diesel-fuelled vehicles in these cities than in the high-income cities of the North. Bangkok, in particular, has a very high level of diesel vehicle ownership and use (pick-ups, trucks and buses). There were about 400,000 diesel-fuelled vehicles in Bangkok in 1990, accounting for approximately 20 per cent of the total motor vehicle fleet. As described previously (section 4.5), diesel fuel accounts for 54 per cent of
Bangkok's total energy consumption in road transport. In addition, many diesel vehicles have poorly maintained engines which can emit SPM levels 10 to 15 times higher than those for well-maintained vehicles (Barter, 1996c). Trucks and buses, often overloaded in Bangkok, are also major sources of black smoke, which contain substantial amounts of SPM. Approximately 40 per cent of SPM in Bangkok is carbon-based black smoke which is way in excess of most other cities (Panich, 1994: 2).

4.7.2.2 Hydrocarbons (HC) or Volatile Organic Compounds (VOC)

Hydrocarbons are organic compounds consisting mainly of carbon and hydrogen. They are one of the precursors (along with nitrogen oxides) in the formation of photochemical oxidants (although photochemical smog or surface ozone is not one of Bangkok's air pollution problems). Conditions for the formation of photochemical oxidants are not met in Bangkok due to a regular sea breeze in the afternoon and evening and its very flat topography (Panich, 1994: 1). The main sources of HC are incomplete fuel combustion in vehicle engines and evaporated unburnt petrol from fuel tanks and carburettors. A major hydrocarbon from transport is benzene, a carcinogen associated with leukemia and found mainly in gasoline exhaust. Other major hydrocarbons are polycyclic aromatic compounds (such as benzopyrene), which are also known mutagens and carcinogens and are by-products of incomplete combustion of diesel fuel (OECD, 1988b: 50; Wijetilleke and Karunaratne, 1995: 2). HC is another serious contributor to air pollution problems in Bangkok with very high levels of emissions, which mean that there are high levels of benzene and polycyclic aromatic compounds exhausted. The level of HC emissions is particularly significant, given the comparatively low total VKT per capita in Bangkok (see Figure 4.48).
Figure 4.48 Bangkok's transport emissions of HC compared to other cities, 1990

Source: Table 4.15

Bangkok's level of HC emissions (23.2 kg per capita) is slightly higher than those of Australian cities, Kuala Lumpur and American cities, despite significantly lower total VKT per capita. The HC emissions level in Bangkok is about twice that for European cities and the other three Southeast Asian cities. From Table 4.15, we can see that only a few cities in the study had higher levels of HC emissions than Bangkok and these were car-based cities such as Houston, Phoenix, Detroit and Perth. Because the main source of HC emissions is incomplete fuel combustion (Barde and Button, 1990: 2), the noticeably high levels of HC emissions in Bangkok can be attributed to three main reasons:36 (1) many motor vehicles in Bangkok are old and have poorly maintained engines; (2) there are a great number of motorcycles in Bangkok, a majority having two-stroke engines, which emit enormous amounts of HC; and (3) severe traffic congestion results in very slow traffic speeds and frequent starts and stops, triggering incomplete combustion. For example, at a speed of 8 km/h, a gasoline-consumption car emits approximately 16.5 grams per km of HC. This is about twice as much as it would emit at a speed of 24 km/h (8.3 grams per km) (TDRI, 1990: Table 5-3). Curves of HC emissions per km travelled relative to speed show this significant drop as speed increases (Kent and Mudford, 1979).

36 See section 4.7.2
4.7.2.3 Sulphur Dioxide (SO$_2$)

SO$_2$ is the major form of sulphur emission from transport. Exhaust from diesel engines is the main source of SO$_2$ in urban areas (Wijetilleke and Karunaratne, 1995: 5; Bridgman et al., 1995: 37). Bangkok has very high levels of SO$_2$ emissions compared to other cities, again, particularly considering its total VKT per capita (Figure 4.49).

![SO$_2$ Emissions Comparison Chart]

**Figure 4.49** Bangkok's transport emissions of SO$_2$ compared to other cities, 1990

*Source: Table 4.15*

Bangkok had the highest level of SO$_2$ emissions of 1.8 kg per capita in 1990, slightly higher even than for Hong Kong (1.7 kg per capita), American cities (1.6 kg per capita) and Manila (1.5 kg per capita). This emissions level is about double the levels for the other three Southeast Asian cities in Figure 4.49, about three times higher than that for the Australian cities and much higher than that for the European cities. As SO$_2$ is basically emitted by diesel engines, the high rates of SO$_2$ emissions in Bangkok are attributable to the high number of diesel vehicles, particularly pick-ups, trucks and buses, as previously discussed, as well as poor quality fuel and poor maintenance (Sayeg, 1992: 62, 73).

4.7.2.4 Carbon Monoxide (CO)

The main source of CO emissions in metropolitan areas is gasoline-fuelled motor vehicles. For example, transport (mainly cars) accounted for approximately 90 per cent of total CO emissions in OECD countries (Barde
and Button, 1990: 1). Emissions of CO in developed countries (e.g. the United States) increased substantially in parallel with dramatic increases in vehicle numbers from the 1940s to the early 1970s. However, emissions of CO in the developed countries has been declining due to the introduction of catalytic converters, more stringent standards and more rapid replacement of older vehicles. By contrast, emissions of CO in developing countries are increasing (Wijetilleke and Karunaratne, 1995: 1). For Bangkok, CO emissions are relatively high compared to other cities, as shown in Figure 4.50.

![Bar chart showing CO emissions per capita (kg) for various cities, including US, Aus, KL, Bkk, Man, Euro, Jak, Sura, HK, and Tokyo. The emissions are in kg and range from 14.3 to 204.5.]

**Figure 4.50 Bangkok's transport emissions of CO compared to other cities, 1990**

Source: Table 4.15

CO emissions in Bangkok in 1990 were approximately 85 kg per capita, higher than those for European cities and the Southeast Asian cities except Kuala Lumpur, although still less than half of those for American and Australian cities. This is due to relatively high levels of car ownership and car use in Bangkok, although like HC emissions, it is also linked to high congestion levels leading to inefficient combustion. Emissions of CO per km drop as vehicle speed increases (Kent and Mudford, 1979). It is also due to poor emission standards in vehicles and poor maintenance in Bangkok. As car ownership in Bangkok is projected to increase rapidly, CO emissions are also likely to rise substantially, particularly if congestion remains chronic.
4.7.2.5 Nitrogen Oxides (NO\textsubscript{X})

The major forms of NO\textsubscript{X} in urban areas are nitric oxide (NO) and nitrogen dioxide (NO\textsubscript{2}) (Bridgman et al., 1995: 34). Transport sectors in both developed and developing countries are major contributors to NO\textsubscript{X} in cities. While the share of transport-related NO\textsubscript{X} emissions from developed countries will likely decline, the developing countries’ share is likely to increase substantially (Wijetilleke and Karunaratne, 1995: 31). However, Figure 4.51 reveals that the per capita level of NO\textsubscript{X} in Bangkok is relatively low.

![Bar chart showing NO\textsubscript{X} emissions per capita for various cities](chart.png)

**Figure 4.51 Bangkok's transport emissions of NO\textsubscript{X} compared to other cities, 1990**

*Source: Table 4.15*

NO\textsubscript{X} emissions in Bangkok were 3.6 kg per capita in 1990. This level is relatively low, only slightly higher than for Surabaya (3.1 kg per capita). In the other cities, levels of NO\textsubscript{X} emissions are relatively high. For example, levels were about 9 kg per capita in Manila, 11 kg per capita in Kuala Lumpur, 16 kg per capita in Jakarta, and 22 kg per capita in Australian and the American cities. This is primarily because motor vehicles emit lower amounts of NO\textsubscript{X} at lower speeds, and traffic speed in Bangkok is much slower than that in all other cities. The Thailand Environment Institute (1994) conducted a study to project emissions from motor vehicles in Bangkok and found that, by the year 2000, total transport-related NO\textsubscript{X} emissions would decrease from the base year (1994) due to decreases in overall average traffic speed.
4.7.2.6 Carbon Dioxide (CO2)

Carbon dioxide is one of the major contributors to global warming through the "greenhouse effect". Approximately 50 per cent of global warming is attributable to CO2. The main sources of CO2 are deforestation and combustion of fossil fuel (Wijetilleke and Karunaratne, 1995: 42). Motor vehicles alone are responsible for almost 15 per cent of the world’s CO2 emissions (Barde and Button, 1990: 3). Figure 4.52 shows levels of transport-related CO2 emissions in Bangkok, compared to other cities.

![Figure 4.52 Bangkok's transport emissions of CO2 compared to other cities, 1990](image)

Source: Table 4.15

Basically, CO2 emissions are proportional to the distance of vehicle travel and the fuel consumed in moving this distance (River and Kenworthy, 1993). Where congestion is high, fuel use is high and CO2 emissions are increased. Of course where electrical energy is involved as in certain transit systems, CO2 emissions depend upon the fuel source used to generate the electricity. Bangkok’s annual CO2 emissions level is about 1,300 kg per capita, the second highest among Southeast Asian cities. It is much higher than that for Manila, about double that for Jakarta, and more than three times higher than that of Surabaya. Although this level of CO2 is still much lower than that in the high-income cities of the North (which have higher levels of vehicle use and per capita fuel use), the trend is for levels of CO2 emissions in Bangkok to steadily increase, in line with the substantial increase in motor vehicle use.
4.8 CONCLUSIONS

The close interrelationship between urban form, land-use and transport parameters is evident from the data and statistical analyses in this chapter. The correlation analysis, which employed the global cities data, has shown a strong link between urban density, the degree of centralisation, the provision of transport infrastructure and transport patterns.

The international comparisons demonstrate that Bangkok, in common with other Southeast Asian cities, has quite dense population and jobs with a fairly strong degree of centralisation. Moreover, it has strongly mixed land-use in the inner area and along the main growth corridors near major traffic spines. These urban form and land-use features are ideal for public transport. In terms of road provision, it is widely believed that Bangkok has a very low proportion of its land area devoted to roads compared to other cities, and that this is the main cause of Bangkok’s severe traffic congestion. The data from this study, however, reveal that although Bangkok's road provision in terms of road length per capita is relatively low compared to those of cities in the developed world such as American cities and Australian cities, it is not unusual compared to other developing Asian cities or even the richer Asian cities like Hong Kong and Singapore. In addition, Bangkok's road provision in terms of road length per ha is in common with the levels found in most cities in the study, thus increasing it substantially will be problematic.

Another key point that seems to emerges from this analysis is that the provision of public transport infrastructure in Bangkok, particularly railways, is evidently low. Worse still, there is no genuine urban rail service for such a big city as Bangkok, only what is essentially an intercity service with a few stops in Bangkok. Although Bangkok has a comprehensive network of waterways and some of them have potential to be developed as a supplementary transport system, little attention has been paid to improve them, apart from the relatively small increase in boats and services over recent years. Moreover, parking provision in Bangkok's CBD, which is one of the important factors encouraging car use, is so generous, approaching that of highly car dependent American and Australian cities.
As traffic congestion in Bangkok has steadily deteriorated, Bangkok's residents have turned even more to the use of private vehicles. Car and pick-up ownership in Bangkok is almost the highest in Asia, and approaching that of Tokyo. The dominant role of private transport in Bangkok is evident from comparison with other cities, particularly cities in Southeast Asia with similar kinds of densities and urban form. The majority of Bangkok's residents travel to work by private transport and the proportion is markedly higher than in any other Asian city, including the richer Asian cities, and is also much higher than European cities. Furthermore, Bangkok has almost the highest occupant kilometres in private transport per capita compared to all Asian cities. Although the level of private vehicle kilometres per capita is still low compared to cities of the North, it is very high compared to other Southeast Asian cities. On the other hand, segregated public transport modes, i.e. trains and boats which have high capacity and greater energy-efficiency, play an extremely small role in moving people in Bangkok. Moreover, non-motorised modes, particularly walking and cycling, which are suitable to the city's structure, play a very tiny role in people's movement, the lowest, in fact, among all Asian cities and European cities.

In terms of transport economics, the comparative study reveals that per capita road expenditure in Bangkok is much higher than that for all developing Asian cities and not far behind the richer Asian cities of Tokyo and Hong Kong. Moreover, Bangkok's road expenditure as a proportion of GRP is the second highest among the global cities, much higher than for cities of the North and richer Asian cities. In addition, driving in Bangkok is relatively cheap, which is most likely a factor contributing to the high level of private vehicle use, although it is not so different from costs in some other developing Asian cities. The study further reveals that, overall, although public transport in Bangkok operates at a slight deficit, its financial status is much better than that in cities of the North. It requires only minimal societal subsidy and it has the potential to be improved to make profits and provide better services for the residents, as in a number of Asian cities.

The severity of Bangkok's traffic congestion has been confirmed by the international comparisons which show that traffic and public transport speeds in Bangkok are currently the lowest among all cities being studied. Private transport energy use per capita in Bangkok is the highest among the
Asian cities. The rate of transport-related deaths in Bangkok is among the highest of all cities in the study. Moreover, the rate of per capita emissions from transport in Bangkok is very high, with the highest levels of SPM, HC and SO2.

Table 4.16 attempts to provide an overview of all the international comparisons of Bangkok with other cities, highlighting the similarities and differences between Bangkok and other cities, particularly Asian cities.

Any attempts to solve Bangkok's traffic problem obviously need to take the main characteristics of Bangkok's transport and land-use into consideration. Chapter 5 highlights the major lessons learnt from this international comparative study and from the study of the development of Bangkok's transport and land-use.
Table 4.16 An overview of the international comparisons of Bangkok with other cities

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Bangkok’s land-use and transport patterns indicated by the international comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>URBAN FORM AND LAND-USE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Population density</td>
<td></td>
</tr>
<tr>
<td>1.1 Whole city density</td>
<td>High density, similar to other Southeast Asian cities</td>
</tr>
<tr>
<td>1.2 Central city density</td>
<td>High density, similar to other Southeast Asian cities</td>
</tr>
<tr>
<td>1.3 Inner area density</td>
<td>High density, similar to other Southeast Asian cities</td>
</tr>
<tr>
<td>1.4 Outer area density</td>
<td>Moderately high density, similar to other Southeast Asian cities</td>
</tr>
<tr>
<td>2. Employment density</td>
<td></td>
</tr>
<tr>
<td>2.1 Whole city density</td>
<td>High job density, similar to other Southeast Asian cities</td>
</tr>
<tr>
<td>2.2 Central city density</td>
<td>Relatively low compared to cities of the North and richer Asian cities, though not much lower than that in Southeast Asian cities</td>
</tr>
<tr>
<td>2.3 Inner area density</td>
<td>Relatively high compared to cities of the North, but similar to that in Southeast Asian cities</td>
</tr>
<tr>
<td>2.4 Outer area density</td>
<td>Relatively high compared to cities of the North, but similar to that in Southeast Asian cities</td>
</tr>
<tr>
<td>3. Degree of centralisation</td>
<td></td>
</tr>
<tr>
<td>3.1 Proportion of population in CBD</td>
<td>Relatively high compared to cities of the North and richer Asian cities, but similar to that in Southeast Asian cities</td>
</tr>
<tr>
<td>3.2 Proportion of jobs in CBD</td>
<td>Relatively low compared to Southeast Asian cities, richer Asian cities, and European cities, but similar to that in American and Australian cities</td>
</tr>
<tr>
<td>3.3 Proportion of population in inner area</td>
<td>Relatively high compared to cities of the North and richer Asian cities, but similar to that in Southeast Asian cities</td>
</tr>
<tr>
<td>3.4 Proportion of jobs in inner area</td>
<td>Relatively high compared to American and Australian cities, but similar to that in Southeast Asian cities, richer Asian cities and European cities</td>
</tr>
<tr>
<td><strong>TRANSPORT INFRASTRUCTURE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Road supply (length of road per capita)</td>
<td>Low level of road length per capita, similar to other Asian cities</td>
</tr>
<tr>
<td>2. Road density (length of road per ha)</td>
<td>Similar level of road density to most other cities around the world</td>
</tr>
<tr>
<td>3. Rail route supply per capita and rail route density</td>
<td>Very low rail route length, particularly compared to richer Asian cities and European cities</td>
</tr>
<tr>
<td>4. Parking spaces</td>
<td>Very high level of CBD parking spaces, particularly compared to Asian cities and European cities or higher than some US and Australian cities</td>
</tr>
<tr>
<td>5. On-street parking</td>
<td>Very high proportion of on-street parking spaces in CBD</td>
</tr>
<tr>
<td>Parameters</td>
<td>Bangkok's land-use and transport patterns indicated by the international comparisons</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>TRANSPORT PATTERNS AND ENERGY USE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Energy use in private passenger transport</td>
<td>Highest level of per capita energy use among Asian cities, though still low in overall international comparisons</td>
</tr>
<tr>
<td>2. Total vehicles on register</td>
<td>Very high vehicle ownership compared to other Asian cities, moderate in an international context</td>
</tr>
<tr>
<td>3. Car ownership</td>
<td>Very high car ownership compared to other Asian cities, moderate in an international context</td>
</tr>
<tr>
<td>4. Average speed of traffic</td>
<td>The slowest speed among all cities in the study</td>
</tr>
<tr>
<td>5. Average speed of public transport</td>
<td>The slowest speed among all cities in the study</td>
</tr>
<tr>
<td>6. Private vehicle kilometres per capita</td>
<td>High compared to other Asian cities, although not high compared to Western cities</td>
</tr>
<tr>
<td>7. Private vehicle passenger kilometres per capita</td>
<td>Very high compared to other Asian cities, although not high compared to Western cities</td>
</tr>
<tr>
<td>8. Public transport passenger kilometres per capita</td>
<td>Relatively low compared to richer Asian cities and Manila, but slightly higher than that in European cities and the other Southeast Asian cities and much higher than that in American and Australian cities</td>
</tr>
<tr>
<td>9. Private transport/public transport balance (% of motorised travel on public transport)</td>
<td>Relatively low proportion of public transport use compared to Asian cities, particularly richer Asian cities, though much higher than that in American and Australian cities</td>
</tr>
<tr>
<td>10. Proportion of public transport passenger kilometres on rail</td>
<td>Extremely low</td>
</tr>
<tr>
<td>11. Rail service kilometres per hectare</td>
<td>Extremely low</td>
</tr>
<tr>
<td>12. Proportion of workers using public transport</td>
<td>Relatively low compared to Asian cities, particularly richer Asian cities, but comparatively high compared to automobile cities in the US and Australia</td>
</tr>
<tr>
<td>13. Proportion of workers using private transport</td>
<td>Highest among Asian and European cities, but considerably less than in US and Australian cities</td>
</tr>
<tr>
<td>14. Proportion of workers using foot or bicycle</td>
<td>Lowest among Asian and European cities, but more than in US and Australian cities</td>
</tr>
<tr>
<td><strong>TRANSPORT ECONOMIC FACTORS</strong></td>
<td></td>
</tr>
<tr>
<td>1. Expenditure on roads</td>
<td>Extremely high level of expenditure per US$1,000 GRP compared to all cities in the study, and the highest level of expenditure per capita among Southeast Asian cities</td>
</tr>
<tr>
<td>2. Cost of private transport use</td>
<td>Relatively low cost of private transport use, particularly compared to richer Asian cities and Western cities, although similar to other developing Asian cities</td>
</tr>
<tr>
<td>3. Cost recovery by public transport</td>
<td>Relatively high compared to Western cities, but still lower than all other Asian cities</td>
</tr>
<tr>
<td>4. Transit fare</td>
<td>Almost the lowest among all cities in the study</td>
</tr>
<tr>
<td><strong>TRANSPORT EXTERNALITIES</strong></td>
<td></td>
</tr>
<tr>
<td>1. Transport related deaths</td>
<td>Among the highest of all cities in the study</td>
</tr>
<tr>
<td>2. Transport emissions</td>
<td>Very high level of per capita transport emissions, with the highest level of SPM, HC and SO2 emissions among all cities in the study. Most other emissions high relative to Bangkok's lower vehicle use compared to cities in Europe, US and Australia.</td>
</tr>
</tbody>
</table>
CHAPTER 5

THE ROOTS OF BANGKOK'S TRAFFIC CRISIS:
LESSONS FROM THE STUDY

5.1 INTRODUCTION

Different groups view transport problems in cities differently, depending on their experiences, attitudes and interests. As a consequence, there will be variability in acceptable responses. Dimitriou (1990) noted that the urban transport problems considered to be "root problems" of urban transport in Third World cities include: increased income and vehicle ownership, increased vehicle use, longer average trip-making, higher population growth, increased urban expansion, inadequate land-use control, poor traffic management and enforcement, incompatible traffic mix, incompatible urban form and density configuration, inadequate transport facilities, poor infrastructure maintenance and management, inefficiently operated public transport services, inadequate cost recovery measures, and inadequately trained staff. Different groups perceive and address these problems differently, depending on their roles in urban transport policy and planning. Differences among engineers, economists, other social scientists, physical planners and politicians have contributed considerably to problems (Figure 5.1). Thus, to achieve a meaningful understanding of complicated transport problems, there is a need to look beyond narrow or confined perspectives, and this will in turn enable problems to be dealt with more effectively.
Figure 5.1 Multiple perceptions and dimensions of the urban transport problem

Source: Adapted from Dimitriou, 1990: 68

In the case of Bangkok, the most obvious problems are severe traffic congestion and its impacts: air and noise pollution, health impacts, energy loss and traffic accidents, as discussed in Chapters 1 and 4. These problems, also experienced in other developing countries, have occurred as a result of the rapid move towards more car-dependent land-use and transport patterns. Newman (1993: 1) identified three major factors contributing to the move towards a car-dependent city: (1) transport policy which gives priority to cars and car use; (2) cultural preferences which tend to favour this preference; and (3) transport investment in infrastructure which tends to be promoted by both of the above factors (Figure 5.2).

Figure 5.2 Factors contributing to growing car dependence

Source: Adapted from Newman, 1993: Figure 4
Two previous chapters of this thesis have provided insights into the roots of the transport problems in Bangkok: the comprehensive study of the development of Bangkok's transport and land-use in Chapter 2, and the comparative study between Bangkok and other cities around the world in terms of urban structure and land-use, transport infrastructure, transport patterns, energy consumption, transport economics and transport externalities in Chapter 4. These analyses reveal that, in Bangkok, traffic congestion and the other problems are interrelated. These problems appear to stem from a combination of several factors such as socio-economic and cultural influences. However, the main contributors seem to be the inappropriate and ineffective urban and transport policy, which is biased towards road based-transport and a city structure which is not supportive of or amenable to high car use. This chapter highlights crucial lessons learnt from the study on Bangkok's transport and land-use development in Chapter 2 and the comparative study in Chapter 4. It provides additional data, particularly comparative figures in section 5.6 showing relationships among urban form, transport patterns and transport infrastructure, to support the discussion.

5.2 BANGKOK'S TRAFFIC PROBLEM IS ONE OF THE WORST

The traffic crisis in Bangkok is clear to the most casual observer. Chapter 2 and Chapter 4 systematically demonstrated that, as Bangkok has grown towards higher car dependence over more than three decades, it has suffered in numerous ways. Traffic congestion, occurring on most main roads in Bangkok, especially in the inner area, is now considered to be at crisis levels. In 1993, the average travel speed of all vehicles in the whole of Bangkok was approximately 13 km/h. Bicycles in modern cities have average speeds considerably higher than this. The overall travel speed inside the middle ring-road zone averages less than a mere 10 km/h. Average speeds along the most seriously congested roads are 3 to 5 km/h or walking pace. Several times in the past few years, traffic has ground to a complete stop for an extended period, producing the world's first examples of total gridlock. This comparative study also confirms that Bangkok has the lowest speed of traffic among all cities under study. Moreover, it is predicted that by the year 2006, unless effective remedial measures are undertaken, the average travel speed of all vehicles in Bangkok will decline to only 5 km/h (JICA, 1990). This is walking speed. This traffic crisis permeates every aspect of Thai life. For
example, there is a joke now told about a man walking along the road who meets a friend in a Mercedes who offers him a lift. The man politely thanks his friend but replies "No, not today, I'm in a hurry."

Severe traffic congestion and the rapid growth in numbers of motor vehicles also contribute enormously to levels of energy consumption. Energy use per capita in transport in Bangkok is among the highest in Asia. Worse still, air quality and noise pollution in Bangkok have been deteriorating for many years, adversely affecting the health of Bangkok's residents. Several air pollutants, particularly SPM and CO, have been found to exceed health standards. The comparative study emphasises that the emissions of SPM, HC and SO2 per capita from the transport sector in Bangkok are among the highest in the world, especially considering the comparatively low per capita private travel which generates these emissions. In addition, the rate of traffic accidents is significantly higher than the rest of Thailand and is steadily increasing. In terms of transport-related deaths, Bangkok ranks among those cities with the highest rate of deaths relative to population, total deaths and passenger kilometres.

5.3 BANGKOK'S URBAN STRUCTURE MITIGATES AGAINST CAR USE

As demonstrated in Chapter 2, Bangkok is an old city, originally designed for water-based transport and walking, modes which are still largely suitable to its geographical features, land-use and density. Although waterway transport declined during the transport modernisation period, tram, train, bus and non-motorised transport, introduced into Bangkok during this period, were nevertheless suitable to the city's structure. This is because, compared to cars, they can carry more people and need less space. Consequently, there was hardly any traffic congestion during this period. In turn, these transport technologies maintained Bangkok as a high-density and mixed land-use city. These land-use characteristics are crucial in reducing average trip lengths for residents.

During Bangkok's motorisation era, a number of roads were built to facilitate road-based transport. Consequently, the road density in Bangkok is relatively high compared to other Asian cities, as discussed in Chapter 4. However, in terms of road provision per capita, the proportion is relatively low compared to cities of the North, but this proportion is similar to that for
the other Asian cities where people live in high-density developments. As shown in Plate 5.1, Bangkok still has a relatively high population density, particularly in the inner area where the density is about 290 persons per ha, over three times higher than that of the average inner-area density of transit-based European cities. It ranges from eight to more than ten times higher than densities of the road-based American and Australian cities. Even the outer areas of Bangkok, which are developed at about 89 persons per ha, resulting from the expansion of Bangkok, still have a density 80 per cent higher than the overall density of European cities (over seven times higher than densities for the outer areas of American and Australian cities). Bangkok therefore has a walking city density in its inner area and transit city density in its outer area.

Plate 5.1 Bangkok is a high density city

This type of city with a high population density is obviously not designed for roads, which need more transport space for private vehicles. Cities with high densities have less space to dedicate to transport activity. As a result, they typically have limited road space, as is commonly seen in most Asian cities. These cities are in need of efficient allocation of city space for all activities. For example, in terms of transport, Bangkok requires certain types of transport technology to carry more people and use less space. Automobile technology is not suitable for this type of city as it is the least efficient transport mode in terms of people moved for a given amount of road. Whitelegg (1993: 78) argues that cars require the largest space for infrastructure such as roads and parking, whereas low speed and non-
polluting modes such as walking and cycling require only little space (Table 5.1).

Table 5.1 Consumption of space by different modes of transport

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Space required per person (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>0.8</td>
</tr>
<tr>
<td>Cyclist</td>
<td>3.0</td>
</tr>
<tr>
<td>Light rail/Metro-full</td>
<td>2.2</td>
</tr>
<tr>
<td>Light rail/Metro-1/3 full</td>
<td>6.9</td>
</tr>
<tr>
<td>Bus-full</td>
<td>9.4</td>
</tr>
<tr>
<td>Bus-1/3 full</td>
<td>28.1</td>
</tr>
<tr>
<td>Fully occupied car</td>
<td>20.0</td>
</tr>
<tr>
<td>Car with 1 person</td>
<td>60.0</td>
</tr>
</tbody>
</table>

Source: Adapted from Whitelegg, 1993: Figure 5.1

In addition Table 5.2 shows how many passengers can pass on a 3-4 metre wide road within one hour. As has been demonstrated by other researchers, only a small increase in the number of cars can fill to capacity the limited road space in dense cities, causing rapidly deteriorating traffic congestion (Figure 5.3).

Table 5.2 Relative passenger carrying efficiency of different transport modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>No. of persons/h on a 3-4 m. wide road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>20,000</td>
</tr>
<tr>
<td>Cycling</td>
<td>13,300</td>
</tr>
<tr>
<td>Car</td>
<td>900-2,300</td>
</tr>
<tr>
<td>Bus</td>
<td>7,000-10,000</td>
</tr>
<tr>
<td>Tram</td>
<td>18,000-25,000</td>
</tr>
<tr>
<td>Rapid rail</td>
<td>40,000</td>
</tr>
<tr>
<td>Commuter train</td>
<td>50,000</td>
</tr>
</tbody>
</table>

5.4 THE MYTH OF ROAD PROVISION

Road provision is the key issue in Bangkok transport policy and investment. This is because the dominant perception of the root of Bangkok's severe traffic congestion is of inadequate road space and a poor road system (in particular, the lack of a proper road hierarchy). A number of transport studies and plans for Bangkok emphasise this issue. Consequently, road and expressway projects receive a high priority. This section analyses this issue in detail, as it appears to be a central point of contention in the debate over Bangkok's traffic crisis.

5.4.1 Inadequate Road Space

In the literature, it is common to find reference to Bangkok's road provision as being 8-10 per cent of the total area, compared to a more typical road proportion of 20 to 25 per cent in cities in developed countries (see, for example: Tanaboriboon, 1993; Bardacke, 1996). These latter figures are usually given as an international benchmark or standard for the amount of space cities should set aside for roads. For example, the Department of Policy and Planning, BMA (1989) depicts the main root of the traffic problem in Bangkok in the following way:

...the increase in vehicle population and the increase in new roads are not compatible. Each year roads space has been increased very marginally....

...private vehicle numbers increase very fast. An estimate of 669,000 private vehicles will be in Bangkok in 1991 compared to road space which
is only 9% of the area. The international standard for road allocation is about 20% of city area... (p. 2)

A further example is from Padeco (1990) in the Survey of Urban Transport Costs and Fares in the SEATAC Region, Phase I, Final Report, prepared for the Southeast Asian Agency for Regional Transport and Communications Development (SEATAC):

Another cause of the city’s congestion problem is the city’s relatively low investment in road infrastructure. Roads occupy only 10.7% of the area within the Middle Ring Road; the comparable figures for London, Paris, and New York are in the range of 20-25%; while the figure for Los Angeles is even higher. (p. 3-44)

More recently, this has been given added status through a report appearing in the Financial Times, stating: "If you’ve only got 8 per cent of road space (compared to 25 per cent in most other cities) it is vitally important to use it efficiently..." (Bardacke, 1996: 6).

As a consequence, most Thai politicians and transport planners assume that Bangkok’s serious traffic congestion is mainly attributable to the low allocation of road space (see Department of Policy and Planning, BMA, 1989: 2; Department of Policy and Planning, BMA, 1993: 1; Tanaboriboon, 1993: 15). Rarely it appears do they realise, that despite Los Angeles having in excess of 25 per cent of its land area for roads, it is hardly a model city in terms of solving traffic congestion. Great care however needs to be taken in the interpretation of these data. It is difficult to find any background data to support the 8 to 10 per cent road space figure in Bangkok. How can this be resolved and what is the significance of the percentage of land area devoted to roads in an international context?

To compare Bangkok’s road provision with that of other cities, road area as a percentage of urbanised area is the most relevant measure because it relates the road area to actual developed land rather than an arbitrary boundary which may include a lot of undeveloped land which does not need extensive road infrastructure. The comparison of road area to total area is meaningless because of the variety of ways administrative boundaries are drawn. Bangkok’s total area is defined by its administrative boundary, comprised of
both urbanised land, which accounts for only around half of the total area, and the remainder which is still farms, orchards or vacant land. By contrast, cities such as London, Paris and New York are more fully developed, though care is still needed to exclude large contiguous areas of vacant and undeveloped land. Comparisons among cities of the proportion of land under roads without attention to contextualising data can often lead to false conclusions.

One of the possible reasons why comparisons of land area under roads are not always correctly carried out is that the data on urbanised land area are not always readily available. Newman and Kenworthy (1989) describe the problems of defining and obtaining the data on urbanised area of different cities in *Cities and Automobile Dependence: An International Sourcebook*:

> Urban land use data were also open to a large degree of interpretation. A consistent definition of what constitutes "urban" was necessary in order to make valid comparisons. Considerable effort was therefore put into ensuring that the physical land areas (i.e. urbanised land) took adequate consideration of what was really "urban". (p. 28)

In order to do this, detailed land-use inventories are necessary in most cities. In this thesis the definition of urbanised area is taken from Newman and Kenworthy’s study. Urbanised land is all land presently developed for residential, industrial, commercial and special urban purposes and includes all streets and roads. It excludes all land that is categorised as agriculture, water bodies, forest, large open space areas (not small local open space), and undeveloped urban zoned land (Newman and Kenworthy, 1989: 28).

Using this definition of urbanised land, Table 5.3 shows the different areas of land devoted to roads in various parts of Bangkok. The data suggest that 11.4 per cent of the Bangkok Metropolitan Administration (BMA)’s urbanised area is under roads. In the old CBD, roads occupy around 16 per cent of the total urbanised land, in the inner, the middle and the outer area, road space accounts for 10 per cent, 13 per cent and 11 per cent of the urbanised land respectively.
Table 5.3 Existing road space in Bangkok as a proportion of urbanised land area

<table>
<thead>
<tr>
<th></th>
<th>CBD</th>
<th>Inner Area</th>
<th>Middle Area</th>
<th>Outer Area</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanised Land Area (ha)</td>
<td>2,056</td>
<td>11,277</td>
<td>14,204</td>
<td>8,177</td>
<td>33,658</td>
</tr>
<tr>
<td>Road Space (ha)</td>
<td>338</td>
<td>1,164</td>
<td>1,790</td>
<td>891</td>
<td>3,845</td>
</tr>
<tr>
<td>% Area Occupied by Roads</td>
<td>16.4</td>
<td>10.3</td>
<td>12.6</td>
<td>10.9</td>
<td>11.4</td>
</tr>
</tbody>
</table>

Source: Calculation based on data from Bangkok Metropolitan Administration (BMA), 1986: Bangkok Land-Use by District Map, 1986

As previously discussed, the road space allocation in Bangkok is generally considered to be low compared to typical western cities where the proportion is said to be 20 to 25 per cent (Tanaboriboon, 1993: 15). Nevertheless, several more accessible cities in developed countries have almost the same proportion of land for roads as Bangkok. Figure 5.4 summarises data on land area under roads in a number of cities around the world where the area of land under roads was available. It shows, for instance, that Paris allocates 11 per cent of urbanised land to roads, Hong Kong 12 per cent, Munich 13 per cent and Tokyo has 13 per cent of its urbanised land devoted to roads. By contrast, a number of American cities devote 30 per cent or more of their urban land to roads, and still suffer from traffic congestion during peak hours (Barter and Kenworthy, 1995: 9). These data suggest that while Bangkok's road area is at the low end of the spectrum, it would appear that it is not necessarily the primary cause of Bangkok's traffic situation.

Figure 5.4 Proportion of urbanised land under roads in selected cities

Source: Kenworthy et al., 1995: 39
The crux of the issue seems to be that those cities which have almost the same levels of road space as Bangkok (for example, the Paris Region, Hong Kong and Munich) also have extremely good public transport services, in particular, very good rail systems. They also have high levels of walking and cycling. Thus, the basic problem in Bangkok seems not to be a lack of road space per se, but a poorly developed transit system as well as very low levels of walking and cycling; in essence some serious mismatches between its basic transport patterns and other characteristics. Bangkok’s public transport system and level of non-motorised mode use would appear not to complement its small road provision to a sufficient extent. In other cities, these factors are better matched and, although there is still congestion, there are not traffic crises of the dimensions experienced in Bangkok.

Moreover, attempts to increase road space in Bangkok to a more typical level of around 20 per cent of its urbanised area (a level still widely accepted among some Thai planners) is not socially, physically or financially feasible. A huge built-up area would have to be bulldozed, thus displacing a population equivalent to that of Chiang Mai, not to mention the loss of a huge number of jobs. This type of action would provoke very serious resistance, require a huge capital investment and would, in itself, generate a high demand for more road space because the displaced population and the jobs relocated on the urban fringe would be highly car-dependent. The implications of such an approach are summarised below in Figure 5.5.

<table>
<thead>
<tr>
<th>Existing road space</th>
<th>3,844 ha</th>
<th>Equal...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra land needed for roads</td>
<td>2,888 ha</td>
<td>Lat Phao district</td>
</tr>
<tr>
<td>Displaced residents</td>
<td>469,000</td>
<td>City of</td>
</tr>
<tr>
<td>Displaced jobs</td>
<td>145,800</td>
<td>Chiang Mai</td>
</tr>
<tr>
<td>Total activities displaced</td>
<td>615,100</td>
<td>10 per cent of BMA</td>
</tr>
<tr>
<td>Land required to resettle</td>
<td>14,598 ha</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.5 Some implication of increasing the percentage of urbanised land under roads in Bangkok to 20 per cent

Source: Kenworthy, 1995: Figure 15

Notes: 1. "Bangkok" for this calculation is the BMA.
2. Land required to settle is based on the assumption that the population and jobs displaced to the fringe would be settled at population and job densities typical of new areas at present.
5.4.2 The Lack of a Proper Road Hierarchy

Several transport studies address what is considered to be another major root of traffic congestion in Bangkok: the lack of a proper road hierarchy. For example, the Seventh Plan Urban and Regional Transport (SPURT), the current major plan for the development of transport in Bangkok and Thailand, reported by Halcrow Fox and Associates et al. (1991), stresses that:

*The lack of distributor roads shows that there is no coordination between the planning and construction of main roads and their supporting roads. There is clearly no planning of access roads, which are generally the incremental product of numerous small, independent private developments. The overall result is a poor and inefficient road hierarchy which leads to excessively long trip distances and innumerable traffic bottlenecks.* (p. 6-26 to 6-27)

The deficiencies in the road hierarchy were also emphasised in another Bangkok major transport plan: *The Revision of the Traffic and Transport Master Plan for the Greater Bangkok Area* (1994), which states:

*A contributing cause of traffic congestion in the Greater Bangkok Area is the lack of secondary roads to assist the distribution of traffic and provide adequate connections between the primary and local road network. In other words, there is no proper road hierarchy.*

*Ribbon development along primary roads within the Greater Bangkok Area has led to large areas of land being locked in, with access only available by means of dead-end sois. This means that access to or from the superblock can be from one side only, and journeys within the superblock are forced to travel out onto the primary road first, and then re-enter at the desired point. This leads to excess traffic on the primary road network.*

(Kasetsart University and Sindhu Pike Bodell, 1994a: 1)

Consequently, the 1994 plan proposed solutions for the superblock problems, emphasising the establishment of a road hierarchy, particularly by building secondary roads parallel to primary roads. Entrances of sois to the primary road would then be closed to reduce unnecessary trips on primary
roads (Figure 5.7). This measure was claimed to offer time saving of 15 to 30 per cent for superblock traffic (Kasetsart University and Sindhu Pike Bodell, 1994a: 2-4).

More recently, in 1996, an article in the Financial Times also addressed the lack of a road hierarchy in Bangkok as the main root of the traffic problem by illustrating what it claimed to be typical comparative diagrams of the road system in central Bangkok and central London (Figure 5.6). The article summarises the situation as follows:

For instance, areas of similar size in central Bangkok (left) and central London (right) illustrate the difference. In addition to less overall road space, the large majority of secondary roads in Bangkok are dead-end, leaving main roads to carry an inordinate share of the traffic burden. (Bardacke, 1996: 6)

Figure 5.6 The Financial Times' comparative diagrams of central Bangkok and central London's road networks, 1996

Source: Bardacke, 1996: 6

The above studies clearly give very high priority to the creation of an appropriate and systematic road hierarchy for Bangkok. Thus, they conclude that the most urgent solution is to build a more comprehensive road network, including adding more expressways and distributor roads and developing a road hierarchy like those in other cities in developed countries (see, for example, Kasetsart University and Sindhu Pike Bodell, 1994b; Kasahara, 1994; Songsaksri, 1995).
Figure 5.7 Concept of secondary road development in Bangkok

Source: Kasetsart University and Sindhu Pike Bodell, 1994a: Figure 3.1
In fact, the effects of road hierarchies on traffic are rather complicated. In addition, the long-term effects of a supply-side approach to road infrastructure are not of less importance than the short-term gains from this approach. Before concluding that the implementation of a more comprehensive road hierarchy can relieve Bangkok's traffic congestion, more careful study is required. Several key points need to be taken into consideration as follows:

(1) First, the comparison of the road network in central Bangkok and central London in the *Financial Time* article, which originated in the *Revision of the Traffic and Transport Master Plan for the Greater Bangkok Area*, can mislead readers into thinking that the traffic problems in central Bangkok stem from the lack of an appropriate and comprehensive road system. In fact, the diagrams in Figure 5.6 overlook two important points. First, the Bangkok road network illustrated is not central Bangkok, but rather an area outside Bangkok's centre. The centre of Bangkok itself contains quite an effective grid system, although it is not as comprehensive as the London system (Figure 5.8). Nevertheless, the most serious traffic congestion still occurs in the central area of Bangkok despite this relatively good road system. The comparison by the *Financial Times* also totally fails to acknowledge that London has an exceptionally good rail system focussed on its centre, which is critical in keeping congestion to within manageable limits. Bangkok does not.

![Figure 5.8 Road network in the centre of Bangkok](image)

Source: Waugh, 1971
(2) Second, typically, a road hierarchy comprises at least four types of road: 1) primary roads; 2) collector roads; 3) local streets; and 4) access streets, each designed to function differently. The main purpose is for "mobility" of motor vehicles. This is a sensible approach from a traffic engineering perspective, as the hierarchy seems to function well in terms of traffic flow. However, the hierarchy concept overlooks the negative impacts on people who do not own cars, for example, pedestrians, cyclists and public transport users. Further, as the hierarchy makes walking and cycling more difficult and increases travel distances, it dissuades people from using these modes of transport and, consequently, encourages more private motor vehicle use (Roberts, 1995). This has been the experience in cities around the world (Figure 5.9). Thus, in the long run the emphasis on the use of road hierarchies may not fundamentally solve Bangkok's traffic problem and might even aggravate it if the facilitation of extra car travel exceeds the benefits of a redistribution of traffic over a more rational road system.

![Diagram](image)

Figure 5.9 Going places in the cul-de-sac street pattern - to walk or to drive?

Source: Roberts, 1995: Figure 4.16

This matter was taken up by Roberts (1995), who conducted a study on the implications of road hierarchies on walking and cycling in Perth. She found that the introduction of road hierarchies in Perth first resulted in a loop pattern, followed by cul-de-sacs. This road system renders a substantial
increase in trip lengths for social and shopping purposes (Figure 5.10). The local purpose of social and shopping trips seems to be more clearly related to local street patterns. Travel for these purposes was increased by some 33 per cent for social/recreational trips and 65 per cent for shopping trips.

![Bar chart showing trip length comparison between different street patterns](image)

**Figure 5.10 Trip type and length compared to street pattern in Perth**

Source: Roberts, 1995: Figure 4.17

(3) Third, there is the argument that road hierarchies lead to improvements in the conditions in superblocks. Superficially, the solution to the lack of road hierarchy is to add distributor roads within these superblocks which will, it is claimed, reduce traffic congestion. Indeed, the first part of the revised Bangkok transport master plan already recommends huge investment in expressways and roads using government and private funds. As discussed later, experience from cities around the world has demonstrated that, although this approach of increasing road supply satisfies many planners and road users in the short term by providing more space for motor vehicles, in the long run it draws more car traffic onto roads. More households are likely to move to locate along these new roads; more people will be encouraged to use cars; and many people will be displaced from dense residential areas. This is likely to cause social upheaval and further traffic. Experience has demonstrated that new roads will reach a congested state in a very short time and at higher traffic volumes. This is the classic congestion-road building "treadmill" for which Los Angeles is famous.
Fourth, the road hierarchy plans overlook the problem that many of the so-called superblocks in Bangkok have at least one canal passing through them or have the river along one side (Figure 5.11). The dead-end sois (small local streets) illustrated in the Bangkok road diagram in fact terminate either at these canals or at the river. They are not strictly dead ends for local people at all, as these canals can be developed with ferry services to provide residents with an alternative to cars, especially with the use of ferries feeders for buses or trains. This problem, and the alternative options it suggests, have not been considered in the road-based solutions proposed for Bangkok's traffic.

5.5 FACTORS AFFECTING THE RAPID GROWTH OF VEHICLE POPULATION AND VEHICLE USE

Chapter 2 showed that during the present motorisation era, beginning with the end of the Second World War, vehicle numbers in Bangkok have risen rapidly, particularly since the 1980s. Not unexpectedly, increasing wealth emerges as an important factor in the underlying patterns of vehicle ownership within Bangkok, though, as discussed later, it is difficult to explain Bangkok's overall vehicle ownership in relation to other cities solely in terms of a wealth factor. Because of the critical importance of motor vehicle ownership in contributing to Bangkok's congestion problems, this section examines the key factors which appear to be behind Bangkok's booming vehicle population.

The startling growth in the motor vehicle population of Bangkok appears to be attributable to four major factors, as depicted in Figure 5.12. These factors are: (1) economic factors; (2) cultural preferences; (3) inadequacy and inefficiency of the public transport service and the non-viability of walking and cycling in Bangkok's hostile urban environment; and (4) transport infrastructure that encourages private vehicle use.
Figure 5.11 Some of the so-called superblocks in Bangkok

Source: Kasetsart University and Sindhu Pike Bodell, 1994a: Figures 4.1 and 4.5
Figure 5.12 Factors affecting the rapid growth of private vehicles in Bangkok

5.5.1 Economic Factors

Since the early 1980s, Thailand has experienced unprecedented economic growth. From 1980 to 1988, the country doubled its Gross Domestic Product (GDP). During the Fifth National Economic and Social Development Plan (1982-1986), economic growth averaged 4.4 per cent per annum. Then, during the Sixth Plan (1987-1991), the GDP dramatically expanded at an average of 10.5 per cent annually, more than doubling the 5 per cent growth target (NESDB, 1987: 4; NESDB, 1992: 1). The Bangkok Metropolitan Region is the core of such growth, as it represents around 50 per cent of the country's GDP and 77 per cent of the country's manufacturing output (Setchell, 1992). The average income per household of Bangkok inhabitants has been increasing markedly since the beginning of Thailand's "growth spurt" in the early 1980s. In 1981, the average income per household in the greater Bangkok area was 71,664 baht (US$2,867), which almost doubled to 140,688 baht (US$5,628) in 1990 (NSO, 1981, 1990b).

The substantial increase in income of people in Bangkok has brought a higher purchasing power, which, of course, extends to the purchase of cars, pick-ups and motorcycles. The relationship between a booming economy and increasing vehicle ownership is recognised in most international
transport studies, and is used as a main indicator for forecasting growth in vehicle numbers. However, although income seems to be a major driving force in motorisation, several other factors, such as duties and taxes on car purchase and car use, have to be considered (Zahavi, 1976). Moreover, the relationship between growing wealth and increasing car ownership can be moderated to a significant degree as experienced in richer Asian cities of Singapore, Tokyo and Hong Kong (Kenworthy et al., 1995).

Figure 5.13 shows the total number of vehicle per 1,000 people in Bangkok in 1990 compared to seven other major Asian cities, along with the city GRP per capita. This diagram clearly shows that there seems to be little correlation between relative wealth levels and total vehicle ownership in the Asian region. Indeed Bangkok with its 348 vehicles per 1,000 people and city GDP per capita of $3,826, stands out as being exceptionally high compared to all the other cities. For example, Hong Kong has only 78 vehicles per 1,000 inhabitants, more than four times lower than Bangkok, while its city GRP per capita is about $14,100, nearly fourfold higher than Bangkok. Likewise, Singapore, has 200 vehicles per 1,000 people, around 43 per cent lower than Bangkok, but it has city GDP per capita of $12,939, more than three times higher than Bangkok. Tokyo has 374 vehicle per 1,000 residents, only slightly more than Bangkok despite its highest national GDP per capita of $36,953, nearly ten times higher than that of Bangkok.

![Diagram showing correlation between total vehicle ownership and city GRP per capita in Asian cities, 1990](image)

Figure 5.13 Correlation between total vehicle ownership and city GRP per capita in Asian cities, 1990

Sources: 1. City gross regional product per capita from Kenworthy et al., 1997: Table 1
2. Total motor vehicle ownership from Table 4.9
Singapore, Hong Kong and Tokyo have dealt with problems connected with the tendency for increased vehicle ownership as wealth increases through some effective physical planning and economic policy measures. For example, Singapore's car ownership in 1982 was predicted to be 270,000 to 340,000 vehicles, based on wealth factors. In practice, it was only 184,000 vehicles. The increased cost of owning and using cars in Singapore (through the traffic restriction zone and heavy taxes and charges on cars generally) rendered void the traditional models linking wealth and car ownership (OECD, 1988a; Kenworthy et al., 1995). Such economic constraints on motor vehicles do not exist in Thailand.

In addition, to a lack of Singapore-like economic controls over car ownership and use in Bangkok, the very popular periodical payment system for vehicles, either directly through car dealers or financial support agencies, provides for convenient vehicle purchase. For example, the average monthly re-payment for a standard new car is around US$400-500. Although this accounts for approximately one-third to one-half of the monthly income of the middle class population, it is still affordable. In addition, lower income people have easy access to the large market for used private cars and pick-ups in Bangkok.

As suggested in Chapter 4, the markedly higher income of Bangkok residents since the early 1980s has been accompanied by a fall in the costs of car ownership and use in Thailand. In 1991, the Thai government lifted the ban on importing fully assembled small-engine cars and dramatically reduced import taxes and duties on small cars from around 400 percent to 176 percent; for large cars the decrease was from around 600 percent to around 200 percent. By allowing foreign competition, the government intended to improve the quality of the local automotive industry. Naturally, as car prices decreased, purchase has become easier, resulting in a further increase in cars on Bangkok roads (Sayeg, 1992: 26; Tanaboriboon, 1993: 18). On top of relaxed import duties, the annual road taxes for cars and motorcycles are extremely low (Tanaboriboon, 1993: 14-23). These low car prices and low annual road tax contribute to the ongoing increase in Bangkok's private vehicle population.
5.5.2 Inadequacy of Public Transport and Other Modes

The inadequacy of public transport services in Bangkok is another major contributor to rapid motor vehicle growth, as it is generally recognised that where public transport is unable to provide adequate, reliable and convenient services, potential passengers will shift to use private vehicles wherever possible (World Resources Institute et al., 1996: 94).

5.5.2.1 Buses

Despite the fact that buses are the backbone of public transport in Bangkok, bus services are generally poor in both quantity and quality of the vehicles. Bus services have been declining substantially. In 1972, buses shared 53 per cent of total trips, compared to only 33 per cent in 1989 (F.H. Kocks KG and Genieurges-MHB, 1975: B22; JICA, 1990: Figure 2.2.4). Two major factors contributing to decline in bus services and use in Bangkok are inadequate services and traffic jams.

(1) Inadequate Services

As discussed in Chapter 2, contrary to the overwhelming increase of private vehicles, particularly the car and pick-up population which has been increasing at around 12-15 per cent annually over the last decade, the total number of buses operating in Bangkok increased on average by just 3.5 per cent annually during 1980-1990.37 The number of buses per 1,000 people has only marginally increased from 1.2 per 1,000 people in 1980 to 1.3 per 1,000 persons in 1990, compared to around 0.9 in 1960 and 1970 (see Figure 2.24), suggesting only a weak attempt to improve the quantity of bus services. In addition, from 1990 to 1993 the number of buses remained almost constant (Figure 5.14). Consequently, buses in Bangkok are always overcrowded during peak hours due to an insufficient number of vehicles (Krynetr, 1988: 4). Moreover, a lot of recent urban development in outer Bangkok has occurred in a way that is unrelated to the bus system and almost totally dependent upon private vehicles (see Plate 5.2). This type of development has further exacerbated the failure of public transport in Bangkok to provide

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37 In 1980 there were 7,900 buses, in 1990 there were 11,100 buses in Bangkok.
adequate and reliable services to its residents. This in turn acts as a catalyst for increasing people's reliance on private transport modes.

Figure 5.14 Number of buses and passengers carried in Bangkok from 1990 to 1993

Plate 5.2 New development in outer Bangkok
(2) Traffic Jams

Buses in Bangkok are severely affected by traffic jams (Plate 5.3). Thus, long waits for buses are common and quite often commuters are unable to get on overcrowded buses during peak hours (Krynert, 1988: 4; Pboon et al., 1994). Furthermore, the bus lanes which were introduced along several main roads in the early 80s, particularly in the inner area, are no longer able to maintain their original travel time improvements due to the high traffic levels and the weaknesses in bus lane enforcement (Marler, 1982).

Plate 5.3 Buses in Bangkok are nearly always caught in traffic jams

As a result, the primary mode of public transport cannot attract the custom of the large number of people increasingly able to afford private vehicles. Given a choice between being jam-packed into buses, often standing in hot and overcrowded conditions for long periods in a traffic jam, or sitting in the same queues in air-conditioned cars or pick-ups, most Bangkokians are going to choose the latter option. Consequently, most Bangkokians do not hesitate to purchase cars or pick-ups when the opportunity arises. As also shown in Figure 5.14, the number of daily bus passengers even slightly decreased from 1990 to 1993.

The relationship between the decline in public transport and the growth in motor vehicle population is often described as a vicious circle. Willumsen (1990) demonstrated that increases in car population were one of the major
causes of declining public transport service. As shown in Figure 5.15, as car numbers in a city increase, numbers of public transport passengers decline. This increases traffic congestion, leading to increased financial losses for public transport and a subsequent reduction of public transport service to cope with financial problems. Consequently, this chain of events and decisions serves to make public transport less attractive, to make the system conducive to increased car use, and to further exacerbate traffic congestion. Thus, the vicious circle continues.

![Vicious Circle Diagram](image)

**Figure 5.15 The vicious circle of increasing cars, declining public transport and increasing congestion**


5.5.2.2 Railways

Railways have a only tiny role in moving Bangkok’s residents, despite the high potential of this mode to be a viable alternative for Bangkokians. As mentioned previously, the rail system has received very little attention over a long period and currently, there is no genuine urban rail service in Bangkok. The only rail service available to residents is a poor system of what might be called suburban trains, which are nothing more than supplementary services to inter-regional trains which serve Bangkok. Several barriers explain the very low use of this service, as shown in Figure 5.16.
Figure 5.16 Factors limiting train use in Bangkok

The major barriers contributing to a very low proportion of train trips in Bangkok can be explained as follows:

(1) The lines and routes of suburban trains are limited to the existing four inter-regional lines. Thus, numbers of trains are very limited owing to their dependence on the timetable of the inter-regional train, which uses the same tracks. In 1995, only 123 trains operated both ways on a weekday basis for Bangkok commuters. The average frequency of trains over the four lines is only 43 minutes, which is not nearly sufficient for a rail service in such a dense city.\(^\text{38}\)

(2) As existing tracks are at-grade, a number of level crossings with road traffic increases traffic congestion during the peak period and these also contribute to the potential for accidents. This conflict was reported as early as 1972 in the Bangkok Transport Study (F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975), and at the same time it also highlighted another point discussed later; the inadequacy of facilities for pedestrians and other non-motorised modes:

\(^{38}\)Number of trains and the average frequency of trains were examined from the 1995 train timetable.
In the core area (of Bangkok) there are 20 railway crossings at-grade, 16 of them with roads of the relevant network. They cause considerable traffic congestion and higher train frequencies would require their removal. Today there is not only interference by vehicular traffic but also by pedestrians. Many people are walking on or along the railway tracks due to the lack of suitable sidewalks and the low train frequencies.

(p. B5)

A recent study by the OCMRT (1992) on solutions to level crossings in Bangkok revealed 23 level crossings with roads on three of the rail lines: the northern line, the eastern line and the Bangkok Noi-Taling Chan line. Each day, 112 trains passed through the crossing points during morning and evening peak hours. Of these, 61.9 per cent were inter-regional trains, 14.8 per cent were commuter trains, and 23.3 per cent were freight trains and locomotives. These movements resulted in 983 closures of road traffic per day. The most frequent traffic closure occurred about every 6 minutes.

As a result, trains are considered to be a major cause of traffic congestion in Bangkok. Therefore, the number of trains operating in the Bangkok area, particularly during peak hours are, ironically, kept to a minimum. Attempts to increase the numbers of trains to cater for Bangkok commuters are likely to meet with little success.

(3) The limited number of railway stations is also a major barrier to train use. Currently, only 30 stations operate within the Bangkok area. Moreover, distances between stations average about 3 to 4 km, a significant distance from the perspective of urban journeys. As a result, these trains cannot provide a viable service for Bangkok residents.

5.5.2.3 Waterway Transport

Because of the comprehensive network of river and canals, waterway transport in Bangkok is another viable alternative means of public transport (Plate 5.4). However, as discussed previously, for more than three decades the government's policy towards transport has focused almost exclusively on land transport. Water transport has attracted very little attention, as illustrated by the relevant development plans and limited investment in this mode.
Plate 5.4 Waterway transport in Bangkok

Even the current Seventh Plan Urban and Regional Transport (SPURT), the first transport master plan for Bangkok and Thailand, pays very little attention to water transport. Proposed investment still focuses on improvements to land transport, with total committed project costs of up to 133,000 million baht (US$5,320 million). By contrast, investment in water transport in this plan is nothing more than a recommended project, with a proposed budget of only 100 million baht (US$4 million). This represents less than 0.03 per cent of the total proposed investment in transport infrastructure during the five years of the plan (Halcrow Fox and Associates et al., 1991). Worse still, the subsequent transport master plan, the Revision of the Traffic and Transport Master Plan (Bangkok Master Plan), which aimed to revise allocations of investment in transport for the last two years of the Seventh National Development Plan (1995-1996), mentions water transport investment only through two second-priority projects for the improvement of piers. The proposed investment is only 20 million baht (US$0.8 million) (Kasettsart University and Sindhu Pike Bodell, 1994b). This lack of commitment of resources is clearly a significant obstacle to the improvement of water transport services. The BMA itself notes that one of the main constraints to opening more boat routes along canals is the lack of financial support from the government (BMA, 1994: 10).

As a result of inadequate attention from the government, the use of waterway transport has been considerably restrained. The main obstacles to the services are:
(1) The Limitations of the Waterway Network

As a number of canals have been filled in and converted to roads, and
several canals have become shallow due to inadequate attention, the
waterway network has become poor. There are therefore limitations to how
intensively it can be extended to serve the needs of Bangkok residents.
Moreover, a number of existing canals have been used for the main purpose
of flood control and drainage, with water gates and blockades constructed
for this purpose (Bongsadadt and Leelahacheeva, 1984: 149-150). The
development of the road system has posed further obstacles to the waterway
system, such as road bridges constructed at low levels so that boats cannot
travel underneath (Pathan, 1996: 9). This naturally creates difficulty in
attempting to use them as transport channels.

(2) The Deficiencies of the Services

In line with the deteriorating traffic situation, the demand for boats has been
increasing markedly, particularly during peak hours, whereas the supply of
services has been only slightly improved. Consequently, overcrowded
boats, particularly the express boats, ferries and the fixed-route long-tail
boats are very common. There is a critical need to increase the fleet supply
to serve Bangkok commuters.

On the other hand, off-peak services, particularly the express boats, are also
inadequate. The boat companies attempt to keep operating costs as low as
possible in order to cope with the financial losses they have reported. Boat
passengers have to wait a long time. For example, the express boats which
are operated by the Chao Phraya Express Boat Company, basically provide
10-minute interval services during peak times, but during off-peak period
they operate at 30-minute intervals. Worse still, there are no boats available
at night time since the express boats operate only from 6 am to 6 pm
(Halcrow Fox and Associates et al., 1991: 11-60).

(3) Passenger Safety

Most express boats and ferries across the river are overcrowded during peak
hours. This is due to the very high demand of passengers who regularly use
them because they live close to the routes or who turn to boat transport to
avoid the horrible road traffic congestion, coupled of course with the limited fleet supply. It is common to see boats carrying double the number of passengers they are officially registered to carry (Plate 5.5). This obviously leads to high passenger risk and there have been some serious accidents.

Plate 5.5 Express boats along the Chao Phraya River are overcrowded during peak hours

The boat companies claim that they have to cope with their losses resulting from untenably low fares which are regulated by a government agency and which have not been changed for 10 years. Overcrowding their boats is the only way the companies can cover their costs (Halcrow Fox and Associates et al., 1991: 11-62).

In addition to the risks of overcrowded express boats and ferries, the passengers are also taking a risk from excessive speed and reckless drivers, particularly on the long-tail boats (Poboon, 1994). As law enforcement is very weak, many drivers do not take any responsibility for passenger safety. As a result, there have been a number of accidents, both along the river and canals.

(4) The Quality of Piers

The piers along the Chao Phraya River and canals are variously owned by the BMA, the Harbour Department or the private sector who let them out to the boat companies. The capacities and built-structures of most of these piers do not conform to the safety standards. As a result, during peak hour when there are a great number of passengers using these piers, several piers are
always overloaded. There have been some terrible tragedies when these piers have capsized.

The most recent event occurred in June, 1995 when one of the most crowded piers located on the Chao Phraya River in the centre of Bangkok capsized during morning rush hour. About thirty commuters died, of which many were students who were going to school (Bangkok Post, 1995b). This sort of risk has, to some extent, inhibited Bangkok commuters from using boats, particularly children and students, whose parents are concerned for their safety.

5.5.2.4 Non-Motorised Modes

In addition to public transport, levels of use of non-motorised modes also affect levels of vehicle ownership and vehicle use, and vice versa. Levels of non-motorised mode use are also closely related to levels of public transport use. That is to say, where the public transport share is high, levels of non-motorised mode use are also high. As a result, proportions of private vehicle use tend also to be low (see section 4.2 in Chapter 4). Compared to Bangkok, non-motorised modes work very effectively in Southeast Asian cities and wealthier cities of Europe and richer Asian cities. For example, in Japanese cities, bicycling plays a vital role for people to commute to rail stations: between 15 per cent and 45 per cent of access to rail stations is by bicycle. In Tokyo, bicycle access to rail stations increased from 4 per cent in 1975 to 11 per cent in 1980, to 13 per cent in 1985, and to about 15 per cent at present (Hook, 1994: 5). In addition, the number of bicycles in Japan has actually increased at a slightly faster rate than the number of cars, particularly since 1970 (Figure 5.17). In Bangkok, only 1 per cent of commuters use bikes to get to work (out of a total 10 per cent using non-motorised modes for the journey-to-work).
Experience from cities around the world suggests that major barriers to non-motorised vehicle use include affordability of vehicles (in the case of very poor countries such as in Africa), street environments that are hostile to non-motorised modes, vehicle theft, negative social and government attitudes to non-motorised vehicles, and excessive and inappropriate regulation of non-motorised vehicles (Replogle, 1992: 24). In particular, Replogle contends that:

*In motor vehicle dependent cities, non-motorised vehicles are usually consigned a role solely as a recreational mode of transport, having been pushed off the streets by heavy traffic and street designs that admit no place for slow traffic or even pedestrians. In such cities, a small number of more adventurous, physically fit, usually male cyclists brave cycle-hostile environments to make work or shopping trips. However, the larger share of cyclists leave their bicycles at home for leisure time, when they ride in parks, if provision has been made for cycle traffic there. (p. 24)*

In addition, Guitink (1993) noted:

*The absence of safe infrastructure, which also includes pedestrian facilities, is a major constraint on the use of non-motorised transport in both industrialised and developing countries. Each year more than 500,000 people die in road accidents and the world road traffic injuries represent more than 2 percent of the global burden of disease. Seventy*
percent of traffic fatalities occur in developing countries and a comparison of fatality rates in the cities of industrialised and developing countries shows that fatalities per 10,000 vehicles are up to 20 times higher... The young and old are particularly vulnerable, as are drivers of non-motorised vehicles and pedestrians. (p. 40)

In Bangkok, a number of obstacles limit cycling and walking. The most serious hindrance is the lack of appropriate infrastructure. As there are almost no bikeways and no ramps at kerbs along footpaths, cyclists must share crowded roads with motor vehicles. Many local streets have been widened to cater for cars, leaving no footpaths for pedestrians (Plate 5.6). Severe air pollution and noise constitute additional barriers to cyclists and pedestrians.

Plate 5.6 A typical local street (sot) in Bangkok, without any footpath for pedestrians

Clearly, urban and transport plans for Bangkok have ignored the significance of non-motorised transport modes, despite their high potential as effective alternatives to private transport for many trips. For example, there are no references to bicycling, rickshaws and walking in any of Thailand's national development plans. Only the Seventh Plan Urban and Regional Transport (SPURT) suggested the investment of 80 million bahts (US$3.2 million) for a pedestrian improvement program during the five-years from 1992 to 1996, which amounts to only 0.02 per cent of the total
investment in transport in Bangkok during the Seventh Plan.\textsuperscript{39} No program was specifically recommended for the improvement of infrastructure for cycling. The bias in transport planning and particularly computer modelling towards motorised transport, especially cars, is likely to be a major contributor in the formation of these transport plans. Chapter 6 discusses this issue in detail.

5.5.3 Transport Infrastructure that Encourages Private Vehicle Use

Transport infrastructure is an important factor affecting transport patterns in any city. Cities with higher levels of public transport infrastructure provision, particularly rail networks, tend to have a higher share of trips on public transport, whereas the automobile cities of America and Australia, have very high levels of road provision. For Bangkok, transport infrastructure factors significantly contributing to private vehicle use are the lack of infrastructure for modes other than private vehicles, in particular, a very low level of railway infrastructure provision (as discussed previously), and very high parking provision in the CBD.

Parking provision in the Bangkok central business district (CBD) is extremely generous, at virtually the same level as American cities and about five times higher than the richer Asian cities. In addition, most of these parking spaces are free of charge or charged at very low rates. This provision clearly encourages car use. For example, Topp (1995) depicts the impacts of parking in the following way:

\begin{quote}
Parking spaces attract cars; so they generate car traffic. Parking needs space, which is not available for other street uses. Nothing else has changed the traditional streetscape as dramatically as parked cars have done during the last few decades. \textit{(p. 17)}
\end{quote}

Cervero (1986) argued that workplaces designed with abundant and free parking provision, as is the case in American cities, reinforce automobile dependency:

\textsuperscript{39}Calculation based on data from Halcrow Fox and Associates et al., 1991: \textit{Seventh Plan Urban and Regional Transport (SPURT)}: Table 12.5.
Almost without exception, America's office parks feature abundant, free parking, on average 1.05 spaces per employee. A common practice is to overbuild parking beyond code requirements as a marketing ploy. In such environments there are no compelling reasons for workers not to drive alone... (p. 391)

The problem with overbuilding parking and deemphasizing transit is that a strong automobile orientation is established at the outset that will be difficult to reverse if and when conditions call for doing so. Although most office parks enjoy good on-site circulation, arteries feeding into them are all too often choked to capacity, partly because these centres encourage automobile commuting by design. Restraints on parking and provisions for front-door transit access might seem trivial, but their importance lies with creating an environment conducive to ridesharing and foot travel, each of which builds upon the other. (p. 392)

Shoup and Willson (1991) conducted a study on the responsiveness of commuters to parking subsidies in Los Angeles, by comparing the behaviour of commuters with parking subsidies to the behaviour of commuters without parking subsidies. They found that 73 per cent of those who can park free if they drive, drive alone to work, whereas only 57 per cent of those who must pay to park drive to work alone. Annual Vehicle Miles of Travel (VMT) and gasoline consumption per employee are around 38 per cent higher in the group with free parking. The study also estimated that the free parking group is responsible for much higher social costs, such as congestion and pollution. In addition, the study suggested that in Los Angeles and Ottawa, when employers "cash out" parking subsidies, the solo drivers' mode share declines on average by 40 per cent and the number of cars driven to work declines by around 27 per cent.

Newman and Kenworthy (1989: 53) in their study of thirty-two cities found a strong positive relationship between central city parking provision and total vehicle ownership and car ownership, passenger kilometres per capita in private cars, private vehicle energy use per capita and the proportion of workers using private transport. In contrast, it was found that central city parking provision has a significant negative correlation with the overall average speed of public transport. That is, as central city parking increases, the overall speed of public transport deteriorates, due primarily to the bus-
based nature of cities with significant proportions of central city parking. By contrast, cities with less parking in the CBD tend to be rail-based cities with faster public transport systems. This pattern seems to hold true for Bangkok as well.

5.5.4 Cultural Preferences

In common with many other places around the world, Bangkok's cultural "love affair" with the car appears to be a significant factor in the rapidly accelerating levels of car ownership. Although no formal studies have proved a definite relationship between Thai cultural factors and higher car ownership rates, that relationship is suggested by anecdotal evidence: cars appear to have become a central icon of status in modern Bangkok. Although this is fairly common throughout Asia, it seems to be particularly marked in Bangkok (Poboon et al., 1994: 20). For example, Iewsriwong (1995) identified two cultural factors behind the drastic increase in car ownership and car use in Bangkok. First:

In Thai culture the general population always give greater levels of esteem to those considered as higher class persons; this group is a numerical minority group and, at present, defined according to economic wealth. As a result, everyone likes to own and use a car, as the car is a symbol of "high class", drawing higher respect and a priority of consideration from the others. (p. 5)

The second dimension is also described by Iewsriwong, as follows:

The car is much more than a mere means of travel in Thai society. It is a symbol and a proof of success in one's life, even more so than a house. A house cannot be brought along to show the success of its owner, but a car does. There is a very marked love affair between middle class people and the car; as such the car is an essential means for shifting one up to the middle and higher classes. (p. 5)

These types of cultural factors strongly suggest a psychological "drive" behind the high levels of car ownership and use in Bangkok. Systematic research is required, however, to verify such claimed linkages, as well as to investigate ways of modifying such behaviour. Comparative studies
between cities on this issue would also help to see if this factor is stronger in Bangkok than elsewhere. Detailed studies would have the advantage of credibility and thus could attract more attention from the relevant bodies responsible for traffic in Bangkok, especially those operating from a policy-making perspective.

5.6 BANGKOK'S TRAFFIC NIGHTMARE: A MISMATCH AMONG BANGKOK'S TRANSPORT PATTERNS, URBAN FORM AND TRANSPORT INFRASTRUCTURE

The comparative study in Chapter 4 and the previous discussion in this chapter reveal that the commonly touted reason of inadequate road provision in Bangkok cannot adequately explain Bangkok's traffic nightmare. Rather, the more complicated interrelationships among Bangkok's urban form, transport patterns and transport infrastructure need to be addressed to provide guidance in helping to solve this problem.

While other cities, particularly Asian cities, share with Bangkok similar levels of density, road provision and traffic congestion, Bangkok suffers from a more severe traffic nightmare. The evidence from the comparative study suggests that Bangkok's traffic disaster stems not merely from comparatively high absolute levels of vehicle ownership and usage per person, but from a significant mismatch among its urban form, transport patterns and transport infrastructure (Figure 5.18). Based on the findings of this study, Barter and Kenworthy (1996) suggest a number of such possible mismatches. The following discussion expands upon and analyses this in detail.
5.6.1 A Mismatch between Vehicle Use and Urban Form

The total private vehicle use rate per person in Bangkok is not high in an overall international perspective (3,200 km per person per year). For example, it is nearly four times lower than that in American cities (12,000 km); nearly three times lower than that in Australian cities (8,020 km); and significantly lower than that in European cities (5,100 km). Nevertheless, this level is much higher than that in the dense Southeast Asian cities (average 2,230 km for the other four cities), and also higher than that for richer Asian cities with well-developed transit infrastructure (average 2,950 km) (see Table 4.9). These comparative data suggest that the level of private vehicle use is much higher than can be accommodated in Bangkok's dense, mixed and tightly woven urban fabric. As shown in Figure 5.19, considering the use of private vehicles relative to the size of the urban area, Bangkok has the highest level of private vehicle use per hectare of all cities in the study. This highlights what appears to be an obvious mismatch between the city's private vehicle use and its urban form and helps to demonstrate why the impact of traffic in Bangkok is so intense. For Bangkok to squeeze more
travel through its urban fabric via new roads, would merely intensify what already is an extreme situation.

Figure 5.19 Bangkok's total private vehicle kilometres per hectare of urbanised land compared to other cities, 1990
Sources: Calculation based on data from Table 4.3 and Table 4.9

5.6.2 A Mismatch between Vehicle Use and Road Supply

From previous analyses in the thesis, it is now possible to draw together the evidence to demonstrate how Bangkok's level of vehicle use is also mismatched to its available road supply. As shown in Figure 5.20 and 5.21, Bangkok's levels of private vehicle use relative to its road provision are the highest of all cities under study.

Figure 5.20 Bangkok's total private vehicle km per length of road compared to other global cities, 1990
Sources: Calculation based on data from Table 4.6 and Table 4.9
Figure 5.21 Bangkok's total private vehicle km per area of road compared to selected cities, 1990

Sources: Calculation based on data from the following sources:
1. Private vehicle km from Table 4.9

Note: Area of land under roads is not available for all cities.

These graphs demonstrate that irrespective of how it is measured, the amount of travel occurring within Bangkok's road system is very high in a global sense. This picture helps to explain the traffic crisis in Bangkok compared to other cities.

5.6.3 A Mismatch among Transit Use, Urban Form and Road Supply

The suggested mismatches among private vehicle use, urban form and road supply are not the only major factors which appear to contribute to severe traffic congestion in Bangkok. The level of public transport use is also a significant factor. Bangkok has approximately 33 per cent of its motorised passenger km catered for by public transport. Although this level is much higher than car-based American and Australian cities, and slightly higher than that for European cities, it is much lower than would be expected in a city of its urban form and limited road availability. As shown in Figure 5.22 and 5.23, transit use in Bangkok is the lowest among Asian cities which share similar patterns of density and road supply to Bangkok.
Figure 5.22 Proportion of motorised passenger km on public transport and urban density in Bangkok compared to selected Asian cities, 1990

Sources: Table 4.3 and Table 4.9

Figure 5.23 Proportion of motorised passenger km on public transport and road length per capita in Bangkok compared to selected Asian cities, 1990

Sources: Table 4.6 and Table 4.9

In addition, as it is well known that rail can effectively provide an alternative to travel by road and relieve pressure on roads, many cities around the world, particularly richer Asian cities and European cities, have demonstrated their ability to avoid serious road traffic congestion partly by judicious design and use of their rail systems. By contrast, Bangkok has an extremely low proportion of rail use (only 0.45 per cent of total public transport passenger km) (Figure 5.24). This is further evidence of another significant mismatch between transit use and Bangkok’s other characteristics which contributes to serious traffic congestion problems in Bangkok.
Moreover, as shown in Figure 5.25, in terms of rail service, Bangkok has an extremely low level of rail service per ha of urbanised land (21 km per ha) compared to cities with similar road provision. In 1990, Hong Kong’s rail service was nearly 8,000 km per ha, Tokyo had over 5,000 km per ha, Munich had about 3,400 km per ha and Paris had 2,300 km per ha. If we compare these data to the previous discussion of Bangkok’s low levels of road provision, especially the proportion of urban land used for roads, a factor that distinguishes Bangkok from other cities around the world with similar levels of land devoted to roads is clearly its low level of rail service.

Figure 5.24 Proportion of public transport passenger km on rail in Bangkok compared to other cities, 1990

Source: Table 4.9

Figure 5.25 Provision of road space and rail service in Bangkok compared to selected cities, 1990

Sources: Figure 5.4 and Table 4.9
5.6.4 A Mismatch among Transit Infrastructure, Urban Form and Road Supply

As mentioned above, to help avoid traffic chaos, many densely populated cities in Asia and Europe have committed themselves to a rail system and many more are in the process of trying to develop significant rail systems. This approach requires that an adequate system of railway infrastructure be provided. Figure 5.26 reveals that Bangkok has only a fraction of the railway routes of other Asian cities which share density levels similar to Bangkok. Consequently, this mode of transit infrastructure is inadequate to meet the transit demands of such a dense city.

Figure 5.27 compares Bangkok's rail network provision to that of some of these cities and shows the proportion of the urbanised area devoted to roads. These data show that for cities with similar levels of road space, Bangkok has only a fraction of the rail route density. Munich has 554 km of railway route length or 8,571 metres per 1,000 ha. Paris has 1,833 km or 7,933 metres per 1,000 ha. Hong Kong has 117 km of metro and light rail or 6,382 metres per 1,000 ha. Tokyo has 1,354 km or 3,022 metres per 1,000 ha. By contrast, Bangkok with only 120 km has only 1,238 metres per 1,000 ha.

![Graph showing urban density and rail route density comparison](image)

**Figure 5.26 Bangkok's rail route density and urban density compared to selected Asian cities, 1990**

Sources: Table 4.3 and Table 4.6
Figure 5.27 Provision of road space and rail network in Bangkok compared to selected cities, 1990

Sources: Figure 5.4 and Table 4.6

As discussed previously in this chapter, in addition to the problems outlined above associated with a poor rail network, the railway service in Bangkok is operated "at grade", using regular level crossings. This creates huge problems with road traffic. As a consequence, it would not be feasible to build any more of this kind of rail infrastructure or to operate suburban trains more frequently, as they are already considered an obstacle to smooth road traffic flow, particularly during peak hours. The only rail options for Bangkok appear to be elevated or underground systems.

5.6.5 A Mismatch between Non-motorised Mode Use and Urban Form

In addition to low levels of public transport use, another major cause of severe traffic congestion in Bangkok is low levels of use of non-motorised modes. In most dense cities around the world, such as the Asian cities and European cities, walking and cycling make a significant contribution to the mobility of urban residents. As these modes require substantially less space than private vehicles, they are much more suitable for the high-density city. Figure 5.28 shows levels of walking and cycling to work in Bangkok, compared to other densely populated Asian cities. This factor is especially important since it is the peak periods in which road space is most limited. The more people walking or cycling to work, the less pressure there will be on roads in this critical period of the day.

The proportion of walking and cycling to work ranges from 17 per cent in the more car-based Kuala Lumpur, to 22 per cent in richer cities of Singapore.
and Tokyo, and to 24 per cent in the "non-motorised" city of Surabaya. By contrast, in Bangkok, these modes account for only 10 per cent of trips to work. This proportion is uncharacteristically low for the dense, mixed-use urban fabric of Bangkok. The picture for the journey-to-work is strengthened by data on the proportion of total trips by non-motorised trips in Asian cities (Figure 5.29). The data clearly show Bangkok to be the lowest of the Asian cities. It would appear from the data that Bangkok needs much higher levels of walking and cycling if the city is to make progress in ameliorating its present traffic crisis.

![Graph showing urban density and non-motorised work trips](image)

**Figure 5.28** Proportion of workers walking and cycling to work and urban density in Bangkok compared to selected Asian cities, 1990

Sources: Table 4.3 and Table 4.9

![Graph showing urban density and non-motorised total trips](image)

**Figure 5.29** Proportion of total trips made by walking and cycling and urban density in Bangkok compared to selected Asian cities, 1990

Sources: Table 4.3 and Figure 4.25

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5.6.6 Summary

In summary, severe traffic congestion problems in Bangkok appear to stem at least partly from some unfortunate mismatches among its urban form, transport patterns and transport infrastructure. The provision for and use of public transport and non-motorised travel modes in Bangkok appear to be grossly insufficient relative to the city's high density and limited road provision. This is seen mostly clearly in the comparisons to the other Asian cities. Traffic jams in Bangkok appear therefore to be inevitable because the city is attempting to carry too much traffic on its limited road network and within its high density structure. It has too small a percentage of passenger travel on public transport or by non-motorised modes, relative to its urban form and provision of roads. In general, these mismatches are the consequences of inappropriate and ineffective urban and transport policies and investment biased towards private transport. The next section discusses this issue in detail.

5.7 THE BIAS IN POLICY AND INVESTMENT TOWARDS ROAD-BASED TRANSPORT

Chapters 2 and 4 revealed that, despite Bangkok having a city structure unsuitable for heavy use of cars, government transport policy has been continuously biased towards road-based transport, especially car use. This is evidenced by continued construction of roads and expressways. This policy was first made explicit in the first Bangkok plan issued in 1960: The Greater Bangkok Plan 2533 (1990), conducted by American consulting firms. The successive plan for Bangkok, The First Revision of the Plan for the Metropolitan Area, prepared by the Department of Town and Country Planning followed suit. Moreover, over the years, most national development plans, which typically include urban and transport plans for Bangkok, have focused on facilitating private vehicle use by proposing the construction of roads and expressways, considered necessary tools for fostering economic growth and a reflection of sensible approaches to the management of traffic congestion.
5.7.1 The First Four National Social and Economic Development Plans (1961-1981)

Since the first five-year national development plan was initiated in 1961, the Thai government has heavily emphasised development of road-based transport throughout the country to facilitate production and marketing. This policy is underpinned by the belief that road transport is a convenient and fast form of transport service. The policy also reflects the philosophies of the "cheap oil era" (Bongsadadt, 1984; NESDB, 1982). Consequently, the road network in Thailand was substantially expanded from 8,500 km in 1961 to 104,000 km in 1980. By contrast, there was almost no expansion of the railway system. Moreover, inland water transport services substantially declined, due to inadequate investment in the rehabilitation of the water transport system. A clear sign of this orientation is the budget allocation of the Fourth National Social and Economic Development Plan (1977-1981). In this plan, communication development accounted for 15 per cent of the total national budget. About 87 per cent of this communication budget was devoted to land transport development, of which 90 per cent was allocated for road construction (NESDB, 1982: 87-88). As described in Chapter 2, this policy enormously affected the structure and prospects of Bangkok - the centre of the country's economic activity. All major highways built during that time (1961-1981) originate in Bangkok. A number of roads were also built inside Bangkok to support this road transport system. No improvements to urban rail transport in Bangkok were made during that time. Further, trams, an efficient means of transport, were completely eliminated in 1968, as they were considered an obstacle to road traffic. Waterway transport also substantially declined during this period.

5.7.2 The Fifth and the Sixth National Social and Economic Development Plan (1982-1991)

The Fifth National Social and Economic Development Plan, which began in 1982, revealed some recognition of the problems of imbalance in the structure of the transport system as a result of the over-emphasis on road construction, the energy intensiveness and inefficiency of the transport system and, problems associated with traffic congestion in Bangkok and other large cities. The realisation was mainly attributable to the emergence of the "expensive oil era" (NESDB, 1982). This plan recommended a
reduction in highway construction in Thailand. For Bangkok, however, it recommended construction of yet another expressway, three bridges across the river, and the road system, but also the construction of a mass transit system to alleviate traffic congestion (NESDB, 1982: 88-90). The Sixth Plan (1987-1991) also recognised the necessity for improvements to public transport to a limited degree. However, the plan still gave priority to construction of road and expressway networks to alleviate serious traffic congestion (NESDB, 1987; NESDB, 1992).

As with policy and planning, so with implementation, analysis of transport investment reveals the focus on road transport in transport plans for Bangkok. For example, the comparative study of expenditure on road construction and road maintenance reported in Chapter 4 revealed high levels of investment on roads in Bangkok, the highest among Southeast Asian cities in 1990 in terms of road expenditure per capita. Moreover, in terms of road expenditure as a proportion of city GRP, Bangkok is the second highest among all cities in the study. The emphasis on construction of road-based transport is further revealed by the proportion of investment in the transport system in Bangkok during this period. As displayed in Figure 5.30, during the five-year Fifth National Social and Economic Development Plan (1982-1987), investment in road and expressway infrastructure accounted for approximately 98 per cent of the total investment of 19,000 million bahts (US$760 million) in transport in Bangkok. Similarly, during the next five years of the Sixth National Social and Economic Development Plan (1987-1991), most of the budget for transport investment in Bangkok was allocated to construction of roads and expressways. In all, this accounted for about 96 per cent of the total investment of 43,000 million bahts (US$1,720 million), whereas public transport received only 1 per cent of this investment (Kasetsart University and Sindhu Pike Bodell, 1994b: 12-13). Plate 5.7 shows the situation with some of several expressways and highways in Bangkok as a consequence of these policy and investment decisions.
Figure 5.30 Transport/traffic investment in Bangkok during the Fifth to the Seventh Plan (1982-1996)

Source: Kasetsart University and Sindhu Pike Bodell, 1994b: Figure 2.1

Plate 5.7 The second stage expressway and the 10-lane northern corridor in Bangkok
5.7.3 The Seventh National Social and Economic Development Plan (1992-1996)

The seventh National Social and Economic Development Plan (1992-1996) examined the results of the development in transport during the Sixth Plan and concluded that the problems were as follows:

*The network of the services is still incomplete and inadequate and unable to offer efficient, convenient and rapid service. Particularly serious is the problem of heavy traffic congestion. Although a number of crucial infrastructure projects have been started, such as... outer ring road around Bangkok Metropolis, the second stage expressway, and the elevated tollway etc., their actual implementation takes a great deal of time. A number of these projects have been facing delays at various stages of implementation, particularly the increasing private sector role in the provision of infrastructure services.* (p. 68)

This overview indicated that the Thai government still viewed construction of roads and expressways as a key means of solving traffic congestion problems in Bangkok. In addition, the government recognised that one of the major barriers in implementing the plan were conflicts and overlapping jurisdictions among projects proposed by different agencies. The narrow focus of this plan reflects the absence of any comprehensive transport master plan and, in particular, the failure of coordination among relevant government agencies (Kasetsart University and Sindhu Pike Bodell, 1994b).

To cope with these problems, the government, through the NESDB, initiated the Seventh Plan for Urban and Rural Transportation (SPURT). Later, the Office of Commission for Management of Road Transport (OCMRT), as the central transport policy agency, was assigned to revise this master plan as it was revealed that plans proposed by all state agencies were incompatible with both financial capacities and travel demands (Kasetsart University and Sindhu Pike Bodell, 1994a: 1).

The master plan proposed transport projects comprising expressways, roads, urban trains, traffic management schemes etc. Such projects required a 335,000 million baht (US$13,400 million) budget. The plans recognised the importance of public transport and proposed several public transport
projects to relieve traffic problems (Halcrow Fox and Associates et al., 1991; Kasetsart University and Sindhu Pike Bodell, 1994b). However, with respect to investment, these approaches still rely on traditional transport policy and planning, which emphasises improvement of infrastructure (particularly roads and expressways) to ease traffic congestion. This is the case, despite proposals for urban train mega-projects. For example, during the five years of this plan, investment in roads, expressways and bridges in Bangkok amounted to approximately 175,000 million bahts, or 52 per cent of the total investment. This is compared to investment in public transport of about 42 per cent of the total investment, as shown in Figure 5.30. Moreover, considering sources of investment, as shown in Table 5.4, the proposed public transport projects rely mainly on private sector investment (81 per cent), with a very small proportion of investment coming from the government. By contrast, road and expressway projects receive about 87 per cent of government investment in various forms i.e., government budget, state-owned enterprise budget, and government loans (Kasetsart University and Sindhu Pike Bodell, 1994b: Figure 2.1). This anomaly is one of the major causes of delays in these public transport projects, as most private sector operators or investors who have received concessions have faced the problems in securing funds for the projects.

Table 5.4 Sources of funds for transport projects in Bangkok during the Seventh Plan (1992-1996)

<table>
<thead>
<tr>
<th>Projects</th>
<th>Proportion of funds by sources (%)</th>
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<td>Government</td>
</tr>
<tr>
<td>Expressways</td>
<td>10.12</td>
</tr>
<tr>
<td>Highway/road/bridge</td>
<td>74.79</td>
</tr>
<tr>
<td>Public transport</td>
<td>4.66</td>
</tr>
<tr>
<td>Other</td>
<td>21.72</td>
</tr>
</tbody>
</table>

Source: Calculation based on data from Kasetsart University and Sindhu Pike Bodell, 1994b: Table 2.4

In fact, this type of policy is the legacy of the traditional transport policy dominating American cities and many other cities around the world during
the 1950s and 1960s. The now-discredited approach has been called the "supply-fix" approach (Goodwin and Hensher, 1978; Kenworthy, 1990a, 1990b; Zegras et al., 1995). This approach emphasises provision of new infrastructure to increase the capacity of road systems to meet demand. Cities using this approach engaged in massive road and expressway-building and improvement programs. This "vehicle-oriented" policy, focused on the mobility of motor vehicles (Pacione, 1988: 160-161). This approach to transport policy has been incorporated into plans for Bangkok since 1960 with the release of the Greater Bangkok Plan 2533 (1990). In addition, the emergence of this approach may be partly attributable to the fact that most policy makers, planners of high rank, and transport bureaucrats are car users, as Thomson (1977) has argued:

Most of the people professionally responsible for urban transport are car owners and drive to their offices everyday. The most powerful transport authorities are usually highway engineering departments occupying premises provided with free parking space to which most of the senior staff commute by car. The senior managers of public transport companies are more likely to arrive by car than by one of their own buses. And one of the first tasks of a team of consultants engaged to undertake an urban transport study is to acquire a fleet of private cars. It is beyond dispute that most important decisions affecting urban transport are made by people whose personal viewpoint of the problem is largely behind the wheel of car. (p. 15)

This perception has led to the emphasis on solving traffic congestion by road and freeway construction to facilitate motor vehicle movement - an approach believed to render more efficient traffic flows.

This supply-side policy of addressing traffic congestion (by building more roads and widening existing roads to acquire higher capacity) may render positive effects with better traffic flow along such roads in the short term, by providing more space for motor vehicles. However, in the long run, this approach triggers a number of adverse consequences. A growing number of researchers express their concerns that this approach will not solve the problems of traffic congestion. For example, Pacione (1988) argued that:
Large increases in highway capacity in many cities tended to exacerbate the problems of traffic congestion and environmental degradation in accordance with Down's (1978) law - i.e. on urban commuter expressways peak hour traffic congestion rises to meet maximum capacity. In addition, the increased mobility of car owners stimulated the development of low-density urban areas with unstructured travel demands resulting in substantial reductions in the role and effectiveness of public transport. (p. 161)

Taking a similar position, Hook (1993) contended that:

...empirical evidence indicates that over the last twenty years expanding capacity has proved to be ineffective in slowing worsening motor traffic congestion, largely because the number of new vehicles on the road continually outstrips the amount of new road infrastructure that governments are able to afford to build. (p. 1)

New urbanist architects Duany and Plater-Zyberk (1992), while not traffic or transport specialists, also noted the spiral mill characteristics of providing more highways:

Building more highways to reduce traffic congestion is an exercise in futility. Whenever it is done, more people are encouraged to take to their cars, and before long the roads are as clogged as ever. (p. 45)

Concrete evidence of the implications of this sort of supply-side policy is found in the study of effects of road programs in the United Kingdom. The Royal Commission on Environmental Pollution - Transport and the Environment demonstrated that only a few years after the widening of many major roads to cope with the traffic congestion, these roads returned, or would return, to the category of congestion experienced in 1990 (Table 5.5).
Table 5.5 Effects of road programs in UK

<table>
<thead>
<tr>
<th>Section of Road</th>
<th>1990 Congestion</th>
<th>Present Width (dual)</th>
<th>After widening (dual)</th>
<th>Return to 1990 congestion</th>
<th>Reach chronic congestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4 (J7-9)</td>
<td>Chronic</td>
<td>3</td>
<td>4</td>
<td>1993</td>
<td>1993</td>
</tr>
<tr>
<td>M25(J26-27)</td>
<td>Chronic</td>
<td>3</td>
<td>4</td>
<td>1995</td>
<td>1995</td>
</tr>
<tr>
<td>M6(J2-3)</td>
<td>Chronic</td>
<td>3</td>
<td>4</td>
<td>1995</td>
<td>1995</td>
</tr>
<tr>
<td>M25(J506)</td>
<td>Chronic</td>
<td>3</td>
<td>4</td>
<td>1996</td>
<td>1996</td>
</tr>
<tr>
<td>M3(I3-4)</td>
<td>Peak</td>
<td>3</td>
<td>4</td>
<td>1990</td>
<td>2000</td>
</tr>
<tr>
<td>M6(J14-15)</td>
<td>Peak</td>
<td>3</td>
<td>4</td>
<td>1990</td>
<td>2001</td>
</tr>
<tr>
<td>M4(J14-15)</td>
<td>Peak</td>
<td>3</td>
<td>4</td>
<td>1993</td>
<td>2004</td>
</tr>
<tr>
<td>M1(J25-26)</td>
<td>Peak</td>
<td>3</td>
<td>4</td>
<td>1995</td>
<td>2006</td>
</tr>
<tr>
<td>A1(M) (M25-A10001)</td>
<td>Peak</td>
<td>3</td>
<td>4</td>
<td>2000</td>
<td>2011</td>
</tr>
<tr>
<td>M20 (J6-7)</td>
<td>Peak</td>
<td>2</td>
<td>4</td>
<td>2003</td>
<td>2014</td>
</tr>
<tr>
<td>M4(J21-22)</td>
<td>Peak</td>
<td>2</td>
<td>5</td>
<td>2011</td>
<td>2023</td>
</tr>
</tbody>
</table>

Source: Royal Commission on Environmental Pollution (UK.), 1994: 86

In addition, a 1994 report by the Standing Advisory Committee on Trunk Road Assessment (SACTRA) in the UK found that all new roads, including by-passes, relief roads, and tunnels, induce new traffic. The report has been accepted by the British Transport Ministry and consequently the Ministry has issued new guidance to road planners asking them to take account of SACTRA's findings. As a result, in 1995, about half of the budget for the British motorway program was cut (270 proposals worth 19 billion pounds). The UK Government has also introduced new legislation (PPG13), designed to minimise the need to travel (Quinn, 1995, cited in Roberts, 1995: 79).

Goodwin (1994) summarises the fact that road capacity influences total traffic volumes in the following way:

*It is odd that this proposition should have turned into a source of such agonized professional argument. The present freight and passenger traffic flows between every city in Europe, and every state in the USA, could not possibly have been accommodated in the road capacity which was available in 1900, or even 1960... ...it simply beggars belief to assert that total traffic volumes would have been the same without the programme of road building that has characterized the 20th century.*

(p. 83)
In fact Goodwin shows with data from the 1937 Highway Development Survey that induced traffic has been known for many years. In this regard, Bressey and Lutyens (1938) make the following remark in relation to the new Great West Road in England which was built parallel to an old road.

...the new route, as soon as it opened, carried 4\(\frac{1}{2}\) times more vehicles than the old route was carrying; no diminution, however, occurred in the flow of traffic on the old routes, and from that day to this, the number of vehicles on both routes has steadily increased.

Despite the growing awareness around the world of the adverse implications of road transport policy based on supply-side fixes, many transport planners and others associated with transport policy persist with it, and this seems especially true in the developing countries (Pendakur, 1992a; Zegras et al., 1995). This fact, together with a combination of other factors, including short-term thinking and an emphasis on "profitability" trigger a vicious circle of traffic congestion, as seen in Bangkok (Figure 5.31).

Figure 5.31 The vicious circle of traffic congestion in Bangkok (as seen in many other cities)
5.8 CONCLUSIONS

It is evident that Bangkok traffic congestion and its related consequences, such as air and noise pollution, health impacts, energy losses and accidents, are among the worst in the world. Bangkok's city structure mitigates against private vehicle use. It has evolved through three key periods of land-use and transport development: a water-based transport and walking period, a transport modernisation period, and a motorisation period. This evolution has left the city with an urban form ideally suited to transit and non-motorised modes, but with nearly all policies and investment directed towards roads, and transport patterns dominated by private motorised modes.

A major issue in Bangkok's transport policy and planning is the belief that the root of the severe traffic congestion in Bangkok can be found principally in inadequate road spaces and the absence of a road hierarchy. This study, however, refutes this idea. Although Bangkok's road provision is relatively low, compared to those of cities in the developed world, such as American cities and Australian cities, it is not unusual for other developing Asian cities, or even for the richer Asian cities like Hong Kong and Tokyo. Furthermore, some cities in European countries, such as Paris and Munich, have almost the same proportion of urbanised space devoted to roads as Bangkok. The crux of the issue is that the other cities with similar provision for roads avoid the traffic chaos characteristic of Bangkok: through commitment to efficient public transport systems, especially rail systems, as well as healthy levels of walking and cycling. In terms of road hierarchies, although these systems may assist traffic flow in the short term, the approach can have several adverse effects on modes other than private vehicles. Certainly, the construction of a significant system of distributor roads may have short term benefits, but it seems unlikely that any amount of road construction in Bangkok could absorb traffic demand indefinitely. It would increase the amount of travel in Bangkok even further, and as shown in this chapter, travel per urban hectare, per kilometre of road and per hectare of road space appear to already be the highest in the world. Rather than offering a solution, adherence to the road hierarchy approach may exacerbate traffic problems in the long run if it serves to divert attention away from even more fundamental causes of Bangkok's transport crisis.
Another significant issue which needs to be addressed is the rapid growth in motor vehicle population and use. This study suggests that this phenomenon results primarily from a combination of four major factors:

(1) rapid economic growth, permitting Bangkok residents to have higher purchasing powers, whereas the cost of vehicle purchase and use remains relatively low;

(2) the inadequacy of public transport and other modes. Buses, the dominant mode of public transport, are rarely able to avoid the ubiquitous and claustrophobic traffic jams, and thus are unable to attract passengers who can afford cars. Other public transport modes, such as railways and waterway transport, are presently limited in their capacity for serving Bangkok residents. This is because these modes have attracted very little attention from government in terms of resources to improve their networks and operations. As a result, they play a very minor role in moving people in the city. Non-motorised modes also have extremely low shares, again due primarily to the lack of infrastructure and the hostile urban environment;

(3) infrastructure features that encourage private vehicle use, particularly the absence of rail infrastructure the high level of spending on roads and the particularly generous and inexpensive parking provision in the central business district (almost at the same level as the car-based American cities and about five times higher than richer Asian cities); and

(4) the cultural "love affair" with the car, which seems to be a very prevalent and persistent feature of Thai society.

It can be deduced from the study that Bangkok's traffic crisis appears to stem not so much from completely high absolute vehicle ownership levels and usage rates per person, but more from a significant mismatch between its transport patterns, urban form and transport infrastructure. This problem has the following five dimensions: (1) a dramatic mismatch between vehicle use and urban form: higher levels of private vehicle use than can be properly accommodated in Bangkok's dense, tightly woven urban fabric; (2) a mismatch between vehicle use and road supply: levels of private vehicle use incompatible with its road availability and which are uncharacteristically high compared to other Asian and international cities;
(3) a mismatch between transit use, urban form and road supply: lower levels of overall transit use than would be expected in a city of its urban form and limited road availability; (4) a mismatch between transit infrastructure, urban form and road supply: a public transport infrastructure inadequate to meet the demands for transit movement inherent in such a dense city, particularly a lack of rail infrastructure; (5) a mismatch between non-motorised modes and urban form: levels of non-motorised mode use uncharacteristically low for such a dense, mixed-use urban fabric. These mismatches generally result from inappropriate and ineffective urban and transport policy and investment, biased towards private transport, as can be seen from the emphasis on massive investments in roads and expressways in previous and current development plans.

These lessons provide insights into the roots of the severe traffic congestion problems experienced by Bangkok. They point to a complex web of interrelated factors (Figure 5.32). These findings are crucial for the formulation of appropriate transport and land-use policies to help cope with Bangkok's traffic disaster. However, to ensure that the suggested policies are practical and implementable in Bangkok's context, the next chapter discusses some major opportunities for, and constraints against, the formulation and implementation of these policies.
Figure 5.32 Factors contributing to a traffic disaster in Bangkok
CHAPTER 6
TRANSPORT POLICY REFORM IN BANGKOK:
SOME KEY CONSTRAINTS AND OPPORTUNITIES

6.1 INTRODUCTION

As highlighted in Chapter 5, the physical planning roots of severe traffic congestion and its related problems in Bangkok appear to be a mismatch between city structure, transport patterns and transport infrastructure. Yet, as traffic congestion has deteriorated, governments have attempted to tackle these problems, mainly through a supply-side approach focused primarily on investment in roads. These measures have proved to be ineffective. Thus, to cope with what is now regarded as the "legendary" traffic congestion in Bangkok, requires a more appropriate approach. This necessitates the formulation of a suite of implementable policies directed at specific aspects of Bangkok's land-use/transport system, the subject of Chapter 7. However, the broader context in which such policies would have to be developed and implemented in Bangkok requires detailed understanding and elaborating for it is this broader context which establishes the plausibility and feasibility of effective change to Bangkok's transport situation. It is thus necessary to examine some key constraints and opportunities which surround effective transport policy change in Bangkok. This chapter therefore begins by investigating some major constraints that hinder the formulation and implementation of appropriate transport policies in Bangkok. It then goes further to examine the opportunities that currently exist to help put forward such policies.

6.2 CONSTRAINTS ON EFFECTIVE TRANSPORT POLICY FORMULATION IN BANGKOK

It needs to be recognised at the outset that there are potentially many barriers which may limit possibilities for the introduction of more suitable policies to help heal Bangkok's chronic traffic problems. These include a number of political, cultural and macro-economic dimensions (see, for example, Diniere, 1995; Pike and Rujopakarn, 1996; Watanabe, 1996), but they are beyond the scope of this study. This study focuses mainly on two key, immediate and direct transport-related constraints: attachment to
conventional transport planning methodologies and institutional fragmentation in transport planning, decision making and implementation. This section discusses these constraints in detail. The other factors are discussed briefly in Chapter 8 under further studies.

6.2.1 The Conventional Urban Transport Planning Model

Ben Bouanah and Stein (1978) state that there is "...a generalised international urban transportation planning process." This process is based on a series of technical procedures which developed originally in response to Mitchell and Rapkin's watershed study in 1954 called "Urban traffic - A function of land use" (Mitchell and Rapkin, 1954). As described in more detail in the next section, this study ushered in a period where cities all around the world attempted to estimate future traffic levels and the transport infrastructure (mostly roads) needed to cope with such projections. The result was the development of a strong supply-side approach to transport which has brought many problems for cities (Kenworthy, 1990a).

The philosophies and procedures embodied in such transport planning have been applied worldwide in most transport studies for cities ever since. Bangkok is no exception. All Bangkok transport studies up until the present day, have adopted this standard model with little or no modification. Application of what has come to be known as the conventional land-use/transport planning process or model has contributed enormously to the development of automobile dependence in cities and its associated traffic, social and environmental problems. For this reason and many other technical reasons, the conventional transport planning model has been severely criticised worldwide (e.g. Atkins, 1986; Whitelegg, 1988; Kenworthy, 1990a). Nevertheless, very few people with policy knowledge or influence in Thailand (particularly transport planners) appear to have recognised or tried to modify this dominant paradigm. The persistent attachment to this model will be difficult to change in the foreseeable future and this is one of the major constraints to introducing more appropriate transport policies to relieve Bangkok's traffic disaster.
6.2.1.1 The Origins and Characteristics of the Conventional Transport Planning Model

The urban transport modelling system was initiated in the USA in the late 1940s. It was not until 1953, however, that it was adopted for the pioneering transport studies in Detroit and Chicago. The model is based on the notion that future traffic can be estimated through a predictive model based on socio-economic characteristics and land-use patterns, such as population and employment (U.S. Department of Transportation, 1972, cited in Prapunpot, 1990: 16). Following its first application in Detroit and Chicago, the model was adopted for studies in Philadelphia, Pittsburgh and Hartford. In the 1950s and 1960s, this "revolutionary" approach was rapidly applied in a series of "grand transportation studies" throughout the USA. The main purpose of these studies was to plan for anticipated growth in population, employment and traffic flows (as far as 20 years ahead) and to maintain a balance between supply of transport facilities and demand for travel. This approach was supported by the emergence of computer technology (Zegras et al., 1995: 4; Kenworthy, 1990a: 1).

During the 1950s in the USA, this new urban transport planning process became a mandatory step for obtaining any federal government funding for transport projects to determine road investment needs. It became known variously as "Urban Transport Planning" (e.g. see Webster et al., 1988: ISGLUTI Study) or simply the "Transport/Land-Use Planning Model" and has been refined over the years. By the 1960s, the process was developed into a standard framework, with sub-components and sub-models, and evolved into what is now called "Conventional Transport Planning". By this time, it was rapidly being exported or adopted by countries around the world, including Third World countries, usually with the help of a number of major transport planning consulting firms (Dimitriou, 1992: 1; Kenworthy, 1990a: 1). This has occurred despite the fact that the context and conditions in which the process emerged were very different to those found in developing countries today which are still trying to apply it (e.g. low density cities in which the problems of trying to "construct away" traffic problems had not been fully realised (see Gunnarsson and Leleur, 1989).

Conventional transport planning or urban transport planning (UTP) for short, is a formalised planning methodology designed to provide guidelines
and priorities for future investment and construction of urban transport infrastructure and facilities. The UTP process is driven by a computer-based approach to project urban transport demand, particularly demand for motorised road traffic (Dimitriou, 1992: 9). The process involves massive amounts of data collection and analysis on travel behaviour, land-use, population, employment and the existing road network. This requires significant investment of time in computer processing, enormous budgets and is extremely time consuming overall. Typically, the major tasks of the UTP process are as set out below and in Figure 6.1:

(1) Formulation of goals and objectives;
(2) Inventories of the present situation on land-use and travel movements, which are then employed in four mathematical sub-models40:

1. Trip generation model (whether to make a trip)
2. Trip distribution model (where to go)
3. Modal split model (which mode of transport to use)
4. Traffic assignment model (which route to use)

(3) Forecasting of demands for land-use, i.e. population and employment, to develop land-use plans and estimate future travel patterns;

(4) Development of alternative transport networks (this is typically focussed mainly on roads, though not excluding consideration of possible new public transit systems) to fit predicted travel and land-use plans;

(5) Assigning estimated movement to alternative networks;

(6) Evaluation of various alternatives according to costs, benefits, impacts and practicality; and

(7) Selection of the appropriate network (which theoretically includes both roads and public transport systems, but the history of the UTP process shows it to have pioneered primarily large highway and freeway systems).

40It is noteworthy that within the overall UTP process, this very well-known set of sub-models utilised for the forecast of traffic movement (which is called the "urban transport modelling process" or the "four stage process"), is often confused with the overall UTP process itself which is in fact broader than just the modelling process (Dimitriou, 1992: 20).
Figure 6.1 The urban transport planning process

Source: Black, 1981: Figure 5.1

6.2.1.2 The Deficiencies and Implications of Conventional Urban Transport Planning

The UTP process developed in line with the strong focus on urbanisation and suburbanisation in American cities, together with the great increase in production of and attachment to automobiles during the 1950s and 1960s. As a consequence, the UTP process placed heavy emphasis on massive
construction of roads to meet the demand for travel, primarily by cars. In the USA and elsewhere, these initiatives led, understandably, to the construction of a comprehensive highway network designed to keep the supply of road space in balance with demand. Studies have revealed that public transport is very often glossed over in the modelling process, as noted by Stopher and Meyburg (1975, cited in Kenworthy, 1990a: 3). Their early analysis revealed the extent to which public transport was dealt with technically in the modal split stage of the US studies: “The earlier in the process that transit trips could be estimated and removed from further consideration, the more efficient would be the resulting highway travel forecasting procedure.” The process proceeds with forecasting based on private transport travel growth and related land-use. One of the implications of the UTP process in the USA has been to contribute to a rapid decline in public transport in many cities such as Denver, Detroit, Phoenix and Houston, and to forestall any consideration of rail systems as a possible worthwhile addition to transport infrastructure in cities (Kenworthy, 1990a: 3).

One of the other major shortcomings of the conventional UTP process is that it more or less totally overlooks walking and cycling. A reason for this is that the origin-destination zones which are used for trip generation and trip distribution are generally too coarse or large to capture the short trips undertaken by foot and bicycle. These usually work out to be what are termed intra-zonal trips (trips that do not cross an origin-destination zone boundary), and are particularly difficult to model or take account of in a technical process geared primarily to dealing with longer motorised trips which go between zones. Walking and cycling thus hardly feature at all in the deliberations of the conventional UTP process and so a whole area of potential transport policy focus is overlooked. This is particularly troublesome in the cities of developing countries where much larger amounts of walking and cycling are done over very short distances due to high densities and mixed land-uses. How to preserve and enhance non-motorised modes in such situations is therefore particularly important, but conventional UTP provides almost no attention to it. This is discussed more later.

By the late 1960s and 1970s, American analysts began to recognise that attempts to supply massive road infrastructure could not keep pace with forecast demand. This was partly because state governments began to run
out of transport funds due to the huge investments required for building roads and highways (Townsend, 1995: 78). While land development could not easily be controlled, emphasis on supply-side provision contributed to many adverse effects such as urban sprawl, high levels of energy consumption, a deteriorating environment and loss of land. This is evident from the international comparative study by Newman and Kenworthy (1989), which revealed that the American cities have the lowest levels of public transport use, the highest private transport use, the lowest density and the highest gasoline consumption per capita of all global cities (Figure 6.2). As a consequence, highway building was increasingly considered as an incursion rather than a means of providing welcome increases in accessibility. In response to a barrage of critiques, the UTP model has been improved to incorporate other alternatives into plans such as public transport and "no-build" options (Gakenheimer, 1993: 312). There are now a wide range of UTP models in use and there are ongoing efforts to improve them and to test them against one another for their appropriateness in different situations (e.g. the effort of the ISGLUTI study: Webster et al., 1988). However, in practice, these models still tend to primarily emphasise private transport movement; with recommendations which usually give priority to the provision of road infrastructure.

Problems with UTP models and their policy outcomes are not confined to the USA. The UK also suffers from the implications of conventional transport planning, as Pearce et al. (1993) discussed. Research reveals the failure of transport policy and planning in that country:

*Transport is one sector of the UK economy in which almost everything has gone wrong. Previous transport policy has resulted in too much pollution, too much congestion, too much investment in 'profitable' roads, too little investment in public transport and planning decisions being taken on the basis of misleading price signals. Without a fundamental change in policy it is inevitable that the transport sector will continue to impose large and growing costs on the natural environment, human health and the competitiveness of the British economy.* (p. 150)
Figure 6.2 Urban density and fuel use per capita in global cities, 1980

Source: Newman and Kenworthy, 1989: Figure 3.1
Despite its conceptual limitation and adverse long-term effects, the conventional UTP process has been adopted worldwide, particularly in Third World countries undergoing significant motorisation. It has provided a lucrative source of work for overseas transport consultants and development agencies, as Dimitriou (1992) noted:

...the UTP process is essentially a standardised process which (either in part or in derivative form) is still applied throughout the world with essentially only marginal modifications made to its fundamental concepts since its inception in the mid 1950s....the process and its derivatives are ostensibly a product of the socio-economic and political environment in which they evolved, and consequently, many of the underlying assumptions and concepts they employ reflect the values, perceptions, and technologies of the USA and (to a lesser extent) European societies at the time of their major development.

...there are certain inherent conceptual limitations to the UTP process and its derivatives which are transferred to Third World countries through studies conducted by international planning consultants and development agencies, as well as leading universities and professional institutions of the industrialised countries through many of their teaching, training and research programmes. (p. 3)

These practitioners still employ conventional UTP approaches to Third World cities with little modification despite a significant mismatch between the underlying assumptions of the UTP process and conditions in Third World countries. This mismatch leads to questionable results and, consequently, adverse implications for these countries. Some of the major deficiencies in the application of UTP in the Third World are shown in Table 6.1.
Table 6.1 Deficiencies of the UTP process as applied to Third World cities

<table>
<thead>
<tr>
<th>The UTP assumptions</th>
<th>Conditions in Third World cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>The urban transport problem is essentially one of overcoming motorised traffic congestion.</td>
<td>The majority of households are not vehicle-owning.</td>
</tr>
<tr>
<td>Increasing levels of vehicle ownership are inevitable.</td>
<td>Several restraints limit increases in vehicle ownership and vehicle use.</td>
</tr>
<tr>
<td>Informal public transport and non-motorised modes do not warrant detailed study.</td>
<td>Informal public transport and non-motorised transport play a very important role in most cities.</td>
</tr>
<tr>
<td>Variables affecting demand do not experience unexpected changes.</td>
<td>Unexpected changes can jeopardise forecasts.</td>
</tr>
</tbody>
</table>

Sources: Adapted from Dimitriou, 1990: 171; McNeill, 1977: 21

In addition, the application of UTP to Third World cities encounters some severe limitations. For example, as the UTP process is so costly, it poses a problem in Third World cities where resources are always scarce. The time-consuming nature of the UTP process often results in plans being ignored, as by their very nature, they cannot keep pace with the rapid change in Third World cities. The unavailability of comprehensive and reliable data in the Third World (as partly revealed by this study) often undermines the reliability of the plan. There is often a lack of co-ordination between the consultants and the client or problem in communication due to the heavy emphasis on the complexity of the models employed. All of these factors present barriers to the effective implementation of a plan (Dimitriou, 1990: 172; McNeill, 1977: 22).

In fact, the model often creates more problems than it solves. The application of conventional UTP in Third World cities is more likely to be the catalyst of the problems rather than the remedy, as revealed by the following factors:

1. Traffic congestion relief (the initial purpose of most plans), remains out of reach. By contrast, congestion continues to increase in most Third World cities.
2. Despite improvements to UTP to include more alternatives to the provision of infrastructure to accommodate private vehicles, most plans proposed for Third World cities still emphasise, as a priority, massive construction of costly road and expressway networks to cope with congestion. This measure has imposed heavy financial burdens on Third World governments due to their limited financial resources.

3. As the conventional UTP model basically ignores the role of modes other than motor vehicle transport, it has significantly imperilled the use of non-motorised modes such as cycling, walking and rickshaws - all widely in use in most developing cities. For example, a road-widening scheme is often accompanied by elimination of footpaths. This may, in the short-term, result in faster traffic flows. However, it makes walking, cycling and the movement of rickshaws very difficult and more dangerous, as well as socially inequitable in many cases.

4. In addition to the direct physical risks for non-motorised transport which flow from the last point, the emphasis on relieving traffic congestion recommended or proposed by conventional UTP models is always conducive to the suppression or elimination of non-motorised transport. This is because these modes are considered to be obstacles to free traffic flow. For example, cycle-rickshaws in Jakarta and Kuala Lumpur have been under serious threat from the government (through banning and confiscation). In Manila and Karachi they were banned years ago and in Dhaka, Bangladesh the city authorities are considering a complete ban on cycle rickshaws, after having banned them on major roads. In another example, some transport planners in China have suggested limitations on bicycle use in large cities. Very heavy bicycle traffic flows, they claim, frequently lead to an overflow of cycle traffic into traffic lanes designated for motorised vehicles (Pendakur, 1992b; Repogle, 1992a; UMPAP, 1996).

Overall, the transport related problems experienced in cities in developing countries can to a significant degree be seen to be associated with the mismatches between the application of the conventional UTP process and the situations in these cities (Figure 6.3), which are: (1) a mismatch between the socio-economic and political environments in which the conventional UTP was evolved and those of Third World cities; (2) a mismatch between the dominant motorised modes of transport typically encouraged and
serviced by the UTP process and the means of transport mainly used by residents of Third World cities; and (3) a mismatch between characteristics of the industrialised cities for which the UTP process was initially designed and the settlements of Third World cities (Dimitriou, 1990: 176).

![Diagram of Mismatches between conventional UTP and Third World cities context](image)

**Figure 6.3 Mismatches between conventional UTP and Third World cities context**

*Source: Dimitriou, 1990: Figure 5.6*

### 6.2.1.3 UTP in Bangkok

The tenacious application of conventional UTP is clearly evident in most urban and transport plans for Bangkok over the last four decades. It first emerged in Bangkok during 1960 in the *Greater Bangkok Plan 2533 (1990)*, prepared by the American consulting firms Litchfield Whiting Browne and Associates and Adams Howard and Greeley. This plan was discussed in more detail in Chapter 2. Without acknowledging the unique features and development of Bangkok (a city built on a waterways network, which then evolved to non-motorised transport and public transport), the plan proposed the construction of a comprehensive road and expressway network to accommodate predicted travel demand about 30 years ahead. Trams and rickshaws were then eliminated for the sake of free traffic flow. As traffic congestion in Bangkok has steadily deteriorated, successive plans and
studies followed suit, giving priority to building roads and expressways. This approach is clearly revealed in the national development plans and the investments discussed in Chapter 5.

Recently, two major transport studies in Bangkok have basically utilised the UTP process and have been widely adopted for the formulating of policies and plans for Bangkok. The first study was the 1990 JICA Study on Medium to Long Term Improvement/Management Plan of Road and Road Transport in Bangkok (SIMR). The second study was the 1994 Revision of the Traffic and Transport Master Plan (Bangkok Master Plan) conducted by Kasetsart University and Sindhu Pike Bodell. The former took about one and a half years to finish. In an approach similar to other transport studies based on the UTP, it omitted trips by bicycles and walking and included only travel by motorised transport in predicting traffic demand. The study recommended a maximum investment of 344 billion baht (US$13.8 billion) for transport infrastructure, of which about half is for roads and expressways, to ensure that Bangkok maintains the same speed level of about 8 km/h by the year 2006. Otherwise, with the "do nothing" alternative, average traffic speeds will drop to only 5 km/h by that year. This study ignored improvements to non-motorised modes and water transport (JICA, 1990).

The 1994 study, whose objective was to review transport projects for Bangkok proposed in the 7th Plan (1992-1996), in the midst of government fiscal constraints, also adopted the UTP model to assess traffic conditions. Its focus was on the year 2001 and investment needed in 1995-1996. The study strongly recommended that government allocate 40 billion baht (US$1.6 billion) annually during 1995-1996 for proposed projects. Most of these were road and expressway construction projects whose primary aim was to maintain the traffic speed. In addition, this study examined superblocks and their lack of connecting roads, and suggested that this is a major cause of severe traffic congestion. Thus, it proposed construction of a network of secondary roads to cope with the problems. This matter was discussed in detail in Chapter 5. In an approach reminiscent of the JICA study, the 1994 Revision totally neglected non-motorised transport and water transport and paid scant attention to the development of public transport (see Kasetsart University and Sindhu Pike Bodell, 1994b).
The implications of these plans are evident in terms of investments in road and expressway construction focusing on keeping pace with Bangkok's traffic growth and traffic congestion (Chapter 5). Despite these much-lauded initiatives, traffic congestion in Bangkok has deteriorated rapidly as vehicle numbers have soared, bringing with it significant implications for the national economy. As Bangkokians and Thais are likely to continue to rely primarily on motor vehicles in the foreseeable future, Thailand has become a major market for overseas car companies. Several major car manufacturers have made large investments in automobile production in Thailand. For example, Japan has selected Thailand as its major automotive production base in Southeast Asia. In June 1996, General Motors announced plans to invest US$750 million in a new Opel plant on the periphery of Bangkok. As well, Thailand is already the second biggest manufacturer of light trucks in the world after the United States (Hiscock, 1996: 25).

In sum, conventional transport planning focuses on building more roads to keep pace with the soaring number of cars. Roads and freeways seem to relieve traffic congestion in the short term, as they provide more space for cars. In the long-run, however, they attract people from other modes and generate new trips, thus leading to an increase in car production and use (Newman and Kenworthy, 1984, 1988b). This phenomenon has been identified in cities around the world, particularly in American cities, where urban road construction has consistently failed to keep pace with extra traffic. The application of the conventional UTP process to transport studies in Third World cities, particularly in Bangkok, without appropriate modification to specific local conditions, has clearly resulted in serious adverse effects. Not only has this approach not solved the traffic congestion problem (the main aim of the UTP), it has generated many serious consequences, including the declining use of non-motorised modes and public transport, and massive investments in roads and parking infrastructure. Both place heavy burdens on cities in Third World countries. It is of even greater concern that the UTP process has contributed to a "vicious circle" of dependence on private vehicles. To escape this vicious circle, Bangkok desperately needs a paradigm change - a major breakthrough in effective transport planning. Any approach, to be effective, must acknowledge the city's unique blend of land-use, socio-economic conditions and available resources.
6.2.2 Institutional Fragmentation among Bangkok's Transport Policy, Decision Making and Implementation Agencies

A major obstacle to implementing transport projects in Bangkok is the bureaucratisation and fragmentation of agencies with responsibility for transport. Surprisingly, over thirty government agencies are responsible for Bangkok's transport policy, management and operation. Moreover, three statutory committees and four ad-hoc inter-agency committees oversee and coordinate the responsible agencies (JICA, 1990: 74). These agencies, each with their own responsibilities, are under the auspices of different government ministries, each supervised by a different deputy prime minister who often comes from different political parties.\(^41\) Table 6.2 identifies the major agencies and their responsibilities.

The three statutory committees with specific responsibilities for urban transport are:

1. Land Transport Policy Committee (LTPC)
2. Land Transport Control Board (LTCB)

The four ad-hoc committees established to address Bangkok's traffic problem are:

1. Bangkok Metropolitan Region Development Committee (BMRDC)
2. Traffic Solving and Illegal Vehicles Management Committee
3. Rattanakosin Island Committee\(^42\)
4. Special Task Committee to Consider the Construction of Elevated Roads above the Canals and Public Lands

Clearly, too many agencies share responsibility for transport in Bangkok. For example, most of these agencies formulate their own transport policies

\(^{41}\) Usually, a Thai coalition government consists of four or five main political parties, each main party has a quota for one deputy prime minister. As a result, there are about four or five deputy prime ministers.

\(^{42}\) Rattanakosin Island is Bangkok's old city centre containing the Grand Palace and a number of historical buildings. The committee has a mandate to consider all developments proposed in this area.
Table 6.2 Agencies involved in transport in Bangkok and their responsibilities

<table>
<thead>
<tr>
<th>Agencies</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ministry of Interior</strong></td>
<td></td>
</tr>
<tr>
<td>1. Department of Town and Country Planning (DTCP)</td>
<td>Preparation of land-use plans, including transportation networks for all major cities in Thailand.</td>
</tr>
<tr>
<td>2. Department of Public Works (DPW)</td>
<td>Planning, design, construction, and maintenance of major bridges across Chao Phraya River.</td>
</tr>
<tr>
<td>3. Traffic Police Division (TPD)</td>
<td>Enforcement of traffic laws and regulations.</td>
</tr>
<tr>
<td>4. Bangkok Metropolitan Administration (BMA)</td>
<td></td>
</tr>
<tr>
<td>4.1 Department of Public Works</td>
<td>Planning, design, construction and maintenance of roads in Bangkok.</td>
</tr>
<tr>
<td>4.2 City Planning Division</td>
<td>Preparing land-use plans, including transport networks for BMA.</td>
</tr>
<tr>
<td>4.3 Traffic Engineering Division</td>
<td>Design and implementation of road improvement/traffic engineering schemes in Bangkok.</td>
</tr>
<tr>
<td>5. Expressway and Rapid Transit Authority of Thailand</td>
<td>Planning, constructing, and operating expressways and rail mass transit in Thailand.</td>
</tr>
<tr>
<td><strong>Office of the Prime Minister (OPM)</strong></td>
<td></td>
</tr>
<tr>
<td>1. Office of the National Economic and Social Development Board (NESDB)</td>
<td>Preparation of Five-Year Development Plans for Thailand including policies for Bangkok within the national context.</td>
</tr>
<tr>
<td>2. Office of the Commission for the Management of Road Transport (OCMRT)</td>
<td>Traffic analysis, traffic policies, and traffic management schemes for major cities in Thailand.</td>
</tr>
<tr>
<td><strong>Ministry of Transport and Communication</strong></td>
<td></td>
</tr>
<tr>
<td>1. Department of Highways</td>
<td>Planning, design, construction, and maintenance of highways in Thailand.</td>
</tr>
<tr>
<td>2. Harbour Department</td>
<td>Planning and regulation of inland waterway and coastal transport including ferry services.</td>
</tr>
<tr>
<td>3. Department of Land Transport</td>
<td>Regulation of bus and truck operations.</td>
</tr>
<tr>
<td>4. State Railway of Thailand</td>
<td>Planning, implementing, and operating national railway.</td>
</tr>
<tr>
<td>5. Bangkok Mass Transit Authority</td>
<td>Operating bus services in Bangkok and surrounding provinces.</td>
</tr>
</tbody>
</table>

Source: Adapted from JICA, 1990: 74
and plans and carry out their projects independently, regardless of whether these coordinate with one another. Four separate agencies (BMA, DOH, DPW, and ETA) build roads in Bangkok. Recently, the State Railway of Thailand has become involved in road building through the massive rail and expressway infrastructure project known as the Hopewell project. Five separate agencies (BMTA, SRT, DLT, ETA, MRTA) are responsible for regulation and operation of public transport and construction of mass rapid transit, and three agencies (OCMRT, TPD, and BMA) are responsible for traffic management. As demonstrated in Figure 6.4, these overlapping mandates cause great confusion and obstruction to transport planning and implementation in Bangkok. A number of proposed projects aimed at solving traffic congestion have been the subject of bitter controversy and are not likely to eventuate in the foreseeable future. In addition to these overlapping mandates, the individual objectives and cultures of each organisation also cause conflicts, as noted by Daniere (1995):

> Each organization has a persistent, patterned way of thinking about the central tasks within an organization that is passed on from one generation to the next. As an example, an agency set up to build roads, inevitably, wants to build roads and to go on building roads. Similarly, an agency charged with building expressways will want to build expressways and as many as possible. These conflicting missions also extend to conflicts over the allocation of the budget. Each agency expects to maintain its share of the financial pie and uses all of its influence to do so  (p. 38)

Although the Office of Commission for Management of Road Traffic (OCMRT) has been assigned to act as the central agency for overseeing and co-ordinating all transport projects, it has no authority to intervene in the formulation and implementation of such projects. As a consequence, many projects which are carried out individually by different agencies appear to conflict or overlap with each other. Often these "boundary disputes" are difficult to resolve, as contracts may have been already signed with concessionaires or projects have been already launched (Bodell, 1995: 2; Wright, 1995: 8). Moreover, the role of the OCMRT itself has sometimes hampered the progress of such projects.
Figure 6.4 The institutional framework of transport planning, policy and implementation in Bangkok

Source: Bodell, 1995: Figure 1
A classic example of the outcome of the institutional fragmentation is the great and continuing conflict among the five proposed "megaprojects" comprising three mass rapid transit projects and two elevated expressways (Table 6.3 and Figure 6.5). Inter-agency conflict has resulted in long delays for these three mass rapid transit projects.

Table 6.3 Details of the five transport megaprojects in Bangkok

<table>
<thead>
<tr>
<th>Projects</th>
<th>Responsible agencies</th>
<th>Characteristics of the projects</th>
<th>Contract signed</th>
<th>Proposed finished time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hopewell</td>
<td>SRT</td>
<td>Elevated railway/expressways 60 km long</td>
<td>December 1991</td>
<td>The first phase by 1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 phases</td>
<td></td>
<td>The whole project by 1996</td>
</tr>
<tr>
<td>Tanayong</td>
<td>BMA</td>
<td>Elevated railway 21 km long</td>
<td>April 1992</td>
<td>By 1996</td>
</tr>
<tr>
<td>MRTA rail</td>
<td>MRTA</td>
<td>Underground railway (previously elevated) 20 km long</td>
<td>(February 1992, abolished June 1992)</td>
<td>By 1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>July 1992 established MRTA to be responsible for the project</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>March 1990</td>
<td>By 1995 (finished)</td>
</tr>
<tr>
<td>The Second Stage</td>
<td>ETA</td>
<td>Elevated expressway 32 km long</td>
<td></td>
<td>By 1995 (finished)</td>
</tr>
<tr>
<td>Stage Expressway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don Muang Tollway</td>
<td>DOH</td>
<td>Elevated expressway 16 km long</td>
<td>August 1989</td>
<td>By 1993 (finished)</td>
</tr>
</tbody>
</table>

Sources: Halcrow Fox and Associates et al., 1991; Tanaboriboon, 1993: 22; DOH, 1992: 32; ETA, 1991: 49-50; Prachachart Thurakit (Special Issue), 1993

The five projects are the responsibility of different five government agencies. These five agencies independently conducted the plans, designed and signed contracts with different construction firms. Some contracts were signed without conducting any feasibility study (Ua-taweekul, 1991 cited in Wongkarn Korsang, 1991: 106). As a consequence, two major problems arose:

1. Physical conflict among these projects, where thirty-three locations were revealed to be impractical for construction. For example, at some points where three elevated rail projects cross each other, the upper system has to
Figure 6.5 The routes of five megaprojects in Bangkok

Sources: Adapted from Halcrow Fox and Associates et al., 1991: Figure 9.1; Kasetsart University and Sindhu Pike Bodell, 1994b: Figure 4.2
be about 27 metres above ground level, approximately at the level of the eighth floor of a building (Stickland, 1993: 1, 6).

2. Duplication among projects. For example, the Hopewell railway/expressway project was designed to be parallel and adjacent to the Don Muang Tollway and the second stage expressway. In some areas, they are only 100 metres apart. The consequences are not only the competition between them, but also their impacts, placing heavy traffic burdens on the surface road network (Halcrow Fox and Associates et al., 1991: 12-4). Moreover, a serious and, at the time of writing, still unresolved legal issue has arisen between the Don Muang Tollway and the Hopewell project. This is because the Don Muang Tollway contract has, as a condition, the prohibition of any competing project built within a distance of two kilometres (Matichon Weekly, 1994: 22; Poboon, 1994).

These conflicts have plagued these projects, particularly the three mass rapid transit projects. To date, only the Tanayong Project has proceeded, but it is still far from completion. Initially, the Tanayong project was to be completed by 1996. However, only some columns have been constructed, and the project has encountered several serious problems involving other agencies, such as a dispute over the site for the depot. Although construction of the Hopewell project has been underway for a few years, very little progress has been made. The project is far behind schedule. For example, the first stage of the Hopewell project was to be completed by 1997. At November, 1996, only 10 per cent of the work had been completed. The project is under a cloud and may even be scrapped. Further, the MRTA project, initially scheduled for completion by 1997, is still at the contract bidding process after four years of delays and procrastination. Apart from the conflicts with other projects, this long delay is due to the continuing struggle among different interest groups about whether it should be built above ground or underground. One of the strongest opponents of the elevated rail projects is a so-called environmental group which claims that the elevated trains would pose immense impact on Bangkok, particularly visual intrusion, and air and noise pollution. The Cabinet eventually decided to build it underground (Bangkok Post, 1996b; Poboon, 1994). In addition to the conflicts among these megaprojects, the strong attempts in 1995 by the OCMRT to change the three mass rapid transit systems to be built underground in the inner city area have contributed to uncertainty and long delays. An interesting aspect
of the environmental opposition to elevated rail projects, is that no such opposition appears to be directed against the elevated expressway projects. This has led some to question the motives of those opposing the rail projects (Pike and Rujopakarn, 1996: 28).

Another example of the result of institutional fragmentation is the proposals for segregated busways which have been proposed several times by different agencies, but no construction has been done at all. For example, the three busway projects recently proposed by the BMA have been cancelled although the budget for these projects was already approved. According to the BMA, it was due to the lack of support from, and cooperation among, numerous relevant agencies and committees such as CMRT, BMTA, ETA, Police Department etc. (Daniere, 1995: 37; Thai Rut, 1994: 10). Furthermore, the canal boat projects on the east bank of the Chao Phraya River which were initiated in 1990 by the BMA have had to be formally called "pilot projects" until the present time, because if they become normal passenger boats, they have to be under the control of the Harbour Department. This would create a number of obstacles to the projects, since the Harbour Department has never had any policy to operate boat services along canals in the east bank, and its regulations seems to discourage the private sector currently operating the boat services.

This fragmented situation is not characteristic of all large Asian cities. In contrast to the chaotic institutional fragmentation described above, several Asian cities have demonstrated effective transport management abilities: their transport systems serve their residents effectively, largely as a consequence of efficient and unified institutional frameworks. For example, as shown in Figure 6.6, in Hong Kong only one transport agency (the Transport Department) is in charge of all transport policy and planning. All other departments must consult this department on transport schemes; all relevant issues must be considered. The Transport Department is capable of coordinating all transport schemes, strengthened by a strong legal framework. The process required for implementation of plans is clearly spelled out: the construction is under the responsibility of the Highways Department or the specific project manager offices established for new towns and reclamation areas (Bodell, 1995: 3).
Figure 6.6 The institutional framework for transport in Hong Kong

Source: Bodell, 1995: Figure 2

This section has argued that in Bangkok institutional fragmentation is a significant factor in hindering the formulation and implementation of transport policies and plans. Unlike the situation in cities such as Hong Kong, inter-agency conflicts and overlapping jurisdictions put effective strategies at risk. Some projects are brought to a standstill by bureaucratic problems. It is argued that this issue must be addressed as a first priority. Any attempt to introduce new transport policies to tackle Bangkok's traffic crisis requires serious consideration of this issue. Suggestions about how to resolve this institutional fragmentation are pursued in Chapter 7.

6.3 OPPORTUNITIES

Amid the many intimidating hindrances to transforming Bangkok's transport system into a more efficient and effective system, some signs of encouragement are offered by both the international movement and local community. These forces are focused on directing Bangkok towards a more liveable pattern of settlement and more sustainable transport system. These pressures are vital to the formulation and implementation of policies proposed to relieve serious traffic and related problems in Bangkok. The following sections therefore describe these forces in terms of the global and local move towards sustainability and the beginnings of perhaps a wider
community-based movement in Bangkok directed at solving its traffic problems. It also examines the role of NGOs.

6.3.1 Ecologically Sustainable Development (ESD): Pressures from the International Community

Human activities, often in the name of "development", have had well-documented negative consequences, on a global scale. In recent human history, this so-called development has led to unprecedented exploitation of resources and, consequently, vast pollution, with adverse impacts on quality of human and non-human life. For example, Boyden et al. (1981: 7-8) depicted the steps human societies have taken which have resulted in an overwhelming increase in energy consumption. They pointed out that from the period of using energy only for the human body's need, human societies passed to the period of utilising extrasomatic energy, which does not flow to living organisms. This use of extrasomatic energy at least doubled the total per capita flow of energy through human societies. Moreover, the introduction of techniques involving the use of fossil fuels has had a substantial influence on energy consumption. In some industrialised countries like the United States, energy use per capita has increased about thirty times since the beginning of the industrial transition.

Likewise, Peeks (1992: 8) criticised current development and extractive economics as destructive agents. According to Peek, current development has been considerably decreasing per capita production of renewables and destroying our real source of wealth, the biosphere.

These concerns prompted movements for more appropriate development now commonly called "sustainable development", a concept which is increasingly being applied to the improvement of cities worldwide (e.g. Newman, 1995).

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43 It is not an intention of this section to pursue a comprehensive literature review on sustainable development, but rather to briefly demonstrate the international movements for sustainability and the application to cities, transport and Bangkok in particular.
6.3.1.1 The Sustainability Movement

The response to concerns about deteriorating environments and other adverse effects on human and other life resulting from development is clearly seen in the movement for sustainability, sustainable development, or ecologically sustainable development (ESD), as it is variously referred to. The origins of the sustainability movement can be traced to the 1972 UN Conference on the Human Environment, where 113 nations pledged to begin improving their performance and to begin the process of tackling environmental issues on a global basis (Newman, 1995: 1). Late in 1983, the Secretary-General of the United Nations asked Norway's Mrs. Gro Harlem Brundtland to put together an independent commission to look at the growing crisis on the environment, particularly in Third World countries, and to suggest ways to cope with these issues into the next century. The group studied, debated and held public hearings on five continents over almost three years. In April 1987, it published *Our Common Future* (the Brundtland Report) submitted to the United Nations General Assembly for consideration. The report describes a future which can no longer be sustained if the present development system continues. It describes many of the changes needed to provide a future basis for development founded on enhanced environmental resources and popular participation in decision-making. It offers a new model of development for our future called *Sustainable Development* (IIED, 1987: 5). The 42nd Session of the UN General Assembly accepted the report in 1987 and advocated sustainable development as a guiding principle for the UN, governments and the private sector.

From the report, *Our Common Future*, the World Commission on Environment and Development (WCED) defined *sustainable development* as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 8).

This definition contains the two fundamental key concepts of needs and limitations:

1 The basic needs of humanity - for food, clothing, shelter, and jobs - must be met. This involves, first of all, paying attention to the largely
unmet needs of the world’s poor, which should be given overriding priority.

2 The limits to development are not absolute but are imposed by the present state of technology and social organisation on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organisation can be both managed and improved to make way for a new era of economic growth.

(WCED, 1987: 8)

Consequently, the World Bank, one of the most powerful institutions in the field of global development, recently redressed its focus on environmental quality together with economic growth. It states its views of the meaning of development and sustainability in the World Development Report 1992: Development and the Environment:

Development is about improving the well-being of people. Raising living standards and improving education, health, and equality of opportunity are all essential components of economic development. Ensuring political and civil rights is a broader development goal. Economic growth is an essential means enabling development, but in itself it is a highly imperfect proxy for progress.

Sustainable development is development that lasts. A specific concern is that those who enjoy the fruits of economic development today may be making future generations worse off by excessively degrading the earth’s resources and polluting the earth’s environment. The general principle of sustainable development—that current generations should “meet their needs without compromising the ability of future generations to meet their own needs”—has become widely accepted and is strongly supported in this Report.

(World Bank, 1992: 34)

Jacobs (1991) presented three elements of sustainable development in The Green Economy: (1) Environmental considerations must be entrenched in economic policy making; (2) Sustainable development incorporates an inescapable commitment to social equity; and (3) "Development" does not simply mean "growth," as represented by increases in national income. We
must learn to live on the interest generated by remaining stocks of living natural capital. Development implies qualitative as well as quantitative improvement.

In sum, three major characteristics of sustainability are: (1) the elimination of poverty in the Third World is necessary not just on human grounds but as an environmental issue; (2) the First World must reduce their consumption of resources and production of waste; and (3) global co-operation on environmental issues, e.g., hazardous wastes, greenhouse gases, CFC's, loss of biodiversity, is no longer a soft option (Newman, 1995: 2). Similarly, Rees (1990) suggested that a new definition of sustainable development is "development that minimises resource use and the increase in global entropy" (Rees, 1990: 19).

Although the term sustainability has been interpreted variously and is almost impossible to define in an operational sense, it has shown a signal of concern on environmental impacts and resource conservation which is based on an understanding of processes as they unfold through time (Whitelegg, 1993: 154). Since the term sustainable development emerged, it has been widely adopted as an agenda devised to tackle global environmental problems and direct development. The sustainability movement was first and foremost a global movement that forced environmentalists and economists to work together. The goal is to synthesise environment and economic development (Newman, 1995: 3). For example, in June 1988, the leaders of the G7 countries adopted the concept and in the summer of 1988 the Secretary-General of the UN initiated a special task force to monitor progress on institutionalising the idea of sustainable development. In November of the same year, the OEC9 commenced a survey of how environmental considerations could be integrated in a system of national accounts (Whitelegg, 1993: 7). Moreover, a large number of international and local meetings have been organised.

Recently, one of the most significant events at a global level was the UN Conference on Environment and Development or the "Earth Summit" held in Rio de Janiero in 1992, after two years of preparatory meetings involving thousands of the world’s scientists and administrators. It assembled together more leaders of government than at any other time. It also attracted observers from 1,400 NGOs and 8,000 journalists (Davison and Barns,
1992: 5). The final resolutions were signed by 179 nations representing 98 per cent of the world's nation states. The documents agreed to were: a statement on sustainability called the "Rio Declaration" and a 700-page action plan for sustainability, "Agenda 21", comprising three main parts: "A Convention on Climate Change"; "A Convention on Biological Diversity"; and "A Statement on Forests" (Newman, 1995: 3-4). A number of governments, industries and communities have applied and adopted the plans into the development of their countries, businesses, and local improvement worldwide. As a result, there have been a number of success stories both at a global level, regional level and local level. Some examples at the global level are the prevention of toxic waste exports, the reduction of production of CFC's, and the control of whaling. In 1989, Thailand also signed the Montreal Protocol to agree on reduction of CFCs use (Buttan, 1993: 30).

In addition, Agenda 21 provides guidance to enable local authorities worldwide to apply principles of sustainable development to the appropriate development of their locality (Greene, 1994; Brown, 1994, cited in Newman, 1995: 4). Local action plans for development of specific localities should be initiated by local people. In practice, Parenteau (1994: 190-191) suggests that local governments, in undertaking and supporting citizens' initiatives for a local action plan, should adopt three principles: (1) the enabling approach: to gain responsibility and to obtain the tools necessary for a local action plan; but also to provide any kind of support and to delegate responsibilities to concerned private and corporate citizens; (2) the subsidiarity principle: according to which, policy formulation, decision-making and administration should be taken at the lowest or most local level commensurate with effectiveness; and (3) the residuary principle: stating that if decisions are not taken at the most appropriate level, they may be taken at other levels.

6.3.1.2 Application of Sustainability to Cities and Transport

Cities are facing a whole host of serious environmental, social and economic problems directly related to transport systems. For example, Stren et al. (1992: 19) pointed out that together with the growth of urbanisation, particularly in developing countries, large cities are faced with various serious pressures, particularly environmental issues and problems of the
poor. Roseland (1992) argued that although common environmental themes unite the world’s communities, cities of the North and of the South face different challenges:

...the basic problem with Northern cities is that they are unsustainable, whereas the basic problem with Southern cities is that they are underdeveloped. Most Northern city dwellers are adequately housed and fed, but they meet their needs by consuming at rates the planet cannot afford and polluting at rates the planet cannot tolerate. Most Southern city dwellers cannot meet their basic needs for food, clean water, clean air, fuel, transport and an environment free of disease-causing agents. While this dichotomy is not entirely clear cut - i.e., there is poverty in many Northern cities, and many Southern cities live beyond their means in terms of consumption of natural resources such as firewood and water - it helps illuminate the essential challenge of urban sustainability both North and South: meeting basic needs without depleting or degrading environmental capital. (p. 22)

Cities themselves have contributed enormously to adverse impacts on the ecosystem. For example, Boyden et al. (1981: 7-19) stressed that:

_Urban settlements are very far from being self-sufficient, and they could not survive for more than a day or two without a massive input of natural resources, renewable and nonrenewable, from rural areas. In fact, from the ecological viewpoint, the city is in many ways rather like a gigantic immobile animal. It consumes vast quantities of oxygen, water and organic matter (in the form of fossil fuels and food substances), it releases carbon dioxide and water vapour into the atmosphere and it excretes into its surroundings organic waste material suspended or dissolved on large volumes of water._

Wackernagel and Rees (1996) have extended this concept through the development of what they call the "ecological footprint" of cities. This means that the resource requirements of cities and their waste outputs can actually be measured as a physical impact over a specific larger area of the earth’s surface than what they physically occupy.
White and Whitney (1990 cited in Roseland, 1992: 23) specifically address the unsatisfactory role of cities of the North, especially their impact on perceptions and policy making in developing countries:

Furthermore, the cities of the industrial world, with their inadequate urban policies and technology, set the standard to which city managers in low-income countries aspire - low density single family dwellings, cars, expressways, waste creation, air conditioning and profligate water use.

Much of the research and policy literature addresses directions to cope with the problems and coax cities towards sustainability. For example, Meadows, Meadows and Renders (1992, cited in Whitelegg, 1993: 154) define a sustainable society as "one that can persist over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine its physical or social system of support". Daly (1991, cited in Whitelegg, 1993: 5) argued that a physically sustainable society should satisfy three basic conditions:

1 its rates of use of renewable resources do not exceed their rates of regeneration;
2 its rates of use of non-renewable resources do not exceed the rates at which sustainable renewable substitutes are developed;
3 its rates of pollution emission do not exceed the assimilative capacity of the environment.

Newman (1995: 4) argued that, although there is no clear guidance from Agenda 21 and other documents on how to apply the sustainability agenda to cities, as probably the major environmental battles of the past were fought outside cities, awareness of the need to come back to cities is now increasingly recognised by environmentalists, government and industry. The OECD, the EEC and even the World Bank now have sustainable cities programs (Newman, 1995: 4). Furthermore, Newman suggested the most fundamental principle for applying sustainability to cities is to recognise that: "sustainable cities are those that are helping make a sustainable world" and the primary goal for a sustainable city is to try and fulfil the global agenda of "reducing the city’s use of natural resources and its production of wastes whilst simultaneously improving its human amenity and human environment". This necessitates the careful integration of the economic, social and environmental
components of the city. This approach, developed by Newman et al. (1996), is called "extended metabolism of human settlements", and is set out in Figure 6.7.

![Extended metabolism model of human settlements](image)

**Figure 6.7 Extended metabolism model of human settlements**

Source: Newman et al., 1996: Figure 3.2

In addition, Anders (cited in Newman, 1992: 1) argued that the sustainable cities movement is characterised as "municipal environmental efforts justified as responses to global environmental problems". She further pointed out that sustainable cities movements have helped make the environment a legitimate concern for cities, and they have given evidence and social acceptability to the idea that people should change their behaviour, at least a little, to help contribute to global sustainability. The application of sustainability to cities thus provides some hope to ease urban problems and direct cities to better settlement and transport patterns for their residents.

With respect to sustainability, one of the most significant sectors in cities is transport. It is one of the major elements which must be addressed if cities are to move towards sustainability. Traffic congestion and related problems (air and noise pollution and accidents) are problems experienced by most large cities. It has long been recognised that the transport sector, particularly
the automobile, is the greatest single source of urban air pollution such as carbon monoxide, hydrocarbons, and nitrogen oxides (Berry and Horton, 1974: 85). For example, it accounts for about 90 per cent of all CO emissions, 50 per cent of NOx and HC emissions, and about 80 per cent of Benzene emissions in European cities (ECMT, 1990: 26). Transport has a severe effect on human health, causing respiratory illnesses, accidents, and loss of independent mobility for children. It is also one of the major sources of greenhouse gases and is responsible for high levels of energy consumption (Whitelegg, 1993). Table 6.4 shows the contribution of motor vehicles to urban air pollution in some major cities.

Table 6.4 Contribution of motor vehicles to urban air pollutant levels in selected cities, 1980s and 1990s

<table>
<thead>
<tr>
<th>City</th>
<th>Year</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>SO2</th>
<th>SPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens</td>
<td>1990</td>
<td>100</td>
<td>79</td>
<td>76</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Beijing</td>
<td>1989</td>
<td>39</td>
<td>75</td>
<td>46</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Budapest</td>
<td>1987</td>
<td>81</td>
<td>75</td>
<td>67</td>
<td>12</td>
<td>na</td>
</tr>
<tr>
<td>Colombo</td>
<td>1992</td>
<td>100</td>
<td>100</td>
<td>82</td>
<td>94</td>
<td>88</td>
</tr>
<tr>
<td>Delhi</td>
<td>1987</td>
<td>90</td>
<td>85</td>
<td>59</td>
<td>13</td>
<td>37</td>
</tr>
<tr>
<td>Lagos</td>
<td>1988</td>
<td>91</td>
<td>20</td>
<td>62</td>
<td>27</td>
<td>69</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>1990</td>
<td>98</td>
<td>62</td>
<td>84</td>
<td>68</td>
<td>11</td>
</tr>
<tr>
<td>Mexico City</td>
<td>1990</td>
<td>97</td>
<td>53</td>
<td>75</td>
<td>22</td>
<td>35</td>
</tr>
<tr>
<td>Santiago</td>
<td>1993</td>
<td>95</td>
<td>69</td>
<td>85</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Sao Paulo</td>
<td>1990</td>
<td>94</td>
<td>89</td>
<td>92</td>
<td>64</td>
<td>39</td>
</tr>
</tbody>
</table>

Source: World Resources Institute, 1996: Table 4.2

Note: na = not available

Newman (1992: 2) places a high emphasis on transport if cities are to achieve sustainability. He stated:

> Our perspective emphasises the problems of the automobile in cities and hence sustainability is defined in terms of moves to reduce the degree of automobile dominance or dependence in our cities. This perspective seeks to make cities more sustainable by a) reducing smog and greenhouse
gases from transport, b) reducing the sprawl of cities in rural and bushland areas, c) reducing the physical, social and emotional damage from traffic in our cities and d) making our cities more people-oriented and less car-oriented.

Whitelegg (1993: 154, 162) argued in *Transport for a Sustainable Future* that measures to reduce environmental impacts from transport emphasising technology-based solutions such as installing end-of-pipe technology and policies which continue to stimulate higher levels of traffic demand (such as pursuing more road construction) are unlikely to be consistent with sustainability concepts based on commitment to reduction of resource consumption. To achieve a more liveable community with better movement, health, psychological well-being and employment, the major commitments need to be a phased reduction in dependence on motorised transport, and a gradual shift in the organisation of land-uses and activities.

In more practical attempts, a number of conferences and workshops have been held around the world to attempt to encourage the movement of cities and transport towards sustainability. For example, one of the most important events was the Second United Nations Conference on Human Settlements known as the Habitat II Conference, or "City Summit" held by the United Nations Centre for Human Settlements (UNCHS) in Istanbul from June 3 to June 14, 1996. At this conference nations gathered to report on progress in achieving sustainability in their cities. About 10,000 participants, including government representatives, academics, and NGOs attended. The mandate for the Summit was to promote basic shelter for all and environmentally sustainable human settlements. Sustainability was progressively acknowledged and incorporated into policies endorsed by governments worldwide. In terms of transport, all signatory governments made the commitment to:

*Improving access to work, goods, services, and amenities, inter alia, by promoting effective and environmentally sound, accessible, quieter and more energy efficient transportation systems and by promoting spatial development patterns and communications policies to reduce transport demand, promoting measures, as appropriate, so that the polluter bears the cost of pollution, taking into account special needs and requirements of developing countries.*

(Barter, 1996: 4)
In more detail, the City Summit documented that:

1) Transport and communication systems are the key to movement of goods, people, information, and ideas. The transport sector is the major consumer of non-renewable energy and of land and is a major contributor to pollution, congestion and accidents. Integrated transport and land-use policy and planning can reduce the adverse effect of current transport systems.

2) Transport management should aim to promote good access for all, while reducing the negative effects of transport on the environment. Transport-system priorities should be given to reducing unnecessary travel, through appropriate land-use and communication policies, mobility alternatives other than automobile, alternative fuels, alternative-fuel vehicles, improving environmental performance of existing modes, and adopting pricing policies.

3) Non-motorised transport is very important for mobility, particularly for low-income, vulnerable and disadvantaged groups. Thus, it is necessary to promote this mode of transport.

To achieve the sustainable transport systems to which the governments present in Istanbul claimed to be committed, governments at appropriate levels need to co-operate effectively with the private sector, the community sector, and other relevant stakeholders (Barter, 1996).

6.3.1.3 Application of Urban Sustainability to Bangkok

For Thailand and Bangkok, environmental concern and the sustainability concept have been gradually developed and adopted, as evidenced in the last three national development plans. The Fifth National Social and Economic Development Plan (1982-1986) was the first to recognise the environmental problems resulting from the previous economic growth e.g. the depletion of land, water and fishing resources, urban problems, particularly traffic congestion in Bangkok and other large cities. In terms of transport, although this plan did not reconcile conflicts between public and private transport, it nevertheless recognised the role of public transport in alleviating congestion problems in cities. For example, the Plan recommended the following policies for traffic development in Bangkok:
(2) Encourage the general public to use public transportation services by implementation of the following measures: - Promote the construction of expressways in accordance with the master plan. The private sector will be encouraged to invest in the construction and operation of the electric mass transit system. Subsidies are not to be provided by the government.

(NESDB, 1982: 95)

This was seen as an auspicious start, although it was somewhat equivocal in its commitment to public transport. Later, the Sixth National Social and Economic Development Plan (1987-1991) recognised the problems associated with depletion and deterioration of natural resources, particularly land and forests, which were over-exploited or used without adequate consideration of environmental or economic impacts. Water pollution and the use of toxic substances in agriculture, industry and public health also received emphasis in the Plan. This Plan also highlighted Bangkok's problems. In terms of transport and traffic improvement, it placed greater emphasises on public transport e.g. improvement of bus services, introduction of segregated busways, and the development of mass transit systems. Nevertheless, the investment plans still gave priority to construction of primary and secondary roads and expressways (NESDB, 1987).

The current plan - the Seventh National Development Plan (1992-1996) - paid more attention to environmental problems. This was because environmental quality during the five years of the Fifth Plan had rapidly deteriorated in line with the rapid economic growth which had been oriented toward modern industry and services (NESDB, 1992: 175). Environmental awareness and sustainability have been increasingly addressed in the current plan. For example, in the chapter on environmental development and better quality of life, the Plan recognised both the local problem of increasingly severe pollution problems e.g. water pollution, air and noise pollution, and global concerns about the global warming phenomenon. It also proposed a set of policies to tackle these problems. To reduce air and noise pollution caused by traffic, in particular, this Plan proposed several environmentally sound measures e.g. reduce lead content in gasoline, set standards for air pollution emitted by vehicles, improve quality of fuels etc. In terms of the global warming problem, it proposed two measures:
3.5.1 Carry out studies quickly to help determine Thailand's position for cooperating with the world community in tackling the global warming problem as well as emphasize reforestation efforts via development of plantations to help absorb carbon dioxide.

3.5.2 Prevent problems associated with global warming and the greenhouse effect, caused by increase in carbon dioxide from fuel combustion, by encouraging planting of trees and reforestation, and carry out public relations campaigns to create understanding by the public about the serious impacts and to seek cooperation in solving the problems.

(NESDB, 1992: 183)

The plan did not, however, specifically address the need to try to prevent further growth in motor vehicle use as a way of reducing Thailand's contribution to global CO₂, and a way of helping to solve the problems associated with chronic congestion in Bangkok.

In sum, environmental concern and the sustainability concept have been gradually accepted and applied to a somewhat limited degree in development in Thailand in general and Bangkok in particular. The impetus has come, not only as a result of the obvious deterioration of natural resources and environmental quality in the country and in Bangkok, but also from strong pressure from the worldwide movements for sustainability and sustainable cities. This changing emphasis can be traced through national development policies. Although a number of the policies with an emphasis on sustainability have been proposed by these national development plans, they have not, as a general rule, been effectively implemented. Nevertheless, this gradual progress, and the ongoing global and local effort focussed on sustainability, provide some hope to direct Thailand and Bangkok towards a better and more sustainable approach to urban settlements.

6.3.2 Pressure from Thai Communities

The international movements for sustainable development have not been the only sources of pressure to move Thailand and Bangkok towards a more sustainable urban development. The local community, including citizens,
the mass media, academics and non-government organisations (NGOs) have recently expressed their outrage at the deteriorating Bangkok environment and made attempts to help direct Bangkok towards a more liveable city.

6.3.2.1 Public Outrage

Bangkokians have, up until now, been suffering silently from the severe traffic congestion and related consequences, such as air pollution and noise, which are clearly detrimental to their health. They are desperately looking for answers to relieve this deteriorating situation. Their suffering is revealed in conversations, and in the media, particularly newspapers and magazines. For example, on June 4, 1996 in Matichon Weekly, one of the most popular magazines in Thailand, the columnist described Bangkok as "the hell of the present and the hell of the future", as there is only concrete jungle, motor vehicles and toxic air pollution everywhere (Vitayaviroj, 1996: 26). In the same magazine, another columnist referred to a research report which identified the most serious problems in Bangkok as: (1) pollution; (2) traffic congestion; and (3) low quality of life. He asked the newly elected Bangkok governor to solve the problems of "the big house which is the dirtiest, most contaminated and extremely chaotic" (Buttan, 1996: 26).

All political parties make the traffic issue a priority in campaigning. For example, during the last general election in 1995, all rival political parties in Bangkok identified solving traffic congestion and air pollution problems as the main issues. Sadly, only a few improvements have materialised. One major reason is the lack of political will and courage to put forward sound policies. Furthermore, there have been serious conflicts between coalition parties and also among government agencies. They often use the issue to attack each other - a response which makes Bangkok residents very confused and angry. Letters and articles complaining about this outrageous problem are common in the daily newspapers. For example, Sinsuwong, in a column on traffic solutions, in the Siam Post, December 27, 1993, complained that:

*The deteriorating traffic congestion problem in Bangkok has been recognised for many years. It has reached this serious stage because the government lacks courage to deal with the right cause of the problems—there are too many cars.... There are already too many talkers but we lack politicians who are decisive and courageous.* (p. 6)
One of the laudable initiatives by the private sector to help relieve the traffic nightmare is the establishment of radio programs to report the traffic situation in Bangkok on a 24-hour basis. The first was the Jor-Sor 100 program, established in 1991, which originally aimed to help motorists choose a faster route and report road accidents. This program succeeded in gaining overwhelming popularity and wide participation from Bangkok's residents, particularly road users. Currently, there are more than 60,000 members of this program (The Nation Weekender, 1996: 42, 59). Motorists, traffic police, and local people report on the traffic situation and share their opinions with others. This program not only helps road users to choose the better route for their trips, it also helps relieve pressure psychologically. In addition, it acts as an information centre, through which travellers who need urgent help such as those who are seriously ill, women about to give birth, but are caught in a traffic jam, can send their messages. Fortunately, through this service, these people generally receive assistance in time. As this program is so popular, another radio station is currently providing a similar service. Unfortunately, it seems that this loose coalition of people galvanised around the traffic issue, has not spawned anything more substantial in the way of organised lobby or pressure groups based around community activism.

Notwithstanding, at the beginning of 1994, there was an unprecedented attempt by prominent members of the public to act on the traffic problem in Bangkok. A group called "Traffic Crisis'94", headed by the popular former prime minister, Anand Panyarachun, was established to brain-storm solutions from local communities. Approximately 300 participants representing Bangkok's residents, businesses, local and national governments, academics and NGOs, participated. The forum divided into 11 working groups to consider and recommend solutions to: (1) mass rapid transit construction; (2) road and expressway construction; (3) freight transport; (4) limitations on car use; (5) bicycle and pedestrian pavements; (6) urban planning; (7) organisation and legal affairs; (8) financial issues; (9) managing traffic around large buildings and public places; (10) managing traffic for education institutes; and (11) other issues.

A strong media campaign was organised to generate public interest. A 63-measure proposal was put forward but unfortunately it did not assess which
measures deserved highest priority. The measures included the improvement of public transport services and infrastructure; a master plan for an electric train and future expressway projects; construction of suburban and minor roads; traffic management; and pavements for bicycles and pedestrians. The proposal was submitted to the government in February 1994. Although the proposal has not been formally implemented, this attempt has been a vital step in the path towards greater community participation in Bangkok in solving traffic problems. This is reflected in the dramatic increase in public debate on transport problems which followed the 1994 forum. Several newspapers and magazines now devote regular columns to traffic issues. Major transport projects were initiated or accelerated. Transport has become a more vital issue in political terms and has generated great heat at both the local and national levels (Nation, 1994: A12; Barter, 1996a: 1; Poboon et al., 1994: 28).

Mass media also act as the centre for activities. In January 1995, Thai Rut, the newspaper in Thailand with the widest circulation, launched the campaign "Thai Rut against Air Pollution Program" and received very high levels of response from both the government and the private sector. For example, the Minister of Science, Technology and Environment announced full support for the program. The Deputy Minister of Transport and Communication promised more strict control on emissions from buses. The two ministers were also keen to phase out lead in gasoline and shift from 2-stroke engines to 4-stroke engines for motorcycles in Bangkok (Thai Rut, 1995).

Traffic congestion and air pollution problems in Bangkok are of great concern, not only among common people, but also with the Royal Family. In 1995, the King gave an unprecedented speech on his birthday and summoned the Prime Minister and two Cabinet ministers responsible for traffic and ordered them to work in harmony. In addition, in an attempt to relieve the problem, the King recently donated a sum of money to support traffic police in obtaining better equipment and welfare to enable them to work more effectively (Poboon, 1994: 28; Hiscock, 1996: 25). Likewise, the Queen gave a speech on her birthday in 1993 expressing her serious concerns about traffic congestion and its negative impacts on all people, Thais and foreigners, and particularly children. She called for concerted actions from all Thai people (Poo Jad Karn, 1993: 29). Furthermore, in April 1996, the
government established an *ad hoc* committee chaired by the Prime Minister to tackle the problem. This was in response to the Queen’s concern that during her trip to Europe, a World Health Organisation official told her that several countries had prohibited children younger than 12 years old from visiting Thailand for fear they would contract air pollution-related illnesses (Bangkok Post, 1996a).

In sum, in spite of the severity of traffic congestion and air pollution in Bangkok, there is a light of hope from the community. Bangkok residents have demonstrated their concerns and their attempts to cope with the problems in several ways, including their participation in the recent problem-solving process (the "Traffic Crisis ‘94" forum). Mass media also play a vital role in what is still on the whole only a fairly loose community movement. Beyond that, the concerns expressed by members of the Royal family, which is highly respected by all Thais, are likely to be a strong force to encourage the government to accelerate its actions. The next section discusses the role of another major facilitator, NGOs, which have recently played an important role in development of Thailand and Bangkok.

6.3.2.2 Non-Government Organisations (NGOs)

NGOs have played an increasingly significant role in development in Thailand, particularly with respect to environmental issues (Ross, 1994: 10). The number of NGOs has been rapidly growing. In 1983, there were about 113 NGOs, but this has increased to approximately 600, of which about 400 are registered (Siam Post, 1993: 2). Among these, about 40 are registered as NGOs functioning on issues related to the environment and natural resources conservation. Of these, about 30 play a role in debates about Bangkok's environmental issues (Department of Environmental Quality Promotion, 1993). These NGOs have played a prominent role in tackling environmental problems in Bangkok. For example, the Thai Environmental and Community Development Association has successfully initiated the "Magic Eyes" program to campaign for a cleaner Bangkok. It is very popular among Bangkokians, particularly children. This program has been widely acknowledged for its contribution to the cultivation of awareness of Bangkok's residents about keeping Bangkok clean and has gained invaluable financial and logistical backing from the business sector (Ross, 1994: 9; Nutting, 1995: 34-35).
In terms of traffic problems and air pollution, several NGOs continue to persevere with the task of addressing the problems. For example, the Foundation for Anti Air Pollution and Environmental Protection, chaired by the current Bangkok Governor, has continuously campaigned for better air quality by demanding stricter vehicle emission controls, covering of construction sites and trucks carrying dirt, and more effective law enforcement. The Thailand Cycling Club has continuously campaigned for local and national governments to improve infrastructure for cyclists and has organised several cycling rallies to demonstrate the benefits of cycling. One of the obvious results of the campaign is the first bikeway for Bangkokians, provided by the BMA in 1995 (Bangkok Post, 1995a: 3). This 4 kilometre path is at least a start to consideration of the benefits of non-motorised transport for Bangkok's residents.

Other NGOs have pursued various activities, such as organising national and international conferences and workshops, conducting studies, campaigning through the mass media, and so forth on Bangkok's traffic and related problems. For example, from October 30 to November 1, 1994, the Thailand Environment Institute (TEI), in cooperation with the International Institute for Energy Conservation (IIEC), organised a workshop called "Bangkok's Traffic Crisis and Air Pollution". There were about 40 attendants (including the author), consisting of Thai government officials from relevant agencies such as OCMRT, Department of Town and Country Planning, BMA, Department of Pollution control etc., transport experts from Thailand and around the world, NGOs and private sector representatives. They exchanged expertise, experience and attitudes and worked together to seek responses to Bangkok's traffic problems and associated environmental concerns. Although participants could not come to an absolute consensus about the policies necessary to tackle traffic problems and air pollution in Bangkok, which in some sense reflected the existing institutional fragmentation, the workshop was part of what must be an ongoing process of awareness raising, education and lobbying for change. The relevant Thai government agencies were able to learn from the experiences of those in other countries, leading to a widening of opportunities for new perspectives on solutions to Bangkok's transport problems.
6.3.2.3 Pilot Survey of the NGOs

As NGOs are at present one of the major facilitators in fuelling change in Bangkok, a pilot survey was conducted as part of this study to explore their perceptions and performance with respect to traffic problems and related issues. The aim of the survey was to examine whether NGOs might act as important agents in the move towards a better transport system for Bangkok and perhaps how they might do this. The results of the survey also provide supplementary evidence for the foregoing argument.

This pilot survey was conducted in March 1995. Brief survey instruments (self-complete questionnaires) were distributed to thirty NGOs presumed to have a role in issues concerning Bangkok's environment. The questionnaire consisted of eight open-ended questions on NGOs' perceptions on environmental and traffic problems in Bangkok, and the role of community and NGOs in solving traffic and related problems. Fifteen NGOs or 50 per cent responded. The results of the survey are shown in Table 6.5. It should be stressed that the categories contained under each question were not given to the respondents as choices. These categories emerged from the analysis of results to an open-ended question in each case. This was situation in every question except Question 2 where the three categories of impact (traffic congestion, air pollution from traffic and traffic noise were supplied, as shown in Table 6.5.

From the survey results, it can be concluded, according to the perception of NGOs involved in environmental problems in Bangkok, that:

(1) The most serious environmental problems in Bangkok are: (1) air pollution; and (2) traffic congestion; with water pollution, garbage and traffic noise being mentioned by significantly less than 50 per cent of NGOs. This perception is consistent with the result from the 1992 survey on Bangkok residents conducted by Ross (Ross, 1994: 1), which revealed that Bangkokians listed traffic congestion and air pollution as the two worst disadvantages of living in Bangkok.
Table 6.5 NGOs' perception of and roles in traffic and related problems in Bangkok

<table>
<thead>
<tr>
<th>Perceptions/roles</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the most serious environmental problems in Bangkok? (can provide more than one answer)</td>
<td></td>
</tr>
<tr>
<td>1. Air pollution</td>
<td>87</td>
</tr>
<tr>
<td>2. Traffic congestion</td>
<td>67</td>
</tr>
<tr>
<td>3. Water pollution</td>
<td>40</td>
</tr>
<tr>
<td>4. Garbage</td>
<td>33</td>
</tr>
<tr>
<td>5. Noise from motor vehicles</td>
<td>27</td>
</tr>
<tr>
<td>2. To what extent do traffic and traffic related problems impact on Bangkok's residents?</td>
<td></td>
</tr>
<tr>
<td>2.1 Traffic congestion</td>
<td></td>
</tr>
<tr>
<td>• Very high impact</td>
<td>100</td>
</tr>
<tr>
<td>• Some impact</td>
<td>0</td>
</tr>
<tr>
<td>• No impact</td>
<td>0</td>
</tr>
<tr>
<td>2.2 Air pollution from traffic</td>
<td></td>
</tr>
<tr>
<td>• Very high impact</td>
<td>93</td>
</tr>
<tr>
<td>• Some impact</td>
<td>7</td>
</tr>
<tr>
<td>• No impact</td>
<td>0</td>
</tr>
<tr>
<td>2.3 Traffic noise</td>
<td></td>
</tr>
<tr>
<td>• Very high impact</td>
<td>93</td>
</tr>
<tr>
<td>• Some impact</td>
<td>7</td>
</tr>
<tr>
<td>• No impact</td>
<td>0</td>
</tr>
<tr>
<td>3. What are the major causes of traffic congestion in Bangkok? (can provide more than one answer)</td>
<td></td>
</tr>
<tr>
<td>1. Motor vehicle numbers have been increasing at rate that exceeds road capacities</td>
<td>87</td>
</tr>
<tr>
<td>2. Bad driving behaviour</td>
<td>67</td>
</tr>
<tr>
<td>3. Inadequate and inefficient public transport service</td>
<td>60</td>
</tr>
<tr>
<td>4. Inefficient traffic management and no city plan</td>
<td>53</td>
</tr>
<tr>
<td>5. Too many people in Bangkok</td>
<td>33</td>
</tr>
<tr>
<td>6. Improper government policy and too many responsible agencies</td>
<td>33</td>
</tr>
</tbody>
</table>
Table 6.5 (cont.)

<table>
<thead>
<tr>
<th>Perceptions/roles</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. What are some plausible solutions for traffic congestion in Bangkok?</strong></td>
<td></td>
</tr>
<tr>
<td>(can provide more than one answer)</td>
<td></td>
</tr>
<tr>
<td>1. Improving public transport services. Construct a mass rapid transit system, particularly electric train</td>
<td>93</td>
</tr>
<tr>
<td>2. Control number of motor vehicles operating on road</td>
<td>53</td>
</tr>
<tr>
<td>3. Improve traffic law and regulation and enforce more seriously</td>
<td>40</td>
</tr>
<tr>
<td>4. Coordinate all parties</td>
<td>40</td>
</tr>
<tr>
<td>5. Conduct a comprehensive study covering all transport network in Bangkok and set a plan that is consistent with urban growth</td>
<td>20</td>
</tr>
<tr>
<td>6. Improve infrastructure for walking and cycling</td>
<td>13</td>
</tr>
<tr>
<td>7. Speed up road construction to keep pace with rapidly growing motor vehicle population</td>
<td>13</td>
</tr>
<tr>
<td><strong>5. Do Bangkok's residents need to participate in solving traffic problems?</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>100</td>
</tr>
<tr>
<td><strong>6. If Bangkok's residents need to participate in solving traffic problems, what should they do? (can provide more than one answer)</strong></td>
<td></td>
</tr>
<tr>
<td>1. Conform to the law and regulation</td>
<td>80</td>
</tr>
<tr>
<td>2. Express their concerns and propose solutions to the government and participate in decision-making processes in all relevant government's projects</td>
<td>67</td>
</tr>
<tr>
<td>3. Reduce motor vehicle use by using telecommunication</td>
<td>20</td>
</tr>
<tr>
<td>4. Pay more tax so it can be used to fund mass rapid transit</td>
<td>13</td>
</tr>
<tr>
<td><strong>7. Do NGOs need to play a role in solving traffic problems?</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>100</td>
</tr>
<tr>
<td><strong>8. If NGOs need to play a role in solving traffic problems, what should NGOs do? (can provide more than one answer)</strong></td>
<td></td>
</tr>
<tr>
<td>1. Disseminate knowledge on traffic problems and solutions to the public</td>
<td>53</td>
</tr>
<tr>
<td>2. Cooperate with and support the government in solving traffic problems</td>
<td>40</td>
</tr>
<tr>
<td>3. Participate in planning processes, conduct research and studies on this issue</td>
<td>40</td>
</tr>
<tr>
<td>4. Create a pressure group to follow up the government's projects</td>
<td>33</td>
</tr>
<tr>
<td>5. Support and publicise good projects that help solve traffic problems</td>
<td>13</td>
</tr>
<tr>
<td>6. Encourage the public to exercise their rights in getting information about traffic solution measures.</td>
<td>13</td>
</tr>
</tbody>
</table>
(2) All NGOs agree that traffic congestion, air pollution and noise from vehicles have very severe impacts on Bangkok's residents and the wider environment.

(3) The major causes of traffic congestion in Bangkok are given as: motor vehicle numbers which have been increasing at a rate that exceeds road capacities; bad driving behaviour; inadequate and inefficient public transport services; lack of efficient urban and transport plans; and lack of their implementation, due to too many responsible agencies, and finally the general overcrowding of Bangkok.

The results here are substantially consistent with the research conducted in this thesis as to the underlying causes of traffic congestion in Bangkok. However, it is interesting that bad driving behaviour is listed so highly, even above the inadequate public transport system, as a major cause of congestion in Bangkok. Notwithstanding, the focus group interview conducted by Poungsomlee in 1992 found that Bangkok residents, particularly those who own a car, considered bad driving behaviour of drivers of other forms of transport, e.g. minibuses, public buses, motor cycles and taxis, as one of major causes of traffic congestion (Poungsomlee and Ross, 1992: 43).

(4) The requirements for solving Bangkok's severe traffic congestion are, in the first instance, a better public transport system (particularly mass rapid transit) which drew a 93 per cent response rate. Other measures suggested include: controlling the number of motor vehicles; improving traffic laws and strengthening their enforcement; improving coordination among relevant parties; and establishing an effective transport and urban plan. Interestingly, the NGOs did not on the whole consider improving facilities for walking and cycling to be a significant solution. In fact, it received the same response rate as building more roads, suggesting perhaps some degree of confusion in the minds of NGOs with regards to how different policies might work in concert with one another and how some may be in conflict. No specific mention was made of water transport improvements.

Also, there are some inconsistencies between Questions 3 and 4. While increasing motor vehicles is cited as the major cause of traffic congestion (87 per cent) and inadequate public transport is cited by only 60 per cent of NGOs as the major cause, better public transport is cited by 93 per cent of
NGOs as being the major solution, while controlling the number of motor vehicle is cited by only 53 per cent of the surveyed NGOs. This tends to suggest some inconsistency by the NGOs in the way they perceive the Bangkok traffic situation.

(5) All of the NGOs in the sample agree that community participation ought to play a very important role in solving traffic problems. They recommend a major role for residents as follows: conforming to traffic laws and regulations; expressing opinions to the government; participating in decision-making and reducing motor vehicle use by means of personal initiatives, though the idea of using extra taxes to help fund mass rapid transit was not a common response. However, there was no suggestion of trying to form a highly organised lobby group to maintain steady and effective pressure on all parties to make concerted efforts to reduce traffic problems. The focus is more on individual action. According to Ross (1994: 10), this is perhaps, because the Thai NGOs' main strategies in helping solving environmental problems are patient public education, coalition building and direct negotiation with other interest groups.

(6) All NGOs agree that they should participate in solving traffic problems in Bangkok by: disseminating information on traffic problems and solutions to the public; participating in the planning process; monitoring the government’s projects through a watchdog/pressure group; supporting good solutions; and encouraging the public to protect their rights to obtain information from government on traffic solution measures.

Overall, the findings from this preliminary pilot survey are reasonably consistent with the general findings presented in this dissertation. For example, the NGOs cite traffic congestion and air pollution as the most serious problems facing Bangkok’s residents. Several of the major causes of traffic congestion identified by the NGOs respondents are similar to findings of this study, as demonstrated in Chapter 5. The solutions suggested by the NGOs are practical and theoretically capable of implementation and are generally, though not perfectly, in line with the findings of this thesis so far with respect to the kinds of areas that need to be addressed to reduce Bangkok’s traffic problem. Interestingly, the building of more roads to keep pace with road traffic is not seen as a popular solution among this group, whereas this approach is still the dominant paradigm in policy-making.
circles. Solutions to Bangkok's traffic crisis are discussed further in the next chapter. Finally, the NGO respondents reveal their willingness to play an important role in a variety of ways to address Bangkok's traffic problems.

This pilot survey has revealed potentially fertile ground in the form of NGO participation in helping to solve traffic problems. However, a much more detailed study than this simple pilot survey would need to be conducted in order to explore exactly how this could occur and the kind of results it might yield in terms of effective change.

6.4 CONCLUSIONS

This chapter suggests that any new policies to cope with Bangkok's traffic nightmare need to recognise and address certain key constraints: (1) the dominance of the conventional transport planning process (UTP) which has been a key force in generating transport policies and strategies which are not necessarily suitable or relevant to Bangkok; and (2) institutional fragmentation among transport policy, decision making and implementation organisations which has hindered several sound transport projects and generally stands in the way of effective action on transport in Bangkok.

Up until present, conventional transport planning, initiated in the USA in the 1950s within a particular social and economic framework peculiar to that time and place, has been adopted for most transport and urban studies in Bangkok with at best only marginal modifications to specific local conditions. This is despite its many acknowledged deficiencies, even within the cities in which it originated. Not only has this approach not solved the traffic congestion problem, which is the main aim of UTP, it has helped to generate several serious consequences, including the declining use of non-motorised modes and public transport, and massive private transport investments conducive to a "vicious circle" of dependence on private vehicles. To escape this vicious circle, Bangkok desperately needs a paradigm change - a major breakthrough in effective transport planning.

It might be concluded from this that a more effective approach to transport planning in Bangkok would be a vision-oriented one, rather than an open-ended one of attempting to predict the extra road supply needed to meet a virtually endless demand for private travel. Such an approach could attempt
to model the results of the changes in the direction proposed in the next chapter, using the extensive data in this thesis as a way of testing the results of different modal splits etc. on congestion levels and environmental factors (see section 8.2.7).

The institutional fragmentation in transport is a vital factor in hindering the formulation and implementation of transport policies and plans in Bangkok. There are too many agencies responsible for transport leading to great overlapping of jurisdictions and conflicts among these agencies in formulating plans, measures and projects and in implementing them. Several transport projects, particularly mass rapid transit projects experience long delays and are put at risk. Hence, any attempt to introduce new transport policies to tackle Bangkok's serious traffic crisis requires that this issue to be addressed, otherwise such policies will never be implemented.

Despite these major constraints, there are signs of hope - forces which could help to direct Bangkok towards a more liveable city. The international ecologically sustainable development movement, along with its local application, provides both guidance and pressure for developing more sustainable urban settlements. A sustainable transport concept can also provide a way of shifting Bangkok away from its present path towards a more automobile-dependent city, towards one with a more appropriate transport system. Such a system would have fewer negative impacts on the environment, health, and would require less energy consumption. The movement towards sustainability at both a global and local level has already had some influence on development in Thailand and Bangkok, as seen from the assimilation of these concepts into the national development plan. Not only have the international movements put pressure on Bangkok to become more sustainable, many people from all classes of Thai society have began to demonstrated a desire for participation in addressing these problems. NGOs, which have an increasingly important role to play in the development of Thailand and Bangkok, have demonstrated a degree of commitment to help solve Bangkok's transport problems. This is a very hopeful signal of support for any attempts to introduce a more sustainable transport system in Bangkok, though much work and effective action remains to be achieved. This matter will be addressed in greater detail in the next chapter.
CHAPTER 7

TOWARDS A SUSTAINABLE TRANSPORT SYSTEM FOR BANGKOK

7.1 INTRODUCTION

Based on the findings from this study of the roots of Bangkok's traffic congestion, and taking account of the factors discussed in the foregoing analysis, such as the historical development of Bangkok's land-use and transport and the existing land-use and transport patterns, this chapter suggests a set of plausible policies to tackle the crisis. These policies embrace social, economic and environmental considerations, as well as constraints and opportunities in formulating and implementing such policies within the Bangkok context, as discussed in Chapter 6. Desirable and undesirable models from other cities are also employed as a lesson. This chapter begins by introducing guidelines for making a shift towards a sustainable transport model.

7.2 A SHIFT TOWARDS A SUSTAINABLE TRANSPORT MODEL

This section attempts to present indicators and set some goals for progress towards a sustainable transport system, which is necessary for the formulation of plausible policies for Bangkok.

7.2.1 Sustainable Transport Criteria

As discussed in Chapter 6, the sustainability concept has become acceptable and applied to most fields of development worldwide (with differing degrees of success). The sustainability concept is based on concern about past and current development that has imposed serious impacts on nature and human well-being. This new paradigm of development therefore has emerged as a new hope to help relieve such problems as well as to direct development in a way that benefits both human society and the environment in the long-term. Cities around the world are facing a number of critical environmental, social and economic problems. Transport is one of the major sectors in a city which contributes enormously to such situations, particularly
environmental problems such as air and noise pollution, water pollution, health impacts and so on. Thus, the sustainability concept has been increasingly called for in cities and especially in transport systems in order to reduce the adverse impacts and yield benefits to city residents and the urban environment. This new transport paradigm is referred to here and elsewhere as a "sustainable transport model".

A sustainable transport model must go far beyond the conventional short-term objective of merely relieving traffic congestion and providing road supply to meet potentially insatiable demand. It should not only efficiently serve the basic needs of residents for movement and exchange of goods and services, but also embrace social and environmental considerations. Furthermore, it should encompass the full variety of transport modes, particularly non-motorised modes which are so often neglected by conventional transport policy and planning. For example, Replogle (1992) called for the incorporation of the sustainability concept into a new transport paradigm and stated that:

The current paradigm for transportation planning seeks to maximize circulatory capacity, travel speed, and mobility. The emerging sustainable transportation paradigm seeks to maximize efficiency in overall resource utilization. This is achieved by increasing modal diversity, paying more attention to the pattern of transportation and land use, and encouraging use of efficient transportation modes whenever practical, often by encouraging better connectivity between modes.

Ecological systems are healthiest when they display great species diversity and many niches for specialization of function and resource utilization. So too are transportation systems healthiest when they display great modal diversity, offering opportunity for selection of the most efficient mode or combination of modes to meet different functional and qualitative demands for movements of people and goods. (p. 6)

Likewise, Birk and Zegras (1993) suggested:

A complex web of inter-related human needs and activities makes up an urban area. To ensure the efficient exchange of goods and services, the fulfilment of residents' needs, and sustained long-term economic growth, urban areas require an efficient transportation system. To endure over
time, such a system must therefore be sustainable—meeting the basic transportation needs of all citizens without excessively depleting the economic and natural resource base. (p. 1)

Pendakur (1992a) addresses the fact that the primary goal of much current urban transport policy has been, and continues to be, "moving vehicles". If cities are to be sustainable, there has to be a new policy regime which has a:

...focus on including all costs and benefits (economic, social, and environmental) of transport mode choice and this regime must be structured to be flexible and dynamic over time. Efforts should be directed towards building efficiency, equity and sustainability. (p. 24)

The World Bank recently acknowledged the significance of incorporating sustainability into transport policies (Figure 7.1). It stressed that an effective transport policy must satisfy three main requirements: (1) economic and financial sustainability, i.e. it must ensure that a continuing capability exists to support an improved material standard of living; (2) environmental and ecological sustainability, i.e. it must generate the greatest possible improvement in the general quality of life, not merely an increase in traded goods; and (3) social and distributional sustainability, i.e. the benefits that transport produces must be shared equitably by all sections of the community (World Bank, 1996: 28).

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![Figure 7.1 Three dimensions of sustainable development: synergies and tradeoffs](image)

Source: World Bank, 1996: Figure 1.5

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Moving towards a sustainable transport system requires indicators to judge whether the transport policies, measures and projects proposed are sensible in terms of directing cities towards a more liveable human environment. For example, Birk and Zegras (1993: 11) recommended two crucial factors for a better transport system: (1) the goal of the transport option is to enhance equal accessibility for all citizens; and (2) a need to integrate all potential transport options into a comprehensive plan. These options need to be compared and assessed thoroughly to see which options would produce the most effective outcomes. Costs other than monetary expenditure such as environmental costs, security costs of increasing dependence on imported oil, and congestion costs, need to be incorporated.

Conventional transport project evaluation focuses mainly on the economic rate of return and is likely to ignore the cost of externalities such as air pollution, energy consumption, accidents, etc. Most transport projects conducted in Bangkok have been assessed only in terms of economic benefit (see for example, DOH, 1990; ETA, 1977; ETA, 1985). Moreover, they tend to exaggerate the benefits and underestimate the associated costs. This approach makes such projects appear very favourable to planners, decision-makers and the public. Yet, after a certain time, these projects have not lived up to the initial feasibility studies. Therefore, there should be new criteria to assess proposed transport policies and projects. Such criteria must cover not only the short-term and direct economic return, but also the wider costs and benefits both in the short-term and long-term.

It is clear that policy making on transport in Bangkok has been very inadequate, both in terms of how it has analysed the problem and the kind of responses that have been made. In particular, there seems to have been no effort to come to terms with the many social, economic and environmental criteria which are important in deciding an overall direction for the future of transport in Bangkok.

New criteria to assess proposed policies and measures should therefore encompass at least five major elements: (1) economic factors; (2) environmental factors; (3) energy use; (4) human/social factors; and (5) land-use integration potential, as outlined in Figure 7.2.
Figure 7.2 Sustainable transport criteria

Note: These sustainable transport criteria were developed based on the sustainable transport concept discussed above and also from several other sources such as Pendakur, 1992a; Kenworthy, 1979; Birk and Zegras, 1993.

The elements of each major factor are as follows:

7.2.1.1 Economic Factors

Economic factors in transport projects embrace the following major items:

(1) Capital costs
(2) Operating and maintenance costs
(3) Time savings
(4) Accident costs, especially transport deaths

The monetary costs of these items constitute the major economic dimensions of any transport project (Laube and Lynch, 1994; Laube, 1997). However, to obtain a complete picture of proposed transport projects, all relevant costs and benefits need to be examined carefully (Pendakur, 1992a: 26). For example, rather than focussing chiefly on capital costs, the operating and maintenance costs for roads and expressways should also be included, as is done for rail or public transport projects. The "durability" of time savings should also be assessed, since new roads are renowned for attracting extra traffic which eliminates time savings very rapidly and congestion occurs again but at a higher volume of traffic. Accident costs can be very significant, particularly in road-based projects and need to be carefully costed. There are
unfortunately a wide range of options in terms of the value attributable to a death. Issues concerning how to value transport deaths are discussed in detail in Laube (1997). The method used will greatly affect the costs attached to this item.

7.2.1.2 Environmental Factors

The major environmental factors that must be considered in transport projects are:

(1) Impacts on land resources
(2) Ability to integrate with existing urban structure without negative impact
(3) Air pollution (including greenhouse impact)
(4) Noise level
(5) Visual intrusion
(6) Severance of neighbourhoods

The potential environmental impact of proposed transport policies and projects should be taken into account. It is advisable that they be quantified and added into the total costs of transport projects. Likewise, the benefit of a project which can reduce such environmental impacts should be calculated and added to the total benefit (Pendakur, 1992a: 26). There are of course a whole host of methodological issues which have to be confronted in attempting to provide a "full transport costing" approach to transport projects. These issues relate to how externalities are valued in monetary terms and various other theoretical dimensions, which are not the primary focus of this thesis. Discussion of these issues can be found in sources such as Quinnet (1990), Whitelegg (1993) and Maddison et al. (1996).

7.2.1.3 Energy Use

The key factors related to energy use in transport projects are:

(1) Energy consumption per vehicle kilometre
(2) Energy consumption per passenger kilometre
(3) Type of fuel (e.g. fossil fuel versus electricity from potentially renewable sources)
(4) Resource security (imported fuel or fuel available locally)
(5) Emissions characteristics of fuel (impacts on health, etc.)
(6) Distribution of emissions (e.g. centralised at power station and relatively easy to control, versus dispersed emissions which are more difficult to control)

The efficiency of energy use should be calculated and compared between options. This figure should be carefully estimated by foreshadowing the future trips that the project will generate. The basic aim should be to demonstrate the total energy requirement of the transport project or facility, versus the size of the passenger demand it will satisfy, while taking into account the other factors of resource security and emissions which influence the overall outcome of transport policies and decisions.

7.2.1.4 Human/Social Factors

The key human and social factors in transport projects are:

(1) Traffic safety impacts
(2) Accessibility changes
(3) Equity impacts among users
(4) Resident and job relocation impacts and costs
(5) Impacts on non-motorised modes of transport
(6) Effects on urban community (e.g. does a project encourage social interaction or generate increasing isolation?)
(7) Urban heritage impacts

These are very important factors which are often neglected by conventional transport planning. In terms of sustainability, a transport system should be a means to improve accessibility for residents of all ages, genders, and social groups, including disadvantaged ones. In addition, it should help enhance the liveability of communities, e.g. by encouraging interaction and reducing the likelihood of traffic accidents. Although these factors are difficult to quantify in an economic sense, qualitative or normative judgements can often be effectively adopted for evaluating projects (Birk and Zegras, 1993: 117).
7.2.1.5 Land-Use Integration Potential

It is important in any transport project to consider the key factor that will generate demand, i.e. the land-use patterns. Transport projects which integrate well with existing and future land-use will tend to produce a better overall outcome by minimising the magnitude of travel demand, especially by motorised modes. The key factors involved in this sustainable transport criterion are:

1. Ability to service and strengthen pre-existing development (e.g. will it foster dispersal or concentration of population and jobs?);
2. Potential for private capital contributions to reduce government costs and to help ensure development is better linked to the transport infrastructure (i.e. whether the project is amenable to joint development/value capture opportunities);
3. Ability to foster intensification and mixing of residential and commercial land-use in ribbons that are easily serviced by public transport and accessible by non-motorised modes;
4. Ability to foster intensification and mixing of residential and commercial land-use in nodes which provide focal points for an effective public transport system;
5. Potential to enhance the viability and attractiveness of walking and cycling (i.e. whether the project promotes dense, mixed land-use suitable to non-motorised modes or dispersed, zoned land-use which tends to require high levels of car use).

As demonstrated and emphasised in this study, land-use has a very close relationship with transport patterns. For example, dispersal of population and jobs encourages long distance trips and a shift to more private vehicle use, whereas dense, mixed land-use fosters non-motorised modes and public transport use. It is therefore necessary to assess the potential of proposed transport policies or projects to contribute to the land-use patterns that reduce private vehicle use and encourage non-motorised travel and public transport use.
7.2.2 Goals for Moving Towards More Sustainable Transport Systems for Cities

In addition to the proposed general sustainable transport criteria, it is advisable to have specific goals or indicators for cities to assess their progress towards a more sustainable transport system, so that local planners and relevant agencies have clear guidelines, as recommended by Agenda 21. These goals are necessary to encompass the three main modes of urban transport: private transport, public transport and non-motorised transport, as well as the critical land-use dimension. For example, Roseland (1992) stressed the importance of transport planning and traffic management to help direct cities to sustainability, and suggested the objectives of such planning and management:

*Transportation planning and traffic management initiatives are critical to sustainable urban development. These initiatives usually have objectives such as reducing the number of automobile trips; increasing opportunities for non-auto transportation including bicycles, walking, rail, buses, and alternative vehicles; and reducing the use of gasoline and diesel fuel in conventional buses, cars and trucks.* (p. 114)

He went on to address the significance and the objective of land-use planning:

*Land use planning and housing initiatives are therefore critical to sustainable urban development. They are usually motivated by the recognition that transportation planning and traffic management initiatives will eventually be thwarted or simply overwhelmed by growth unless accompanied by long-term efforts to reduce the need for travel.* (p. 50)

Ideally, private transport use should decrease or at least remain stable, while factors affecting higher private vehicle use, such as the provision of parking or the costs of private vehicle use, should be manipulated in such a way as to decrease private vehicle use. On the contrary, the use of public transport and non-motorised transport which are more effective, efficient and generally have less negative impact on society and environment, should increase. All factors affecting the use of these modes, particularly infrastructure, should be
managed in such a way as to support these modes. Land-use, can be encouraged to develop in ways which reduce trip distances, integrate with public transport and the non-motorised system, and reduce the loss of agricultural land and natural environment.

A set of goals presented below, which is derived initially from Newman, (1995) and modified in Kenworthy et al. (1995: 65) and Barter and Kenworthy (1995: 15), put forward some suggested annual objectives for a move towards better cities through a better transport and land-use system. The urgency of particular objectives in any one city will tend to vary depending on specific local circumstances. The list of objectives is potentially very large and these do not claim to be exhaustive. However, this set of goals appears to be especially pertinent to Bangkok in its present transport and land-use situation, as quantified and discussed throughout this thesis.

7.2.2.1 Private Transport Objectives Each Year

Sustainability demands that the role of private passenger transport in any city be strictly managed, and in most instances, either remain stable in its present level of use or be decreased. The following objectives appear to be particularly relevant indicators of whether a city is heading in a sustainable direction in terms of private transport.

(1) Car and motorcycle use per capita, stable or decreasing;
(2) Modal share of private vehicles for work, school and all trips, stable or decreasing;
(3) Parking spaces relative to number of jobs in the CBD and sub-centres, decreased;
(4) Proportion of transport capital spent on infrastructure for cars, especially roads, decreased;
(5) Real costs of owning and using private vehicles, increased;
(6) Physical restrictions on private vehicles in worst congested parts of the city, increased;
(7) Enforcement of parking and traffic law violations, increased;
(8) Fuel efficiency of private passenger vehicles, increased;
(9) Emission rates per kilometre of private passenger vehicles, decreased;
(10) Number of accidents and deaths per million passenger kilometres of private transport, decreased.
7.2.2.2 Public Transport Objectives Each Year

Sustainability generally demands that public transport’s role in any city be optimised. The following indicators capture some key directions that appear to be necessary:

(1) Modal share of transit for work and other trips, maintained or increased;
(2) Average speed of public transport relative to cars, increased;
(3) Proportion of transit passenger kilometres which are totally segregated from traffic (e.g. on rail, boat), increased;
(4) Service kilometres of transit per kilometre of road, increased;
(5) Proportion of the transit system which is integrated between other transit modes and non-motorised modes, increased;
(6) Number of good quality public transport vehicles per number of residents, increased;
(7) Ease and speed of interchange between public transport vehicles, increased;
(8) Diversity in transit system, including paratransit, increased;
(9) Proportion of transport capital spent on infrastructure for transit, particularly segregated systems, increased;
(10) Amount of road system and number of intersections having transit priority, increased;
(11) Recovery of transit operating costs from the farebox, increased.

7.2.2.3 Non-Motorised Mode Objectives

Non-motorised modes are the most efficient and least resource intensive of all transport modes and are generally placed high on any urban sustainability agenda. Some key objectives for enhanced use of non-motorised modes would generally include:

(1) Quantity and quality of footpaths and pedestrian crossings, increased;
(2) Modal share of non-motorised modes for work and all trips, increased;
(3) Fatalities and injuries per year of pedestrians and NMV users, decreased;
(4) Length of segregated routes for NMVs, increased;
(5) Length of roads and streets being shaded through tree-planting or rooves, increased;
(6) Number of activity centres (offices, shopping centres, transit stations etc.) with bicycle facilities, increased;
(7) Pedestrian and NMV only area in CBD and sub-centres, increased;
(8) Interchange points of NMVs with public transport systems, increased.

7.2.2.4 Land-Use Objectives Each Year

It is critical to any move towards sustainable transport that land-use patterns be supportive. The following objectives are relevant in most circumstances:

(1) Loss of agricultural and natural environment at the urban fringe, reduced;
(2) Number of specially zoned, transit-oriented locations, or within a walking/cycling distance to offices and other facilities, increased;
(3) Number of new developments located where there are no public transport services, decreased;
(4) Average distance to work and other destinations, decreased;
(5) Density of employment and population in transit-oriented locations, maintained or increased;
(6) Proportion of population living in single use, car-based areas, decreased.

According to the sustainable transport concept presented above, proposed expressways and new road projects are unlikely to perform satisfactorily on a majority of criteria. Rather, they are likely to direct Bangkok to an undesirable path. Expressways and roads are superficially considered as the necessary tools to solve the traffic problem because they can obviously provide more space for motor vehicles. Hence, a reduction in congestion and an increase in vehicle speed are generally to be expected. This may be true to a small extent in the short-term, although pent up demand and traffic saturation on most routes are so high in Bangkok that even this must be questioned. Lessons from cities around the world certainly show that in the long-run, large new roads attract more cars and encourage more trips and trigger dispersed land-use patterns (Goodwin et al., 1991; Goodwin, 1994; Newman and Kenworthy, 1988b). Moreover, their indirect costs, such as energy consumption, air and noise pollution, accidents and discrimination against non-motorists, can be enormous. The next section suggests sustainable solutions for Bangkok's traffic disaster which go beyond traditional transport policy and planning which has tended to emphasise this supply-side approach based on new roads.
7.3 SUSTAINABLE TRANSPORT POLICIES FOR BANGKOK

The main lessons of this study, highlighted in Chapter 5, suggested that the root of the traffic crisis in Bangkok is a mismatch among the city structure, transport patterns, and transport infrastructure. While its city structure mitigates against heavy private vehicle use, Bangkok has nevertheless experienced rapid growth in its motor vehicle population. Public transport, waterways transport and non-motorised transport have been noticeably declining during the motorisation period. For such a dense city, these modes represent a small proportion of total transport use. Moreover, transport infrastructure continues to encourage private vehicle use, contributing to a continuation of inadequate public transport infrastructure, particularly railways. These problems are, in the main, the consequence of what has been shown to be policy and planning biased towards private transport.

Based on these findings, this dissertation proposes a set of land-use and transport policies to help deal with Bangkok's severe traffic problems. In line with global trends towards sustainability as an organising principle for urban policy development, these policies are offered within a framework of developing a more sustainable transport system in Bangkok embracing economic, environmental and social dimensions. Critical to the success of these policy initiatives is that they take the constraints and opportunities discussed in Chapter 6 into consideration. The following policies would appear to offer hope for all Bangkokians, not only those who own private vehicles, but also the rest of the community who have fewer options. These proposals attempt to help return Bangkok to a city for people, not a city simply for cars.

7.3.1 Giving Priority to Public Transport

The low level of use of public transport, particularly rail, appears to be one of the most important factors contributing to traffic problems in Bangkok. A dense city like Bangkok needs an efficient means of transport which can carry large numbers of people and not make heavy demands on space. In addition, public transport, particularly rail, is much more environmentally-friendly than reliance on private vehicles, as it emits much less pollution per passenger kilometre. Furthermore, to attract motorists to use public
transport, it is necessary to provide a convenient and reliable alternative. Tackling Bangkok's congestion problem must seriously address this issue.

Many international examples offer hope for reprioritising public transport. In some automobile-based cities such as Portland and Los Angeles in the USA, and in Asian cities such as Metro Manila and Kuala Lumpur, public transport, particularly urban rail, has been introduced to provide an alternative to cars. In Portland, Oregon, one freeway was demolished and a public park built in its place. Another planned freeway in Portland (the Mt. Hood freeway) was scrapped and funds used to build a light rail line. Extensions to this initial system are underway. In Los Angeles, the first new urban railway system was finally opened in 1990, after having removed a comprehensive electric rail system decades earlier and built a massive freeway system in its place (Poboon, 1994: 4). In Manila, the first elevated rail system has operated since 1984, with a plan for four more urban rail lines. In Kuala Lumpur, the first electric suburban rail opened since 1995. The first urban mass rapid transit system in that city opened in 1996, and another line is under construction. There are plans for several more routes (see Chapter 4). In addition, Curitiba in Brazil (a city now well known for its friendly and innovative urban policies) has for many years successfully integrated land-use with a revitalised bus system. The Curitiba experience demonstrates how commitment to efficient public transport system can contribute not only to efficient travel, but also to people's lives, including those with less opportunities such as people with disabilities and older citizens (Rabinovitch, 1992, 1993). Both Singapore and Hong Kong have built extensive rail rapid transit systems in the 1980s and 1990s and integrated development around them (Kenworthy et al., 1994).

These examples are of course only a small sample of the innumerable cities in Europe, Asia, Canada and the United States which have, or are beginning to, focus increasingly on better public transport, especially the introduction or extension of rail systems (e.g. see Barry, 1991; ECMT, 1994; Transportation Research Board, 1989).

As already discussed, from an international perspective Bangkok's density is very high. Normally, mass rapid transit works best in denser urban forms. In Tokyo and Singapore, for example, which have significantly lower density than Bangkok (Tokyo has 71 persons per ha, Singapore has 87 persons per
ha, compared to 149 persons per ha in Bangkok), mass rapid transit systems based primarily on heavy rail systems have proved to work effectively. These cities have, in effect, avoided the traffic disaster of Bangkok at least partly through extensive use of railway systems. In 1990, about 96 per cent of all public transport passenger kilometres in Tokyo were by rail, the figure was about 31 per cent in Singapore and 43 per cent in Hong Kong, though rail systems in these two cities are very young and less developed compared to those in Tokyo.

Unlike road-based public transport, mass rapid transit avoids the problems of passengers being caught up in traffic. It is usually of a high standard in terms of interior comfort and safety. As a result, mass rapid transit has potential to attract people from cars. It can also be attractive to the growing middle class. The possibility of an enthusiastic response in Bangkok to the introduction of better rail systems is evident from the results of a recent survey conducted in Bangkok by the TDRI (1993). The study revealed that a significant number of current commuter railway passengers use the limited Bangkok service despite its inadequacy and low accessibility. According to the commuter train passenger survey, about 44 per cent of railway passengers live within five km of a railway station. Interestingly, the rest of the passengers (56 per cent) live further than five km from the railway stations, with some (7 per cent) living more than 20 km from a station (Table 7.1). These committed rail passengers took the train even though most of them (96 per cent) had access to other means of transport. They stated their main reasons for train travel as follows: reaching the destination faster; more comfortable travel; greater safety; and cheap fares (Table 7.2).
Table 7.1 Average travelling distance from origin to railway station, Bangkok, 1993

<table>
<thead>
<tr>
<th>Distance (km.)</th>
<th>% of Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>43.7</td>
</tr>
<tr>
<td>6-10</td>
<td>23.9</td>
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<tr>
<td>11-15</td>
<td>11.3</td>
</tr>
<tr>
<td>16-20</td>
<td>14.1</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: TDRI, 1993: 99

Note: n=374

Table 7.2 Reasons passengers take trains in Bangkok, 1993

<table>
<thead>
<tr>
<th>Reasons</th>
<th>% of Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach destination faster</td>
<td>63.6</td>
</tr>
<tr>
<td>More comfortable</td>
<td>47.1</td>
</tr>
<tr>
<td>More safety</td>
<td>36.9</td>
</tr>
<tr>
<td>Cheaper fare</td>
<td>26.7</td>
</tr>
<tr>
<td>Available trains at wanted time</td>
<td>25.1</td>
</tr>
<tr>
<td>Better service</td>
<td>6.4</td>
</tr>
<tr>
<td>Cannot use other means of transport</td>
<td>5.3</td>
</tr>
<tr>
<td>Others</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Source: TDRI, 1993: 100

Notes: 1. Multiple selections
       2. n=374

While these statistics are certainly encouraging, a new urban railway system will take years to complete and its service may not cover the whole built-up area of the city. Thus, priority also needs to be given to buses. If buses are operated on the same congested roads as other vehicles, they will never be able to attract people who can afford cars. One suggestion for improvement could be properly policed bus-only lanes in both contra and normal flow directions. Traffic signals, designed to provide priority to buses, could also help to create an attractive public transport system by improving speed and reliability. With the advent of a rail system in Bangkok, priority will need to be given to ensuring that the buses operate properly in a feeder role. This will maximise transit use and minimise use of cars to access the rail system. Improvement in the quality of bus vehicles will also assist (e.g. having all buses air-conditioned).
In addition, paratransit modes such as *tuk-tuks, silor-leks* and hired motor cycles, which effectively function as feeders to public transport, should receive more attention. Improvements can also be made to them in terms of safety, and reliability. This can be managed through better regulation, enforcement and training (see Pboon et al., 1994).

Although there are some signs of recognition of the importance of public transport in Bangkok in recent and existing development plans (as demonstrated in Chapter 5), progress is still far from adequate, particularly in terms of investment. Past experience has shown that, although development plans have already allocated a majority of the government budget for road construction, several governments have sought additional funds for extra road projects. This is because road construction continues to be seen as the priority of such governments. This policy would appear to be an attempt to win popularity. For example, the current government, upon coming to power in November 1996, announced their transport policy: the extension of all inter-regional highways from four lanes to six lanes and the extension of provincial highways from two lanes to four lanes nationwide (The Nation, November 21, 1996).

Clearly, Bangkok needs a paradigm shift in policy, investment and implementation of its public transport system. The government must make a firm stand and give priority to the improvement of public transport infrastructure and services in policies and plans, proposed investments and project implementation. The nature of the required paradigm shift is illustrated by Figure 7.3, which reveals the following:

1. In the context of policy and plans, the government must state clearly that public transport should receive high priority.

2. In proposed investment (consisting of the financial details associated with proposed transport projects), the government must emphasise that the majority of investment is to be allocated to the construction of public transport infrastructure, e.g. mass rapid transit, busways, etc., and improvement of public transport services.
Figure 7.3 The required paradigm shift in policy and planning for public transport in Bangkok
3. The majority of the government budget must be allocated for the construction of public transport infrastructure and the improvement of public transport services. The past policy of the government, which was largely reliant on private sector investment for construction and operation of a large public transport system, has proved its ineffectiveness due in large part to difficulties experienced by the private sector in securing financial sources and in conflicts between different private sector projects. This can be solved by reallocating a large part of the government budget from road projects to public transport and also through more coordinated government-level planning of projects which avoid the present conflicts (see discussion in Chapter 6 on institutional fragmentation in Bangkok).

4. Public transport projects, particularly segregated systems, such as mass rapid transit and busway projects, must be pursued at all cost. In addition, full support from the government should be addressed to the improvement of existing public transport services, such as buses and paratransit and also water transport (see section 7.3.3).

7.3.2 Transit-Oriented, Mixed Land-Use Development

Transit-oriented development as a key planning principle to resist automobile dependence is an issue widely canvassed in the urban research literature (e.g. see Newman, Kenworthy, and Lyons, 1990; Newman and Kenworthy, 1991, 1992; Calthorpe, 1993; Beimborn et al., 1991; Rabinowitz et al., 1991; Bernick and Cervero, 1996). Transit-oriented development would appear to be one of the most vital aspects of the city of tomorrow which aims, firstly, to reduce the need to travel, and, secondly, to foster the potential to use transit and to walk and cycle to many destinations. As argued in Chapter 4, Bangkok's inner area already has a high walking city density with intensive mixed land-uses, whereas the outer area is structured as a series of reasonably high density, mixed use transit corridors. Thus a major part of Bangkok today already has transit-oriented development but without an effective transit system. However, new development in Bangkok, which is occurring at a rapid rate, is increasingly oriented to the use of private vehicles (cars and motorcycles). The absence of an effective mass rapid transit system in outer areas to focus development is one reason why new development is tending to spread into rice paddies, a long distance away from major transport infrastructure.
As demonstrated in Chapter 2, transport technologies have a strong effect on any urban land-use development pattern. While car dependence leads to dispersed settlement and long distance trips, as evident in American and Australian cities, public transport, particularly urban rail systems, can have a noticeable effect on shaping land-use development into more dense and mixed use forms. In support of this argument, Walmsley and Perrett (1991) have identified the medium to long-term effects of urban rail systems:

There can be no doubt that, in the long term - after fifty or a hundred years - urban rail systems have a profound effect on urban development; large cities like London and Paris would not have developed in the way they have without their Metro and suburban rail systems. The effect of urban rail on the shape of the city over twenty years or so is also clearly visible in cities where Metros were introduced in the Sixties; the newer areas of Toronto, Montreal and Hamburg are evidence of this. (p. 8)

Of course, land-use effects can occur even quicker, depending on the general economic and planning environment. For example, the development effect of the Skytrain in Vancouver which opened in 1986 are very clearly visible around stations (i.e. in a period of 10 years or so. Plate 7.1 shows some of these effects in Vancouver; see also Gallin, 1996).

In turn, dispersed urban form increases the costs of construction and provision of public transport. Moreover, it makes the use of public transport less convenient compared to private vehicles, as discussed in Chapter 4 and 5. One of the obvious examples in Southeast Asian cities is the development of toll roads connecting Jakarta with the nearby towns of Tangerang, Bekasi, and Bogor. The development of these toll roads has resulted in a marked extension of housing and industrial development far from the capital city, thus greatly increasing car traffic (World Resources Institute et al., 1996: 119).

Many large cities in Europe (e.g. Munich, Zurich, Vienna, Copenhagen and Stockholm), and increasingly in North America (e.g. Portland, Oregon, Toronto, Ontario and Vancouver, British Columbia), have successfully directed high-density residential and commercial development around public transport stations (Plate 7.1). This type of development can effectively increase transit ridership and reduce energy use (see for example Newman
and Kenworthy, 1992; Newman, 1993; World Resources Institute et al., 1996: 119). In addition, efforts are being made to de-emphasise parking provision in high-density urban village style developments and to focus heavily on foot and bicycle use for local trips and transit for longer trips (Newman et al., 1992).

One of the remarkable examples of integrative rail transit and urban development is Stockholm. The city has been transformed from a pre-war, monocentric city to a planned, post-war multi-centred metropolis, instead of shifting to an automobile-dependent city, despite its economic boom and abundance of open land. New towns are linked with the city centre by an extensive electric rail network. The combination of a multi-centred settlement pattern and an effective railway network contributes enormously to efficient travel patterns and focussed land-use development. For all new towns, where houses and workplace concentrate around railway stations, over half of all workers and more than one-third of residents commute via transit each day. In addition, the share of walking, cycling and bus for internal commuting is relatively high. This type of development enables Stockholm to maintain the vitality and liveability of the city centre, as well as its many station precinct areas in the suburbs (Cervero, 1995).

Furthermore, Asian cities like Singapore, Tokyo and Hong Kong reveal evidence of the successful emphasis on integrative transit and land-use development. A high proportion of new development is linked to transit, particularly rail stations. For example, in Tokyo, after the Second World War, the city experienced strong suburbanisation. Unlike in the USA where freeways paved the way for suburbanisation, the new towns on the periphery of Tokyo are rail-oriented. Most rail lines have been privately built, linking new town developments with the Tokyo city centre. Activities in these new towns are concentrated around railway stations. Although there has been no strong control of land development in Tokyo, the integrated privately-built rail and new town developments have demonstrated the capacity to shape land-use patterns of the city. This type of development benefits equally the railway business (profiting from high levels of patronage), and the public who benefit from low-cost and efficient transport services (Bernick and Cervero, 1996: 307-329).
Plate 7.1 Transit-oriented development in some European and North American cities

All photographs except lower right are by Jeff Kenworthy. Lower-right photo is from the Toronto Transit Commission
Consequently, these Asian cities report very high proportions of people living close to railway stations and high levels of transit use. For example, in 1990, in Tokyo about 63 per cent of total passenger kilometres were on transit of which 96 per cent were on rail (see Chapter 4). In Hong Kong, 50 per cent of the population lives within 500 metres of an MTR station and 69 per cent walk to and from the system. In Singapore, 50 per cent of the population lives within 1 km of an MRT line; 65 per cent of passengers walk to and from stations. In addition, the official plan calls for a hierarchy of centres to be developed at the interchanges between five radial MRT lines and three proposed circumferential MRT and light rail lines (Kenworthy et al., 1995: 63).

In Bangkok, all present patterns of new high-density apartments and dispersed townhouse and condominium developments are predicated on high car use. Cars feature strongly in the marketing of these new developments, with large parking areas or parking structures central to the designs (see Pornchokechai et al., 1993; Townsend, 1995). In addition, little attempt is being made to integrate new developments with public transport systems, especially the planning of new rail systems, to develop transit oriented sub-centres, or to encourage walking and cycling in the local area. Both dispersed development and high-density projects, orient mostly towards private cars, and are leading to significant new pressures on Bangkok's road system.

A recent study, Strategic Planning for Metropolitan Bangkok, conducted by the Massachusetts Institute of Technology (MIT) consultant team prepared for the Bangkok Metropolitan Administration, proposed a metropolitan subcentre program comprised of eleven new towns surrounding the metropolitan area. These new towns, according to the proposal, will be located along the outer ring road (see Gakenheimer et al., 1995). Although this plan is sensible in terms of promoting subcentres for the predicted population and jobs in the fringe of the city, rather than letting the built-up area expand in a haphazard fashion, it emphasises reliance on road transport, both private vehicles and buses. As the plan proposed:

*The circumferential highway, which serves as a spine through these metropolitan subcenters, should be developed as an "intelligent highway/transit corridor", incorporating electronic traffic control methods as suggested in a later section of this report.* (p. 3)
In more detail, the MIT plan recommended:

Rather than use past technologies for the outer ring road, we envision the creation of an intelligent transportation corridor. It should incorporate the most advanced intelligent vehicle highway system (IVHS) technologies and provide exclusive lanes for high capacity express bus service in a way that is integrated with the highway from the outset. Access locations for the highway should be coordinated with arterial roadways serving adjacent development. We believe that a right-of-way of at least 50 m should be acquired on open sections of the outer ring road between centers, with at least 60 m in the area of the proposed subcenters. Additional land area will, of course, be required at interchange locations. (p. 12)

Although this plan is suggesting the incorporation of exclusive lanes for a high capacity express bus service, it is likely to also encourage increased use of private vehicles through provision of an extensive road network, in spite of the high technology approach which the consultants recommend. While travelling between sub-centres on the new roads with exclusive lanes, buses could be attractive, but these buses will still have to negotiate the congested road network in other parts of Bangkok which will reduce their attractiveness and use. As discussed previously, this prototype is, overall, likely to aggravate, rather than alleviate, Bangkok's already severe traffic congestion.

Overall, to direct Bangkok's land-use towards a more sustainable path, the government should therefore pay attention to the following two key recommendations:

1. give priority and provide incentives to development projects which attempt to integrate with public transport and contribute to the improvement of the quality of public transport. Proposals designed to facilitate high levels of walking or cycling for local needs should also be encouraged and rewarded.

2. initiate plans to establish sub-centres comprised of high density, mixed activities linked by public transport services. The proposed metropolitan subcentres development plan should be reconsidered. It should seriously
take the integrative transit/land-use approach into consideration. Instead of building new towns based primarily on an intensive road network for private vehicle use, these new towns should be redesigned so that they can be well-served by an effective rail system. A priority bus system connecting the sub-centres circumferentially is unlikely to be able to cater for many of the travel needs of residents and workers in the area and would need to be supplemented by a more significant investment in segregated public transport to other parts of the city. Nodes or centres based on transit, walking and cycling, should have priority in development plans. Activities should be compact and mixed to permit short walking and cycling distances, and public spaces should be car free or "traffic calmed" to ensure an attractive environment.

In sum, integrated transit/land-use development has great potential to encourage transit use, walking and cycling, while reducing private vehicle use. This approach will help to move Bangkok toward a more sustainable city. Much of Bangkok already has transit-supportive land-use and urban form, but lacks the effective transit option. However, in new development the danger is that if centres are initially established on the basis of elaborate road networks, high parking and high car use, they are hard to turn around even with the advent of a good transit system. In Bangkok, with its large population and high density, it would certainly be better to implement some form of rail-based system as an anchor for new transit-oriented development at the outset and to properly support the transit-oriented development that already exists.

7.3.3 Improvement of Waterway Transport

Bangkok's comprehensive network of river and canals is unique compared to other cities around the world. Even though some have been filled in and replaced by roads, many canals still have the potential to be developed into an attractive transport alternative for Bangkokers, particularly those who live along the river and canals. According to the BMA information on canals in Bangkok, there are approximately 640 km of canals with a width of around 8 metres or more. These canals have the potential to fulfil transport functions, as demonstrated in Chapter 4. The existing boat services along the river and along a few canals have proved they can provide faster, speedier services than road-based transport without the choking air pollution of the
streets. The boat service initiated by the BMA on the east bank six years ago has now expanded from two canals to serve four canals. The number of passengers also substantially increased from only a few thousand in 1990 to around 70,000 daily in 1995. However, as discussed in Chapter 5, although waterway transport in Bangkok has its advantages over road transport in terms of speed and reduced pollution, it encounters several problems and constraints due to inadequate attention and support from the government. The main problems are: (1) the limitation of the network; (2) deficiencies of the services, particularly during peak periods; (3) safety problems for passengers due to overcrowded boats (express boats and ferries across the river) and reckless drivers (particularly those with long-tail boats); and (4) safety problems caused by the low quality of piers.

Although water transport does not currently play an important role in transport in Bangkok because of the problems and constraints noted above, there is a very high potential for this mode to be developed as another significant alternative for Bangkok commuters. For example, the overall average speed of the fixed-route boats along canals is up to 25 km per hour, compared to the overall average speed of a bus (only about 9 km per hour and only 5-6 km per hour during rush hour). As a consequence, the canal service has become very attractive to Bangkok commuters who live close to the network.

Boat services have become more popular, not only in Bangkok, but also in other cities such as New York, even though it does not have such a comprehensive network of waterways as Bangkok. Currently, about 250,000 commuters use ferry services from New Jersey to Manhattan to travel to work daily. These services provide a much better alternative to the congested road crossing between the two states. Operated by a private company, these services have grown very rapidly successful, receiving good support from the government. Some new routes are to be opened to respond to increasing demand. The benefit of the ferry services is noted by the New Jersey director for the Regional Plan Association: "It may be a real answer to our horrendous congestion problems.... It's another example of taking what was historically successful at the turn of the century, bringing it back into this century and showing that it can still be successful" (Thompson, 1995: 3).
In order to improve and expand the waterway transport service in Bangkok, the government must consider waterway transport as an important transport function and incorporate it into all urban and transport plans. More support is needed for the improvement of waterway transport in regard to the following issues:

1. Improvement of existing express boat, ferry and canal boat services. This can be done by:

1.1 improving the safety of piers, e.g. setting a standard for piers, employing better technology and materials to build them, improving lighting of walkways, and requiring responsible agencies, e.g. the Harbour Department, to monitor pier safety on a regular basis;

1.2 constructing more terminals, both on government land, where suitable, and on private land, if available, to provide more accessible services for boat users;

1.3 integrating design for accessible and convenient linkages between boat services and other modes of public transport and non-motorised modes, e.g. by locating bus stops close to piers, constructing more piers close to proposed mass rapid transit stations, providing convenient walkways, and providing parking facilities for bicycles at piers;

1.4 providing shelters and service information for passengers at piers;

1.5 strictly controlling the number of passengers on board to prevent accidents. Where possible, boats of better quality with greater capacity should be introduced; and

1.6 in case of financial loss for the private operators, the government may deregulate the fare system so they can adjust fares to cover costs, and make a reasonable profit. Hence, private operators can improve the services.

2. Steps should be taken to open more waterway transport routes along canals where possible. As the initial boat projects along canals have proved their success, the BMA and relevant agencies should expand the services by conducting further studies to identify appropriate canals. The government
should invest in the projects or support the private sector to operate boat services.

3. One of the major obstacles to operating boat services along canals, particularly on the east bank of Bangkok, are the existing canals which have been used for the main purpose of draining, where water gates and blockades have been constructed for this purpose. The drainage policy should be revised to address the issue of improving these canals as transport channels, and not merely for flood prevention purposes (see Bongsadadt and Leelahacheeva, 1984). This can be done by:

3.1 technically improving water gate and blockade systems to serve both transport and flood prevention purposes;

3.2 employing a new management system to encompass the transport function of these canals; and

3.3 improve the canals and the whole waterway network by:

- dredging canals which have become shallow so they can be used by boats all year-round; and

- digging additional canals. As a number of canals have been filled in or have become shallow (causing missing links in the waterway network), there are limitations to how far they can be extended. It is necessary to dredge these existing canals and dig additional canals to act as links or feeders for the main canals to complete the waterway network. This approach is similar to the government's approach to the road network. A more efficient waterway network would increase access to boat transport and make it more convenient so it can function as a viable alternative to land transport.

7.3.4 Transport Demand Management

As stressed in Chapter 5, another root cause of Bangkok's traffic, apart from inadequate use of public transport, is the relatively high use of private vehicles for a city of its type. With Bangkok's limited road network and the enormous increase in the number of private vehicles, two basic responses can be made. The first (a supply-side approach) is to increase road supply by continuing to build more roads. The second (a demand-side approach) is
to manage the transport system more effectively by controlling the use of private vehicles. The first alternative is a very common reaction among most Bangkokians, but, as explained earlier, this approach will not lead to a more sustainable urban system. The second alternative is, therefore, unavoidable for Bangkok. Moreover, it is a potentially effective measure which complements the provision of public transport. TEI et al. (1994) concluded in their study of air pollution in Bangkok that no amount of technological change alone to vehicles would be able to actually reduce air pollution in Bangkok. They conclude that technological change, in conjunction with improved public transport and a coordinated transport management strategy would be the only way to reduce air pollution levels.

Conventional urban transport planning has failed to supply the necessary transport infrastructure to meet the city's rapidly growing demands. Hence, a new methodology has emerged to shape and reduce demand, particularly for private trips (e.g. see Goodwin et al, 1991). This approach has been widely accepted by transport planners in many countries. Two major strategies adopted for reducing private vehicle use are physical restraint and an appropriate transport pricing system, as shown in Table 7.3.

Table 7.3 Measures used for control of private vehicle use

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Method</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical restraint</td>
<td>1. Area limitation</td>
<td>1. Traffic cells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Traffic mazes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Area licences/permits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Cordon collars</td>
</tr>
<tr>
<td></td>
<td>2. Link limitation</td>
<td>1. Access metering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Signal timing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Reduced capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Public transport priority</td>
</tr>
<tr>
<td></td>
<td>3. Parking limitations</td>
<td>1. Parking space limits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Parking access controls</td>
</tr>
<tr>
<td>Pricing</td>
<td>1. Road pricing</td>
<td>1. Tolls</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Area entry fees/licences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Congestion pricing/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>electronic road pricing</td>
</tr>
<tr>
<td></td>
<td>2. Parking prices</td>
<td>1. Short-term priority policies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Higher entry costs</td>
</tr>
<tr>
<td></td>
<td>3. Taxes</td>
<td>1. Higher fuel taxes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Parking taxes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Higher ownership taxes</td>
</tr>
</tbody>
</table>

Source: Adapted from Black, 1992
Controlling the use of private vehicles in Bangkok could include at least three key measures: (1) increased vehicle taxes, registration duty and fuel tax; (2) introduction of an area licensing scheme; and (3) parking limitations and pricing. These three approaches are discussed below.

### 7.3.4.1 Increased Vehicle Taxes, Registration Duty and Fuel Tax

The first transport demand management approach is increasing vehicle taxes, registration duty and fuel tax. This measure would discourage people from purchasing new cars and using cars. This measure is based on the principle of "Let the users pay real cost". Currently, car users do not need to pay for their external costs such as damage to the environment, health deterioration from air pollution, impacts on climate change, and deaths and injuries from accidents (INFRAS, 1991). For example, Pearce et al. (1993) demonstrated that in the UK, road transport has triggered a number of social costs such as congestion costs, road damage costs, air pollution, noise, and accidents, which altogether amounted to approximately £22.9-25.7 billion in 1991 (Table 7.4).

#### Table 7.4 The external costs of road transport in UK, 1991

<table>
<thead>
<tr>
<th>Types of external costs</th>
<th>Costs (billion pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion</td>
<td>13.5</td>
</tr>
<tr>
<td>Road damage</td>
<td>1.3</td>
</tr>
<tr>
<td>Air pollution</td>
<td>2.8</td>
</tr>
<tr>
<td>Noise</td>
<td>0.6</td>
</tr>
<tr>
<td>Accidents</td>
<td>4.7 to 7.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22.9 to 25.7</strong></td>
</tr>
</tbody>
</table>

Source: Pearce et al., 1993: Table 10.7

The authors of the UK study strongly addressed the failure of transport policy to charge motorists for the real costs they impose, which leads to an overwhelming use of private vehicles:

> At the root of these problems lies the free address nature of the roads and the atmosphere, enabling motorists to impose costs on others which they do not bear themselves. Any policy to tackle these problems must involve confronting the motorist with the true cost of his or her journey. (p. 150)
As discussed in Chapters 4 and 5, the costs of car purchase and car use in Bangkok are relatively low, particularly compared to Singapore, Tokyo and Hong Kong. These low costs contribute to a high rate of car purchase and use, clearly inconsistent with the city's structure and road provision. Singapore has successfully suppressed its car ownership levels relative to wealth through financial measures (Ang, 1991: 42; OECD, 1988a: 72). In Singapore, the cost of owning and operating a car has been progressively increasing and is now regarded as a major deterrent. Car ownership costs in Singapore are among the highest in the world. Since 1972, import duties, annual registration fees and an annual road tax have significantly increased. To own a car, a Singaporean must now hold a Certificate of Entitlement (COE), which as of January 1994 could cost up to S$63,000 for a large car, and S$43,700 for cars of 1,001 cc to 1,600 cc and taxis, though prices vary continually. This cost is in addition to the car purchase price (Ang, 1996; The Straits Times, 1993). In addition, the annual road tax in Singapore has been raised periodically, with cars with a higher engine capacity attracting higher rates. On average, between 1974 and 1988, the purchase price of a new car increased by 200 per cent, and the operating cost increased by 40 per cent (Ang, 1991: 49). These fiscal measures have effectively impeded the growth in the Singapore vehicle population. For example, car ownership in Singapore rose to only 184,000 vehicles in 1982, while income increases and comparisons to other Southeast Asian cities would have suggested an expected Singapore fleet of between 270,000 and 340,000 vehicles (OECD, 1988a: 203).

Increasing fuel tax is another tax measure to deter private vehicle use. A study of 17 countries in Europe and North America suggested that travel costs significantly influence automobile use. It predicted that high gasoline prices relative to public transport prices (the transport price ratio) will significantly change people's travel habits. The study revealed that the automobile's share of urban trip-making shows a strong negative correlation to the transport price ratio (Pucher, 1988, cited in Birk and Zegras, 1993: 83).

Bearing these factors and examples in mind, it appears that it is necessary to impose financial disincentives to influence car ownership and use in Bangkok. However, Bangkok cannot rely solely on increasing vehicle taxes, registration fees and fuel taxes to constrain demand for private vehicle purchase and use. Many cities have demonstrated that it is also necessary to
impose additional disincentives, e.g. Area Licensing in Singapore, and parking limitations and pricing systems in many other cities.

7.3.4.2 Introduction of an Area Licensing Scheme (ALS)

The second measure suggested by this thesis would be to introduce an Area Licensing Scheme (ALS) or Area Pricing. This approach aims to reduce demand for private vehicle travel within the heavy traffic areas of a city. Drivers must pay a fee to enter a given area, either by purchasing a pass in advance or by paying at a toll booth. This measure works very effectively in Singapore and markedly reduces car traffic in congested areas. Singapore was the first city in the world to apply the ALS idea to curb traffic congestion in 1975. Initially, charges were levied only for cars entering the central area zone (620 ha) during the morning rush hour between 7.30 and 9.30 am Monday to Saturday. Car pools of four or more riders were admitted free. Parking charges were increased. Drivers were required to purchase licenses in advance and place them on vehicle windshields. Several aspects of the scheme have been improved over the years, such as: extending the restricted time to cover all day from 7.30 am to 6.30 pm; raising fees progressively; expanding the ALS area; eliminating the car pool exemption (as it was reportedly taking passengers away from public transport); and including motorcycles and taxis in the restriction (Pendakur, 1993: 60-61; Birk and Zegras, 1993: 81; Kenworthy et al., 1994: 26).

This restriction scheme has enormously benefited Singapore. For example, after its introduction, motorised traffic was estimated to have dropped by 50 per cent of the level it would have been without the scheme (Ang, 1991: 46). By 1983, the share of car traffic had decreased to 46 per cent from 56 per cent in 1975, while the share of buses rose from 33 per cent to 46 per cent for travel into the Restricted Zone (OECD, 1988b: 73). A survey in 1989 revealed that an average of 51,000 vehicles (of which 16,500 were private cars) entered the zone daily between 7.30 am and 10.15 am, compared to 74,000 vehicles (42,500 private cars) in 1975 before the implementation of the scheme (Ang, 1991: 46).

Based on the research presented in this dissertation, it is argued that a similar scheme be introduced for Bangkok's inner area where traffic congestion is very severe. Initially, it should be implemented during
morning peak hour. Then, if the program proves successful, it could be extended to cover the evening peak hour and, finally, all day. It should, if successful, reduce private vehicle traffic - alleviating traffic congestion and reducing transport-related air pollution. However, successful implementation of this approach requires the simultaneous improvement of alternative travel modes, particularly the public transport system. The existing bus service needs to be managed to serve commuters move efficiently. This can be achieved, for example, by operating more bus lanes, introducing busways, and increasing the number and quality of buses. Mass rapid transit is the most attractive alternative and would enhance the feasibility of introducing the ALS. The improvement of waterway transport is also necessary, as it can help relieve the pressure on land transport. The provision of at least some park-and-ride facilities in some certain areas would also be a necessary supplement to this scheme.

7.3.4.3 Parking Limitations and Pricing

Bangkok's central area parking provision is too generous for a city with such complex traffic problems. Within the CBD, the level of parking spaces per 1,000 workers is almost as high as levels in automobile-dependent cities in the USA and Australia. Moreover, most parking facilities are free of charge, or attract only a very low fee. Thus, parking policy is a significant factor contributing to heavy use of cars in Bangkok. Although the government in 1994 abandoned on-street parking on many roads in Bangkok, the aim was to facilitate more efficient traffic flow, not to restrain car use.

Many cities have demonstrated their commitment to deterring the use of private vehicles by restricting parking provision. For example, Munich has enacted a policy to prohibit new business offices having off-street parking in buildings and has banned downtown on-street parking for non-residents. In Hamburg, the number of parked vehicles allowed in the city has been limited, and there are peripheral "park and ride" facilities linked with mass transit (Birk and Zegras, 1993: 77). In the Netherlands, as one of the main themes of the traffic and transport policy is to restrict the growth of mobility, one of the major measures adopted has been to impose a more stringent parking policy (Ministry of Transport, Public Works and Water Management, 1992: 11). Over a 20 year period, Copenhagen has systematically removed, each year, 3 per cent of its central city parking stock.
(Jan Gehl in Newman, 1993: 16). Portland, Oregon, for many years had a cap on central city parking supply of 40,855 (City of Portland, 1981). In Singapore, financial measures associated with parking have been implemented to curb the use of cars. Parking fees have been substantially increased. In 1992, the day-time parking fee for cars in public car parks in the CBD was S$1.60 (US$0.80) per hour. The parking fee in private car parks was even higher (Ang, 1991: 48).

To discourage car use in Bangkok, the government should issue regulations to increase parking fees, both off-street and on-street. This measure would also serve to make public transport more competitive in terms of the costs of travelling. Revenue from this parking fee could be allocated to provide selected park-and-ride facilities on the city outskirts. Another effective new regulation could be that developers initially not be required to provide parking spaces directly related to building size. The next step could be that this regulation be amended so that new buildings provide only a minimum amount of parking space.

While they could be very effective, the implementation of these private vehicle use control measures is likely to meet with strong resistance from car users and car companies. Thus, the government would need to set its priorities and focus directly on the overall health and welfare of residents and reduction of negative environmental impacts on a wider scale. An aggressive public campaign is a necessary tool to build understanding and shape the attitudes of local people. Furthermore, the disincentive and restrictive measures would need to be implemented gradually, with a simultaneous improvement of public transport and other modes as alternatives to car use. Handled sensitively, these measures could reduce opposition from motorists and relevant groups and serve to make the measures acceptable to the wider public.

7.3.5 Facilitation of Walking and Cycling

The major cause of Bangkok's unusually low levels of walking and cycling is that these two modes of travel have been almost totally ignored in all Bangkok transport policies and plans at all levels. The tremendous increase in the number of motor vehicles on the roads in recent years has suppressed the use of bicycles and walking by imposing the twin hazards of risk and
severe air pollution (as well as extreme noise). Moreover, footpaths have been eliminated in the process of widening streets for motor vehicles, particularly in sois, with almost no improvement in facilities for cycling. Not surprisingly this hostile environment enormously hinders walking and cycling in Bangkok.

By contrast, in a number of cities around the world, walking and cycling play a very important role and provide great benefits to city living. In most cities in Europe, as well as in Singapore, Tokyo and Hong Kong, pedestrians receive a high priority. Basic infrastructure such as footpaths and pedestrian crossings are well provided. Moreover, roads and streets are increasingly being shaded through tree-planting and provided with attractive street furniture to strengthen the appeal of walking and to significantly reduce ambient air temperatures in hot climates. Whole sections of cities, particularly central city areas, are being permanently closed to traffic, especially after good quality rail transport has been provided to increase accessibility (Poboon, 1994: 4).

In terms of cycling, one outstanding example is the Netherlands, where all cities have high bicycle use, which is accorded priority in traffic and provided with extensive infrastructure. The Netherlands is the country with the highest proportion of bicycles relative to the population. There are about 14 million bicycles among 15 million inhabitants. In 1990, walking and cycling made up about 46 per cent of the total trips, of which cycling had a very high share of 29 per cent and walking accounted for 17 per cent. Approximately 35 per cent of trips to the railway station were made by cycling. The main underlying reason for the high use of bicycles is the massive provision of convenient infrastructure and facilities for bicycles, aided by flat topography (see Plate 7.2). There are about 15,000 kilometres of cycle tracks in the Netherlands (1 metre per person). This is the result of the government's traffic and transport policy that places an emphasis on stimulating use of bicycles, as an alternative to cars (Ministry of Transport, Public Works and Water Management, 1992). For example, in the Dutch cities of Groningen and Houten, road systems have been constructed to reduce the attractiveness of short trips by car and to increase accessibility by bicycles and public transport. The results show that in Groningen in 1979, 50 per cent of residents cycled to work, and from 1977 to 1984, bicycle traffic rose by 20 per cent. In Houten, car use was reduced by 25 per cent during
the same period, with the alternatives being use of bicycles or trains. The number of road accidents in that city was three times less than the national average in 1991 (Ministry of Transport, Public Works and Water Management, 1992: 21; Greenpeace, 1993).

Similar success stories have also been reported for Freiburg, Munich, Copenhagen, Tokyo and other cities (Poboon et al., 1994: 24). For example, in Freiburg, Pucher and Clorer (1992) report that bicycle trips increased by 96 per cent between 1976 and 1991 and the bicycle's share of non-pedestrian trips rose from 18 per cent to 27 per cent. The chief factors underlying this trend were a focus on high quality, green cycleway networks and aggressive traffic calming and pedestrianisation of its central and inner areas (Plate 7.2).

Plate 7.2 Cycling tracks in Groningen, the Netherlands and in Freiburg, Germany

Photos by Jeff Kenworthy
Even in car-dominated American cities, more people are realising the benefits of cycling and a strong advocacy for this mode is now evident (e.g. see Herman et al., 1993). There is also much greater recognition today in both Europe and North America about the value of creating environments which encourage and cater for walking and cycling (Poboon, 1994: 4).

For a dense and mixed land-use city like Bangkok, promotion of walking and cycling has high potential. From the study conducted by JICA (1990), out of a total of 13.4 million trips made by motor vehicles in Bangkok daily, 51 per cent or about 6.8 million trips were less than 6 kilometres long.\textsuperscript{44}

These comparatively short trips are very suitable to changeover to walking or cycling, depending on specific distances. People generally do not want to walk more than 1 km, preferably less than 500 m. Repogle (1992a: xv) suggested that the primary market for efficient bicycle use is generally from six or eight hundred metres to distances of five to seven kilometres. If only 25 per cent of the 6.8 million trips of 6 km or less were substituted by cycling or walking, this would mean an overall reduction of 13 per cent in daily motor vehicle trips. Consequently, there would be more road space available for both bicycles and motor vehicles.

A study by the Transportation Research Unit, Chulalongkorn University (1992) prepared for the BMA on the feasibility of providing bicycle ways in Bangkok, revealed that with development of appropriate bicycle ways, the share of bicycle use is predicted to substantially increase from the existing 1 per cent to about 4.4 per cent of total trips, or about 220,000 trips of the total five million trips per day in the study area. In addition, if there is also an effective public campaign, it is predicted that the share of bicycling will rise to about 5.1 per cent of total trips in four years' time. In terms of the financial rate of return, the benefit from investment in the construction of bicycle ways was estimated to cover the cost within only one month of operation.

To enhance the level of bicycling and walking in Bangkok, the policies suggested are as follows:

\textsuperscript{44}Calculation based on data from JICA, 1990: 51-53.
1. The first and most vital step is for government to reconsider its transport policy and planning to incorporate non-motorised transport modes and regard them as legitimate functions in moving people. Pendakur (1992a: 24) argues strongly for a new transport policy which emphasises "Feet First, Pedal Next, and Motor Maybe". The formulation of government policies and plans needs to reflect the validity of these modes, as do its investment plans and implementation procedures.

Such an approach has been taken by Singaporean planners. Singapore's current urban development plan has a strong focus on improvements to walking and cycling facilities, as well as improvements to the urban environment to attract pedestrians and cyclists (URA, 1991). For cycling, facilities such as cycleways and bicycle parks will be built in Singapore's new towns. Bicycle ways will be built both along streets and, where possible, completely separated from traffic. The plan also aims to make Singapore more "pedestrian-friendly" by eliminating cars and other motor vehicles from certain areas to increase pedestrian freedom. Parts of the city are planned to become pedestrian districts where all traffic access is denied (URA, 1991: 39). In addition, to emphasise the need for bicycle use, the central government of the Netherlands in 1991 issued the "Bicycle Master Plan", possibly the first national bicycle plan in the world. This plan aims to stimulate cycling, particularly for distances under 10 kilometres, and to encourage the combined use of bicycle and public transport for distances over 10 kilometres. The cycling distance in the Netherlands is longer due to ideal topographical conditions throughout the country. It was argued that this approach would effectively attract motorists to shift to bicycles and public transport (Ministry of Transport, Public Works and Water Management, 1992).

2. To encourage people in Bangkok to walk and cycle more, infrastructure improvement is desperately required. This research revealed the need for footpaths for pedestrians along all roads; footpaths should also be rebuilt along sois where they have been eliminated. Where feasible, bicycle lanes should be built to facilitate cycling. As a first step, while bicycle lanes are still not available, ramps at the kerbs along all footpaths should be provided. At appropriate speeds, cyclists can share these spaces with pedestrians, rather than risk travelling along road pavements.
3. In addition to the provision of footpath and bicycle ways, it is necessary to pay attention to the other needs of pedestrians and cyclists. Some significant improvements include the following: shaded routes with trees or shelters, necessary for a tropical city like Bangkok; continuity of footpaths and cycling routes; separation from dangerous traffic, addressing of noise considerations; and providing parking facilities for bicycles at destinations, e.g. at offices, schools, shopping centres.

4. Integration of foot and bicycle traffic with the public transport system should be extensively encouraged. This can be done primarily by improving accessibility to railway stations, bus stops or piers by providing high-quality footpaths and bicycle ways. Providing secure and adequate cycle parking facilities at transit stops is also very important.

It is evident in Japan that the massive use of bicycles, particularly for commuting to rail stations, has both encouraged and been facilitated by the rapid improvement of bicycle parking facilities. The Bicycle Law, passed in 1977, provided public funding and tax incentives for the construction of bicycle parking facilities. Japan's 1980 Bicycle Law requires newly constructed or enlarged department stores, supermarkets, and banks to provide bicycle parking. Japan has spent around US$10 billion on bicycle-related infrastructure over the past two decades. This has led to the construction of some 8,700 parking facilities accommodating nearly three million bicycles. About two-thirds of these parking spaces were within 100 metres of a rail station entrance (Plate 7.3). One-half to one-third of the capital costs of construction can be met by public subsidies. Tax benefits and subsidised financing are available to the private sector for providing bicycle parking (Hook, 1994: 5).
Plate 7.3 A parking facility for cycling in Japan

Photo by Jeff Kenworthy

Accommodating walking and cycling by providing basic infrastructure and creating an attractive walking and cycling environment is very cost-effective and can potentially attract people from motor vehicles. This approach would be particularly effective in Bangkok, as more than half of daily trips in Bangkok are potentially within walking or cycling distance. Improvement of walking/cycling and public transport integration can attract motorists for longer trips. These measures could potentially help relieve Bangkok's severe traffic congestion and related problems.

In addition to the direct policies to enhance walking and cycling recommended above, the policies suggested to improve public transport performance, to integrate transit and land-use development and to control private transport use, can also assist walking and cycling by reducing congestion, and decreasing transport-related environmental impacts such as noise and air pollution.

7.3.6 Institutional Reform of Bangkok's Transport Decision-Making Structure

Institutional fragmentation in Bangkok is a major barrier to implementation of transport policies and plans. This research has highlighted the fact that too many agencies are responsible for Bangkok's transport planning and implementation, causing overlapping in mandates and many conflicts. There is a critical need to revise the functions of all relevant agencies and
committees, otherwise they will continue to act as a barrier to progress in traffic improvement. The set of policies recommended above to direct Bangkok towards a more sustainable transport system will require significant reform of the institutional framework.

In Curitiba, Brazil, the Instituto de Pesquisa e Planejamento Urbano de Curitiba (IPPUC, or Research and Urban Planning Institute of Curitiba) since 1972 has had authority for designing and implementing a wide range of policies, many of them cutting across several government departments. The well-known success story of the development of the bus system in Curitiba is attributable to its clear-cut authority and its abilities in coordinating the different agencies (Birk and Zebras, 1993: 117).

In the Philippines, the act creating the Metropolitan Manila Development Authority (MMDA) was enacted in July 1994. The MMDA has a mandate plan, monitoring and coordination functions, and exercises regulatory and supervisory authority over the delivery of metro-wide services within Metro Manila. The aim of the legislation is to achieve coordination without diminution of the autonomy of local government units concerned with purely local matters. The MMDA's mandates include development planning, transport and traffic management, land-use planning, health and sanitation, and pollution control. The governing board and policy-making body of the MMDA is the Metro Manila Council, composed of the mayors of all cities and municipalities in the Metro area. The heads of all relevant departments or their duly authorised representatives attend meetings as non-voting members (Republic of the Philippines, 1994).

There are lessons for Bangkok from both these examples. For Bangkok, a major reform of the transport institutional framework is desperately needed. A much smaller number of agencies with responsibility for Bangkok's transport management and operation is required; each should have a clear-cut function. For example, this research suggests the need for the following: a single agency responsible for each main section of transport: a single agency for the construction and operation of the mass rapid transit system; a single agency for the construction and maintenance of the road system; a single agency for water transport operation; a single agency for non-motorised transport; and a single agency for road traffic management.
In addition, a single agency should have the authority to formulate transport policy and plans for Bangkok, have decisive power to oversee and coordinate all relevant agencies, and have the authority to recommend decision-making to the government. It should also have the authority to monitor all plans or projects implemented by relevant agencies. Its functions should encompass at least transport and land-use planning, which are the major areas of urban planning.

While in principle this approach seems logical and feasible, in practice, it is problematic to reduce the number of agencies responsible for transport. The major obstacle would arise from strong resistance from those who will lose position or influence or who will be forced to change established practices (Halcrow Fox and Associates et al., 1991: 27-15). Consequently, it is foreseeable that there will be no attempt from any politicians to put forward such reform proposals as they are mainly concerned with their popularity, since in Thailand the bureaucratic system is still very strong. Moreover, as Thai politicians are not likely to be sufficiently secure in their offices, they tend to acquire more electoral visibility from monumental projects such as freeways, than from systematic reforms to the transport system (Ross, 1994: 9). The only possible change, which can be confidently recommended at this stage, although difficult, would be to improve the mandates of these relevant agencies by amending the relevant laws so that their jurisdictions do not overlap.

Creating a powerful new agency to oversee all other agencies is also problematic, as its mandate would overlap with the existing central agency, the Commission for the Management of Road Traffic (CMRT) and its secretariat, the Office of Commission for the Management of Road Traffic (OCMRT). This research leads to the conclusion that the most plausible and feasible solution to the institutional fragmentation in transport in Bangkok would be to strengthen the authority of the existing CMRT and OCMRT in formulating and deciding policies and plans, and overseeing, coordinating and monitoring all relevant agencies. Under this proposal their authority and responsibilities would be extended to cover not only road traffic, but all transport functions and land-use planning, and they would report directly to the Cabinet. It would be appropriate to then rename these agencies "The Transport and Land-use Development Board (TLDB)". The membership of this Board would consist of existing members of the CMRT, which comprises
Ministers and Permanent Secretaries from the relevant Ministries, the Secretary-General of the NESDB, the Director of Budget Bureau and the Governor of Bangkok, with the Prime Minister acting as Chairman. The major responsibilities of this Board would be:

1. formulation of strategic transport and land-use policies and plans;
2. decision-making on transport and land-use projects;
3. decision-making on traffic management;
4. control of approval and financing of all relevant transport and land-use projects;
5. coordination of all relevant agencies;
6. monitoring of all relevant agencies in the implementation of transport and land-use projects; and
7. authority to change or modify any project implementation where appropriate.

Under this proposal, the existing OCMRT would be simultaneously upgraded to be the Office of Transport and Land-Use Development Board (OTLDB), acting as the secretariat of the TLDB. It would function as the servicing agency for the TLDB, to prepare policies and plans, and analyse and provide relevant information for the TLDB. It would also function as an operating agency in coordination with relevant agencies, to monitor project implementation and report to the TLDB. However, to handle this task, the OTLDB would require substantial improvements in its capacity. A number of additional specialised staff in the public transport, non-motorised transport, water transport and land-use planning areas would be vitally needed, although in the preliminary stages, while staffing is still inadequate, consultancy firms could be engaged to conduct necessary studies to acquire information for preparation of policies and plans and to support the necessary decision-making.

Correspondingly, the other existing committees or ad-hoc committees responsible for the same issues should be dissolved or re-assigned to function under this Board. The mandates and responsibilities of other relevant government agencies would be modified to be primarily concerned with implementation of the policies, plans and projects to be decided by the TLDB. Figure 7.4 illustrates the recommended institutional framework.
Figure 7.4 Proposed new institutional framework for transport and land-use decision making in Bangkok

Note: Some concepts adapted from Wilbur Smith Associates et al., 1994; Halcrow Fox and Associates et al., 1991; Bodell, 1995.

In order to initiate the policies suggested above, the government, as a major actor, will be required to undergo a fundamental change in its perceptions of Bangkok's traffic problems. As this research has suggested, the sustainable transport model must be adopted to replace the conventional model. The main aims of transport policy should be to foster accessibility and equity for all, as well as to improve the quality of life for residents and contribute to the reduction of the wider negative environmental impacts of traffic. This calls for strong political will and courage.

In addition to the government role in carrying out the suggested policies, development of public understanding and public participation is also vital. The government should therefore provide comprehensive and unbiased information to the public on major plans and projects. Moreover, to gain
public support for the implementation of these policies, particularly the control of private vehicle use, an aggressive and continuous public campaign would need to be undertaken, with simultaneous development of viable alternatives. Public hearings should also be conducted, as in other countries, during the decision-making process to minimise the serious conflicts which are occurring at present among agencies. Public involvement processes, properly undertaken, may reduce the power plays between agencies, as these processes can at least reveal the real issues. As previously discussed, the "Traffic Crisis 94" group has demonstrated its ability to provide such positive input. Moreover, the NGOs, whose views have been briefly canvassed in Chapter 6, have a high potential to be major facilitators in stimulating the formulation and implementation of the recommended policies, as well as disseminating information to the public (see also Ross and Poungsomlee, 1994; Poungsomlee et al., 1995).

7.4 CONCLUSIONS

In order to tackle Bangkok's traffic chaos and work towards a more sustainable city, it is necessary to develop new policies and measures. The new solutions should encompass not only economic considerations but also environment, energy use, human/social and land-use criteria. Although this more holistic approach has not yet been widely recognised among Thai planners, decision-makers and the public, this approach is probably the only course of action able permanently to relieve Bangkok's horrendous traffic problems. Based on the findings of this study, the concept of sustainability, and the constraints and opportunities within the Bangkok context, the suggested solutions for Bangkok are as follows: (1) giving priority to public transport, in particular a high profile, quality rail system; (2) transit-oriented, mixed land-use development; (3) transport demand management; (4) improved and expanded water transport; (5) facilitation of walking and cycling; and (6) institutional reform to ensure policies can be implemented. For these proposed measures to be successful in gradually changing Bangkok into a more liveable city, there needs to be a fundamentally different approach on the part of government. The proposed approach would place planning for "the common good" and ecologically sustainable approaches above the needs of sectional private interests. In addition, public understanding and participation, including full involvement of NGOs, are
vital for effecting the necessary change. Given these opportunities, with the set of policies suggested, there is potential to guide Bangkok towards a more liveable and ecologically sustainable form of settlement.
CHAPTER 8
CONCLUSIONS

8.1 SUMMARY OF FINDINGS AND CONCLUSIONS

8.1.1 Study Rationale and Questions to be Answered

Bangkok, the Thai capital of about six million people, has earned an international reputation for its traffic disaster. Despite public awareness and a number of proposed measures to solve the problems, Bangkok's traffic continues to deteriorate. Along some main roads during peak hour, traffic speed is almost at walking pace. Air pollution is very severe and adversely impacts the health of Bangkok residents, as well as contributing to global ecological problems. Energy and time loss in the idle traffic are enormous. Thus, the main aims of this dissertation have been to develop new insights into the roots of Bangkok's severe traffic problems, to suggest a series of potential solutions and policy responses to help direct Bangkok to a more sustainable and healthy future, and to examine some of the key transport policy constraints and opportunities in implementing such potential policies.

The extent of the traffic crisis in Bangkok is evident to the most casual observer. Not necessarily so clear are the factors underlying the crisis. This is because no systematic and sufficiently broad examination of the problem has been undertaken, in particular, no study has ever attempted to compare Bangkok in a comprehensive way with other world cities to determine similarities and differences which may lead to valuable policy insights. Nor has there ever been any systematic analysis of the land use and transport evolution of Bangkok from its establishment to the present day. Therefore until this study, it has not been possible to see clearly the path Bangkok has taken to its present crisis.

One obvious and much-touted explanation for Bangkok's traffic nightmare is simply that Bangkok does not have enough roads and that the structure of the road system is inadequate. But are such explanations adequate? Why do other cities not have traffic crises of the magnitude of that experienced by Bangkok? And, most importantly, what can be done to ameliorate Bangkok's traffic crisis and transport-related problems.
This dissertation therefore posed the following overall question which shaped the research undertaken:

*Can Bangkok’s traffic disaster be analysed and better understood through a detailed investigation into its historical land use and transport development and through a comprehensive comparison of Bangkok to other cities around the world, especially those in Asia, and can such a new understanding reveal potential sustainable solutions to its traffic crisis?*

A series of more detailed questions then flowed from this:

1. What path has Bangkok followed in land use and transport terms to arrive at its present traffic crisis?

2. What influence, if any, has this land use and transport evolution had on the present traffic situation, and does an understanding of this path help to elucidate any causes or potential solutions to the problems?

3. How does Bangkok compare internationally to a large sample of other cities, especially other Asian cities, in terms of land use, transport infrastructure, transport use patterns, energy consumption in transport, transport economics and transport externalities. Are there significant interrelations among these factors which help to explain Bangkok’s present transport condition?

4. What lessons or insights does a detailed international comparison of Bangkok (showing similarities and differences between Bangkok and other cities), provide about the magnitude of the transport problems facing the city and possible root causes of Bangkok’s traffic problems and what do such lessons teach about possible solutions to the traffic crisis?

5. Are the traditional explanations of the major roots of traffic congestion in Bangkok, in terms of an inadequate road system, sufficient to understand Bangkok’s traffic situation?

6. Are solutions derived from this traditional approach effective and suitable for Bangkok?
(7) What are some of the key constraints behind formulation and implementation of effective transport policies within the Bangkok context and conversely, what are some of the key opportunities?

(8) Based on the research in this dissertation, what are the key policies which appear to be necessary to help resolve Bangkok's traffic disaster, incorporating principles of Ecologically Sustainable Development?

To contribute answers to such questions, this dissertation adopted two methodologies for investigating the roots of Bangkok's traffic crisis: A review of the evolution of Bangkok and a detailed international comparative study. In addition, it reviewed literature and undertook a small pilot survey to establish some key constraints and opportunities surrounding transport policy in Bangkok.

8.1.2 The Land-Use and Transport Evolution of Bangkok

The first method involved a detailed examination of Bangkok's transport and land-use development, since the establishment of the city, to develop an understanding of the interrelationship between the evolution of transport technologies and land-use change, as it unfolded in Bangkok. This methodology is based on the theory of the stages of development of Western cities postulated by Newman et al. (1992). This approach helps to reveal the path Bangkok has followed in arriving at its present state of traffic crisis and suggests answers to questions 1 and 2 above.

The history of Western cities has shown that walking, transit, or the car (the major forms of transport) are key factors affecting city form. The three periods of the development of cities are the traditional walking city, the transit city and the automobile city. Based on Bangkok's transport features, this study suggests that Bangkok has evolved through three key periods of land use and transport development: a water-based transport and walking period; a transport modernisation period; and a motorisation period. During each period, Bangkok has seen major changes in transport technologies which influenced the city's size, structure and land use.

During the first period (1782-1868), Bangkok was characterised by water-based transport and walking, modes which were very compatible both with
the city landscape and with its small area. These modes of transport allowed the city to be very compact, with a dense population and a mixed land use. Then, during the transport modernisation period (1868-1946), Bangkok experienced the introduction of a variety of new transport technologies. Water transport, on the other hand, declined. However, public transport, particularly trams, coupled with non-motorised modes, played a major role because of the low numbers of motor vehicles. The city was, therefore, still dense, with mixed land use, and though its physical built-up area did expand nearly fivefold due to the enhanced speed of public transport modes, development remained closely linked to the public transport network, since cars and motor cycles were almost non-existent amongst the general population. The city remained dependent upon public transport, walking and cycling.

After the Second World War, Bangkok entered the motorisation period. Private vehicles (cars, pick-ups and motorcycles) rapidly began to dominate roads, and buses became the dominant means of public transport. Water transport rapidly declined to the point where it now plays only a minor role. Trams were eliminated from the streets by 1968. Although the rather weak inter-urban rail system within Bangkok was expanded, rail availability declined relative to population.

This major change in transport technologies has significantly affected the city's basic urban structure, though densities and mixed land uses have remained high. Most new development has taken place along main road corridors, as ribbon development in the outer areas of Bangkok, but some has moved away from major roads into rice paddies along minor roads and now extends a significant distance from the city centre. However, despite this linear growth outwards and at least some ad-hoc dispersal, overall city density has only moderately declined from 1970 (it has always been 145 persons per ha or more) and mixed land-use development still strongly characterises the greater part of Bangkok's development.

In other words, the city, despite some major changes in the dominant transport technologies, has always maintained what might be called a typical "Asian city" type of urban land use pattern characterised by densities traditionally associated with "walking cities" (i.e. well in excess of 100 persons per ha), and certainly more than high enough to support a high
quality public transport system. Mixed land uses have remained strongly in
evidence throughout its history. Bangkok's dependence on the automobile,
though high within an Asian city context, is low in an international context
and the city clearly is not yet an 'automobile city.'

Much of Bangkok remains in transit-oriented form with development having
tended to follow most strongly the major road corridors in a linear form
which allows easy access to both the bus services and private road transport.
Those to whom a car was freely available in 1990 still constitute a minority,
so for pure access reasons it has not generally been possible to disperse too
far from the major transport corridors where many urban activities are
located and where the various forms of public and paratransit are
concentrated. However, this form of development, which places all
transport demand onto road corridors with limited road space and capacity,
in contrast to many cities with excellent rail systems, has helped to generate
Bangkok's terrible road traffic conditions. Due to a series of transport policy
and financial decisions over many years to focus more on road
infrastructure, Bangkok has failed at every turn to develop the low land
requirement, high capacity rail system so suitable to strong corridor
development amidst the extreme spatial constraints imposed by high
density, mixed use development.

In summary, one way of depicting Bangkok's transport/land use evolution
is to imagine a gradual process of divergence between the land use patterns
and transport infrastructure designed to serve them. In the first period, land
use and transport seemed largely to be in harmony with one another, with
walking and water modes ideally suited to the compact, mixed use structure
and small city size. Later, in the second period as the city grew, new public
and non-motorised transport technologies continued to ensure a manageable
relationship between travel demand and the form of the city. However, in
the motorisation period, the gradual and then faster build up of motor
vehicles began to get out of synchrony with development patterns. A
modern, highly space-consumptive transport technology with mass appeal,
begin to come into conflict with the city's pre-automobile form. Road
infrastructure could not be built fast enough to keep pace with traffic
growth, try as the government did to achieve this, and new investment in
high capacity public transport systems, including rail, renewed water
transport and busways, failed to materialise and to curb this motorisation process.

A fundamental conflict between the city's urban form and transport technologies appeared to have taken shape which continued to fuel a worsening traffic situation. This conclusion from the history of Bangkok tends to be supported by the next approach to the study which was to undertake a detailed comparison of Bangkok with other international cities, especially Asian cities, to see what further new insights into the traffic crisis could be provided.

8.1.3 Understanding Bangkok in an International Context: Insights and Lessons

The second methodology thus involved placing Bangkok into an international perspective by comparing Bangkok to thirty-three other cities in the United States, Europe, Australia and Asia. This methodology involved an update and extension of the approach used by Newman and Kenworthy (1989) in Cities and Automobile Dependence: An International Sourcebook, which revealed large differences in the basic land-use and transport characteristics of cities and suggested reasons for these differences, as well as proposing a series of policy options for reducing automobile dependence in cities. This second approach was directed towards providing answers to questions 3, 4, 5 and 6 of the thesis.

Answering these questions involved a detailed and systematic data collection, collation and analysis process, focussed on developing a data set of over forty-five factors under the following headings: (1) urban form and land-use; (2) transport infrastructure; (3) transport patterns; (4) transport energy use; (5) transport economics; and (6) transport externalities. To obtain data for Bangkok, two data collection trips were conducted in Bangkok. The first was from December 1992 to February 1993, and the second from October 1994 to March 1995. These efforts involved about thirty government and non-government organisations, as well as many other data sources. In addition, a pilot survey of thirty NGOs involved in environmental issues in Bangkok was also conducted during the second data collection period to obtain information on their attitudes toward and levels of participation in addressing traffic problems (this exercise was focussed on question 7 of the thesis). For comparative purposes, data from other cities
were derived from the parallel work of Dr. Jeff Kenworthy and three PhD students at the Institute for Science and Technology Policy (ISTP), Murdoch University. The Bangkok data were analysed and standardised to be comparable to those of the other cities.

The international comparative study confirms the close interrelationships among urban form, land use and transport parameters. The correlation analysis, which employed the global cities data, revealed the strong link among urban density, the degree of centralisation, provision of transport infrastructure and transportation patterns. It demonstrates that Bangkok, in common with other Southeast Asian cities, has high population density and concentrated employment with a fairly strong degree of centralisation. Moreover, the city has strongly mixed land-use, particularly in the inner area and along the main growth corridors near major traffic routes. These urban form and land-use features are ideal for walking, cycling and public transport.

In terms of transport infrastructure, although Bangkok’s road provision is relatively low compared to those of cities in the developed world such as American and Australian cities, it is not unusual for other developing Asian cities or even the richer Asian cities such as Singapore and Hong Kong. On the other hand, the provision of public transport infrastructure in Bangkok, particularly railways, is very low. In addition, although Bangkok has a comprehensive network of waterways and some of them have potential to be developed as a supplementary transport system, little attention has been paid to improve them. Parking provision in Bangkok’s CBD, an important factor encouraging car use, is exceptionally generous, approaching the levels of the car-dependent American and Australian cities.

Transport patterns in Bangkok are clearly dominated by private modes. The dominant role of private transport in Bangkok is evident from the comparison with other cities, particularly cities in Southeast Asia with similar kinds of densities and urban forms. The majority of Bangkok’s residents travel to work by private transport. The proportion is markedly higher than for any other Asian city, including richer Asian cities, and is also much higher than the situation in European cities. Furthermore, Bangkok has almost the highest passenger kilometres in private transport per capita of all the Asian cities studied, but a relatively low percentage of passenger
kilometres on public transport compared to Asian cities of similar density (approximately half the level found in wealthy Asian cities). Likewise, non-motorised modes, particularly walking and cycling, which are suitable to the city’s structure, play only a very tiny role in people movement, the lowest, in fact, among all Asian and European cities. One consequence is that energy consumption per capita in transport is the highest of all Asian cities.

With respect to transport economics, the costs to users of owning and operating private vehicles in Bangkok are relatively low. They are much lower than those in Singapore, Tokyo and Hong Kong, where financial constraints are imposed to control private vehicle ownership and use. Expenditure on road construction and maintenance in Bangkok is relatively high, one of the highest in the world in proportion to the Gross Regional Product (GRP). In terms of public transport cost recovery, despite the financial problems associated with government bus services, buses in Bangkok have, overall, much higher rates of cost recovery compared to cities of the North, although slightly lower than those for most Southeast Asian cities where public transport services are profitable operations.

The comparative study also confirms that Bangkok’s traffic speed and public transport speed are currently the lowest among all cities being studied. In addition, impacts from transport in Bangkok in terms of emissions and transport-related deaths are among the worst in the world. For example, transport deaths per 100,000 people are second highest in the survey. SPM, HC and SO2 per capita are the highest in the international sample.

A significant finding of this study is that Bangkok’s city structure mitigates against private vehicle use, as seen in its evolution through three key periods of land use and transport development. This evolution has left the city ill-equipped to cope with the automobile, despite the fact that levels of vehicle ownership and vehicle use per capita in Bangkok are still much less than American, Australian and European cities, although the levels are among the highest of Asian cities. As a consequence, Bangkok’s traffic crisis appears to stem, not so much from high absolute vehicle ownership levels and vehicle usage rates per person, but from what might be termed a significant mismatch among its transport patterns, urban form and transport infrastructure. This problem has the following five dimensions:
(1) A dramatic mismatch between vehicle use and urban form: higher levels of private vehicle use than can be properly accommodated in Bangkok's dense, tightly woven urban fabric. Bangkok is shown already to have the highest vehicle kilometres of travel per urban hectare of all cities in the study. Consequently, any efforts to increase the percentage of urban land devoted to roads, such as through a better secondary road system, will mean more roads per hectare and hence more travel per hectare than is already occurring and which already appears to be at the very extreme of international experience. In addition, the study shows that the length of road per hectare in Bangkok is already similar to virtually all other cities in the study, so that any attempt to increase this to accommodate more private travel will involve significant impacts on the city's dense urban fabric.

(2) A mismatch between vehicle use and road supply: levels of private vehicle use incompatible with Bangkok's road availability and uncharacteristically high compared to other Asian cities. The comparative study confirms for example that the total vehicle kilometres of travel per kilometre of road is the highest in the international sample of cities and that private transport use for the journey-to-work and for total trips is the highest of all the Asian cities in the sample. As well, vehicle kilometres per hectare of actual road area are also the highest in the study, for those cities where data on road area are available.

(3) A mismatch between transit use, urban form and road supply: lower levels of overall transit use than would be expected in a city of its urban form and limited road availability. The data show, for example, that Bangkok experiences about half the proportion of total motorised travel on public transport compared to the wealthy Asian cities in the sample, as well as being the lowest in developing Asian cities of similar urban form. In addition, the proportion of people using public transport for work in Bangkok is well below the average for the other Asian cities (30 per cent compared to 45 per cent). The peak period is of course when road space is at a premium and such relatively low transit use for work exacerbates the traffic problem. The proportion of public transport travel on transit is very low compared other dense Asian cities with similar road supply per capita, and within transit, rail use is extremely low so transit provides little relief on road space. Finally, Bangkok's level of rail service per hectare of land is almost non-existent compared to cities with virtually identical proportions of
urban land devoted to roads. In summary, roads have to carry virtually all Bangkok's travel demand, which clearly they cannot do effectively.

(4) A mismatch between transit infrastructure, urban form and road supply: a public transport infrastructure (particularly an absence of rail infrastructure) inadequate to meet the demands for transit movement inherent in such a dense city where road space is under intense pressure. Bangkok is shown in the international comparison to have a poorly developed rail system relative to its high density and quite low proportion of land devoted to roads. The rail system is also more inter-city than urban in character, with a level of rail infrastructure provision per person and per hectare amongst the lowest in the study. The proportion of public transport passenger kilometres on rail is, as a consequence, extremely low in an international comparative sense.

(5) A mismatch between non-motorised modes and urban form: levels of non-motorised mode use uncharacteristically low for such a dense, mixed-use urban fabric. The international comparisons suggest that the use of walking and cycling in Bangkok, both to work and for all trips, is uncharacteristically low for an Asian city with a walking city density and a lot of mixed land uses which normally facilitate non-motorised modes through a shortening of trips distances and times. Only 10 per cent of Bangkokians walk or cycle to work compared to 20 per cent in the other Asian cities. Likewise, an average of 33 per cent of total trips in this sample of Asian cities (excluding Bangkok) are by non-motorised modes, compared to 15 per cent in Bangkok. The extra traffic implied by this low level of non-motorised mode use, both in the peak and throughout the day, also contributes to the traffic crisis.

These mismatches generally result from a history of inappropriate and ineffective urban and transport policy and investment decisions, biased towards private transport, as can be seen from the emphasis on massive investments in roads and expressways in previous and current development plans. As late as 1990, Bangkok had the second highest expenditure on roads per US$1,000 of GRP of all cities in this study. Such policies can at least partly be seen to derive from the influence of the traditional urban transport planning process, as discussed in Chapter 6 and highlighted in 8.1.4.1 below.
This study therefore refutes the suggestion that the root of the severe traffic congestion in Bangkok can be found principally in inadequate road spaces and the absence of a road hierarchy. Although Bangkok’s road provision in terms of the proportion of urban land devoted to roads, is relatively low compared to many cities of the North, it is not unusual for other developing Asian cities, or even for the richer Asian cities like Hong Kong and Tokyo and some European cities, such as Paris and Munich. However, such cities with similar dedication of land to roads appear to avoid the traffic chaos characteristic of Bangkok through commitment to efficient rail systems, as well as by encouraging healthy levels of walking and cycling. In terms of road hierarchies, although these systems may assist traffic flow in the short term, the approach can have several adverse effects on modes other than private vehicles. Moreover, adherence to the road hierarchy approach may exacerbate traffic and environmental problems in the long run if it increases the attraction of car travel and serves to divert attention away from what appear from this study to be more fundamental causes of Bangkok’s transport crisis.

Another significant factor which has been highlighted by the international comparison is the rapid growth in motor vehicle population in Bangkok. This study suggests that this phenomenon results primarily from a combination of four major factors, which are mostly also linked to the discussion just presented.

First, there is the problem of rapid economic growth, permitting an increase in Bangkok residents’ purchasing powers, whereas the costs of vehicle purchase and use remains relatively low. Second, the inadequacy of provision of public transport and non-motorised modes is a major problem in terms of a lack of competition to private transport. While buses, the dominant mode of public transport, are unable to provide satisfactory services as they are mostly caught in serious traffic congestion, other public transport modes, such as railways and waterway transport, which are the fastest modes in Bangkok, are presently limited in their capacity to serve Bangkok residents as they have received very little support from government to improve their networks and operations. Further, non-motorised modes also have extremely low modal shares, due primarily to the absence of infrastructure and the hostile urban environment. These
factors fuel greater car ownership rates as well as increase the attraction of motor cycle purchase. Third, infrastructure features encourage the private vehicle. This is particularly because of the absence of rail infrastructure, high levels of spending on roads and the particularly generous and inexpensive parking provision in the central business district. Finally, the rapid growth of motor vehicle population may at least be partly attributable to the cultural 'love affair' with the car, which appears to be a persistent feature of Thai society, though not necessarily significantly different to that which exists in many other societies in the developed and developing world (section 8.2 acknowledges that further work is necessary in Thailand on this subject). Of course, escalating car ownership can also be attributed to aspects of industrial, trade and foreign policy, as also acknowledged in section 8.2, although with better physical planning policies, this could be mitigated in large cities such as Bangkok.

Overall, the international comparison has provided significant and useful answers to questions 3, 4, 5, and 6 of the thesis. In summary, the study suggests that there is a need to look much deeper to find the physical planning roots of Bangkok's traffic crisis and solutions to it. The roots of the crisis cannot be found in simple explanations about inadequate road space, but rather in what appear to be some significant conflicts or mismatches among Bangkok's urban form, transport infrastructure and transport patterns which began to emerge in the motorisation period from 1946, and most dramatically in the post-1980 period.

Specification of these conflicts or mismatches has only been possible through a detailed study comparing Bangkok to a large sample of other cities around the world. The numerous transport studies and reports cited throughout this dissertation which have confined themselves only to Bangkok have not been able to provide satisfactory explanations about why Bangkok has such a nightmarish traffic situation, nor have they been able to yield policies or strategies which provide enduring relief from the situation.

The findings in this dissertation go further in providing an understanding of Bangkok's traffic and potential policy responses, though as recognised in section 8.2, numerous other investigations could further elucidate the subject. The findings here do however mean that conventional road building solutions derived from explanations of the problem which stress
inadequate road space or a poor road hierarchy are unlikely to contribute significantly towards a sustainable solution to Bangkok’s traffic crisis.

For example, the research estimated the very large implications, in terms of extra land area and displacement of population and jobs, of efforts to increase Bangkok’s percentage of urban land area devoted to roads from 11 per cent to 20 per cent. This, as shown in the dissertation, is a prevalent policy position in Bangkok, but such a position cannot be justified or sustained by the findings in this work. In addition, the research suggests that if road area and the area devoted to canals in Bangkok are combined, then some 24 per cent of Bangkok is potentially already available for transport purposes. However, canals do not fulfil a large passenger transport role today due to widespread neglect, and would need large scale revitalisation to contribute significantly to passenger transport.

8.1.4 Some Constraints and Opportunities in Reforming Transport Policy in Bangkok

Before recommending policies to address Bangkok’s traffic nightmare, this study recognises the need to examine certain major transport policy and planning constraints which stand in the way of implementing effective action to improve Bangkok’s traffic situation, as well as some key opportunities which may assist the process. These constraints are seen as being within the direct purview of this study which focuses on direct transport issues. Of course, the thesis recognises that these are by no means the only constraints and that further studies are needed to investigate other areas which would complement the research in this thesis.

This study, in answer to question 7, has identified two major barriers in Bangkok to formulating and implementing more innovative transport policies: (1) the conventional transport planning process (UTP), which has been and remains an obstacle to a shift toward a more appropriate transport system; and (2) institutional fragmentation, which has hindered a number of potentially sound transport projects and stands constantly as an obstacle to effective change. To escape the vicious circle of emphasising building more roads and expressways to facilitate motor vehicle traffic (while simultaneously suppressing use of non-motorised transport and public transport, leading to increased automobile dependence), Bangkok desperately needs a paradigm change - a major breakthrough towards
effective transport planning and away from approaches which are limited by the conventions of the traditional transport planning process, especially computerised traffic demand prediction models.

In addition, to introduce new transport policies better suited to tackling Bangkok’s traffic crisis, serious consideration of the issue of institutional fragmentation is required. Without attention to these two issues in particular, little progress can be expected.

8.1.4.1 The Urban Transport Planning Process

The dissertation has highlighted the problems of the conventional transport planning process and in particular, the four-stage computer-based transport planning model used to predict future traffic levels and the new road infrastructure required to meet these projections. Although such models do include predictions of future demand for public transport and new infrastructure to meet that demand, history has tended to show that public transport becomes marginalised in most major transport planning exercises based on these methods. Such transport planning methods were developed initially in the United States in the 1950s and 1960s. The low density, zoned urban environments to which the models were first applied, are very different to those found in the cities of developing countries today. The models were also introduced in the West during a period of immense optimism and lack of knowledge and experience about the self-fulfilling nature of traffic predictions and supply-side approaches to road infrastructure.

These methodologies have been "imported" to Bangkok (and other developing cities) for many years and their "predict and build" approach to roads has been employed almost to the complete exclusion of all other investments in transport infrastructure. Non-motorised modes have been virtually excluded from any consideration. This approach has presided over a rapid decline in the road traffic situation in Bangkok and a severe deterioration of the urban environment, without any serious attempts to question or modify the methods in the face of such negative results.

The findings of this thesis lead to a conclusion that transport planning and modelling in Bangkok might be better applied in testing some of the results
of the present work. That is, it should be possible, for example, to model the
effect on traffic levels, environmental pollution, travel speeds and so on, of
changes in Bangkok's transport infrastructure and travel patterns in the
directions that are suggested as necessary by the major findings just outlined
and by the specific policy conclusions summarised below. This would
constitute transport planning in pursuit of a vision or set of desirable goals,
rather than the open-ended process which it tends to be today, of predicting
how many new roads are going to be needed to cope with expected travel
demand.

8.1.4.2 Institutional Fragmentation

To put any new policies or strategies into action, the study has suggested the
need for overcoming the overwhelming fragmentation of transport decision
making in Bangkok today. It is difficult to imagine how to actually
overcome such fragmentation, the vested interests which underpin it, and
the political processes which might be involved in changing it (such topics
are clearly beyond the scope of this thesis, as recognised in the suggestions
for future studies at the end of the dissertation). However, an alternative
decision making structure for transport planning is outlined in Figure 7.4
which involves a rationalisation and reformation of the number of bodies
involved, but which retains certain key elements of the existing situation.

8.1.4.3 Opportunities

Amid these intimidating constraints, there are however signs of hope -
forces which could help to direct Bangkok towards becoming a more
liveable and ecologically sustainable city. The international ecologically
sustainable development movement provides guidance for a more
sustainable settlement pattern and transport system. A sustainable transport
concept can provide a way to shift Bangkok from moving towards an
automobile-dependent city, to one with a more appropriate transport
system, which would have fewer negative impacts on the environment and
human health, and require less energy consumption.

The movement towards sustainability has already had some modest
influence on development in Thailand and Bangkok, as seen from the
assimilation of sustainability concepts into national development plans. Not
only have the international movements put pressure on Bangkok to become

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more sustainable, but there are signs that many people are expressing a desire for participation in addressing these problems. Environmentally-oriented NGOs, which have played an increasingly important role in the development of Thailand and Bangkok, have suggested an understanding of the traffic problem more in line with the findings of this study than with conventional explanations, and a commitment to addressing these problems, as revealed by the small pilot survey conducted as part of this research. This is a very hopeful signal of support for attempts to move forward with a sustainable transport system for Bangkok, especially in the face of what has been historically a fairly mute response by Bangkok citizens to the gradual destruction of their environment through traffic.

8.1.5 Policy Conclusions: Towards a Sustainable Solution to Bangkok's Traffic

Based on the findings from the study of Bangkok's land use and transport development, as well as the international comparative study, this dissertation, in answer to question 8, suggests a series of land use and transport policies to help address Bangkok's traffic disaster. The new approaches encompass not only economic considerations but also environmental, energy use, human/social and land-use criteria. Although such a holistic approach has not yet been widely sought or recognised among most Thai planners, decision-makers and the public, it appears to be the only course of action capable of permanently relieving Bangkok's horrendous traffic problems. The constraints and opportunities examined by this study have also been taken into consideration in formulating the policies. Desirable models and successes from other cities around the world, particularly the Asian cities, have also been briefly examined.

The policies suggested are:

(1) giving priority to public transport, not only in the statement of policies and plans, but also in investment and implementation;
(2) commitment to and support of transit-oriented, mixed land-use development, both that which already exists, and in new development farther from the centre of Bangkok;
(3) adherence to principles of transport demand management through physical and economic means, such as imposing financial disincentives to
the purchase and operation of private vehicles and the control of parking provision;
(4) expansion of waterway transportation by improving facilities such as piers and fleets, combining them with other modes of transport, and building a more extensive network of canals;
(5) facilitation of walking and cycling, particularly by providing attractive footpaths, bicycle ways and bicycle parking; and
(6) institutional reform of Bangkok's transport decision-making structure by upgrading existing agencies so that they have the authority to address all relevant transport and land-use issues.

Figure 8.1 summarises the overall findings of the study in schematic terms, showing the suggested roots of the traffic disaster and recommended policy responses.

For the measures proposed above to have any hope of gradually changing Bangkok into a more liveable and ecologically sustainable city, the major actors are the local and national government. It is vital that government employ a fundamentally different approach. This approach would elevate planning for "the common good" above sectional private interests. In addition, there is a desperate need for strong political will. A major factor in achieving consistent policy and effective implementation for traffic improvement in Bangkok is public understanding and participation. The government should therefore provide to the public, comprehensive and unbiased information about major plans and projects. Moreover, to win public support for the implementation of these policies, particularly the control of private vehicle use, an aggressive and continuous public education and information campaign must be undertaken, simultaneously with development of viable alternatives. Public hearings and other participatory processes should also be conducted, as has been done in other countries, as part of the decision-making process, to minimise the serious conflicts currently occurring among agencies and different interest groups.

As already suggested in this dissertation, public participation can contribute enormously to stimulating the government to address traffic problems. Thus, with the encouragement of government, Bangkok's residents should persevere with their nascent demands for participation through all available channels, such as organising workshops, seminars, expressing their ideas
Figure 8.1 The roots of Bangkok's traffic disaster and suggested policies for more sustainable transport and a more liveable Bangkok
through mass media, and participating in the decision-making processes related to proposed transport policies and plans. All of these processes, however, will be greatly enhanced if they have the support of government and major proponents of development. Moreover, the NGOs have high potential to be major facilitators in stimulating the formulation and implementation of the suggested policies, as well as disseminating information to the public.

8.2 FURTHER STUDIES

In addition to the findings and policies suggested in this study, some further studies are recommended.

8.2.1 Public Participation

As noted in this study, public participation can play a vital part in developing alternatives and implementing sustainable transport policies. Due to time and financial constraints, a comprehensive study of public participation, including the NGOs' role, could not be conducted as part of the current research. It would be worthwhile to investigate in detail the views of the community at large and of the relevant NGOs with respect to Bangkok's traffic problems and to canvass their possible options for participation in addressing traffic problems.

8.2.2 Political Issues

Apart from institutional fragmentation, past experience has shown that politics is also a significant factor affecting the implementation of transport and land-use policies in Bangkok, and indeed in any city (see Dariere, 1995; Pike and Rujopakarn, 1996). Although it is not a simple task to undertake a comprehensive study of political issues, such a study, possibly undertaken by specialists in urban politics or political economy, could assist in contextualising the findings of this research and identifying particular political constraints and opportunities. Such a study could fruitfully examine the policy environment and political context of the automobile industry in Thailand and what might be needed in this area of industrial policy and trade for a reduction in the rate of growth in car ownership and use in Bangkok. Relationships with Japanese and other overseas car
manufacturers, as well as international aid/lending institutions could be a useful focal point of such a study.

8.2.3 Cultural Issues

Another factor likely to be significant in addressing traffic issues in Bangkok is the distinct characteristics of Thai culture (see Watanabe, 1996). This dissertation could only briefly examine the effects of Thai culture on vehicle ownership and use. Apparently, no systematic study has been conducted on this issue. Thus, to obtain a better understanding of the contribution of cultural factors to traffic issues and possible ways to address these issues, a comprehensive study is required.

8.2.4 Macro-economic issues

Some analysts in the literature reviewed argued that to solve traffic problems in Bangkok, a change in the distribution of the country's prosperity to rural area is required (see, for example, Santiwong, 1995; Wongphiromsant, 1996). They suggest the development of rural areas so that rural people can sustain their life in their home places, thus choosing not to migrate to Bangkok and its vicinity. This issue needs to be addressed. It is clear that a reduction in Bangkok's population, or at least its growth, would decrease overall demand for travel. Thus, further investigations are required to explore the implications of rural development for Bangkok's traffic problems. This is a highly complex matter, however, and is beyond the scope of the current research.

8.2.5 Control over Land-Use in Bangkok

As noted in this thesis, considerable development is occurring within Bangkok and its surroundings in the form of ad hoc residential development with a range of densities and styles. These developments are more or less totally car-dependent or at least, motor cycle-dependent. Public transport services do not reach them and they are located off the main road corridors along lesser connecting roads and often completely surrounded by rural land.

Prevention of this kind of sprawling, car-based development is a challenge in any city, but is generally much more challenging in developing countries.
where traditions of physical planning control are often weak. Where this situation exists, control over land use development, its form and location, can be partially gained by more effective control over the type and location of major transport infrastructure (e.g. road or rail), due to the fact that improved accessibility of given locations usually acts as a magnet to new development. It is, however, desirable to put into place more direct controls over where new development can and cannot occur and over the form it takes.

It is beyond the scope of this study to look in detail at town planning in Bangkok, its strengths and weaknesses and its legal framework, but clearly greater control over the development described above would ease the still worsening traffic burden in Bangkok. A study which attempted to examine Bangkok's land use planning laws and policy environment with a view to finding out what is needed to strengthen land use controls, would obviously be beneficial and would supplement the findings of this thesis.

8.2.6 Overcoming Institutional Fragmentation in Transport Policy and Decision-Making in Bangkok

Quite clearly, the issue of institutional fragmentation in the transport field in Bangkok is a vexed issue. It is one thing to suggest a new structure and quite another to put it in place. Specific work is needed on the political process whereby such a difficult problem might be unravelled. It may perhaps be necessary to examine the detailed history of the origins of this fragmentation and the key underlying factors which keep it so firmly in place.

8.2.7 Modelling Alternative Transport and Land-Use Scenarios Based on the Findings of This Study

In order to quantitatively test the detailed traffic and environmental results of moves in the policy directions suggested by this thesis, some specific modelling could be undertaken. As suggested earlier, such modelling could constitute a more constructive and vision-oriented approach to transport planning than currently exists in Bangkok and would provide an even firmer basis to move in the directions suggested. However, such modelling would have to go beyond existing methods which do not consider non-motorised modes and which are not adequate in their treatment of public transport.
8.3 CONCLUDING COMMENTS

In summary, this dissertation demonstrates that to address the complex and severe traffic problems in Bangkok, it is necessary to examine the physical planning roots of the problem. The superficial explanations and solutions proposed to date have not solved the problem. On the contrary, they have served to aggravated the crisis. The study of the historical development of Bangkok's transport and land use and the international comparative study employed by this research suggest that the main root of the traffic crisis is a mismatch among city structure, transport infrastructure and transport patterns, resulting from policy and investment decisions biased towards road-based transportation. The policies recommended by this dissertation extend beyond conventional policy approaches, which emphasise provision of road infrastructure to meet growing traffic demands. These policies also embrace principles of ecological sustainability and address a range constraints and opportunities in the Bangkok context. The success of the recommended policies also relies on major actors, the government and public, including NGOs.

While the prospect of redressing the huge traffic problems in Bangkok is formidable, there is considerable hope, not the least of which is Bangkok's existing urban form which is inherently favourable to public transport, especially rail, as well as to high levels of walking and cycling. Provision of well-planned infrastructure for these modes could potentially yield significant reductions in car and motor cycle use within a short number of years. Cities in the North on the other hand, which are already much more highly dependent on the automobile, not only have to build the public transport and non-motorised mode infrastructure necessary to lessen this dependence, but they must also selectively reshape their land use patterns to support higher public transport and non-motorised mode use.

The approaches discussed in this dissertation, taken together, could direct Bangkok toward a more liveable and ecologically sustainable future. Such a change will not come tomorrow. But eventually, perhaps in a decade or more, a more sustainable future will be reached. The hope expressed above illumantes a better future, not only for the residents of Bangkok, but also for those in other places who experience the negative environmental impacts which such a large polluted city creates.
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## APPENDIX A

### Bangkok Data Sheet

<table>
<thead>
<tr>
<th>INDICATORS</th>
<th>1970</th>
<th>1990</th>
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<tbody>
<tr>
<td><strong>POPULATION AND AREA</strong></td>
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<td>Bangkok Metropolitan Area</td>
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<td>Greater Bangkok Area</td>
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<td>JICA study area</td>
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<td>Urbanised area (ha)</td>
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<td>Number of jobs in the inner city</td>
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<tr>
<td><strong>PARKING SUPPLY IN THE CBD</strong></td>
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4. Parking supply data from JICA, 1990
5. Road network data from F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975; JICA, 1990
6. Motor vehicle on register data from Bongsadadt, 1973: The Analysis or Bangkok & Thonburi Transportation; Department of Land Transport, 1990
7. Private transport indicators data calculation based on data from F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975; JICA, 1990; Kasetsart University and Sindhru Pike Bodell, 1994 (see Chapter 3 for methodology)
8. Transport energy use data calculation based on data from Petroleum Authority of Thailand, 1990 (see Appendix C)
10. Average trip lengths data from F.H. Kocks KG and Rhein-Ruhr-Ing.-GMBH, 1975; JICA, 1990
13. Average bus, train and boat trip lengths from JICA, 1990
14. Passenger kilometres on buses, trains and boats calculation based on number of passengers and average trip lengths
16. Energy consumption for buses calculation based on data from Petroleum Authority of Thailand, 1990 (see Appendix C). Energy consumption for trains calculation based on data from SRT, 1990 (see Chapter 3). Energy consumption for boats calculation based on data from Department of Energy and Promotion, 1993
## STANDARDISED DATA

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### PUBLIC TRANSPORT PARAMETERS

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#### Passenger trips per person

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#### Passenger trips per vehicle kilometre

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#### Passenger kilometres per person

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#### Average speed of public transport (km/h)

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</tr>
</tbody>
</table>

#### Vehicular energy efficiency (MJ/km)

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buses</td>
<td>?</td>
<td>33.07</td>
</tr>
<tr>
<td>Rail</td>
<td>?</td>
<td>34.45</td>
</tr>
<tr>
<td>Trams</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ferries</td>
<td>?</td>
<td>26.98</td>
</tr>
<tr>
<td>Overall</td>
<td>?</td>
<td>32.96</td>
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</table>

#### Modal energy efficiency (MJ/pass km)

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buses</td>
<td>?</td>
<td>1.58</td>
</tr>
<tr>
<td>Rail</td>
<td>?</td>
<td>0.47</td>
</tr>
<tr>
<td>Trams</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ferries</td>
<td>?</td>
<td>1.73</td>
</tr>
<tr>
<td>Overall</td>
<td>?</td>
<td>1.57</td>
</tr>
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</table>
## APPENDIX B

### Rail Route Length in Global Cities, 1990

<table>
<thead>
<tr>
<th>Cities</th>
<th>Heavy Rail (km)</th>
<th>Light Rail/ Tramway (km)</th>
<th>Total (km)</th>
<th>Population</th>
<th>Route length per cap m/1000 persons</th>
<th>Urbanised area (ha)</th>
<th>Route length density (m/1000ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>US Cities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boston</td>
<td>500</td>
<td>50</td>
<td>550</td>
<td>4,056,947</td>
<td>135</td>
<td>361,559</td>
<td>1,521</td>
</tr>
<tr>
<td>Chicago</td>
<td>981</td>
<td>0</td>
<td>981</td>
<td>7,261,166</td>
<td>135</td>
<td>410,380</td>
<td>2,390</td>
</tr>
<tr>
<td>Denver</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,787,928</td>
<td>0</td>
<td>118,840</td>
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<tr>
<td>Detroit</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,912,679</td>
<td>0</td>
<td>289,940</td>
<td>0</td>
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<td>Houston</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,462,529</td>
<td>0</td>
<td>304,930</td>
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<td>Los Angeles</td>
<td>0</td>
<td>360</td>
<td>360</td>
<td>8,665,164</td>
<td>41</td>
<td>370,878</td>
<td>97</td>
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<td>0</td>
<td>1,207.2</td>
<td>16,409,019</td>
<td>839</td>
<td>958,372</td>
<td>1,575</td>
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<tr>
<td>Phoenix</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,122,101</td>
<td>0</td>
<td>191,940</td>
<td>0</td>
</tr>
<tr>
<td>San Francisco</td>
<td>360</td>
<td>0</td>
<td>360</td>
<td>3,686,592</td>
<td>64</td>
<td>226,390</td>
<td>1,049</td>
</tr>
<tr>
<td>Washington</td>
<td>360</td>
<td>0</td>
<td>360</td>
<td>3,524,913</td>
<td>104.7</td>
<td>244,660</td>
<td>1,508</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>354.8</td>
<td>11.3</td>
<td>366.1</td>
<td>5,798,704</td>
<td>52.6</td>
<td>347,709</td>
<td>814</td>
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<tr>
<td><strong>Australian Cities</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adelaide</td>
<td>128</td>
<td>11.4</td>
<td>139.4</td>
<td>1,023,378</td>
<td>136.2</td>
<td>87,045</td>
<td>1,601</td>
</tr>
<tr>
<td>Brisbane</td>
<td>196</td>
<td>10.4</td>
<td>196</td>
<td>1,333,773</td>
<td>147.0</td>
<td>136,338</td>
<td>1,438</td>
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<tr>
<td>Melbourne</td>
<td>336</td>
<td>342.0</td>
<td>678</td>
<td>3,022,910</td>
<td>248.3</td>
<td>202,698</td>
<td>3,345</td>
</tr>
<tr>
<td>Perth</td>
<td>63</td>
<td>0</td>
<td>63</td>
<td>1,142,646</td>
<td>55.1</td>
<td>107,463</td>
<td>596</td>
</tr>
<tr>
<td>Sydney</td>
<td>850</td>
<td>36</td>
<td>853.6</td>
<td>3,539,033</td>
<td>241.2</td>
<td>210,407</td>
<td>4,057</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>314.6</td>
<td>119.2</td>
<td>336.9</td>
<td>2,022,348</td>
<td>160.8</td>
<td>146,790</td>
<td>2,205</td>
</tr>
<tr>
<td><strong>European Cities</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Amsterdam</td>
<td>41</td>
<td>123.9</td>
<td>164.9</td>
<td>702,731</td>
<td>234.7</td>
<td>14,392</td>
<td>11,458</td>
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<tr>
<td>Brussels</td>
<td>95</td>
<td>134.0</td>
<td>229.0</td>
<td>964,385</td>
<td>237.5</td>
<td>12,872</td>
<td>17,791</td>
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<td>Copenhagen</td>
<td>284</td>
<td>0</td>
<td>284</td>
<td>1,711,254</td>
<td>166.0</td>
<td>99,285</td>
<td>4,739</td>
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<td>Frankfurt</td>
<td>292</td>
<td>70.3</td>
<td>362.5</td>
<td>2,802,816</td>
<td>208.8</td>
<td>65,367</td>
<td>5,117</td>
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<td>Hamburg</td>
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<td>0</td>
<td>290.7</td>
<td>2,470,000</td>
<td>117.7</td>
<td>77,676</td>
<td>3,742</td>
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<td>London</td>
<td>394.4</td>
<td>3,220.6</td>
<td>3,615</td>
<td>17,380,000</td>
<td>247.1</td>
<td>585,841</td>
<td>6,221</td>
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<tr>
<td>Munich</td>
<td>60.5</td>
<td>85.3</td>
<td>145.8</td>
<td>2,296,870</td>
<td>285.7</td>
<td>64,616</td>
<td>8,571</td>
</tr>
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<td>Paris</td>
<td>1,833</td>
<td>0.1</td>
<td>1,833.1</td>
<td>10,661,937</td>
<td>171.9</td>
<td>231,085</td>
<td>7,933</td>
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<td>Stockholm</td>
<td>288</td>
<td>5.7</td>
<td>293.7</td>
<td>1,641,669</td>
<td>178.9</td>
<td>44,555</td>
<td>6,538</td>
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<tr>
<td>Vienna</td>
<td>272</td>
<td>225.9</td>
<td>498.9</td>
<td>1,500,000</td>
<td>332.0</td>
<td>22,547</td>
<td>22,097</td>
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<tr>
<td>Zurich</td>
<td>427</td>
<td>120.2</td>
<td>547.2</td>
<td>787,740</td>
<td>694.6</td>
<td>16,731</td>
<td>32,706</td>
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<tr>
<td><strong>Average</strong></td>
<td>386.4</td>
<td>365.0</td>
<td>751.4</td>
<td>3,872,491</td>
<td>361.3</td>
<td>106,725</td>
<td>11,536</td>
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<tr>
<td><strong>Richer Asian Cities</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>77.2</td>
<td>40.1</td>
<td>117.3</td>
<td>5,522,281</td>
<td>21.2</td>
<td>18,380</td>
<td>6,382</td>
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<td>Singapore</td>
<td>67.0</td>
<td>67.0</td>
<td>67.0</td>
<td>2,705,115</td>
<td>24.8</td>
<td>31,160</td>
<td>2,150</td>
</tr>
<tr>
<td>Tokyo</td>
<td>2,142.2</td>
<td>172</td>
<td>2,315.4</td>
<td>31,796,702</td>
<td>67.9</td>
<td>440,000</td>
<td>4,820</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>762.1</td>
<td>28.7</td>
<td>781.2</td>
<td>13,341,366</td>
<td>38.9</td>
<td>165,847</td>
<td>4,451</td>
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<td><strong>Southeast Asian Cities</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangkok</td>
<td>120</td>
<td>120.0</td>
<td>240.0</td>
<td>7,639,342</td>
<td>15.7</td>
<td>96,914</td>
<td>1,228</td>
</tr>
<tr>
<td>Jakarta</td>
<td>55.0</td>
<td>55.0</td>
<td>55.0</td>
<td>9,387,000</td>
<td>5.5</td>
<td>48,129</td>
<td>1,143</td>
</tr>
<tr>
<td>Kuala Lumpur</td>
<td>47.0</td>
<td>47.0</td>
<td>94.0</td>
<td>3,125,355</td>
<td>15.0</td>
<td>17,654</td>
<td>2,662</td>
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<tr>
<td>Manila</td>
<td>62.0</td>
<td>15.0</td>
<td>77.0</td>
<td>7,946,392</td>
<td>9.7</td>
<td>40,135</td>
<td>1,919</td>
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<tr>
<td><strong>Average</strong></td>
<td>71.0</td>
<td>15.0</td>
<td>76.0</td>
<td>7,025,022</td>
<td>11.6</td>
<td>50,708</td>
<td>1,705</td>
</tr>
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</table>

Sources: 1. Bangkok route length data from State Railway of Thailand’s train timetable and measured from Bangkok Map.  
4. Brussels’s Suburban heavy rail measured and calculated based on Brussels map.  
9. Population for Bangkok is Greater Bangkok  

Note: Bangkok data are for the Greater Bangkok Area (GBA)
# APPENDIX C

## Energy Use in Road Transport in Bangkok, 1990

<table>
<thead>
<tr>
<th>Transport Mode</th>
<th>Total fuel consumption per year (mill. litres)</th>
<th>Total energy consumption per year (000 MJ)</th>
<th>Energy consumption by mode (000 MJ)</th>
<th>Energy consumption per capita (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gasoline</td>
<td>HSD</td>
<td>LPG</td>
<td>Gasoline</td>
</tr>
<tr>
<td>Cars</td>
<td>1,052.00</td>
<td>42.30</td>
<td>18.00</td>
<td>36,493,880</td>
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<tr>
<td>Motorcycles</td>
<td>405.20</td>
<td>0.00</td>
<td>0.00</td>
<td>14,056,388</td>
</tr>
<tr>
<td>Taxis</td>
<td>18.30</td>
<td>1.90</td>
<td>111.00</td>
<td>634,827</td>
</tr>
<tr>
<td>Motor tricycles</td>
<td>0.50</td>
<td>0.00</td>
<td>30.40</td>
<td>17,345</td>
</tr>
<tr>
<td>BMTA Buses</td>
<td>0.00</td>
<td>223.90</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Other Buses</td>
<td>0.00</td>
<td>369.60</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Buses (Total)</td>
<td>0.00</td>
<td>593.50</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Trucks (Total)</td>
<td>0.00</td>
<td>675.70</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Total private</td>
<td>1,573.40</td>
<td>1,478.20</td>
<td>173.70</td>
<td>54,581,246</td>
</tr>
<tr>
<td>Total</td>
<td>1,573.40</td>
<td>2,071.70</td>
<td>173.70</td>
<td>54,581,246</td>
</tr>
</tbody>
</table>

Source: 1. Interpolation and calculation based on fuel consumption by transport mode data from Petroleum Authority of Thailand, 1990

Notes: 1. Conversion for each 1 litre of fuel to energy
   - Gasoline 1 litre = 34.69 MJ
   - Diesel (HSD) 1 litre = 38.29 MJ
   - LPG 1 litre = 26.26 MJ
2. Population in Greater Bangkok Area 1990 = 7.639342 million
3. HSD stands for high speed diesel.
APPENDIX D

Metropolitan Area Definitions

Introduction

The following description of the metropolitan areas of the other cities to which Bangkok is compared is derived directly from Laube (1997). Data collection on these cities was carried out by others in the wider global cities project, as acknowledged in the main body of the thesis.

The metropolitan area is defined as the functional urban area of a city. This wording removes the definition away from what the administrative boundaries of a particular territorial unit may be that carries the name of the city under whose name the area is generally known. For example, the City of Sydney, whose name is commonly used to describe a metropolitan area with a population of over 3 million, only contains the most central part of this area, home to only a fraction of the number of people. Most national statistical systems recognise this problem and have created criteria that define the outer boundary of functional urban areas. The most common amongst these relate to home and work locations of residents, where there is often a certain percentage of workers required to work inside the metropolitan area for a territorial unit at its fringe to be included or excluded. Likewise, the structure of the urbanised area can be used, whereby there is a maximum gap in the urbanisation defined which is allowable for a marginal outlying settlement to be included. In practice, variations on such definitions are used, depending on data availability. Sometimes, for reasons of inadequate data, it is necessary to take an area which is less than the true functional urban region. Nevertheless, data can still be compared as long as the data remain internally consistent. Comparison of individual data items between individual cities can be done with a full awareness of the exact areas being compared, using the metro area definitions provided below.

In Australia, all the studied metropolitan areas are well defined in the census statistical system and known as Statistical Divisions. In the United States, the census defines Standard Metropolitan Statistical Areas (SMSAs) for every census, according to its data on urbanised areas, which
are based on one or several Counties that are in part urbanised. Europe presents a mixed situation, with some metropolitan areas being roughly equal to a traditional city state, others forming a province or region in the respective national administrative system, and yet others very difficult to equate to administrative units. In Asia, the situation is at times more difficult again, with the exception of Hong Kong and Singapore, where national boundaries equate the boundary of the functional region reasonably well.

**Specific metropolitan area definitions**

The following provides an alphabetical listing of the definitions of all the metropolitan areas to which Bangkok is compared.

In **Adelaide**, the metropolitan area is defined as the Adelaide Statistical Division, for which good data is available as it is a definition used by all agencies across the board. It is also a good description of the functional region.

For **Amsterdam**, there are two definitions that were used. Most data relate to a definition of the Amsterdam agglomeration which includes the Gemeenten (municipalities) of Amstelveen, Amsterdam, Diemen and Ouder-Amstel, though for some data, it was only possible to retrieve it for Amsterdam, which contains 87% of the agglomeration's population, but is actually a discontinuous unit with Diemen sitting in between the two parts. Given the high proportion of the population covered by the smaller definition, there aren't really any major problems to be expected from its use where no wider data could be found. This definition is a tight one, but the data situation makes it difficult to expand it without taking in the entire Randstad, a major multi-nuclear urban conglomeration, home to a good part of the Netherlands' population. Due to its very compact character, its situation on mostly reclaimed land and the very planned and systematically developed layout of Amsterdam and its neighbouring cities, it seems reasonable that the sample presented here gives a good impression of an even wider area.
In Boston, there are two definitions. Most data have been collected for the Standard Metropolitan Statistical Area as defined by the United States Bureau of the Census in 1980, comprising 103 towns. Some agencies however use a larger definition named the Greater Metropolitan Region of Boston which consists of 164 towns and this therefore had to be used where applicable. Both areas represent an acceptable definition.

In Brisbane, the metropolitan area is defined as the Brisbane Statistical Division, for which good data are available. It is also a good description of the functional region, despite covering a large territory, which contains large genuinely unpopulated areas. On some, isolated occasions, data were only available for a larger area called Southeast Queensland, which includes the Brisbane and Moreton Statistical Divisions, thus expanding the covered area to the coastal holiday resort strips of Gold Coast and Sunshine Coast to the north and south of Brisbane, which are essentially urban in character.

Brussels is defined as the Brussels Capital Region, which is one of three Regions in Belgium and for which good data are available. The functional region has however somewhat outgrown this area, but the data situation outside this boundary is complicated as the former province of Brabant which contains the hinterland of Brussels has been divided into its Flemish and Wallonian parts, and data, where available, would have to be assembled by individual municipalities. This is in stark contrast with the situation for the Capital Region alone, so it was seen to be more valuable to present a high quality set of data for this area alone.

The Chicago agglomeration extends well into the State of Indiana in the South, and into the State of Wisconsin in the North. To keep the data collection manageable, it was however necessary to constrain the definition to six counties in the State of Illinois, which contains the majority of the region. These counties are Cook, Du Page, Kane, Lake MacHenry and Will and are also known as the Northeastern Illinois Planning Commission Area.

Good data for the Copenhagen functional region are available for a territory called 'Hovedstadsregionen' or the Danish Capital Region,
containing the independent cities of København and Frederiksberg, as well as the counties of København, Frederiksborg and Roskilde.

In Denver, there are two main definitions, namely the official Standard Metropolitan Statistical Area, including the counties of Adams, Arapahoe, Boulder, Clear Creek, Denver, Douglas, Gilpin and Jefferson. For most data however, the more marginal, much less developed counties of Clear Creek, Gilpin and Douglas have been eliminated from this definition. This area still contains significant genuinely rural areas, especially in the east end, and most modelled data applies to definitions that are independent of county boundaries. Where this was the case, the correct populations have been used in the standardisation process.

For Detroit, a somewhat reduced version of the Standard Metropolitan Statistical Area was used as the outer counties of Lapeer, Livingston and St. Clair only have a very small population and are generally rural in character. The counties included are thus Macomb, Oakland and Wayne.

Frankfurt is really part of a multinuclear agglomeration called the Rhein-Maingebiet. This area encompasses the cities of Mainz and Wiesbaden in the west, Darmstadt in the south and Hanau in the east of Frankfurt. The administrative boundaries of this large area are exceedingly complicated and regional co-operation is in its early stages, which means that consistent regional data are mostly unavailable. For this study, the Stadt (City of) Frankfurt am Main was used for most data, with some public transport data relating to a larger region serviced by the Frankfurter Verkehrsverbund (FVV).

The traditional city state of (Freie- und Hansestadt) Hamburg contains most of the Hamburg functional metropolis. As it is a state in its own right within the Federal Republic of Germany, there are excellent data available for this definition throughout. Only the public transport data relate to the somewhat larger area serviced by the Hamburger Verkehrsverbund (HVV) for which the appropriate population was used.

Hong Kong is very well represented by the area included in the British Crown Territory of Hong Kong, and good, well-published data are available throughout.
The **Houston** Standard Metropolitan Statistical Area includes the six counties of Brazoria, Fort Bend, Harris, Liberty, Montgomery and Waller. Galveston is excluded as it is considered to be a separate conurbation. This is a wide definition, but good data are available for this area.

The Indonesian National Capital District of Jakarta (Daerah Khusus Ibukota Jakarta) serves as a fair representation of the **Jakarta** metropolitan area. It is a little constrained as the city has somewhat outgrown this area. The definition is however acceptable as it enables data collection of reasonable quality.

The **Kuala Lumpur** area is most commonly defined as the Klang Valley, which includes the Federal Territory of Kuala Lumpur as well as four districts (Klang, Petaling, Ulu Langat and Gombak) in the State of Selangor which surrounds it. This is a very appropriate definition and was used for all but few data, where they were only available for the entire State of Selangor and the Federal Territory of Kuala Lumpur.

**London** was defined as the area commonly referred to as Greater London. This area represents only the core of the much wider Southeast England metropolitan area. Greater London alone however produces consistent data over its territory, which has meant that this definition had to be used.

**Los Angeles** is part of a larger conurbation covering a good part of Southern California. This complicated situation has meant that the Los Angeles Standard Metropolitan Statistical Area is considerably smaller than the Los Angeles Census Urbanized Area, two definitions that are usually only marginally different, with the latter generally being smaller. For the purpose of this study, all data collected refers to Los Angeles County only, thus leaving out the five other counties that could be included, namely Imperial, Orange, Riverside, San Bernardino and Ventura. As this larger area is genuinely decentralised, it can be considered fair to look at this one county only. Also, a check on some key data items such as vehicle kilometres per capita reveals little variation between Los Angeles County and the wider area.
For **Manila**, the co-operative body of Metro Manila has reasonably good data for what covers most of the conurbation. Metro Manila includes the four cities of Caloocan, Manila, Pasay and Quezon as well as the municipalities of Las Piñas, Makati, Malabon, Mandaluyong, Marikina, Muninlupa, Navotas, Parañaque, Pasig, Pateros, San Juan, Taguig and Valenzuela which are spread over two provinces.

In **Melbourne**, the metropolitan area is defined as the Melbourne Statistical Division, for which good data are available as it is a definition used by all agencies across the board. It is also a good description of the functional region.

**Munich**'s peculiar urban form with a core and spines along it's radial S-Bahn suburban express rail system with rural areas in between the spines means that what is known as Planungsregion 14 in Bavaria should really be used as a metropolitan definition. This area however cuts across district (Landkreis) boundaries and data availability is poor. The solution had to be to report data on the Landeshauptstadt (City of) München only, which covers most of the central part of this agglomeration. There, good data are available, though for some data such as for public transport, larger areas are used with appropriate adjustments to population.

The metropolitan area of **New York** extends into three states and data collection is therefore sometimes difficult, though some co-ordination on a regional level exists, which is helpful. This made it possible to use a comprehensive definition that includes the following territorial units: State of Connecticut Planning Regions of Central Naugatuck Valley, Greater Bridgeport, Housatonic Valley, South Central, Southwestern and Valley; State of New Jersey Counties of Bergen, Essex, Hudson, Middlesex, Monmouth, Morris, Passaic, Somerset and Union; State of New York Counties of Bronx, Dutchess, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk and Westchester.

The Région d'Ile-de-France gives an excellent definition of the **Paris** metropolitan area, for which equally good data are consistently available.
In Perth, the metropolitan area is defined as the Perth Statistical Division, for which good data are available as it is a definition used by all agencies across the board. It is a good representation of the metropolitan area, although the recently fast growing City of Mandurah to the south of it should probably be included.

Phoenix is defined as Maricopa County which contains the metropolitan area but also includes large, mostly unpopulated desert areas to the west of it.

The San Francisco metropolitan area, also termed the Bay Area has been defined as a five county area including Alameda, Contra Costa, Marin, San Francisco and San Mateo Counties. Other counties in the vicinity that are often seen as part of that area are Napa, Santa Clara, Solano and Sonoma Counties. Apart from Santa Clara, these counties are truly marginal, and their inclusion would have significantly complicated the data collection task. Santa Clara has its own genuine core with San Jose, which the US Census in fact considers a separate urbanised area.

In Singapore, national boundaries provide a good definition, although there is some interaction mainly with Johor Bahru in adjacent Malaysia. The Republic of Singapore has been used for all data. Good information is available through national agencies.

Stockholm presented some more difficulties, with the true metropolitan area represented by Stockholms Län (County), although it contains vast, mainly forested areas. The data availability for the County however is low and it was necessary to resort to using Stockholms Staden (City) only on a consistent basis. It was however possible to retrieve some data on a County level, especially on private and public transport, in which case appropriate population data were used.

The Kotamadnya Surabaya covers a good part of the Surabaya functional region and was thus used as a metropolitan area definition.

In Sydney, the metropolitan area is defined as the Sydney Statistical Division, for which good data are available. It is a good representation of
the metropolitan area, extending to Wyong in the North but excluding Wollongong in the South.

Tokyo is generally defined as Tokyo-to or Tokyo Metropolis. However, the functional region extends well beyond this narrow definition which only contains one third of the area's inhabitants. The Tokyo Metropolitan Region that was used wherever possible includes additionally the prefectures of Chiba-to, Kanagawa-to and Saitama-to.

Vienna is a city state within the Republic of Austria, which is equal to the Stadt Wien, for which excellent data are kept. The functional region extends somewhat outside those boundaries, but data availability deteriorates dramatically.

Washington's metropolitan area extends over the District of Columbia and into the two adjacent states of Maryland and Virginia. The definition that was used corresponds to the 1980 Standard Metropolitan Statistical Area and includes the District of Columbia, Montgomery and Prince Georges Counties in the State of Maryland, and in the State of Virginia the Counties of Arlington, Fairfax, Loudoun and Prince Williams, as well as the independent Cities of Fairfax, Falls Church, Manassas and Manassas Park. Data collection for this tri-state area was complicated, but a comprehensive set of data was collected.

The agglomeration of Zurich is defined by the Swiss census according to a large number of Gemeinden (municipalities) which spread across two Kantone (States). As data collection for this complicated definition would have been a very difficult task indeed, and taking the entire Kanton Zürich would have included large rural areas in its north, a definition using Planungsregionen (Planning districts) that correspond reasonably well with the census agglomeration was applied. The following Planungsregionen were included: Furttal, Glattal, Knonauer Amt, Limmattal, Pfannenstil, Zimmerberg and Zürich. It was possible to retrieve reasonable data for this definition.