ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

ROAD TRANSPORT AND THE ENVIRONMENT

AREAS OF CONCERN FOR THE ASIAN AND PACIFIC REGION

UNITED NATIONS

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UNITED NATIONS
New York, 1997

ST/ESCAP/1840

This publication was prepared with the help of T.F. Fwa and M.A. Aziz, and with financial assistance from the Government of Germany through GTZ German Technical Cooperation.

CONTENTS

			Page
LIST OF TABLES			ix
LIST OF FIGURES			x
ABBREVIATIONS			xi
1	**INTRODUCTION**		**1**
	1.1	Background and objectives of study	1
	1.2	Methodology of study	2
	1.3	Structure of the report	2
2	**CURRENT SITUATION IN ASIA-PACIFIC COUNTRIES**		**4**
	2.1	Economic outlook for Asia-Pacific countries	4
	2.2	Urbanization in Asia-Pacific countries	4
	2.3	Motorization in Asia-Pacific countries	7
	2.4	Road transport infrastructure development in Asia-Pacific countries	10
	2.5	Road transport and the environment	13
	2.6	Road transport assistance activities by international organizations	14
		2.6.1 Examples of activities and programmes	14
		2.6.2 Benefits and effectiveness of assistance programmes	23
	2.7	Economic groundings of countries	23
		2.7.1 Basis for grouping of countries	25
		2.7.2 Road transport features of countries by groping	25
	2.8	Summary	27
3.	**MAJOR AREAS OF ENVIRONMENTAL CONCERN IN ROAD TRANSPORT SECTOR**		**29**
	3.1	Road transport and environment	29
	3.2	Environmental impacts of road transport	29
		3.2.1 Vehicular impacts	29
		3.2.2 Safety and operational impacts	29
		3.2.3 Roadway impacts	29
		3.2.4 Impacts during construction	29
	3.3	Matrix of environmental impacts and road transport system stages	31
	3.4	Environmental impacts of roads and traffic	32
		3.4.1 Vehicular impacts	33
		3.4.2 Road related problems	49
		3.4.3 Safety and capacity impacts	49
		3.4.4 Roadway impacts	58
		3.4.5 Construction impacts	60
	3.5	Summary of various impacts	60
		3.5.1 Impacts on natural environment	60
		3.5.2 Impacts on man-made environment	60
		3.5.3 Impacts on human welfare	61
		3.5.4 Socio-economic impacts	61

Page

3.6 Environmental impact assessment of proposed road transport developments 61
3.6.1 Contents of a road transport environmental impact assessment 62
3.6.2 Impact identification 62
3.6.3 Impact prediction/assessment 62
3.7 Sources of road transport related environmental problems 62
3.7.1 Vehicle related problems 63
3.7.2 Road related problems 64
3.7.3 User related problems 65
3.7.4 Policy and management related problems 65
3.8 Issues and problems in road transport policy and management 65
3.8.1 Institutional and financial problems 65
3.8.2 Technical, organizational, and human resource problems 66
3.8.3 Lack of integrated approach to policy formulation and ineffective policy implementation 67
3.8.4 Lack of integrated multi-modal road transport system 67
3.8.5 Lack of technological capability and trained manpower 67
3.8.6 Lack of adequate information system 67
3.9 Summary 68

4 **MEASURES TO REDUCE ADVERSE ENVIRONMENTAL IMPACTS** 70
4.1 Traffic management systems 70
4.1.1 Area traffic control 71
4.1.2 Traffic restraint measures 71
4.1.3 Measures to increase road capacity 73
4.2 Demand management in road transport 74
4.2.1 Road transport pricing measures 74
4.2.2 Vehicle ownership restraint measures 75
4.2.3 Decentralization of commercial centres 75
4.2.4 Measures to reduce work trips 75
4.3 Promoting the use of public transport system 76
4.3.1 Mass transit options 76
4.3.2 Efficient management of bus service 78
4.3.3 Roles of paratransit 80
4.4 Transportation and socio-economic planning 81
4.5 Zero-emission vehicles 82
4.5.1 Electric vehicles 82
4.5.2 Non-motorized vehicles 84
4.6 Use of environmentally friendly fuels 85
4.6.1 Unleaded petrol 85
4.6.2 Alcohol fuels 86
4.6.3 Natural gas (LPG and CNG) 86
4.6.4 Hydrogen 88
4.7 Regular and effective vehicle inspection and maintenance programme 90
4.8 Noise abatement measures 90
4.8.1 Reducing vehicle noise at the source 90
4.8.2 Noise reduction by regulating traffic flow 91
4.8.3 Noise barriers and insulation 91
4.8.4 Traffic noise control through integrated transportation planning and road design 91

		Page
4.9	Air pollution mitigation measures	92
4.9.1	Increasing road capacity	92
4.9.2	Integrating landuse planning	92
4.9.3	Promoting public transport	92
4.9.4	Management of vehicle ownership and use	92
4.9.5	Controlling the quality of vehicles	93
4.9.6	Exhaust/emission standards	93
4.9.7	Revitalizing the vehicle population	93
4.9.8	Legislations and regulations	93
4.9.9	Other measures	93
4.9.10	Policy instruments	94
4.9.11	Overall strategies for road transport related air pollution mitigation measures	94
4.10	Road safety	96
4.10.1	Mitigation measures	96
4.10.2	Traffic safety action programme	99
4.10.3	Coordinated road safety policies	100
4.10.4	Road infrastructure improvement	100
4.10.5	Training to inculcate good road use behaviour	101
4.10.6	Road safety database and analysis capability	101
4.11	Integrated multimodal passenger transport system	101
4.12	Environmental awareness	102
4.13	Participation of citizens and non-government organizations	103
4.14	Environmental impact assessment of road transport systems	103
4.14.1	Evaluation practices	104
4.14.2	Activities of environmental impact studies	107
4.15	Road construction and maintenance	107
4.15.1	Environmental considerations in road construction	107
4.15.2	Environmental consideration in road maintenance	108
4.16	Road transportation of dangerous goods	108
4.16.1	Present situation	108
4.16.2	Stakeholders	109
4.16.3	Responsibilities of all parties involved	110
4.16.4	Selection and monitoring of transport companies	111
4.16.5	Design and specification of equipment	112
4.16.6	Selection criteria for containers	112
4.16.7	Recruitment and training of drivers	112
4.16.8	Control of all operations	113
4.16.9	Emergency response	113
4.16.10	Common violations	114
4.16.11	General regulations governing land transportation of dangerous goods	114
4.17	Effective financing mechanisms	116
4.17.1	Private financing and public/private partnership (PPP)	116
4.17.2	Public/private cooperation and joint ventures	116
4.17.3	Innovative approaches to user charges	116

Page

4.18 Institutional roles 117
4.18.1 Rational motorization and road development policy 117
4.18.2 Environmentally conscious transport policies 117
4.18.3 Coordinated government agency involvement 118
4.18.4 Effective policy implementation and enforcement 119
4.18.5 Development of information system and database 119
4.19 Summary 119

5. **RECOMMENDED PRIORITY ACTIONS AND REGIONAL IMPLEMENTATION POTENTIALS OF ENVIRONMENTAL PROTECTION MEASURES** 124
5.1 Implementation potential of traffic management measures 125
5.1.1 Area traffic control 125
5.1.2 Traffic restraint measures 126
5.1.3 Measures to increase road capacity 126
5.2 Implementation potential of demand management measures 127
5.2.1 Road transport pricing measures 127
5.2.2 Vehicle ownership restraint measures 127
5.2.3 Decentralization of commercial centres 128
5.2.4 Measures tp reduce work trips 129
5.3 Implementation potential of measures to promote the use of public transport system 129
5.3.1 Mass transit options 129
5.3.2 Efficient management of bus service 130
5.3.3 Management of paratransit 131
5.4 Regional implementation potential of transportation and socio-economic planning 132
5.5 Regional adoption potential of zero-emission vehicles 133
5.5.1 Electric vehicles 133
5.5.2 Non-motorized vehicles 134
5.6 Regional adoption potential of environmentally friendly fuels 135
5.6.1 Unleaded petrol 135
5.6.2 Compressed natural gas (CNG) 136
5.7 Regional implementation potential of vehicle inspection and maintenance programme 138
5.8 Regional implementation potential of integrated multimodal passenger transport system 138
5.9 Implementation potential of noise abatement measures 139
5.9.1 Emission standards 140
5.9.2 Emission standards 140
5.9.3 Planning measures 140
5.9.4 Infrastructure measures 140
5.9.5 Economic instruments 141
5.9.6 Operations procedures 141
5.9.7 Research and development 141
5.9.8 Education and information 141
5.10 Regional implementation potential of air pollution mitigative measures 141
5.10.1 Vehicular emission levels 141
5.10.2 Alternative fuels 142
5.10.3 Monitoring, regulation and enforcement 142

Page

	5.10.4	Possible policy instruments	143
	5.10.5	Action programmes	144
5.11	Regional implementation potential of road safety measures		144
	5.11.1	Coordination and administration of road safety at national level	145
	5.11.2	Road accident data systems	145
	5.11.3	Funding road safety initiatives and role of insurance	145
	5.11.4	Safe planning and design of roads	145
	5.11.5	Safety improvement of hazardous locations	145
	5.11.6	Road safety education for children	146
	5.11.7	Driver training and testing	146
	5.11.8	Road safety publicity and campaigns	146
	5.11.9	Vehicle safety standards	146
	5.11.10	Traffic legislation	147
	5.11.11	Traffic police and law enforcement	147
	5.11.12	Emergency assistance to road accident victims	147
	5.11.13	Road safety research	147
5.12	Regional implementation potential of environmentally sound road construction and maintenance practices		148
	5.12.1	Environmentally sound road construction practice	148
	5.12.2	Sound road maintenance management	148
5.13	Regional implementation potentials of key issues for road transportation of hazardous goods		150
	5.13.1	Legislations, rules and regulations	150
	5.13.2	Coordination and cooperation	151
	5.13.3	Enforcement	152
	5.13.4	Education and training	153
	5.13.5	Information, risk analyses, contingency plans and emergency response	153
5.14	Environmental impact assessment (EIA) system in road transport project		154
	5.14.1	Improvement of environmental assessments	154
	5.14.2	R & D activities	155
	5.14.3	Strategic environmental impact assessment	156
	5.14.4	Environmental impact assessment at project level	157
5.15	Regional implementation potential of effective financing mechanisms		157
	5.15.1	Private financing and public/private partnership (PPP)	157
	5.15.2	Toll roads and private financing	158
	5.15.3	Public/private cooperation and joint ventures	160
	5.15.4	Innovative approaches to user charges	160
5.16	Implementation potential of environmental awareness programmes		161
	5.16.1	Environmental awareness of policy makers	161
	5.16.2	Public awareness	161
	5.16.3	Regional cooperation programmes	162
	5.16.4	Participation of citizens and non-governmental organizations	162
5.17	Enhancing institutional roles		163
5.18	Summary		164

Page

6 **SUMMARY AND CONCLUSIONS** 165
6.1 Current situation of road transport and environmental protection in ESCAP member countries 165
6.2 Environmental issues and remedial measures in road transport 165
6.3 Implementation potential of environmental protection measures in ESCAP region 166
6.4 Concluding remarks 167

REFERENCES 168

LIST OF TABLES

		Page
Table 2.1	Economic forecast for Asia-Pacific countries	5
Table 2.2	World megacities in year 2000	6
Table 2.3	Road network length and density in selected ESCAP countries	13
Table 2.4	Environment-related road transport programme areas in Asia -Pacific region by various international organizations	15
Table 2.5	Environment-related road transport programme activities in Asia-Pacific region by various international organizations	16
Table 2.6	Area, population and per capita GNP for some Asian countries	24
Table 3.1	Typical environmental impacts resulting from road transport operations and infrastructure construction	32
Table 3.2	Environment impacts of roads and traffic	33
Table 3.3	Typical road traffic noise levels	36
Table 3.4	Road traffic noise levels of some cities of the region	37
Table 3.5	Degree of hearing loss due to noise	37
Table 3.6	Emission factors for road vehicles	42
Table 3.7	Contribution of motor vehicles to air pollution in selected cities	42
Table 3.8	Estimation of emission trends in Delhi, India	43
Table 3.9	Forecasts of air pollution in selected countries of ESCAP region	43
Table 3.10	Adverse health effects of pollutants from road transport	45
Table 3.11	Road accidents and fatalities of some ESCAP member countries	50
Table 3.12	Percentage of accidents by vehicle type in some ESCAP member countries	51
Table 3.13	Generic checklist of impacts	63
Table 3.14	Typical assessment techniques for environmental impacts	64
Table 4.1	Urban mass transit systems in Asia	77
Table 4.2	Relative concern of health and safety related factors for different fuels	87
Table 4.3	Comparison of emissions of diesel and CNG engines	88
Table 4.4	Average emission values of different diesel and CNG engine concepts	89
Table 4.5	Overall strategies for road transport related air pollution mitigation measures	95
Table 4.6	Types, causes and countermeasures of pedestrian accidents	97
Table 4.7	Effects of physical safety countermeasures on accessibility and environment	98
Table 4.8	Effects of traffic safety management countermeasures on accessibility and environment	99
Table 4.9	Current status of legislation/regulations, institutions, and manpower capabilities for land transportation of hazardous materials in selected countries of the Asia-Pacific region	115
Table 4.10	Need for environmental protection measures in road transport in the ESCAP region	120
Table 5.1	Approximate estimated commercial speed for selected systems	130
Table 5.2	Predicted increase in buses required if half the number of cyclists in 1985 used buses instead of bicycles	132
Table 5.3	Share of diesel vehicles by vehicle class	136
Table 5.4	Diesel vehicle fuel consumption characteristics	137
Table 5.5	BOT transport infrastructure projects in Asia	159

LIST OF FIGURES

		Page
Fig. 2.1	Annual growth of road vehicle fleet in some ESCAP countries	7
Fig. 2.2	Road vehicle fleet populations	8
Fig. 2.3	Road vehicle composition in some ESCAP countries	8
Fig. 2.4	Population per vehicle rates in selected Asian countries, Europe, United States	9
Fig. 2.5	Average annual growth in total road network length, 1985-1992	10
Fig. 2.6	Road network density	11
Fig. 2.7	Growth in paved road length, 1985-1992	12
Fig. 2.8	Sources of external aid in the urban transport sector, 1980-1989	19
Fig. 3.1	Road transport system: inputs and outputs	30
Fig. 3.2	Environmental impacts of road transport system	31
Fig. 3.3	Effects of traffic flow, speed and composition on noise levels	35
Fig. 3.4	Constituents of vehicle exhaust emissions	39
Fig. 3.5	Interactions between various air pollutants	41
Fig. 3.6	Pollution caused by vehicle emission: propagation and reception cycle	41
Fig. 3.7	Pollution share of different vehicles in Bangkok	46
Fig. 3.8	Lead content in gasoline in selected countries	47
Fig. 3.9	Sulphur content in diesel in selected countries	47
Fig. 3.10	Percentage of road accidents in some ESCAP countries	52
Fig. 3.11	Commercial vehicle involvement in road accidents in some ESCAP countries	52
Fig. 3.12	Bus involvement in road accidents in some ESCAP countries	53
Fig. 3.13	Car involvement in road accidents in some ESCAP countries	53
Fig. 3.14	Cyclist involvement in road accidents in some ESCAP countries	54
Fig. 3.15	Pedestrian involvement in road accidents in some ESCAP countries	54
Fig. 3.16	Fatalities per 10,000 vehicles in selected ESCAP countries and UK	55
Fig. 3.17	Fatality index (deaths/total casualties as percentage) in selected countries	56
Fig. 4.1	Staff per bus ratios in selected Asian and the Pacific city bus companies	79
Fig. 4.2	Vehicle ranking for natural gas fuelling	89
Fig. 4.3	Environmental impact assessment of a road transport project - common situation	105
Fig. 4.4	Environmental impact assessment of a road transport project - full integration	106
Fig. 5.1	Mass transit passenger flows	131
Fig. 5.2	Roadside lead levels in Singapore	135
Fig. 5.3	Relation between selected policy instruments, action measures and goals	143
Fig. 5.4	Proposed world-wide toll facility projects, as at March 1994	158
Fig. 5.5	Encroachment of road route	163

ABBREVIATIONS

ADB	Asian Development Bank
ALS	Area Licensing Scheme
ASEAN	Association of South East Asian Nations
ATC	Area Traffic Control
BOO	Build-Operate-Own
BOT	Build-Operate-Transfer
CBD	Central Business District
CFC	Chloroflurocarbons
CMB	China Motor Bus
CNG	Compressed Natural Gas
COE	Certificate of Entitlement
dBA	Decibel
EC	European Community
ECE	Economic Commission for Europe
EIA	Environmental Impact Assessment
ERP	Electronic Road Pricing
FHWA	Federal Highway Administration (USA)
GRT	Guided Rapid Transit
GDP	Gross Domestic Product
GNP	Gross National Product
HDM	Highway Design and Maintenance
IRF	International Road Federation
IRRD	International Road Research Documentation
IRTAD	International Road Traffic and Accident Database
JICA	Japan International Cooperation Agency
KMB	Kowloon Motor Bus
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit
MRT	Mass Rapid Transit
MTR	Mass Transit Railway
NCTS	National Centre for Transportation Studies (Philippines)
NMV	Non-Motorized Vehicle
ODA	Overseas Development Organization (UK)
OECD	Organization for Economic Cooperation and Development
PIARC	Permanent International Association of Road Congresses
PLB	Public Light Bus
PSL	Passenger Service License
PMS	Pavement Management System
RTR	Road Transport Research
REAAA	Road Engineering Association of Asia and Australasia
SEIA	Strategic Environmental Impact Assessment
SUSTRAN	Sustainable Transport Action Network
TBA	Tertiary Butyl Alcohol
URA	Urban Redevelopment Authority
USEPA	United States Environmental Protection Agency
VQS	Vehicle Quota System
WHO	World Health Organization

1. INTRODUCTION

1.1 Background and Objectives of Study

The ESCAP region is one of the fastest developing regions in the world. Since the mid-1980s, the developing economies of the ESCAP region have recorded growth rates of gross domestic product (GDP) higher than global growth rates. Of even greater significance is the fact that, during the same period, the trade growth of the developing countries of the region was much higher than the global average. Another salient feature of the region's trade growth in recent years has been steadily increasing significance of intraregional trade, although the trade with the rest of the world retains its importance. The region has experienced not only rapid increases in output and trade but also increasing number of tourists (around 80 million per year) visiting many developing countries in the region. This growth is causing increasing demand for road transport services which results in the number of vehicles on the road growing rapidly. According to ESCAP studies, there were about 102 million registered road vehicles plying about 5 million kilometres of road network in Asia-Pacific region in 1991. In 1992, the corresponding estimated figures were 130 million and 6 million respectively.

Besides the overall positive effects, there are some unwanted side-effects of this growth in road traffic and expansion of roads of which accidents, traffic congestion, air pollution and noise are the most crucial ones. These adverse environmental impacts of road transport are therefore becoming of increasing concern to developing countries of the region. It is therefore timely and appropriate to assess the current situation in the region, identify possible trends of the road transport development and likely adverse environmental impacts, and develop concepts and propose alternatives and measures to mitigate or eliminate adverse environmental impacts.

Motorized road transport is an integral element of modern life contributing to economic growth and enhancement of the quality of life by providing essential access. Unfortunately, the burning of petrochemical fossil fuels and construction of road related infrastructure is also a significant source of dangerous pollutants and environmental degradation that threatens to destroy the natural environment. In the ESCAP region, due to the unprecedented and largely unregulated growth in road traffic and transport infrastructure, people are confronted on a daily basis with a whole range of pollutants including noxious gases and noise. In particular, the unplanned development of major cities with the absence of alternatives to road transport, has resulted in a concentration of vehicle created pollution which is far above even safe or acceptable levels.

The main environmental impacts of road transport mode are noise, air pollution; water and land pollution; solid wastes; damage to the natural environment such as destruction of farm land, forests, and wild life habitats; and other impacts such as human distress brought about by traffic accidents and congestion. Some of these environmental impacts of road transport related developments are already evident in a number of ESCAP member countries, and the others are expected to be felt soon if timely mitigation measures are not implemented as steady economic growth continues.

The adverse environmental consequences of road transport development can be significantly reduced by means of environmentally friendly transport practices and policies. Countries in the fast developing ESCAP region have much to learn from the developed countries in North America and Europe in respect of their positive and negative experiences in road transport related development. They could also learn from countries in the region on strategies to adapt proven environmentally friendly policy to suit local conditions, and to avoid mistakes that have led to poorly conceived road network development and severe traffic conditions.

This study is aimed at complimenting and not duplicating works that have already been carried out by other agencies. It has been commissioned to (a) analyze the growth experiences in the road transport sector in both developed and developing economies to identify the nature of road transport related environmental concerns associated with different phases of the economic growth process; (b) review and evaluate the measures that can prevent and/or mitigate the adverse environmental consequences of road transport developments, and (c) identify specific schemes or measures with good potential for application in the ESCAP region. The study also reviewed some of the activities which have been undertaken by some regional and international organizations in the area of road transport and environmental protection.

1.2 Methodology of Study

To achieve the objectives of the study, it has been necessary first to evaluate the current situation in the region. Since the nature and severity of environmental impacts of road transport are functions of the stage of economic development of a nation, this study divides the countries in the region into four groups according to economic growth and state of road transport development. The road transport related environmental problems within each group of countries have been identified.

The environmental problems identified for the countries in the region have been analyzed with respect to their causes and applicable remedial measures. The causes of the environmental impacts are classified as either road-related, vehicle-related, user-related or policy-related. Through this analysis, the areas that require either preventive or corrective measures are identified, and their implementation potentials are critically discussed.

1.3 Structure of the Report

The report is divided into 6 chapters. Chapter 1 presents the background, objectives, methodology and the contents of the report. Chapter 2 reviews the current situation of road transport and its environmental impacts in the Asia-Pacific region. ESCAP member countries are classified into four economic groupings, and road related environmental problems are identified for each group.

Chapter 3 analyses various major areas of environmental concern in road transport highlighting on the environmental impacts generated and the adverse consequences resulting out of such impacts. Examples of environmental impacts and adverse consequences in various groups of countries in the region are highlighted. Various road transport problems are classified as road-related, vehicle-related, user-related and policy-related.

Chapter 4 discusses preventive and corrective policies, measures and technologies available for the road transport related environmental problems and concerns discussed in Chapters 2 and 3. Relevant examples from developed and developing countries around the world are examined. In the analysis, important factors that have led to the success or failure of the cases studied are identified. It also presents actions required, the constraints and preconditions necessary to make interventions effective.

Chapter 5 critically describes areas of recommended priority actions and discusses the implementation potentials of various mitigation measures for adverse environmental impacts generated by road transport infrastructure development and operations. Special emphasis is placed on examples of countries and cities in the ESCAP region. An assessment is made on the needs for the various environmental protection measures by different economic groups of ESCAP member countries, particularly the Group 2, 3 and 4 countries.

Chapter 6 presents a summary of the findings and conclusions of the study. Emphasized in this chapter is the importance of an integrated approach in the planning, development and management of an environmentally sound and sustainable road transport system. Another conclusion stresses the need for government commitment and strong institutional role to achieve efficient management of road transport projects and enhance environment protection. The potential benefits of regional cooperation to promote an overall environmental awareness in road transport development in the ESCAP region is highlighted.

2. CURRENT SITUATION IN ASIA-PACIFIC COUNTRIES

2.1 Economic Outlook for Asia-Pacific Countries

Many countries in the Asia-Pacific region have been enjoying the highest growth rates in the world in the last decade. They are expected to continue to surge ahead of the rest of the world in economic growth into the next century. Table 2.1 shows the economic forecast made by the Asian Development Bank (ADB) that compares the predicted growth rates in some ESCAP member countries with those of the rest of the world (ADB 1996). Besides those countries listed in the table, China is expected to continue to register economic growth of at least 8 per cent. In South Asia, including India and Pakistan, the effect of several years of structural economic reforms is beginning to have some positive effects (ADB 1993; 1994). The growth in GDP of the East Asian region as a whole has averaged nearly 7 per cent per annum during the 1980s. The per capita income in the developing countries in East Asia is projected to grow at 5.1 per cent leading to 6.5 per cent rise in average incomes by the year 2000. This expected growth rate is well ahead of the corresponding rates of 2.6 per cent for industrial countries and 2.1 per cent for Europe, Middle East and North Africa (Midgley 1994).

2.2 Urbanization in Asia-Pacific Countries

Rapid urbanization rates are a common feature in the Asian cities. According to a study on world urbanization by the United Nations (United Nations 1991a), the urban population is expected to increase by 420 million from 1.2 to 1.6 billion. This would bring the proportion of urban residents in the total population from 39 per cent in 1990 to 46 per cent by the year 2000. In 1908, Asia had 72 cities with population exceeding 1 million. The number increased to 101 in 1990, and is estimated to reach 160 by the end of this century. In terms of the number of megacities (cities with a population in excess of 10 million), 13 of the 21 expected world megacities will be found in the Asia-Pacific countries, as depicted in Table 2.2 (ESCAP 1993a). The Asian Development Bank has predicted that, by the year 2020, about half the world's urban population will be in the Asia Pacific Region.

The large migration of population towards the cities in the region is a by-product of its strong economic growth. The urban economies have higher production rates and have generated greater volume of goods and services far in excess of their share of national population. In the Philippines, the urban population is about 14 per cent of the total population but contributes 33 per cent of country's total GDP. Karachi has only 6 per cent of Pakistan's total population but contributes 15 per cent of Pakistan's GDP. Similarly, Bangkok has about 10 per cent of total population of Thailand while contributing as high as 74 per cent of its overall manufacturing output. Jakarta with its only 5 per cent of country's population contributes to 11 per cent of GDP. China's urban population is estimated to be about 10 per cent of the total and its contribution to national industrial output is almost 87 per cent. In Bangladesh, half of the manufacturing jobs are in Dhaka.

Table 2.1 Economic forecast for Asia-Pacific countries

Country/Region	Growth rate, per cent			Forecast rate, per cent	
	1993	1994	1995	1996	1997
World	**2.0**	**2.7**	**2.6**	**3.2**	**3.5**
Industrialised Countries	0.9	2.6	2.1	2.4	2.6
United States	2.2	3.4	2.1	2.2	2.3
Japan	-0.2	0.5	0.5	2.5	2.5
Germany	-1.2	2.2	2.1	1.9	2.5
Newly Industrialising Economies	**6.4**	**7.5**	**7.6**	**6.7**	**6.4**
Hong Kong, China	6.4	5.4	4.6	4.5	4.5
Republic of Korea	5.8	8.4	9.2	7.5	7.0
Singapore	10.1	10.1	8.9	8.0	7.5
Taiwan Province of China	6.3	6.5	6.3	6.4	6.3
Southeast Asia	**7.1**	**7.8**	**7.9**	**7.8**	**7.6**
Cambodia	4.1	4.0	7.5	7.5	7.5
Indonesia	7.3	7.5	7.6	7.8	7.7
Lao People's Dem. Rep.	5.9	8.1	7.1	7.5	7.0
Malaysia	8.3	9.2	9.3	8.5	8.0
Myanmar	5.9	6.8	7.7	n.a.	n.a.
Philippines	2.1	4.4	4.8	5.5	5.7
Thailand	8.3	8.7	8.6	8.3	8.0
Viet Nam	8.1	8.8	9.5	9.8	9.9

n.a. = not available

Source: ADB (1996). *Asian Development Outlooks 1996 and 1997.* Manila.

Table 2.2 World megacities in year 2000

Region/country	No.	Megacity: Name	Megacity: Population (million)
Asia/Pacific	**13**		**179.4**
Bangladesh	(1)	Dhaka	12.2
China	(3)	Beijing Shanghai Tianjin	14.0 17.0 12.7
India	(3)	Bombay Calcutta Delhi	15.4 15.7 13.2
Indonesia	(1)	Jakarta	13.7
Japan	(1)	Tokyo	19.0
Republic of Korea	(1)	Seoul	12.7
Pakistan	(1)	Karachi	11.7
Philippines	(1)	Manila	11.8
Thailand	(1)	Bangkok	10.3
Africa	**2**		**24.7**
Nigeria	(1)	Lagos	12.9
Egypt	(1)	Cairo	11.8
Latin America	**4**		**71.1**
Argentina	(1)	Buenos Aires	12.9
Brazil	(2)	Rio de Janeiro Sao Paulo	12.5 22.1
Mexico	(1)	Mexico City	25.6
North America	**2**		**30.7**
United States	(2)	Los Angeles New York	13.9 16.8
Total	21		306.9

Source: United Nations (1990). *World Urbanization Prospects.* United Nations. New York.

2.3 Motorization in Asia-Pacific Countries

The startling statistics and predictions in the preceding sections point to a trend of urbanization that simply cannot be ignored by city planners and transport authorities of the Asia-Pacific region. The picture is even more alarming if one considers the potential of motorization in the region under the interaction of the following three forces: (a) expected continued strong growth of economy in the coming decade, (b) large population base and the trend of rapid urbanization, and (c) current low level of motorization (ESCAP 1987).

Asia has more than half of the world's population, but accounts for just over 10 per cent of the world's automobile population and about 25 per cent of the global truck and bus fleet (Midgley 1994). The average annual growth rates of road vehicles are shown in Fig. 2.1 (ESCAP 1995c). The vehicle growth rates appear to be very high over 1988-1992 period in the Lao People's Democratic Republic (24.85 per cent), the Republic of Korea (21.2 per cent), India (17.2 per cent), Thailand (12.3 per cent), and China (11.8 per cent). Vehicles with four or more wheels clearly dominate the scenario in the Republic of Korea where they increased at the rate of 25 per cent. However, the increase in the number of vehicles in the Lao People's Democratic Republic, China and Thailand was largely due to the rapid increase in two or three wheelers over this period. In most cities of the region, the growth of motor vehicles far exceeds that of the already over stressed urban road network. In Seoul, vehicle population is doubling every four years and in Bangkok, the daily increment in the population of private cars was estimated at 575 during 1983-1991. Total road vehicle fleet population is shown in Fig. 2.2 (ESCAP 1994a).

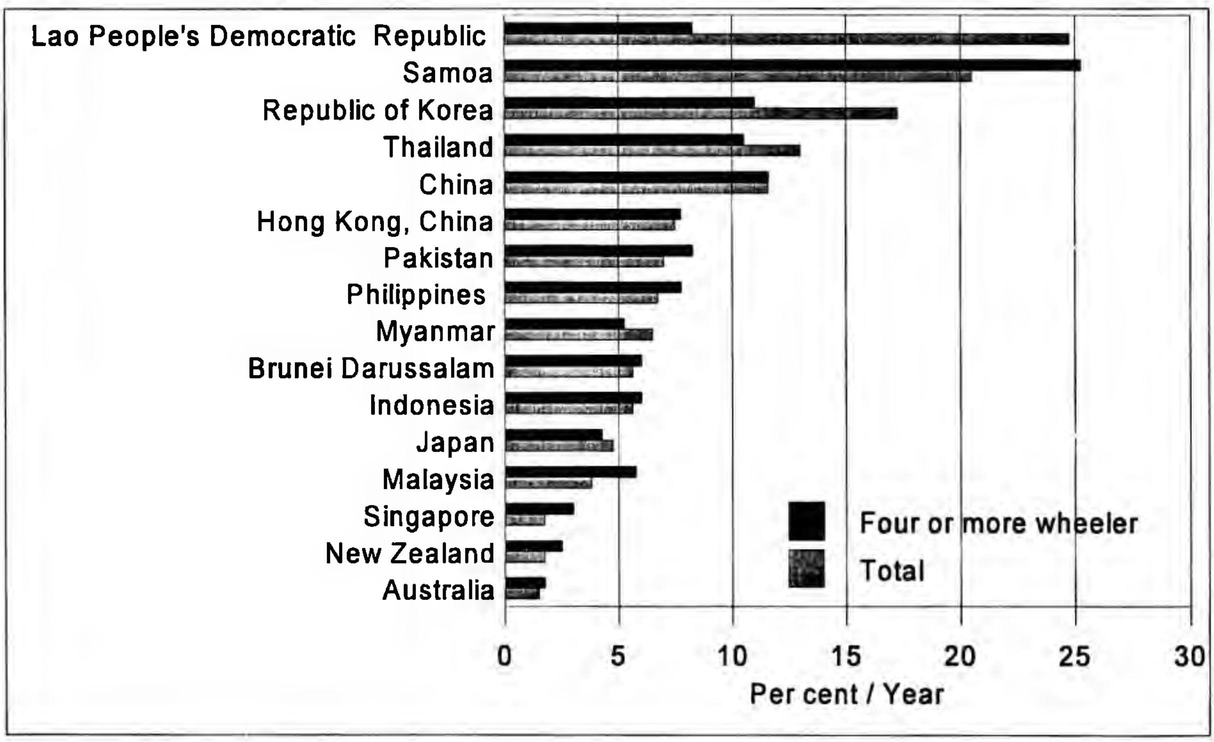


Fig. 2.1 Annual growth of road vehicle fleet in some ESCAP countries

Source: ESCAP (1995). *State of the Environment in Asia and the Pacific.* United Nations, New York.

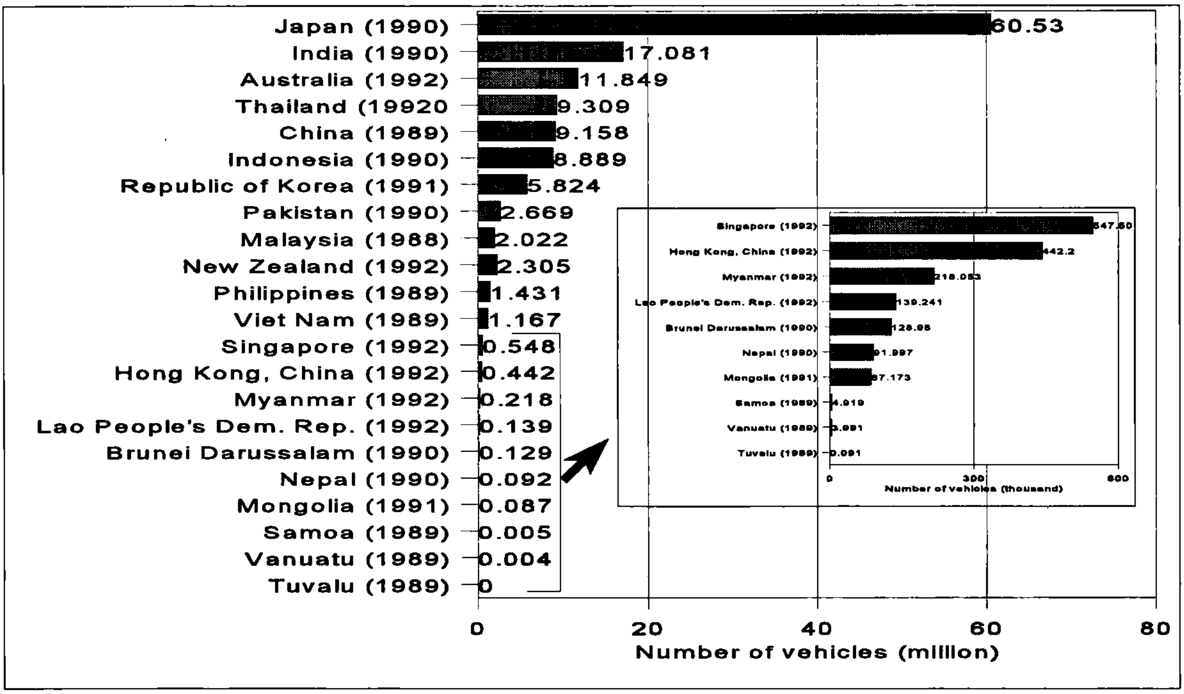


Fig. 2.2: Road vehicle fleet population

Figure 2.3 further elaborates the vehicle fleet composition in the region (ESCAP 1995c). Typically, motor cars account for over 60 per cent of the total fleet of road vehicles in the developed countries and in Brunei Darussalam, Malaysia and Samoa; Philippines and China have relatively high proportions of goods-carrying vehicles and the percentage of motorcycles (including three wheelers) generally exceeds 50 per cent in Viet Nam, the Lao People's

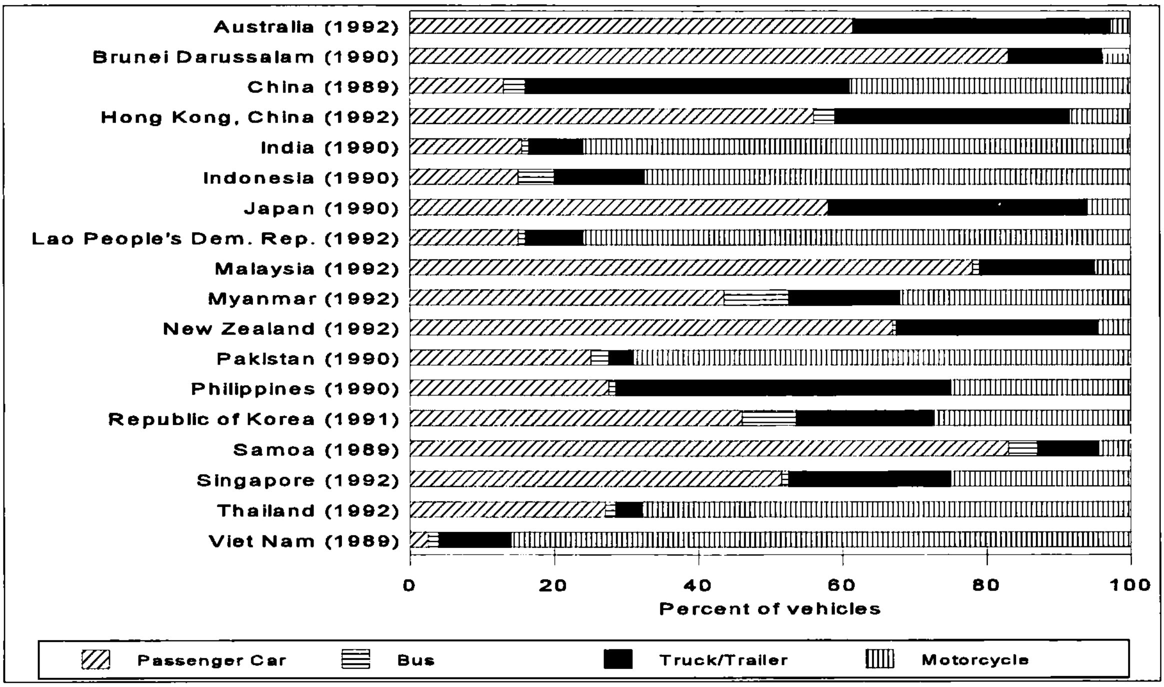


Fig. 2.3 Road vehicle composition in some ESCAP countries

Democratic Republic, India, Indonesia and Sri Lanka, where motor cycles and three wheelers are important means for commuting in the cities.

Figure 2.4 shows the population per vehicle rates in selected Asia-Pacific countries in 1988 (Midgley 1994). If the rate of vehicle ownership of China, India, and Indonesia were to reach the level of ownership of Malaysia, the total number of vehicles in the world would be more than doubled. In fact, the number of vehicles in East Asia has risen six fold between 1980 and 1992 and the trend has been steeply upwards. The Republic of Korea alone saw an increase of about 800 per cent. The estimated total number of registered vehicles in the region excluding the central Asian republics was over 132 million in the year 1992 with an annual growth rate of 3 to 4 per cent (ESCAP 1991b, United Nations 1994).

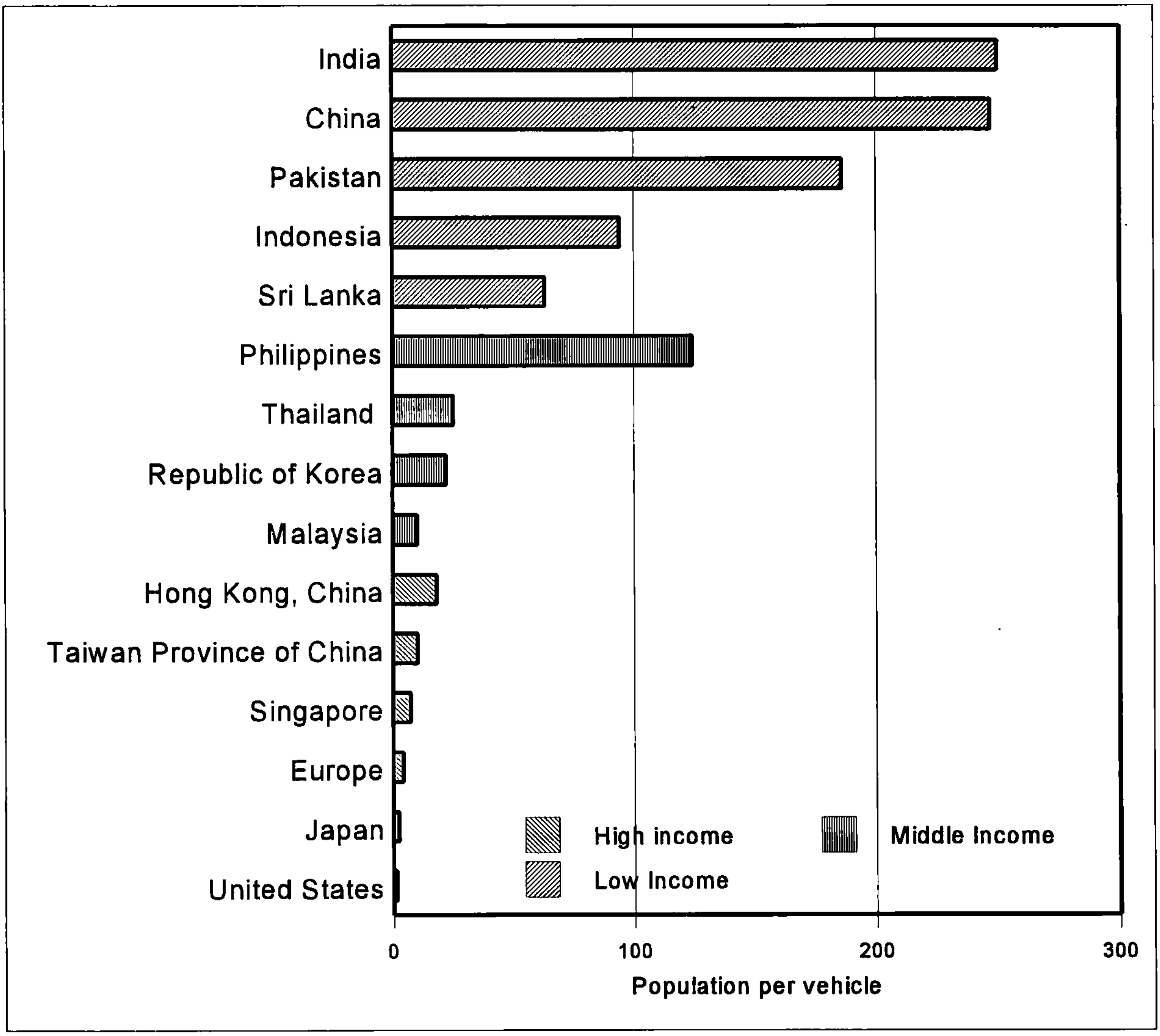


Fig. 2.4 Population per vehicle rates in selected Asian countries, Europe, United States

Source: Midgley, P. (1994). Urban transport in Asia - an operational agenda for the 1990s. World Bank Technical Paper No. 224. Washington DC.

2.4 Road Transport Infrastructure Development in Asia-Pacific Countries

The total length of roads in the region is estimated at about 6 million km (excluding roads in the six Central Asian republics). out of this total length, expressways and national highway networks, forming major (trunk) road networks in each country, account for approximately 1 million km (ESCAP 1994a).

The growth of roads averaged about 2 per cent per year during the period 1985-1992. Figure 2.5 shows the average annual growth rate of road network in selected countries in the region, over the 1985-1992 period (ESCAP 1995c). It is clear that remarkable development has been achieved in terms of annual increment in Bangladesh, Brunei Darussalam, Indonesia, Nepal, Pakistan and Thailand. For all these countries, annual growth of road network length exceeds 4 per cent.

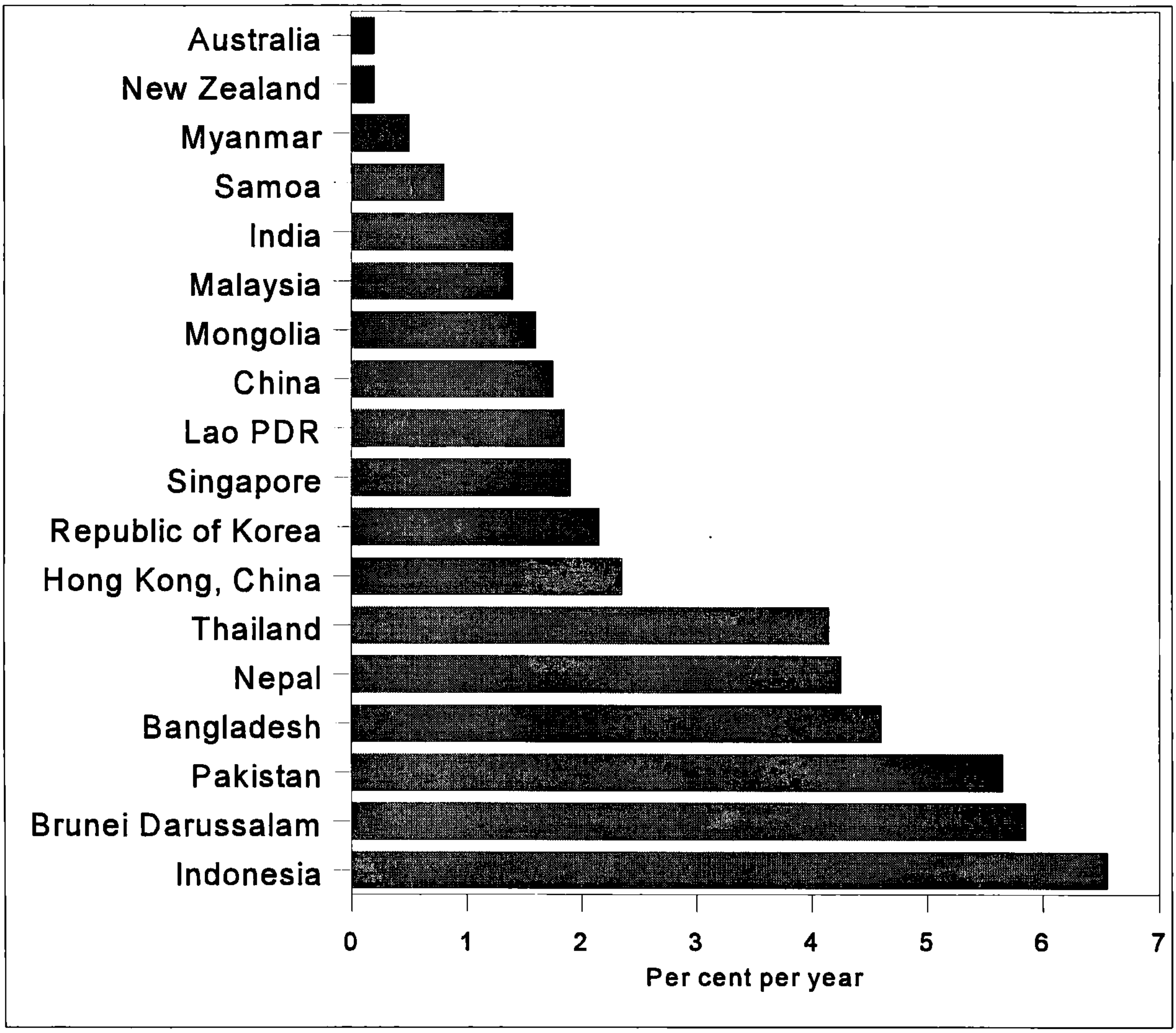


Fig. 2.5: Average annual growth in total road network length, 1985-1992

Source: ESCAP (1995). *State of the Environment in Asia and the Pacific.* United Nations, New York.

Figure 2.6 shows road network density (kilometres of road length per square kilometre of land area) - a road density index which reflects the level of development of road infrastructure - in the countries of the region (ESCAP 1994a). One can see that Hong Kong China, Japan and Singapore, all of which are characterised by their small land area, high population density and high concentration of economic activity, have relatively dense road networks. The least developed countries of the region, such as Bangladesh, Lao People's Democratic Republic, Papua New Guinea, Nepal, Myanmar and Mongolia, which have low level of economic activity, have road networks of low density. Therefore, it appears that there is some correlation between economic performance and density of road networks.

There also exists a wide variation in the percentage of paved road length forming the main (national) road networks among countries and territories of the region. This percentage varies from 38 per cent (Myanmar) to 100 per cent (Australia, Brunei Darussalam, China, Hong Kong China, Republic of Korea, Singapore, Sri Lanka and Thailand).

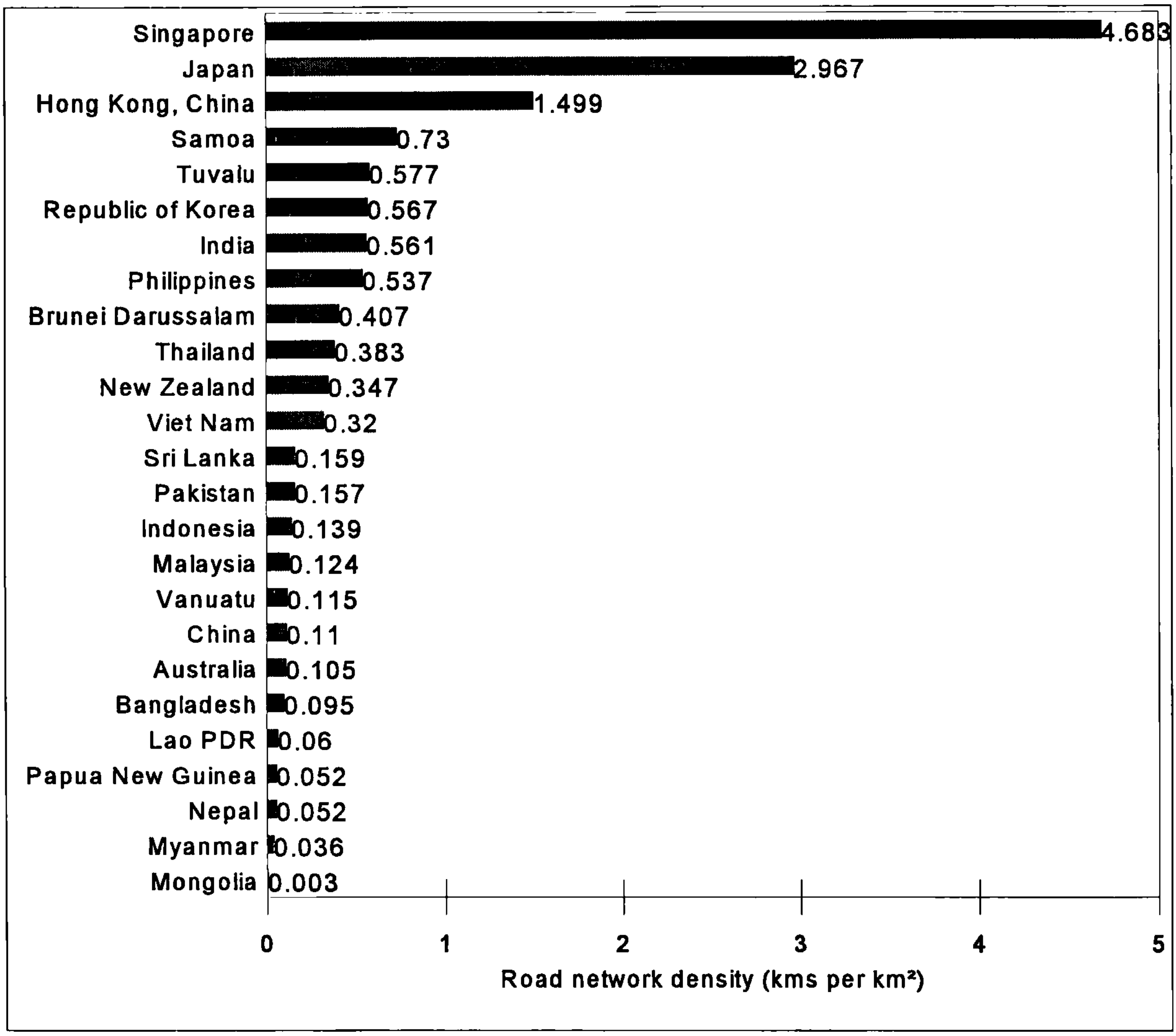


Fig. 2.6: Road network density

Source: ESCAP (1994). *Review of Development in Transport and Communications in the ESCAP Region 1993* (ST/ESCAP/1333). United Nations, New York.

Figure 2.7 compares kilometres of paved road per 1,000 persons by groups of countries in Asia and how this has changed over the period 1985-1992 (ESCAP 1994a). According to an estimate by ESCAP, over 2 million kilometres of paved roads need to be built in the ESCAP region by the year 2000 to meet the growing demand for passenger and goods transportation. This represents an increase of about 40 per cent over the existing capacity (ESCAP 1994a).

The high rate of economic upsurge in many Asia-Pacific countries has created a tremendous demand for an efficient nation-wide road network system and increased road capacity in the cities (Chan 1993). For example, in China during the period from 1985 to 1992, the annual growth in road freight and passenger movement by road transport were 8.7 per cent and 10.3 per cent respectively. Other developing countries in the region, including Indonesia, Malaysia, Thailand, Viet Nam and other Indo-China nations, are also equally committed in seeking ways to extend their road and transport networks.

An examination of the existing road infrastructure in selected ESCAP countries would reveal the bottleneck to economic development caused by the lack of road transport facilities due to past under-investment (United Nations 1995). Table 2.3 shows the road network length and density in selected ESCAP countries. Road transport so far has not been able to keep pace with the region's high economic and industrial growth. Insufficient road transport capacity and infrastructural services are considered to be a major drag on the economic growth in the Asia-Pacific countries. The list of road transport projects and infrastructure development required in the region is so extensive that no country can afford the cost. According to ESCAP estimations (ESCAP 1994a), by the year 2000, about 200,000 kilometres of new roads with an investment of US$162 billion would be required for road related infrastructure facilities in its member countries (excluding Australia, New Zealand and Japan). In a separate estimate by the World Bank, the total investment requirements in transportation infrastructure in East Asia from year 1995 to 2004 is US$607 billion (South China Morning Post, 9 Nov. 1995). The financing of these projects, the planning, design, construction, and the management of the development present a severe challenge to the road authorities and policy makers in the region.

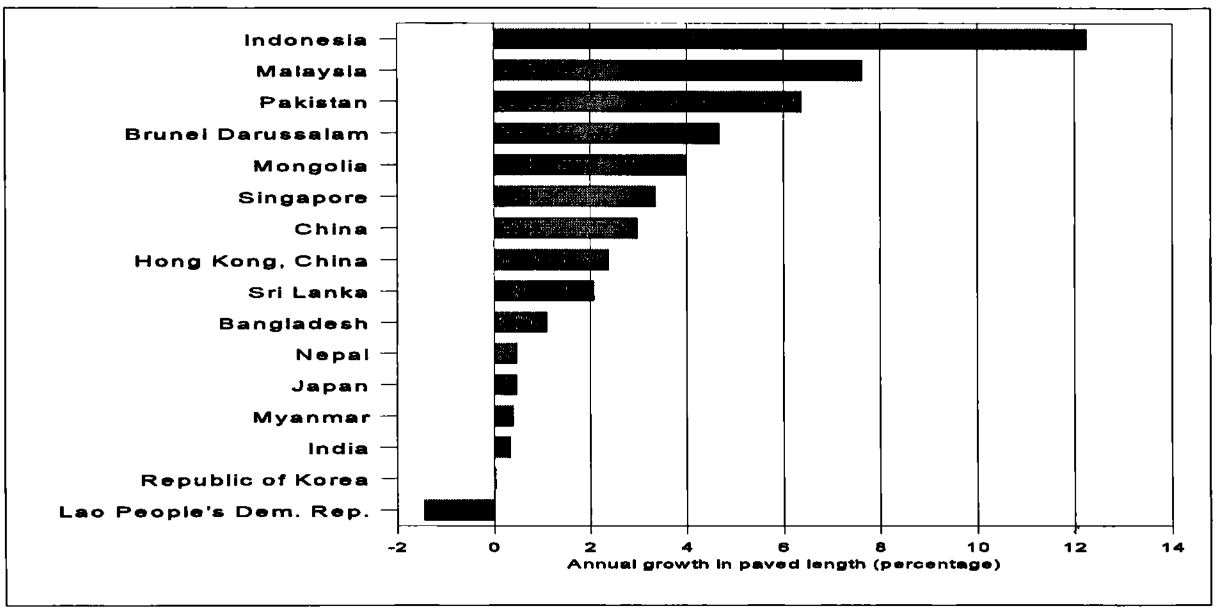


Fig. 2.7: Growth in paved road length, 1985-1992

Source: ESCAP (1994). *Review of Development in Transport and Communications in the ESCAP Region* (ST/ESCAP/1333). United Nations, New York.

Table 2.3 Road network length and density in selected ESCAP countries

Country/Territory	Length (km)	Density (km/sq.km)
Mongolia	4321	negligible
Myanmar	24422	0.04
Nepal	7036	0.05
Bangladesh	12960	0.10
Australia	810300	0.11
China	1028000	0.11
Malaysia	50836	0.12
Indonesia	266330	0.14
Pakistan	64393	0.16
Sri Lanka	25952	0.16
New Zealand	93000	0.35
Thailand	44409	0.38
Brunei Darussalam	2348	0.41
Philippines	157253	0.54
India	1970000	0.56
Republic of Korea	56481	0.57
Samoa	2089	0.73
Hong Kong, China	1484	1.50
Japan	1115000	2.97
Singapore	2882	4.68

Source: United Nations (1995). *World Urbanization Prospects*. United Nations. New York.

2.5 Road Transport and the Environment

While the Asia-Pacific countries have achieved the best overall economic growth in the world since the 1980s, the same cannot be said of their achievement in the protection of the environment. The Asian Development Bank has identified urban congestion and pollution caused by uncontrolled urbanization and motorization as reasons for the most serious environmental problems in the region (ADB 1994). Along side the phenomenal growth in terms of vehicles, road infrastructures, passenger and freight kilometers, a host of environmental problems have been created. Consumption of non-renewable resources, adverse effects on land-use, emission of pollutants in the atmosphere and growing congestion on urban roads are the major problems associated with road transportation growth in Asia and the Pacific. Road transportation sector has visibly contributed to a considerable extent towards the environmental degradation resulting in the decay of urban environment and air pollution in the metropolitan areas. A more detailed description of the adverse environmental impacts and consequences in the region is presented in Chapter 3.

Among the major underlying causes of environmental degradation in the region singled out by ADB (1994), the following are related to the problems in the road transport sector: (a) policy failures, (b) uncontrolled urbanization and motorization, (c) unplanned industrialization, (d) shortage of financial resources, (e) poor project management, and (f) weak environmental institutions. In Chapter 4, possible remedial measures to these problems are given, and also highlighted the mitigating measures to reduce or eliminate the undesired impacts.

2.6 Road Transport Assistance Activities by International Organisations

Concerns about the damaging effect on the environment of badly planned road transport policy or poorly controlled motorization and traffic operation has received the attention of a number of international organisations since as early as the late 1960s. Such concern is also receiving increasing attention from policy makers, road authorities and the governments in the region.

Tables 2.4 and 2.5 highlight the related activities in the region that have been undertaken by various international organisations. Based on the amount of financial aid provided to the countries in the region as shown in Fig. 2.8 (Midgley 1994), Japan has been the main of bilateral financing in the urban transport sector in Asia between 1980 and 1989. World Bank was the next major source of external aid after Japan. Other bilateral resources were provided by Australia, France, Germany and the United Kingdom (Midgley 1994). Besides the World Bank, other multilateral aid was from the Asian Development Bank, and the United Nations Development Program (UNDP). The resources by Japan, the World Bank and ADB have been provided to low- and middle-income countries, while other bilateral funding has been made exclusively to low-income countries.

Nearly half of the total external aid in the region was allocated to the urban road infrastructure sector for construction, improvement and maintenance. Urban rail investment and traffic management were respectively the second and third biggest items of the total external aid. These were followed next by technical assistance programme and bus-related activities.

The financial and technical aid programmes of the various international agencies have made it possible for the recipient countries to obtain not only the needed fund for road infrastructure development, but also technologies for road construction and maintenance, and environment protection. Such programmes have permitted ESCAP member countries to acquire appropriate technologies and expertise from all over the world and adapt them for their local conditions.

2.6.1 Examples of activities and programmes

Table 2.4 gives a summary of the environment-related road transport programme areas in Asia-Pacific region by various international organisations. Further details of the type of programme activities are found in Table 2.5. Descriptions of the background and operations of these organisations are given in the following subsections.

Japan International Cooperation Agency (JICA)

Japan's financial aid in the region has concentrated mainly in Southeast Asia. Around 47 per cent of the financial aid went to Indonesia, and 21 per cent and 14 per cent went to Thailand and the Philippines respectively. Other low-income countries like China, India, Pakistan and Bangladesh have received relatively low amount of aid from Japan. About 52 per cent of Japan's aid has been allocated to financing long-term development projects of urban rail (mostly mass rapid transit), and 40 per cent to urban toll roads and major highways. Japan's approach has apparently relied heavily on the successful experience and technology with urban rail systems of its many cities.

Table 2.4 Environment-Related Road Transport Programme Areas in Asia - Pacific Region by Various International Organisations

	World Bank	ADB	WHO	ESCAP	UNEP	UNDP	UNIDO	OECD	PIARC	IRF	REAAA	SAE
Road Development	✓	✓		✓		✓						
Road Management	✓	✓		✓		✓		✓	✓	✓	✓	
Traffic Management	✓	✓				✓		✓	✓	✓	✓	✓
Public Transport	✓	✓				✓		✓	✓	✓	✓	✓
Transportation Planning/ Survey	✓	✓				✓		✓	✓	✓	✓	
Environmental Protection/ Pollution Control	✓	✓	✓	✓	✓		✓	✓	✓			✓
Energy/Alternative Fuels	✓	✓		✓	✓	✓	✓	✓	✓			✓
Vehicle Protection & Maintenance							✓					✓
EIA in Transport Project	✓	✓		✓				✓	✓			
Road Safety	✓	✓		✓				✓	✓	✓	✓	✓
Traffic Noise Abatement								✓	✓	✓		✓
NGO Programme												
Citizen Participation Programme												
Financing Mechanism	✓	✓		✓		✓		✓	✓	✓		
Transport of Hazardous Goods				✓	✓			✓	✓	✓		
Multimodal Transport	✓	✓				✓		✓	✓	✓	✓	
Non-motorised Transport				✓								

Table 2.5 Environment-Related Road Transport Programme Activities in Asia-Pacific Region by Various International Organisations

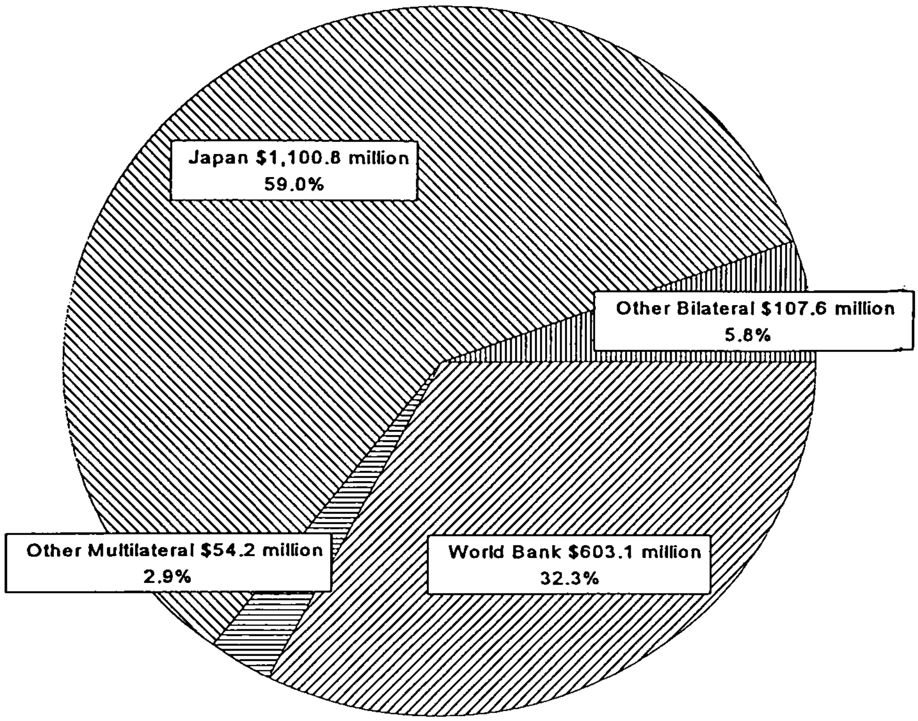
	Road Transport Database	Periodicals/ Journals/ Professional Magazines	Research Studies/ Technical Reports	Conferences/ Symposia	Seminars/ Workshops	Short Courses/ Degree Programme	Guidelines/ Standards	Advisory Services	Study Tours/ Technical Visits	Financial Assistance of Infrastructure Projects	Funding of Planning Surveys and Feasibility Studies
World Bank			• Road infrastructure development • Road management • Public transport • Road financing • EIA • Transport statistics		• Road infrastructure development • Road management • Public transport • Road financing • Traffic management • EIA	• Road development • Road management • Public transport • Traffic management	• Road development • Road management	• Road development • Road management • Public transport • Road financing • Traffic management • Environment protection		• Road infrastructure development • Road management • Public transport • Traffic management • Environment projects	• Road infrastructure development • Public transport • Traffic management
ADB			• EIA implementation • Road safety • Growth statistics		• EIA • Road safety • Environment/Social development	• Assistance in higher degree learning	• EIA	• Road development • Road management • Public transport • Traffic management • Environment protection		• Road infrastructure development • Road management • Public transport • Traffic management • Environment projects	• Road infrastructure management • Road management • Public transport
WHO			• Environmental health • Environmental pollution		• Environmental health • Environmental pollution		• Environmental pollution standards	• Environmental pollution standards			

Table 2.5 (cont'd)

	Road Transport Database	Periodicals/ Journals/ Professional Magazines	Research Studies/ Technical Reports	Conferences/ Symposia	Seminars/ Workshops	Short Courses/ Degree Programme	Guidelines/ Standards	Advisory Services	Study Tours/ Technical Visits	Financial Assistance of Infrastructure Projects	Funding of Planning Surveys and Feasibility Studies
ESCAP	• Regional Database on Road Safety • Computerised Asian Highway Database	• Annual economic forecast • ESCAP population data sheet	• Environmental impacts • Energy/fuel • Road safety • Non-motorized transport • Dangerous goods transport	• Asian road safety Conference • Management of Dangerous goods • Asian Highway development	• Energy • Management and financing of road maintenance		• Management of dangerous goods	• Road financing/ taxation system • CNG conversion technology	•Energy/fuels		
UNEP		• UNEP Industry & Environment • Environment data report	• Energy • EIA • Pollution control	• Energy • Pollution control • Environment	• Energy • Pollution control • Environment	• Energy • Pollution control • Toxic & hazardous materials • Environment • Coastal pollution	• Toxic & hazardous materials • Air pollutant control Guidelines	• Various environmental issues	• Various environmental fields		
UNDP					• Energy • Road infrastructure development • Urban transport			• Road infrastructure • Urban transport • Energy		• Road infrastructure • Urban transport • Energy	• Road infrastructure • Urban transport • Energy
UNIDO			• Emission control • Motor vehicle technology		• Emission control • Motor vehicle technology • Motor vehicle maintenance		• Emission standards • Fuel quality standards • Automotive component standardisation				

Table 2.5 (cont'd)

	Road Transport Database	Periodicals/ Journals/ Professional Magazines	Research Studies/ Technical Reports	Conferences/ Symposia	Seminars/ Workshops	Short Courses/ Degree Programme	Guidelines/ Standards	Advisory Services	Study Tours/ Technical Visits	Financial Assistance of Infrastructure Projects	Funding of Planning Surveys and Feasibility Studies
OECD	• Road Research Documentation Database • International Road Traffic & Accident Database		• Various aspects of road research and transport issues	• Asian road safety Conference (1993, 1996)	• Road management • Energy • Pollution • Policy • Public transport • Traffic management • Freight						
PIARC	• World Road Transport Interchange Network	• "Road"		• World Meeting	• Road engineering • Policy				• Road development		
IRF	• World Road Statistics	• "World Highways"	• Road engineering	• World road Congress • Regional Meetings		• Road engineering • Fellowship programme for higher degree learning	• Road construction • Road management		• Country visits		
REAAA		• REAAA Journals	• Road safety	• REAAA Conference series	• Road safety	• Traffic management			• Road Safety		
SAE	• Motor Vehicle Growth Statistics • Automobile Engineering Research Database		• Automobile Engineering	• Annual SEA Meetings	• Automobile engineering			• Automobile engineering	• Country visits		



Total US$1,8657.7 million

Fig. 2.8: Sources of external aid in the urban transport sector, 1980-1989

Source: Midgley, P. (1994). Urban transport in Asia - an operational agenda for the 1990s. World Bank Technical Paper No. 224. Washington DC.

Japan has also been providing scholarships to students from Southeast Asian countries to study in Japanese universities. There is also an active programme for sponsored short-term study visits to research institutions or major private corporations in Japan by government engineers and professionals from these countries. The transportation technology transfer and assistance programme provided by Japan to the Philippines through the Japan International Cooperation Agency (JICA) gives a good example of another form of Japanese aid programme undertaken by Japan. Since 1975, Japanese experts in the field of transportation and urban development have been working with the planners and engineers of the different agencies of the Philippines Government such as the Department of Transportation and Communications, the Department of Public Works and Highways, Philippines Port Authority, and the Metro Manila Development Authority. With funding from JICA, a National Centre for Transportation Studies (NCTS) was set up in Manila. The activities of the centre focus mainly on training, research, setting up of transport databases, and conducting of seminars and conferences. In 1994, Japan also provided the fund to set up the Eastern Asia Society of Transportation Studies which held its first conference in 1995 jointly with the NCTS.

World Bank

The World Bank policy of urban transport lending in Asia has been based on the following twin objectives (Midgley 1994): poverty alleviation and improved city efficiency. So far the lending has been either in the form of free-standing urban transport projects or as components within urban development projects, with emphasis on short-to-medium term investments in road-related infrastructure and services. Examples of the projects include road construction, street improvement, road maintenance, traffic management, bus rehabilitation and acquisition, bus facilities, bus priority schemes, pedestrian facilities, and technical assistance and training. It is interesting to note that the World Bank has to date not allocated resources to the urban rail sector.

One of the World Bank's notable efforts in ensuring the success of its assistance programme in road-related infrastructure development has been the development of the Highway Design and Maintenance Standards (HDM) model for use in economic and technical analyses of investments and expenditures in the development and management of roads. It provides a useful tool for the evaluation of road projects, strategies and standards. Various versions of the HDM models have been used for World Bank funded projects in developing countries for over two decades. As a requirement of World Bank assistance programmes, the HDM models have been applied in many ESCAP member countries, including Bangladesh, India, Indonesia, Pakistan, and the Philippines. In 1993, the World Bank jointly funded a collaborative HDM-4 study in Kuala Lumpur together with the Overseas Development Administration (ODA) of the United Kingdom, the Asian Development Bank, and the Swedish National Roads Administration. The study's objectives were to upgrade the technical capabilities of the HDM models for more effective applications in planning, programming, budgeting, project analysis, and research studies of highway expenditure and work (Kerali 1994).

United Nations

The United Nations (UN) has been involved in providing assistance programmes in the region for many years through its various agencies such as United Nations Development Programme (UNDP), United Nations Environmental Programmes (UNEP), Economic and Social Commission for Asia and the Pacific (ESCAP), and United Nations Industrial Development Organization (UNIDO). This section describes some examples of related projects to illustrate the type of activities undertaken so far by UNIDO and ESCAP.

A major UNIDO project entitled "Regional Network for Control and Regulatory Measures Concerning Motor vehicle Emissions" has been completed recently. Guidelines on emission standards for new and in-use vehicles, fuel quality standards and practical policy changes have been prepared. Ten countries/territories in the region participated in the study. Four Expert Group Meetings were held on the following topics: inspection of in-use vehicles held in Seoul, emission standards for new vehicles held in Jakarta, fuel/lubricant quality and standard held in Beijing, and maintenance of vehicles held in Bangkok. There is also another UNIDO project in Indonesia that addresses automotive components standardisation.

ESCAP has embarked on a Highway Transport Engineering Assistance project with programme elements that address also the environmental concerns of road transport (ESCAP 1995e). One was the promotion of energy efficiency and alternative energy sources, and another is road safety. On the first topic, the project dealt with CNG conversion of diesel-fuelled buses in Karachi and has developed instructions and guidelines on different aspects of CNG conversion

(ESCAP 1993d and 1994c). The road safety study project, completed in 1997, aimed at the development of a Guidelines on Road Safety Action Plans and Programmes. the programme will focus inter alia in 1998-1999 on activities related to environmental protection and mitigation measures in the road transport sector.

Asian Development Bank

Like the World Bank, the Asian Development Bank (ADB) also directs its financial assistance programmes mainly at road related activities instead of urban rail transport systems. Shortly after its establishment in 1966, ADB recognised that environmental issues should be incorporated in its operations. It has now Office of the Environment which ensures that, from the outset, environmental protection measures are incorporated into relevant ADB operations, in particular its lending and technical assistance activities, and economic and sector work (ADB 1994). In all ADB aided road projects, compliance with EIA is mandatory.

The ADB has also become increasingly concerned about the growing road safety problems facing its developing member countries. It has recently approved a Regional Technical Assistance grant to address this problem in a systematic, comprehensive way and to develop long term strategies and initiatives for future actions. This project, to be completed by December 1966, will review previous implementation experience, analyse road safety trends in the region, pinpoint special characteristics of road safety problems in the region and develop potential solutions, assess road safety activities and training needs, develop guidelines for policy makers, and identify possible initiatives to improve road safety.

Road Engineering Association of Asia and Australasia

The Road Engineering Association of Asia and Australasia (REAAA) was formed in 1973 in Kuala Lumpur by nine countries with the objective to promote exchange of technological information in the area of road development in the Asia-Pacific region. Its members comprise road authorities of the countries in the region, academic institutions and individual experts of the road industry. The main activity of REAAA has so far been restricted to organising a regional road engineering conference once every two to three years.

Organisation for Economic Cooperation and Development

The Organisation for Economic Co-operation and Development (OECD) was formed in 1961 by 18 European countries and two North American countries (Canada and United States). Subsequently, Japan, Finland, Australia and New Zealand also became members of OECD. It promotes policies to achieve economic growth in its member countries, and to contribute to multilateral world trade. It has a Road Transport Research (RTR) programme that is geared towards adopting technico-economic approach to solving road transport issues identified by OECD member countries. RTR has two main fields of activity: (a) international research and policy assessments of road and road transport issues to provide support for decisions by member governments and international governmental organisations; and (b) technology transfer and information exchange through two databases - the International Road Research Documentation (IRRD) and the International Road Traffic and Accident Database (IRTAD).

The RTR programme has published a series of research project reports covering a wide range of road transport issues. These projects are conducted by various scientific expert groups engaged by RTR. While most of the RTR's research activities are concerned with issues of interest to OECD member countries, their global interaction has also led to research topics related to ESCAP region. For example, a recent project on integrated advanced logistics for freight transport has covered issues on multilateral cooperation involving countries of the ESCAP region. Road safety issues in developing countries are another focus area of RTR. Under the joint sponsorship of RTR, WHO and ESCAP, the First Asian Road Safety Conference was held in Kuala Lumpur in 1993, the Second Asian Road Safety Conference was held in Beijing in 1996. An ESCAP/ADB Seminar-cum-Workshop on Road Safety in Asia and the Pacific was also organized in September 1996 (ESCAP 1997c).

International Road Federation

The International Road Federation (IRF) is a non-profit, non-political service organisation. Its original purpose and continuing objective is to encourage better road and transportation systems worldwide, and to assist in the application of technology and management practices that will produce maximum economic and social return from national road investments. Founded in 1948, it has as its members more than 600 companies, national and regional associations of the road transport industry. Its principal base of support has been in the private sector. It has a Fellowship Programme which provides grants to graduate engineers and transportation managers for post-graduate studies at universities in a transportation-related field. The programme gives preference to applications from developing countries. ESCAP member countries that have benefited from this programme include China, India, Indonesia, Japan, Korea, Malaysia, Myanmar, Philippines, Thailand and Viet Nam. IRF conducts World Meetings once every four years and Regional Meetings at a smaller scale, both featuring hundreds of technical presentations and scores of exhibits. It also organises trade missions to promote opportunities for international commerce.

IRF publishes a professional magazine "World Highways" approximately 9 times a year. Over the last ten years, IRF has developed a comprehensive transportation training aid library which include many broadcast-quality videotapes in eight languages. It reports on road networks, production and export of motor vehicles, vehicles in use, road traffic, motor fuels, road accidents, rates and basis of assessment of user taxes, examples of average annual taxation, and overall road expenditure (IRF 1994). The data were collected from Europe, Africa, the Americas, Asia and the Middle East and Oceania by mailing some 300 questionnaires in the month of May of each year to national road administrations, road federations and state statistics offices.

Permanent International Association of Road Congresses

The Permanent International Association of Road Congresses (PIARC) was established in 1909 with the main goal of promoting international cooperation in the field of roads and road transport. Its members consists mainly of the road authorities and related organisations of various countries. The main activities of PIARC are carried out through a number of Technical Committees and working groups formed with specific terms of references. Covering all topics of interest to the road community, the committees gather international groups of experts to exchange opinions, interpret results of research, and put up recommendations as how to use them in practice.

Technical Committees are grouped under six topic areas, each being coordinated by a member of the Executive Committee which is the managing body of PIARC. The six topic areas are: (a) road technology, (b) road management, (c) sustainable development and role of roads in the transport system, (d) the user's perspective, (e) value for money, and (f) technology transfer. The main tangible products arising from the committee work are (PIARCC 1995).

- Technical reports to be disseminated to member countries and representative
- seminars aimed at presenting the outputs to a wider audience
- technical articles published in PIARC's quarterly journal "Road'
- Annual report to the Executive Committee
- Reports presented at the PIARC World Road Congress which is held once every four years.

2.6.2 Benefits and effectiveness of assistance programmes

Practically, all the external aid projects or programmes are the results of a thorough process of focus-area identification and work-scope definition by experts, and have gone through close scrutiny of the donor organisations. Most projects have been economically viable and have created long lasting beneficial impacts on the recipient countries. Examples include the UNDP aided Comprehensive Land Transportation Study in Singapore in the late 1960s that resulted in the Concept Plan which formed the overall blue print for master development plan of Singapore; the World Bank projects in India which has benefitted from more efficient bus operations; and the Japanese Assistance Programme in the Philippines in traffic management and transportation information system since the 1970s.

There are, however, limitations of how much external assistance could do for the recipient countries. For example, external assistance projects are often directed at specific components or specific geographic locations of the entire road transport system. In some cases, the benefits of the interventions of these assistance projects were limited in scope. In other cases, the lack of continuity has left the recipient countries with little means to build further on the foundation laid. There has also been a tendency of over-emphasis on the provision of infrastructure works and equipment at the expense of policy development and institutional strengthening (Midgley 1994).

Despite many external assistance activities and programme undertaken by various international bodies, the total volume of external aid has been small in comparison with the entire needs of the region. For instance, it was pointed out that in the ten-year period between 1980 and 1989, the total external aid amount was less than half of the total urban transport expenditure of Hong Kong China in the same period, or just about a quarter of the proposed expenditures on BOT schemes in Bangkok (Midgley 1994). This constraint of funding probably explains why several important issues in road transport sector in the region have not been adequately addressed. These issues include environment protection requirements, use of non-motorised vehicles, paratransit, freight transportation, and transport of hazardous goods.

2.7 Economic Groupings of Countries

The road transport and environmental problems faced by countries at different stages of economic development are not the same. To effectively tackle road transport created environmental impacts in the various countries in the region, different environmental protection emphases and strategies have to be developed to meet the needs of countries at different levels of economic development. From Table 2.6, the Asia-Pacific region as can be seen consists of countries and territories at various stages of development (ST 1/3/96 and PIARC 1995). For the purpose of the present study, the countries in the region are grouped into four categories of Group 1 to Group 4 based on their economic status and development as classified below.

Table 2.6 Area, population and per capita GNP for some Asian countries

Country/Territory	Area (sq km)	Population (million)	Per capita GNP US$
Singapore	620	2.8	19,310
Brunei Darussalam	5,770	0.3	14,144
Philippines	300,000	67.0	830
Republic of Korea	99,020	44.4	7,670
China	9,596,960	1178.4	490
Indonesia	1,909,570	192.2	730
Thailand	513,120	57.5	2,040
Viet Nam	331,690	72.3	170
Japan	377,800	124.4	31,450
Malaysia	329,750	19.6	3,160
Cambodia	181,000	8.7	200
Sri Lanka	65,600	17.2	500
Hong Kong, China	1,100	5.9	13,200
India	3,288,000	865.0	330
Pakistan	796,000	115.8	400
Nepal	141,000	19.1	180
Lao People's Dem. Rep.	237,000	4.3	230
Bangladesh	144,000	108.8	220
Taiwan Province of China	36,000	20.2	8,000
Myanmar	679,000	42.5	200

Source: PIARC (1995). *Priority Needs of Road Development in Asian Countries Roads*, No. 287, Permanent International Association of Road Congress. Paris.

2.7.1 Basis for grouping of countries

Group 1: High income countries such as Hong Kong China (US$6,340 per capita), Japan (US$31450 per capita), Republic of Korea (US$7,670 per capita) and Singapore (US$19,310 per capita).

Group 2: Medium income countries such as Indonesia (US$730 per capita), Malaysia (US$3160 per capita), Philippines (US$830 per capita), and Thailand (US$ 2,040 per capita).

Group 3: Low income countries such as China (US$490 per capita), India (US$330 per capita), Pakistan (US$400 per capita), and Sri Lanka (US$500 per capita).

Group 4: Lowest income countries with per capita income around US$250 or below such as Afghanistan, Bangladesh, Cambodia, Lao People's Democratic Republic, Mongolia, Myanmar, Nepal and Viet Nam.

Road density in the Asia-Pacific countries have shown close relationship with the economic conditions of each country. For example, Hong Kong China and Singapore have high quality roads with high values for total length of road per square kilometre area, and the pavement ratios of over 90 per cent. On the other hand, for countries like Myanmar, Laos and Bangladesh, the total length of road per square kilometre area is below 10 per cent. Therefore it seems prudent that in the present study of the road related environmental problems, the countries of the Asia-Pacific region could be classified into four groups depending upon the economic conditions of each country.

2.7.2 Road transport features of countries by grouping

Group 1 Countries

The Group 1 countries such as Australia, Hong Kong China, New Zealand, Republic of Korea, Singapore and Taiwan Province of China have already established national road infrastructure of satisfactory standards. Cross country expressways have been substantially provided for. Except Singapore where active traffic management measures, and effective demand control are effectively in place, practically in all the cities of these countries/territories, urban traffic congestion continues to pose a constant threat due to the ever increasing volume of vehicle traffic. The countries are seriously looking into advanced technologies such as intelligent vehicle-highway systems and innovative road pricing mechanisms for solutions to meet future challenges. Traffic noise and vehicle emission are other areas of common concern and complaints as the standard of living is becoming higher as a result of economic progress. This group of countries/territories have the highest level of environmental awareness in the Asia-Pacific region. For example, proper vehicle inspection systems, effective traffic law enforcement, satisfactory mass transit systems, and integrated transportation and land use planning are already in place in these countries. However, more effort is needed to further strengthen environmental protection activities because the level of commitment and achievement in general are still lagging far behind the developed countries in North America and Europe. For example, with the exception of Japan, the advantageous use of non-motorised vehicles for short urban trips has largely been ignored in these countries.

Group 2 Countries

The Group 2 countries are represented by countries such as Indonesia, Malaysia, the Philippines and Thailand, which have enjoyed very high rates of economic growth in recent years. These countries are characterised by severe urban traffic congestion caused by rapid urbanization and motorization in their major cities. Figure 2.2 shows the rapid growth in vehicle population for these Group 2 countries as compared to a typical Group 1 country - Singapore (Vaughan 1992). Inadequate mass transit capacity, ineffective traffic law enforcement, weak institutional capability, lack of financial resources, poorly coordinated transportation and land use planning, and insufficient environmental protection policies are some of the problems common to these countries. These inadequacies and shortcomings are the major causes to other road transport related problems such as high road accident rates, excessive vehicle emission, overloaded commercial vehicles and unacceptable traffic noise.

In these countries, the existing road transport infrastructure (both the urban street and national road networks) are unable to cope with the needs of industrialisation and economic development. Uncontrolled motorization and make-shift measures to meet the demand for passenger and goods transport needs have led to a host of adverse environmental consequences in the major cities. There are now tremendous political and public pressures for the government and road authorities to implement corrective measures to mitigate or eliminate the environmental problems. Pure technical solutions (such as various traffic management schemes and new intelligent transportation systems) alone are unlikely to provide a effective cure to the various road transport related problems. A more comprehensive corrective package covering institutional, social, and policy issues as well is necessary to offer a long term solution.

Group 3 Countries

The Group 3 countries consists of low income nations such as China, India, Pakistan and Sri Lanka etc. As the economies of this group of countries are also beginning to take off, the road transport related problems faced by Group 2 countries are also present in their more developed regions due to over-population in major cities caused by migration from rural areas. As seen from Table 2.2, out of the 13 Asian megacities expected in the year 2000, 7 of them will be from Group 3 countries. The impacts will be of a much significant scale than in Group 2 countries if corrective and preventive mitigation measures are not implemented in time. On the whole, Group 3 countries are progressing at a much lower level economically as compared to Group 2 countries. There is a big imbalance in economic development among different regions within each of the Group 3 countries. Each of these countries is dominated by large areas of rural agricultural regions where there is a pressing need for a better rural transport infrastructure. Accessibility and availability of transport is vital for the structural transformation from subsistence to market economy. Securing external aid from international organisations and sourcing of funds from the private sector appear to be a crucial factor in developing the needed road infrastructure. It is important to ensure that environmental protection consideration be incorporated as an integral part of such a large scale road development effort. Special effort should be made in the acquisition and dissemination of the wide range of road development and environment protection technologies for planning, survey, design, construction and maintenance of the road infrastructure.

Group 4 Countries

Group 4 represents countries with the lowest income. The countries included in this group are Bangladesh, Cambodia, Lao People's Democratic Republic, Myanmar, Nepal and Viet Nam etc. In these countries, large scale motorization has not yet taken place. The low level of economic activity is reflected in their low density road networks (less than 0.1 km/sq.km area) as compared to the medium density of Group 2 and Group 3 countries (up to 0.57 km/sq.km area) and the high density of Group 1 countries (1.5 to 4.68 km/sq.km area).

One of the most pressing needs in these countries is the securing of external assistance, both financially and technologically, to upgrade their national road infrastructure, including bridges and tunnels. It is noted that effective expansion of rural road network would not be feasible without adequate financial and institutional arrangements for planning, construction and maintenance. Attention must also be given to the shortage of technical staff, qualified planning personnel and policy makers in these countries. The lack of rural infrastructure management capabilities severely constrain resource mobilisation and maintenance.

Another area that deserves attention relates to the role of non-motorised vehicles and the need to provide improvements to off-road intermediate means of transport. Careful management of existing non-motorised vehicles could enhance their beneficial role in complementing other transport modes to derive optimal economic benefits. Off-road intermediate means of transport refers to those transport modes intermediate between walking/headloading and motor vehicles. They can contribute significantly to the accessibility and personal mobility of rural people.

2.8 Summary

A grouping of the ESCAP member countries into four main groups based on their economic development is adopted in the present study for the purpose of analysing road transport and environment protection issues. The sustaining high economic growth of the many countries of Group 1, 2 and 3 in the last decade has created waves of impacts and challenges to the road transport sector of all the countries in the ESCAP region to provide the needed support for the growing economies. These challenges have arisen from the following related developments: (a) rising trade and globalisation of the economies demand a good road transport infrastructure which is currently lacking in many countries due to past under-investment; (b) rapid urbanization which has created a sudden huge requirement for passenger and goods transport facilities which are beyond the existing road capacities of many cities in the region; and (c) high growth rates in motorization which have generated a host of environmental problems that have in turn hindered economic development in some countries.

It is important that a road transport system must be operated and maintained efficiently to give a high level of service, and be environmentally friendly at the same time for the total enhancement of the quality of life. The provision of an efficient and environmentally friendly road transport to act as catalyst for stimulating further economic development is crucial for the region to sustain the strong economic growth into the next century. Road transportation developments that ignore environmental impacts may lead to adverse consequences which not only create stumbling blocks for long-term economic growth but also generate social and health problems that may haunt the populations of the present and future generations.

Typical road transport and environmental problems in the four groups of countries respectively are identified in this chapter. More detailed descriptions of these issues and some country specific problems are presented in the next chapter. The problem of the lack of area-wide databases in road transport and environment protection information in the region is highlighted. Such databases would be valuable input for policy formulation and decision making.

Various international financial and technical assistance programmes have played a role in advancing positive developments in road transport and environment protection in the region. Such programmes and activities need to be continued to benefit more countries.

3. MAJOR AREAS OF ENVIRONMENTAL CONCERN IN ROAD TRANSPORT SECTOR

3.1 Road Transport and Environment

Road transport conveys many benefits. It allows personal mobility for both work and leisure activities and transportation of goods. Road transport like most other productive processes and sectors of the economy, produce Fig. 3.1 many unintended by-products in addition to the primary product (which is transportation of goods and people). Some of these unintended products or effects are unpleasant and undesirable. These side-effects of road transport, commonly known as **environmental effects** or **environmental impacts**. In some situations, these are overriding considerations in deciding what type of changes to make in road transportation system and the services it provides.

3.2 Environmental Impacts of Road Transport

Environmental impacts of road transport are many and varied as shown in Fig. 3.2 (ESCAP 1995c). Road transport impacts, which are mainly adverse, can be divided into four categories.

3.2.1 Vehicular impacts

Noise, vibration, air pollution, litter and anxiety resulting from the traffic generated by a road transport development, a road improvement or a traffic management scheme.

3.2.2 Safety and operational impacts

Impacts on the existing road transport system including additional delays to all road users.

3.2.3 Roadway impacts

Visual intrusion, severance, disturbance of archaeological, historical or amenity areas, effects on the aquatic ecosystem, demolition of property, impacts on the urban fabric, on employment, etc. These impacts are usually associated with the construction of major new roads what is generally termed infrastructural developments.

3.2.4 Impacts during construction

These include the impacts of construction traffic and other temporary disturbances such as those resulting from the temporary diversion of streams, construction noise, etc. In some countries, the safety and capacity impacts of road construction and improvement proposals are considered separately from the project environmental assessment since these impacts can be incorporated into an economic evaluation using standard monetary costs for accidents, for travel time and for vehicle operating costs. However, the total impact of a road development on the receiving environment should be included in an environmental assessment. This is necessary in order to satisfy environmental directives locally and regionally.

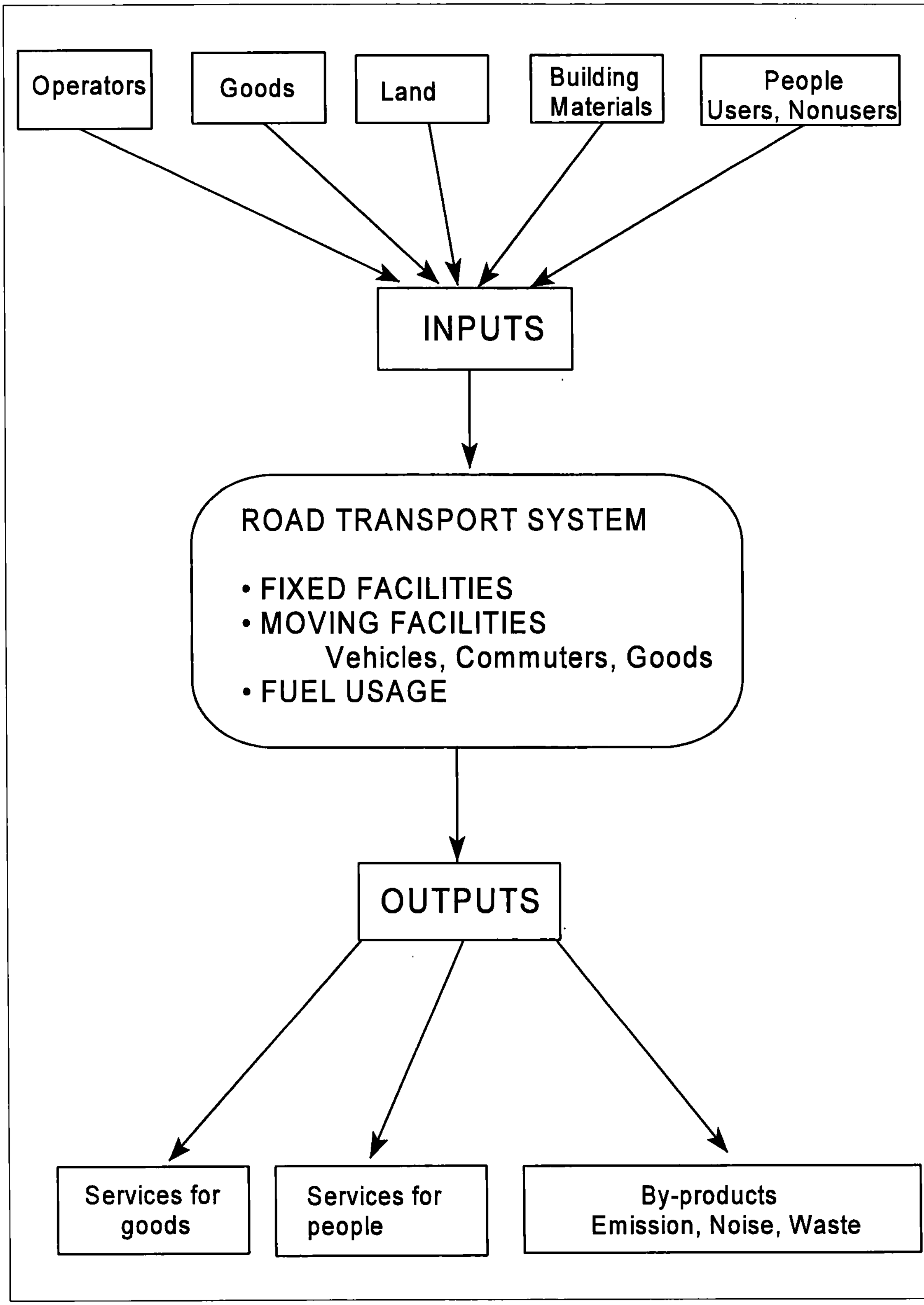


Fig. 3.1: Road transport system: inputs and outputs

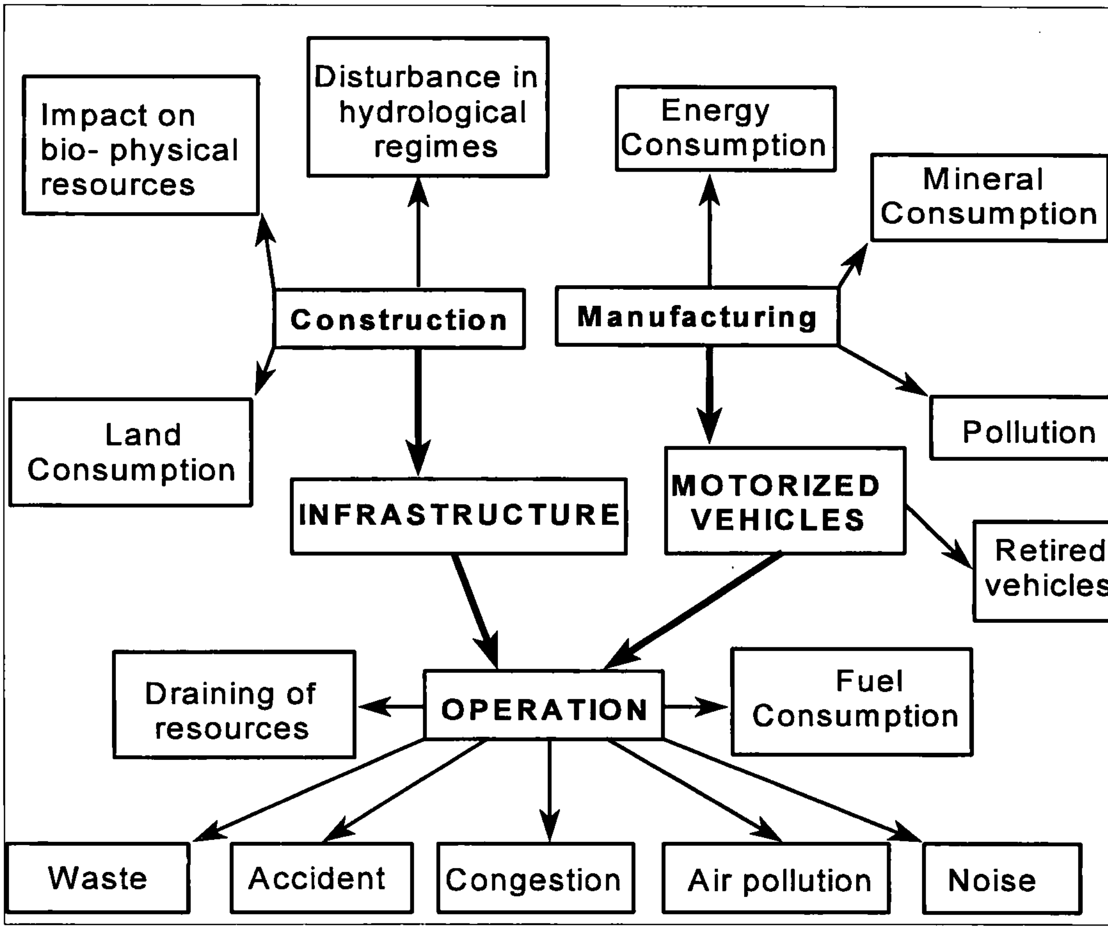


Fig. 3.2: Environmental impacts of road transport system

Source: ESCAP (1995). *State of the Environment in Asia and the Pacific.* United Nations, New York.

3.3 Matrix of Environmental Impacts and Road Transport System Stages

In evaluating the potential environmental impacts of any proposed change in road transportation system or the transportation implications of a proposed development, the following questions should be asked for each of the six environmental subsystems shown in Table 3.1 (Kiely 1997).

1. Is there a potential impact on the environment, and is it positive or negative?
2. How serious is such a change?
3. What is its expected magnitude of change?
4. How certain is the effect to occur?
5. What further assessment or research is required?

Environmental impacts including health effects, might occur in any of the four stages of the road transport system:

- Production of vehicles and fuels
- Construction of the road transport infrastructure
- Operation of the road transport system
- Decommissioning and disposal of vehicles and infrastructure

Table 3.1 Typical environmental impacts resulting from road transport operations and infrastructure construction

Environmental subsystem	Road transport operations	Infrastructure construction
Ecosystem	- Runoff from fuelling facilities - Ingestion of lead	- Disruption of streams - Blocking of animal movements
Resources	- Consistent fuel supply - Maintenance skills for electric vehicles and other advanced technologies	- Parking spaces - Capital, particularly for urban mass transit system construction
Physical environment	- Vehicle exhaust emissions - Deposition in water or rain of exhaust emissions - Noise - Aesthetic impacts	- Dust - Runoff - Noise - Aesthetic impacts
Health	- Spills of toxic materials - HC, CO, NO_x, SO_2 - Particulates - Photochemical smog	- Injection of dust - Noise - HC
Safety	- Spills of hazardous goods - Traffic accidents	- Construction accidents
Socioeconomic environment	- Maintenance costs - Enforcement problems - Impact on local employment	- Resistance to new Construction/fuel storage

Source: G. Kiely (1997). *Environmental Engineering.* McGraw-Hill Book Co., Singapore.

The impacts of the first stage, which range from runoff and groundwater pollution from metal mining to fuel spillages during road transport from plant to sales point, are not considered here. Table 3.1 summarizes typical environmental concerns resulting from the second and third stages (infrastructure construction and transport operations), while disposal of engine lubricating oil on land, disposal of metals such as nickel, cadmium and chromium, burning of tyre and batteries, car junk yards, derelict vehicles, etc., are the principal concerns in the fourth stage of the transport system. A more comprehensive matrix of the areas of environmental impact and each of the above transport stages should be developed for actual projects.

3.4 Environmental Impacts of Roads and Traffic

Environmental impacts resulting from changes in road transport system are usually perceived as being adverse, however, road transportation also has positive impacts such as improving the residential environment by permitting the development of homes in areas with new roads or by the removal of through traffic following the construction of new urban roads. The principal adverse environmental impacts are summarized in Table 3.2 (Kiely 1997). These cover a wide spectrum of both physical and perceived impacts but only a limited number normally result from a specific road transport development. Generally the physical impacts such as noise can be quantified, but the perceived impacts (e.g. anxiety) are difficult to evaluate except in qualitative terms. It is also difficult to determine acceptable values of many of the physical impacts; (e.g. what levels of noise or air pollution are acceptable?) Few legal thresholds or standards exist for the impacts shown in Table 3.2 since they are seldom directly harmful to people or to the local ecology in the short term, but are primarily concerned with the quality of life and as such are subjective. Also human's perceptions of many of these impacts change over time.

3.4.1 Vehicular impacts

These are impacts on the receiving environment caused by the road traffic generated by a proposed development. The effects of this traffic on the operation and safety of the roadway system are considered separately.

Table 3.2 Environment impacts of roads and traffic

Vehicular impacts	- Noise - Vibration - Air pollution - Litter - Physical damage - Anxiety
Safety and capacity impacts	- Accidents - Effects on the operation of roads and intersections
Roadway impacts	- Visual intrusion and aesthetics - Severance - Land consumption and loss of property - Changes in land access and land values - Planning blight - Effects on wildlife, plants and the aquatic ecosystem - Impacts on historic and cultural resources - Impacts on utilities and drainage systems - Employment/business impacts
Construction impacts	- Damage to local roads - Disturbance to roadside residents and other road users - Effects on ecosystem and drainage - Impact at source of materials - Litter, mud, odours, etc.

Source: G. Kiely (1997). *Environmental Engineering.* McGraw-Hill Book Co., Singapore.

Noise: The noise generated by a stream of traffic depends on the following factors:

- traffic volume and speed
- traffic composition (percentage of heavy commercial vehicles)
- road gradient
- traffic flow conditions (free flowing or stop and go)
- road surface type and irregularities

For free-flowing traffic with at least 5 percent heavy vehicles, the traffic noise level drops to a minimum at an average speed of 30 to 40 km/hr irrespective of the traffic volume (DOT, 1988).

The noise level at the reception point is influenced by (EC 1997):

- distance from the road to the reception point
- height of the reception point above the road
- intervening ground surface conditions
- presence of obstructions (including noise barriers) between the road and the reception point
- presence of nearby buildings, walls or ground surfaces which reflect noise

The wind speed and direction will also influence the noise level, but this is frequently omitted from consideration.

As it can be seen, urban traffic noise is produced by many individual sources which include traffic flow, traffic composition, vehicle speed, road intersections, pedestrian crossings, road gradient, road width and road surface as shown in Fig. 3.3 (WB 1994c). Of these, the most important one is the traffic speed. Under the uninterrupted traffic flow condition, the faster the traffic travels, the greater the noise level. The construction of new expressway/motorways and the widening and improving of the existing roads have increased the speed of traffic flow in and around built-up areas. Speed limits have arisen from 50 km/hr to 70 or 80 km/hr on many roads. All these road developments have invariably been in urban communities or adjacent to them where roads pass through commercial and residential areas. The results is increased traffic noise to all the inhabitants (Dix 1984). Road traffic noise is especially nuisance in urban areas and alongside major trunk arteries and at locations around transport terminals.

Road traffic noise fluctuates according to a number of operating factors. Noise is produced by all vehicles from the engine, tyres, gearbox and exhaust system. Heavy vehicles also produce rattles, squeaks and vibrations according to the degree of loading and age. All vehicles produce more engine noise at faster speeds, and a doubling of average speed can increase the noise level by 9 dBA to 13 dBA. For a constant average speed, doubling the number of vehicles per hour increases average noise level by 3 dBA to 5 dBA. "Stop and go" traffic introduces higher peak levels. Smooth but slow traffic has a low average and low peaks. Also tyre noise increases with speed and a wet road can increase the noise level by about 10 dBA. Generally, a heavy goods vehicle produces twice as much noise a private car. According to some study (WB 1994c, OECD 1994a, 1994b) on an expressway, the noise from one heavy lorry equals that from 10 passengers cars. The actual pattern of traffic noise on a main urban road is complex. There is a general noise level as long as any traffic is moving and this varies with the traffic density and time of the day. It is common on urban road to have regular distinctive traffic peaks in the morning and evening as people travel to and from workplaces. Superimposed on this general level are peak traffic noise levels of a few seconds duration when individual vehicles

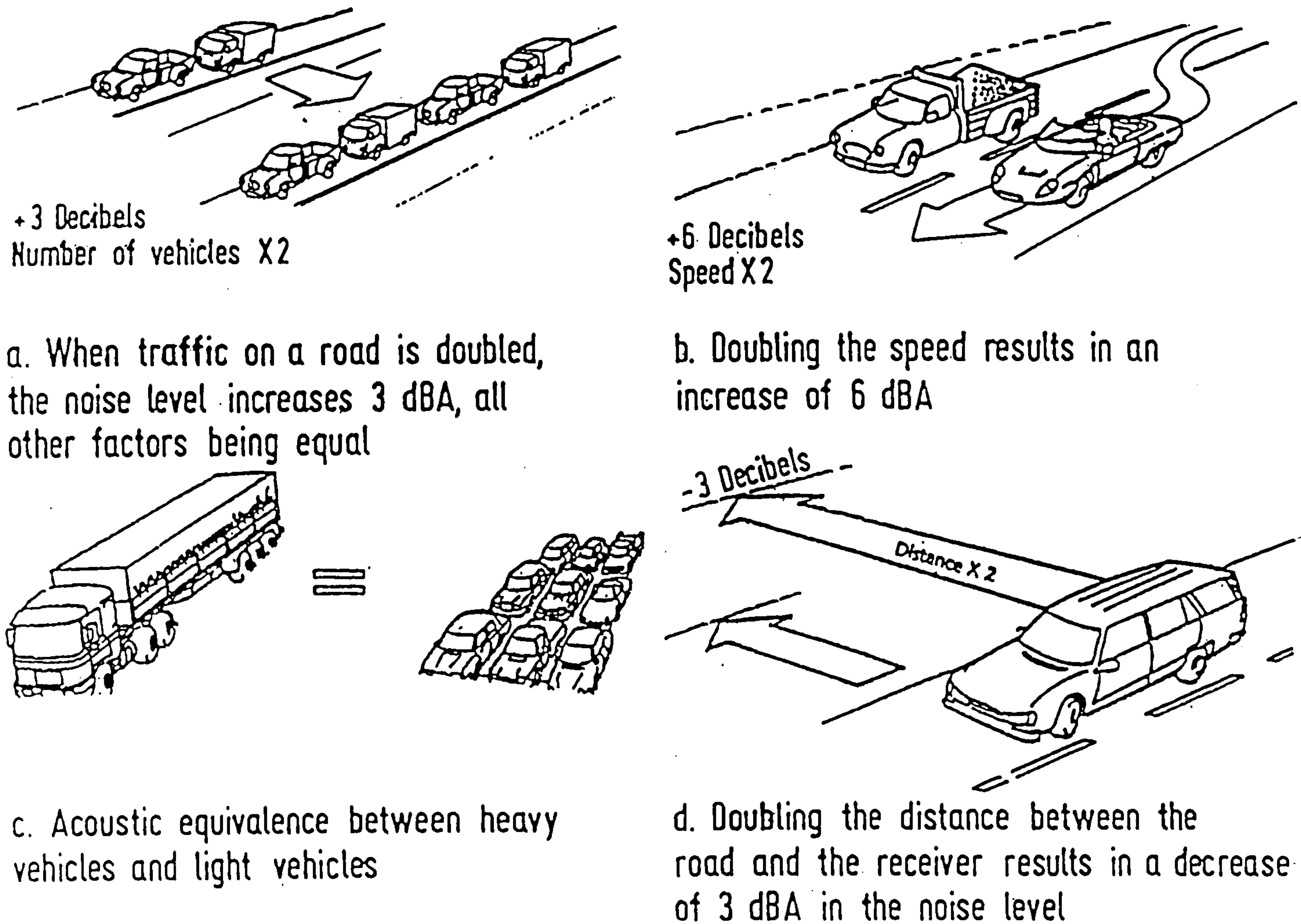


Fig. 3.3 Effects of traffic flow, speed and composition on noise levels

Source: World Bank (1994c). *Roads and the Environment - A Handbook*. Report TWU 13, World Bank, Washington DC.

are passing any given location. These individual noise peaks vary according to the size, type and speed of vehicles. For example, heavy diesel-engined goods vehicles are the noisiest vehicles on the roads today. Average city traffic noise is around 80 dBA whereas the heavy city traffic noise is around 90 dBA. Many organisations have studied and estimated road traffic noise levels. Table 3.3 shows typical road traffic noise levels (Dix 1984). Noise levels of some cities of the region are given in Table 3.4 (ESCAP 1993a, 1995a, 1995b, 1995c).

The World Health Organization (WHO) has set recommended maximum noise levels at 55 dBA for ambient exposure. But many cities of the region have far exceeded that limit (Table 3.4). In New Delhi, Dhaka, Karachi, Jakarta, Manila and some other cities, two and three wheeled motor bikes roar around at 92 dBA at 40 km per hour. Similarly, heavy vehicles which have faulty transmission systems can raise 85 dBA to 97 dBA at 35 km to 50 km per hour (ESCAP 1993a and 1995c).

Table 3.3 Typical road traffic noise levels

Situation	Average traffic speed, km/hr	Intervening ground	Noise level dBA
Residential road parallel to busy main road	48	Houses	60
18 m away from busy main road in residential areas	48	Paved areas	70
18 m from motorway with high volume of heavy vehicles	96	Grasses	80
3 m from main road in residential areas	48	Paved areas	80

Source: H.M. Dix (1984). *Environmental Pollution.* John Wiley International, New York.

Urban road traffic noise has become an important environmental concern. It is recognised as an unjustifiable interference and imposition upon human comfort, health and the quality of life. Noise can damage the ear and cause temporary and permanent noise induced hearing loss, depending upon the intensity and the duration of the noise level. The most commonly occurring ear damage is caused by continuous periods of high intensity noise. If the ear receives a noise of over 90 dBA in the mid-high frequency range for more than a few minutes, then the auditory sensitivity is reduced. The degree of hearing loss due to noise has been shown in Table 3.5 (Dix 1984). Besides progressive hearing loss, there can be instantaneous pathological or psychological disorders. Pathological effects can result from particular noise frequency causing vibrations or resonance in human bodies. High frequencies, or ultrasonic sound above the normal audible range, can affect the semi-circular canals of the inner ear and cause nausea and dizziness. Alternatively, very low frequency noise can cause resonance in the body organs, producing the effects of decreased heart beat, vibrations in blood pressure, and breathing difficulties. Mid-audible band frequencies are known to cause resonance in the skull and so affect the brain and nervous system with consequent effects upon thinking and co-ordination of the limbs. In many cities of the region, the road traffic noise level is in the range of 80 to 90 dBA which has caused severe health effects to the city-dwellers and road users (ESCAP 1993a, 1995a, 1995b and 1995c).

Table 3.4 Road traffic noise levels of some cities of the region

City	Noise level, dBA
Bangkok	72 - 95
Beijing	65 - 90
Bombay, Calcutta, Delhi	80 - 95
Jakarta	65 - 90
Kuala Lumpur	60 - 90
Manila	65 - 85
Taipei	55 - 85
Tianjin	62 - 75

Sources: ESCAP (1993). *State of the Urbanization in Asia and the Pacific* (ST/ESCAP/1300). United Nations, New York.
ESCAP (1995). *State of the Environment in Asia and the Pacific.* United Nations, New York.

Table 3.5 Degree of hearing loss due to noise

Degree of hearing loss	Noise level (dBA)
No real difficulty in hearing	less than 25
Difficulty in hearing soft speech	25 to 40
Difficulty in hearing normal speech	40 to 55
Difficulty in hearing loud speech	55 to 70
Only shouted speech understood	70 to 90
Unable to hear even amplified speech	90 or more
Requires hearing aid	60 or more

Source: H.M. Dix (1984). *Environmental Pollution.* John Wiley International. New York.

Vibration: Vibrations from passing traffic are a common source of environmental nuisance, particularly for those living beside main roads. They may be the most frequent environmental complaint made by residents to local authorities, probably because of the fear that the vibrations could damage buildings. Traffic-induced vibrations may be airborne or groundborne and are almost entirely associated with heavy vehicles (Kiely 1997).

Airborne vibrations: Airborne vibrations are caused by low-frequency sound (50 to 100 Hz) produced by large vehicle engines and exhausts. The resonant frequencies of rooms may be excited by acoustic coupling through windows and doors. This produces annoying rattling of doors, windows and small objects in the front rooms of buildings. At the most exposed locations acoustically induced floor vibrations can become perceptible (Watts 1990). The presence of such airborne vibrations can be detected by noting whether front room windows and doors rattle when a bus or another heavy vehicle passes. Low-frequency noise can be perceived directly and can sometimes lead to annoying muffled sensations in the ears and perceptible chest vibrations (Watts 1990).

Groundborne vibrations: Groundborne vibrations are caused by varying forces between the tyres of heavy vehicles and roads surfaces which result from irregularities in the road surface. They can become perceptible in buildings located within a few metres of the carriageway when heavy vehicles pass over irregularities of the order of 20 mm in the road surface. Groundborne vibrations are of lower frequency than airborne vibrations (8 to 20 Hz) and enter buildings through the foundations. Both compression and shear waves are produced in the ground, which can result in structural damage to poorly maintained buildings. Consequently groundborne vibrations are potentially more serious than airborne vibrations. Their presence can be felt as short duration impulsive vibrations, particularly in the middle of upper floors of buildings. However, a major investigation (including extensive site studies) carried out by the Transport and Road Research Laboratory (TRRL) UK concluded that there is no evidence to support the assertion that traffic vibrations can cause significant damage to buildings, although severe nuisance to occupants can occur (Watts 1990).

Air pollution: Air pollution is caused by a wide variety of man-made and natural sources. Fuel combustion has been identified as the largest single contributor to air pollutant emissions. In this category, stationary and mobile sources (internal combustion engines) are however, varying significantly for individual pollutants. Mobile sources include motor vehicles, aircraft, ships, railways, etc., of which road traffic is by far the dominant source of air pollutant emissions. Road traffic, in turn, includes light and heavy duty vehicles fuelled with either gasoline, diesel, compressed natural gas (CNG) or liquefied petroleum gas (LPG), and motorbikes usually fuelled with gasoline.

Motor vehicle exhaust emissions include emissions from the exhaust pipe, blow-by from the engine crankcase, fuel evaporative emissions from the fuel tank and carburettor as well as particulate emissions from the wear and tear of tyres and brakes. The air pollutants emitted from gasoline driven vehicles are carbon monoxide (CO) and hydrocarbons (HCs) or more correctly, volatile organic compounds (VOCs) resulting from incomplete combustion, nitrogen oxides (NO_x) generation under high combustion temperatures mainly from oxygen and nitrogen in the combustion air, and lead (Pb) from fuel-lead which is added to attain the desired octane rating (Faiz et al 1992). CNG and LPG-driven cars have lower HC and CO emissions from the exhaust pipe because of more complete combustion (Verloop 1992). Nitrogen oxide emissions are comparable to those from gasoline cars. No lead is emitted from CNG-and LPG-fuelled cars. Diesel driven vehicles also have better combustion efficiencies, therefore, emitting lower rates of HC and CO, and they emit fewer NO_x (on an uncontrolled basis) due to lower ignition temperatures. Diesels emit no lead. However, diesel engines emit fine particles including polycyclic organic matter (POM) - a group of genotoxics, SO_2 due to the higher sulphur content in diesel compared to gasoline, and more aromatic HCs which cause an unpleasant odour and simultaneously have negative health effects, and of which some are carcinogenic (Faiz et al 1992). Aromatic HCs are not only emitted from diesel vehicles but also from gasoline cars. An example of a carcinogen emitted in this group is benzene which, to a large extent, is formed furring combustion. Particulate emissions from the wear and tear of tyres and brakes include asbestos which is also carcinogenic. Further, the use of regenerated lubricants containing PCBs may lead to emissions of dioxins.

Figure 3.4 shows the constituents of vehicle exhaust gas divided into noxious and innocuous compounds (Claus et al 1993). Although carbon dioxide is not an innocuous compound (vis-à-vis health), it is undesirable as it is a contributor to global warming.

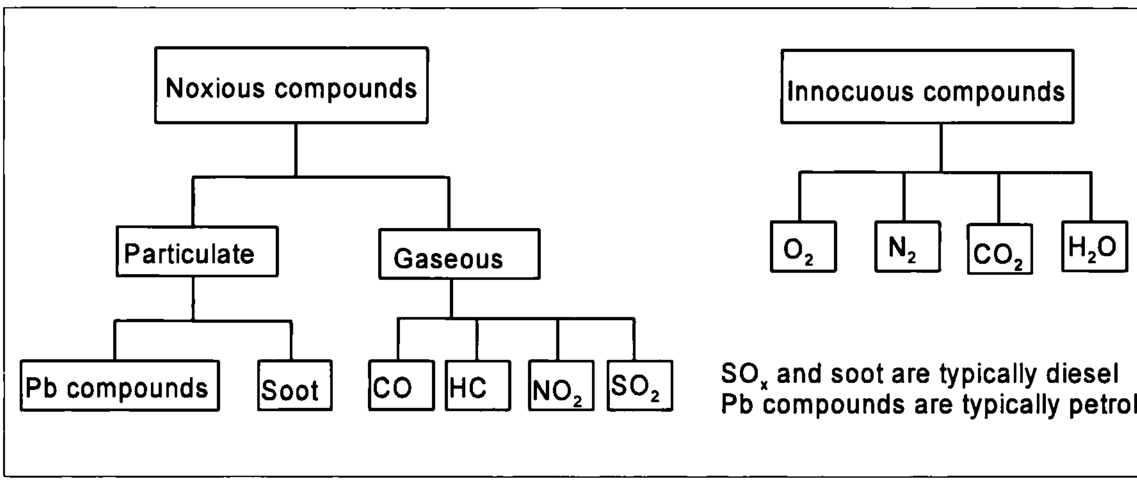


Fig. 3.4: Constituents of vehicle exhaust emissions

Source: H.J. Claus, K. Susanne, M.S. Michael and T. Henning (1993). Transport planning and policy: The Danish experience. *UNEP Industry and Environment*. Vol 26, No. 1, pp. 11-14.

Petrol engines are considered less obnoxious than diesel engines although diesel engines burn fuel more efficiently resulting in lower pollution emissions (e.g. diesel engines emit only one-fifth the quantity of carbon monoxide). However, since diesel engine pollution is more visible and emits odours, it causes more public disquiet and the relatively high emissions of inhalable particulate matter and associated hydrocarbons raises health and environmental concerns.

Since lead is taken up in the biological chain and has been shown to cause behavioural problems in children, the EU and US Environmental Protection Agency (USEPA) have pursued a policy of reducing the amount of lead in petrol engines (there is no lead in diesel fuel).

Comparing emissions from the transport sector to overall man-made emissions on a national basis, about 90 percent of all CO emissions originate from the transport sector, mainly automobiles. In most Asia-Pacific countries, anthropogenic NO_x emissions stem to approximately equal parts from the transport sector and the energy and industrial sectors. In urban areas, 50 percent of total HCs are often emitted from automobiles. Of all, benzene emissions around 80 percent originate from gasoline-powered motor vehicles if uncontrolled. Lead emissions are due to automobiles to at least 50 percent.

The relative contribution from motor vehicles to ambient air quality in cities is higher than their emission shares on a national basis. In the centre of an average built-up area, traffic usually accounts for 100 percent of CO and lead levels, for at least 60 percent of NO_x and hydrocarbon levels, for about 10 percent of SO_2 and 50 percent of particulate levels. These shares can increase further with respect to the street environment itself.

Local air pollution can affect the health of those living and working near the road, as well as soils, crops, water, and facades of buildings. This is mainly of concern in areas of high population density. Regional and/or global effects of air pollution are **greenhouse effect**, **destruction of protective ozone layer** and **acid rain** (Mackenzie and Walsh 1995). Air pollution caused by vehicles follows a cycle. Emission of pollutants depends on type of vehicle, type of engine, engine maintenance, and fuel quality (OECD 1994a). Figure 3.5 shows the interaction between various pollutants. **Propagation** of air pollutants in the air depends on the local topography, temperature, rainfall, and wind pattern whereas the **reception** of air pollutants is by humans, soil, fauna, and flora as shown in Fig. 3.6 (WB 1994c).

A major source of CFCs in the atmosphere is motor vehicle air conditioning. It is estimated that from 1987 onward, approximately 50 percent of all new cars, trucks and buses manufactured worldwide were equipped with air conditioners. CFCs are also used as a blowing agent in the production of seating, lining and other foam products used in motor vehicles. Annually about 120,000 tonnes of CFCs are used in new vehicles and in servicing air conditioners in old vehicles. In all, these vehicular uses account for around 30 percent of the global demand of CFCs. According to USEPA, vehicular air conditioners are the single largest users of CFCs (Mackenzie and Walsh 1995).

Tables 3.6 and 3.7 give the emission factors for road vehicles and contribution of motor vehicles to air pollution in selected cities respectively (WB 1993, Bose and Mackenzie 1993). An estimate of road transport emissions in Delhi, India is given in Table 3.8 (ESCAP 1995c). The gravity of the problem posed by worsening pollution throughout the region is illustrated in the Table 3.9 (ESCAP 1995c) which contains forecasts of the extent of pollution in selected countries of the Asia and the Pacific region until the year 2000. These forecasts which were made in a joint study by ADB and ESCAP (ESCAP 1994a) focus on all forms of emissions, but in all probability understate the likely growth in atmospheric pollution due to motor vehicle exhaust emissions, because the latter would be increasing considerably faster than other forms of pollution. The forecasts indicate that a business as usual scenario, without the implementation of any additional control measures would mean that pollution levels in Republic of Korea and Thailand by the year 2000 would be more than 3 times their 1991 level (United Nations 1991b). Indeed the prediction for other ESCAP countries only slightly more optimistic, since most of these countries could have more than double their pollution level in 10 years.

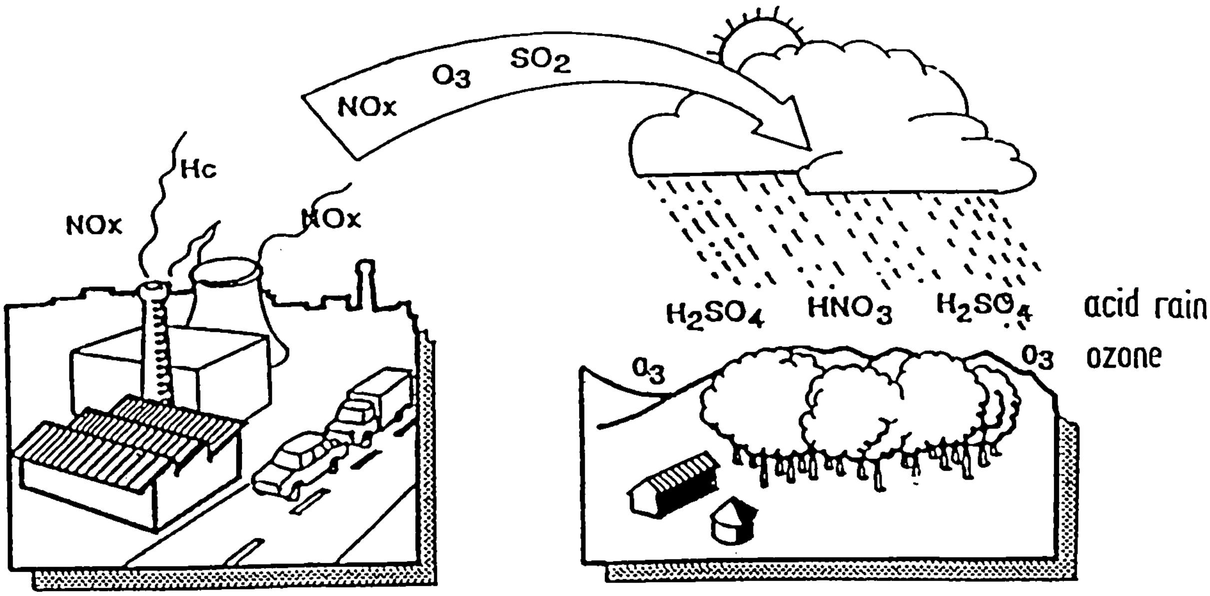


Fig. 3.5 Interactions between various air pollutants

Source: World Bank (1994). *Roads and the Environment - A Handbook.* Report TWU 13, World Bank, Washington DC.

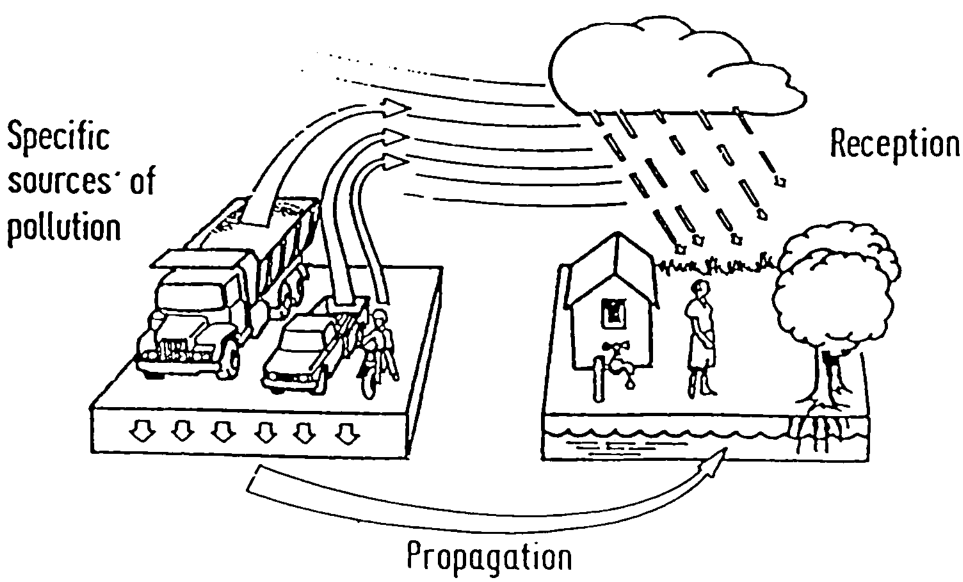


Fig. 3.6 Pollution caused by vehicle emission: propagation and reception cycle

Source: World Bank (1994). *Roads and the Environment - A Handbook.* Report TWU 13, World Bank, Washington DC.

Table 3.6 Emission factors for road vehicles

Vehicle	Fuel	Emissions (g/L)					
		CO	HC	NO_x	SO_2	SPM	Lead
Car	Gasoline	261.93	28.91	17.11	0.58	n.a.	0.18
Jeep	Gasoline	271.30	40.31	17.73	0.58	n.a.	0.18
Jeep	Diesel	2.36	0.91	4.45	6.20	0.15	n.a.
2 wheeler	Gasoline	368.52	229.92	n.a.	0.58	n.a.	0.18
3 wheeler	Gasoline	249.00	155.40	n.a.	0.58	n.a.	0.18
Bus	Diesel	18.84	7.30	35.61	6.20	1.18	n.a.

n.a. = Data not available.

Source: R.K. Bose and G.A. Mackenzie (1993). Transport in Delhi: energy and environmental consequences. *UNEP Industry and Environment.* Vol. 1, Nos. 1-2, pp. 21-25.

Table 3.7 Contribution of motor vehicles to air pollution in selected cities

City	Year	Total emissions all sources (x1000 t/a)	Percentage attributable to motor vehicles					
			CO	HC	NO_x	O_x	SPM	Total
Beijing	1989	n.a.	39	75	46	n.a.	n.a.	n.a.
Bombay	1981	564	86	20	44	n.a.	3	31
Calcutta	1978	537	87	15	25	n.a.	n.a.	n.a.
Delhi	1987	428	90	85	59	13	37	57
Kuala Lumpur	1987	423	97	95	46	1	46	79
Seoul	1983	n.a.	15	40	60	7	35	35
Manila	1987	496	93	82	73	12	60	71

n.a. = Data not available.

Source: World Bank (1993). *Towards an Environment Strategy for Asia.* Washington DC.

Table 3.8 Estimation of emission trends in Delhi, India (Tonnes/years)

	1990/91	2000/01
Carbon monoxide	179.59	286.33
Hydrocarbons	73.00	116.39
Lead	0.10	0.17
Nitrogen oxides	16.12	25.70
Sulphur dioxide	2.27	3.63
Total suspended particles	0.36	0.58

Source: ESCAP (1995). *State of the Environment in Asia and the Pacific.* United Nations, New York.

Table 3.9 Forecasts of air pollution in selected countries of ESCAP region

Country	Pollution index		
	1991	1993	2000
Afghanistan	100	116	193
China	100	125	268
India	100	121	233
Indonesia	100	120	223
Malaysia	100	121	238
Nepal	100	118	209
Pakistan	100	123	252
Philippines	100	111	159
Republic of Korea	100	128	302
Thailand	100	129	314

Source: ESCAP (1995). *State of the Environment in Asia and the Pacific.* United Nations, New York.

Primary pollutants such as benzene, carbon dioxide (CO_2), and chlorofluorocarbons (CFCs) are transformed into secondary and tertiary pollutants such as ozone and acid rain through various chemical reactions (Fig. 3.4) linked to various meteorological factors, air temperature and humidity, and the topography of the site. Impacts of specific pollutants can be roughly grouped as follows: **greenhouse effect** (CO_2, CO, NO_x, CFCs), **acid rain** (HCs, NO_x, SO_2), **health** (CO_2, CO, HCs, NO_x, SO_2, lead, CFCs, benzene). **Ozone layer depletion, greenhouse effect** and **acid rain** associated with vehicular emissions and other emissions from industries are major issues on the global agenda for sustainable development (ESCAP 1994c). It is now evident that the depletion of the ozone layer increases the amount of ultraviolet radiation reaching the earth's surface. This in turn not only leads to an increase in skin disease, but also significantly contributes to global warming (Mackenzie and Walsh 1995). Similarly, a high level of respiratory diseases, such as bronchitis, tuberculosis, skin allergies and eye irritation, is always associated with air pollution. Various adverse health effects air of pollutants from road transport are presented in Table 3.10 (Faiz et al 1992).

In Asia-Pacific region, a relatively heavy concentration of road networks and vehicles in a few cities has resulted in high levels of pollution which invariably become a serious health hazard when aggravated by the high density of vehicles sitting in slow moving traffic. In many of the major cities of the region, road transport accounts for a major share of air pollution load e.g. Delhi, 57 percent; Beijing, 75 percent; Manila, 70 percent; Bangkok, 80 percent; and Kuala Lumpur, 76 percent (ESCAP 1995c).

In Thailand, the main pollutants from the transport sector (mainly road transport) are lead, carbon monoxide, nitrogen oxides, hydrocarbons and smoke resulting from incomplete combustion in diesel and two-stroke motorcycle engines. Transport is the single largest contributor of NO_x emissions (64 percent of total NO_x) and hydrocarbons (41 percent of the total). The transport sector contributes less than industry and power generation, however to the total concentrations of SO_2 and SPM (ESCAP 1995c). The problem of vehicular air pollution in Bangkok has been one of the most acute in the region.

In the Republic of Korea, approximately 38 percent of air polluting substances come from motor vehicles. Exhaust emissions from road vehicles contribute 65 percent of total CO emission, 83 percent of HC, 44 percent of NO_x, 6 percent of SO_2 and 19 percent of particulates. As of the end of 1993, 52 percent of the total number of motor vehicles were concentrated in the six largest cities, which include Seoul; air pollution from road vehicles occurred mostly concentrated in these cities (ESCAP 1995c).

In Indonesian city of Surabaya, measurements of air quality show that some areas consistently exceeded the standards set for SPM and noise, but SO_2, NO_x and CO did not exceed the maximum allowed in any test, although in some cases, the level of these pollutants increased over time (ESCAP 1995c).

In the least developing countries of the ESCAP region, although pollution from transport sector may not be a major environmental issue, increasing vehicular pollution in the major urban centres is becoming an area of growing concern. The problems of air pollution arising from operation of motorised vehicles are primarily precipitated by poor maintenance of vehicles, the degraded condition of roads and use of dirty fuels. A study conducted in Bangladesh found 86 percent of different vehicles on road emitting black smoke at an unacceptable level (ESCAP 1995c).

Table 3.8 shows an estimate of transport emissions in Delhi for the years 1990/91 and 2000/01 (ESCAP 1995c). Each of the pollutants exhibits a rising trend. The emissions of carbon monoxide, hydrocarbons and lead are primarily from two and three wheeler gasoline engines while TSP, NO_x and SO_2 are from diesel vehicles.

Table 3.10 Adverse health effects of pollutants from road transport

Pollutant	Adverse health effects
Lead	Affects circulatory, reproductive, nervous and kidney system; suspected of causing hyperactivity and lowered learning ability in children; hazardous even after exposure ends. (Lead is injected through the lungs and the gastrointestinal tract).
Particulate matter	Irritates mucous membranes and may initiate a variety of respiratory diseases; fine particles may cause lung cancer and exacerbate morbidity and mortality from respiratory dysfunctions. A strong correlation exists between suspended particulates and infant mortality in urban areas. Suspended particulates have the ability to adhere to carcinogens emitted by motor vehicles.
Carbon monoxide	Interferes with absorption of oxygen by haemoglobin (red blood cells); impairs perception and thinking, slows reflexes, causes drowsiness, brings on angina, and can cause unconsciousness and death; it affects fetal growth in pregnant women and tissue development of young children. It has a synergistic action with other pollutants to promote morbidity in people with respiratory or circulatory problems; it is associated with reduced worker productivity and general discomfort.
Sulphur dioxide	A harsh irritant; exacerbates asthma, bronchitis and emphysema; causes coughing and impairs lung functions.
Nitrogen oxides	Can increase susceptibility to viral infections such as influenza; irritate the lungs and cause oedema, bronchitis and pneumonia; and results in increased sensitivity to dust and pollen in asthmatics. Most serious health affects are in combination with other air pollutants.
Hydrocarbons (HC)	Low molecular weight compounds cause unpleasant effects such as eye irritation, coughing and sneezing, drowsiness and symptoms akin to drunkenness, heavy-molecular weight compounds may have carcinogenic or mutagenic effects. Some hydrocarbons have a close affinity for diesel particulates and may contribute to lung disease.
Ozone (Precursors HC and NO_x	Irritates mucous membranes of respiratory system causing coughing, choking and impairing lung functions; causes eye irritation, headaches and physical discomfort; reduces resistance to colds and pneumonia; can aggravate chronic heart disease, asthma, bronchitis, and emphysema.
Toxic substances	Suspected of causing cancer, reproductive problems, and birth defects. Benzene and asbestos are known carcinogens linked to leukaemia and lung cancer; aldehydes and ketones irritate the eyes, short-term respiratory and skin irritation and may be carcinogenic.

Source: A. Faitz, C. Weaver, K. Sinha, M. Walsh and J. Carbajo (1992). *Air Pollution from Motor Vehicles.* World Bank, Washington DC and UNEP Industry and Environment Office, Paris.

Apart from the number of motor vehicles, the air pollution problem in the cities of the ESCAP region is aggravated by the specific characteristics of road traffic. Domestically manufactured motor vehicles, especially in India, People's Republic of China and Philippines have performance and emission characteristics of 1950-60 vintage vehicles and lack pollution controls. The relatively high cost of vehicle ownership compels people to continue using vehicles much longer than their normal life. This results in very low scrappage rates leading to higher proportion of older and poorly maintained vehicles on the road. For example, in Bangkok which is experiencing a high rate of economic growth accompanied by a rapid expansion of disposable income allowing for affording newer automobiles by people, the average vehicle age is 9 years. The average vehicle age for other less developing countries is even higher. In Katmandu, about 38 percent of the trucks are 15 years old and 17.5 percent as old as 20 years (ESCAP 1995c).

The traffic composition in most cities is typically characterised by an exceptionally high proportion of motorcycles. Many motor cycles are powered by old design two-stroke engines that emit up to ten times more hydrocarbons and smoke per kilometre than do the newer four stroke engines of cars and trucks (ESCAP 1995c). In Bangkok, of total vehicle emissions, 54 percent of the hydrocarbons and 88 percent of the organic particulate matter are emitted by motor cycles as shown in Fig. 3.7 (ESCAP 1995c).

Another major factor responsible for the growing air pollution problem in ASEAN region cities is the use of poor quality fuel especially with regard to sulphur content in diesel and lead content in gasoline. The pollution intensity of vehicles using such contaminated fuels might be several times higher than that of vehicles using cleaner fuels. Figure 3.8 shows the level of lead content in gasoline in selected countries. Pakistan, India, Indonesia and Thailand are still using fuels with high lead contents. Combustion of such fuel increases concentration of lead into the

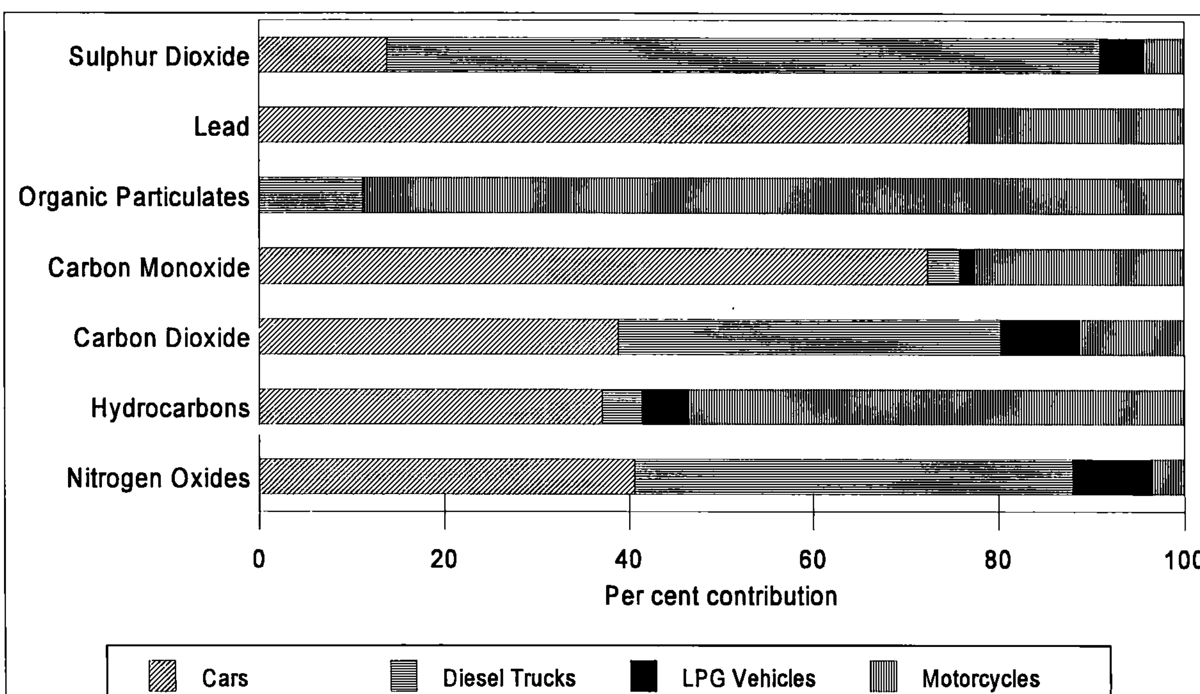


Fig 3.7 Pollution share of different vehicles in Bangkok

Source: ESCAP (1995), *State of the Environment in Asia and the pacific*, United Nations, New York.

atmosphere (ESCAP 1995c). Likewise, Fig. 3.9 shows the level of sulphur content in diesel for selected countries. Pakistan, India, Indonesia and Thailand exhibit a significant level of sulphur in diesel which will result in higher levels of SO_2 in the exhaust gases of diesel vehicles operated in these countries (ESCAP 1995c).

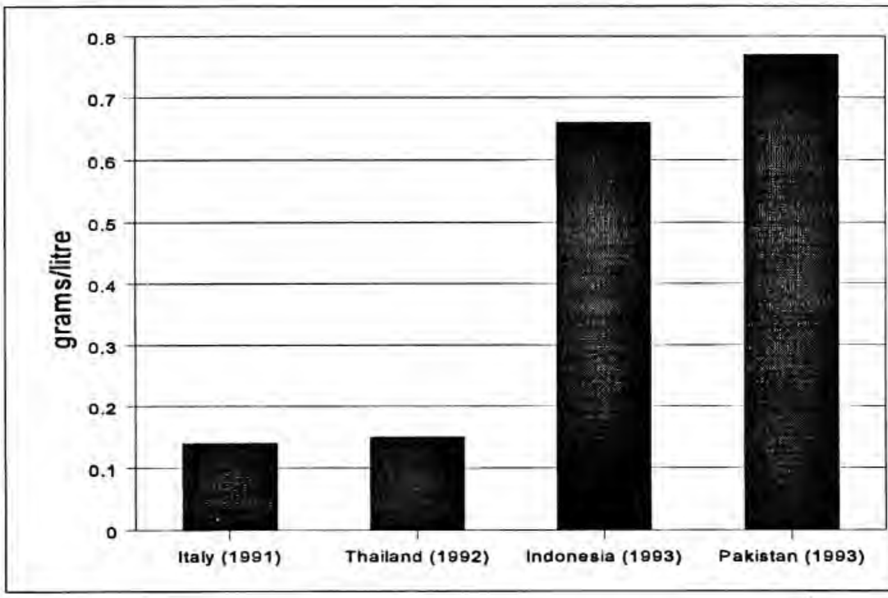


Fig. 3.8: Lead content in gasoline in selected countries

Source: ESCAP (1995). *State of Environment in Asia and the Pacific.* United Nations, New York.

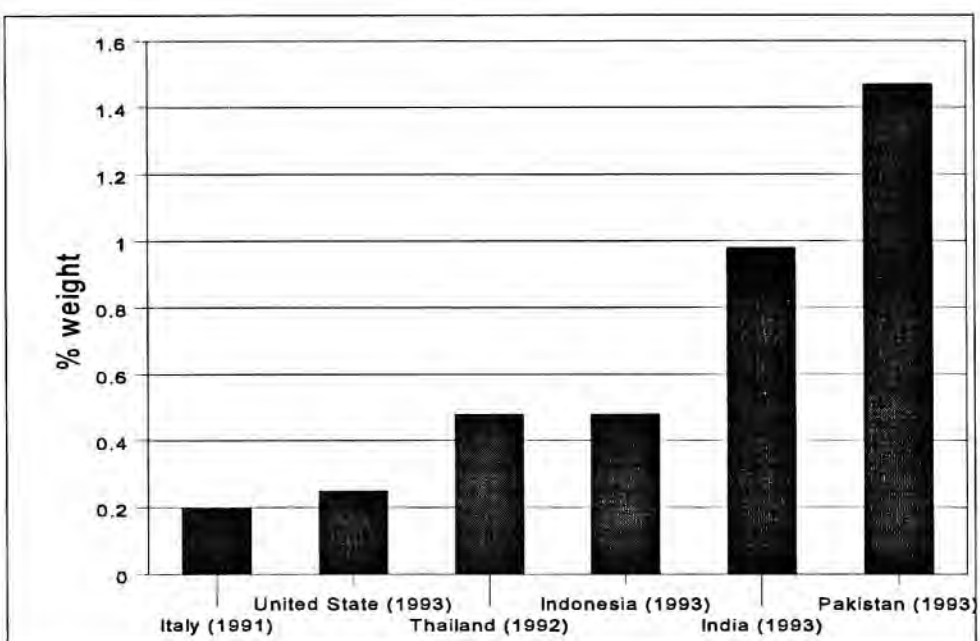


Fig. 3.9: Sulphur content in diesel in selected countries

Source: ESCAP (1995). *State of Environment in Asia and the Pacific.* United Nations, New York.

Air pollution is closely related to the type of fuel used by motor vehicles (Faiz et al 1992). In Jakarta, motor vehicles emitted around 4,000 kg of lead per day in 1987 (ESCAP 1993a); in Delhi, the amount was estimated at 600 kg per day. Various other air toxics (e.g. benzene, ethylene and formaldehyde) are also associated with gasoline and diesel. Vehicle exhausts have given the city of New Delhi the dubious reputation of being the most polluted city in the country. One-third of the smoke and dust emitted in the city comes from automobile use, and over the past decade, the pollution has increased by 75 percent. Heavy vehicles, mostly diesel, constitute only 8 percent of the total vehicles, but they consume 70 percent of petroleum products and produce 47 percent of pollutants. Two-wheelers and three-wheelers constitute 63 percent of the number, consume 9 percent of petroleum and produce 13 percent of the total pollution. Scooters and motorcycles emit twice as much hydrocarbons as cars and the same as heavy vehicles. They contribute 29 percent of all the hydrocarbons - eight times more, per unit of fuel consumed, than heavy vehicles. Not less than 400 kg of lead, a lethal air contaminant, is released in New Delhi every day. Road construction and maintenance workers are particularly vulnerable to it. Samples from leaves on certain roads show a lead concentration of up to 5 ppm (ESCAP 1993a). Children can absorb it five times faster than adults.

The problem of air pollution from road transport has thus become quite acute in many major cities of the Asia-Pacific region. However, the intensity of particular pollutants in different cities varies. Normally, in cities where the density of private passenger vehicles mostly operated with gasoline is rapidly growing, gasoline-based pollutants like NO_x, CO, HC and lead are dominant. On the other hand, in many cities, the most common form of air pollution is suspended particulate matter.

Vehicular-borne litter: Litter is reported as a major environmental nuisance in public opinion surveys and certain areas, such as the outskirts of towns, can be spoiled by car-borne litter. Abandoned cars and illegal dumping may also constitute problems. The provision of convenient litter receptacles appears necessary in such circumstances since exhortation or enforcement alone are often insufficient (Kiely 1997).

Physical Damage: Heavy vehicles cause physical damage not only to the road pavement itself but also to roadside objects such as signs, footpaths and gateposts, particularly on narrow roads. Cars and heavy vehicles splash pedestrians in wet weather. Adequate road maintenance and design, heavy vehicle entry restrictions and enforcement appear the only available remedies (Kiely 1997).

Anxiety: Anxiety or the feeling of not being safe (unsafety) are strongly associated with heavy vehicles and with high speeds. Older people are particularly affected as are parents who worry about their childrens' safety on the roads; parents of young children who cycle are especially worried. An allied environmental impact is the disturbance to social life by not being able to talk on the footpath because of passing traffic. The implementation of traffic calming methods such as speed control and heavy vehicle restrictions can reduce these vehicular impacts. Generally, a detailed local study is necessary in order to determine the necessity for traffic calming and to identify appropriate remedial measures (Kiely 1997).

3.4.2 Road related problems

As is evidenced in many developing countries, a carefully planned highway development would generate a string of economic activities along it. Road development provides the necessary access and mobility required for economic growth. However, care must be exercised to minimize adverse impacts of road development activities. In general, road construction and maintenance involve consumption of natural resources, disfiguration of natural landscape, destruction of area drainage pattern, disruption of natural wildlife and eco-environmental system, and relocation of communities and human settlement.

Poor structural design or sub-standard construction leads to premature road failure, which is a waste of investment and natural material resources. Besides the problem of weak design and poor construction, lack of proper road maintenance has been a wide-spread problem in developing countries. Poorly maintained roads are known to be responsible for high vehicle operating costs and short vehicle service lives in developing countries The high accident rates in developing countries as compared with industrialized nations, are partly related to the generally poorly maintained state of road networks as well as inadequate geometric design.

3.4.3 Safety and Capacity Impacts

These include road accidents, traffic congestion, spillage of hazardous goods and road safety.

Road accidents: The traffic generated by a proposed road development (including pedestrians and cyclists) may affect the safety of the existing road network, particularly if there is a high accident rate at present. Road transport is an inherently dangerous activity. There are, on a day-to-day basis, many fatal and serious accidents as can be seen from Figs. 3.10 to 3.15 (ESCAP 1995d). Road accidents cost many lives. Road accident is becoming increasingly more alarming in this region. Fatality rate due to road accidents is considerably higher in many cities as shown in Figs. 3.16 and 3.17 (ESCAP 1995d). Figure 3.16 shows the number of fatalities per 10,000 vehicles for the latest available year (mostly 1992/93) for many countries in the Asia-Pacific region and also UK for comparison. It can be seen that Australia, Japan and Taiwan Province of China characterise the fatality rate of industrialised countries, which is usually about two fatalities per annum per 10,000 licensed vehicles. In contrast, it can be seen that many developing countries in Asia-Pacific region have extremely high fatality rates, between 20 and 70 deaths per 10,000 vehicles.

This single indicator - annual fatalities per 10,000 vehicles - indicates clearly the severity of the road accident problem in many countries in the Asia-Pacific region. Even in emerging, newly industrialised countries such as Thailand and the Republic of Korea there are between 11 and 15 deaths per 10,000 vehicles, i.e. about eight times higher than in the most fully developed countries of the region. It is interesting to note that if Japan had a comparable fatality rate to, say, the Republic of Korea, the number of people killed on Japan's road per annum would be 116,000 as opposed to the 13,800 "standard 30 day deaths" which occurred in 1994.

Many Asia-Pacific countries have an extremely high fatality index (deaths divided by total casualties, i.e. injured and killed) expressed as a percentage. This is in stark contrast to industrialised countries, which are typically characterised by low indices of the order of between one and two percent. Thus, in Fig. 3.17, it can be seen that Japan has an index of 1.55 whereas many developing countries in the region have indices between 20 and 42, indicating that the relative risk of death if involved in a road accident is 13 to 27 times higher in such countries.

Ever since the advent of motor vehicles, many have been content to accept road fatalities as a fact of life. The tragedy of modern life is that road accidents are no more newsworthy (Ross et al 1991). It is surprising that road safety features are not high in priorities in many countries of this region (ESCAP 1993c, 1995d, 1997c). Table 3.11 shows the accident and fatality statistics of some selected countries of the region (ESCAP 1995d).

Road accidents rank among the ten most causes of death in the ESCAP region. Fatality rates range from 30 to 140 per 10,000 registered vehicles (Fig. 3.16). Various factors affecting road accidents are road users (drivers and pedestrians), vehicles, roads and their environmental conditions (geometric variables, construction defects, damaged and uneven shoulders, potholes, slippery pavements, lack of road signs and markings, insufficient road lighting, lack of guard rails and overloading of vehicles. The available data (ESCAP 1995d) indicates that the human factor is the highest contributing cause of accidents (78 to 90 percent). Driver error dominates the contribution. The second highest contributing factor is the road and its environmental conditions (6 to 18 percent), while the lowest contribution is made by the vehicles (1 to 5 percent).

Table 3.11 Road accidents and fatalities of some ESCAP member countries

Item	Indonesia	Philippines	Sri Lanka	Thailand
Number of registered vehicles	8,243,982	1,620,624	628,624	6,487,022
Number of accidents	25,241	10,627	104,747	24,132
Number of fatalities	10,887	1,427	1,596	2,104
Number of serious injuries	46,143	3,120	1,647	n.a.
Number of slight injuries	n.a.	10,812	9,130	10,252
Accident rate	29	66	167	37
Fatality rate	12	9	25	3

Note: Accident/fatality rate = accidents/fatalities per 10,000 registered vehicles.
n.a. = not available

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

Table 3.12 shows vehicle involvement in road accidents in some ESCAP member countries (ESCAP 1995d, 1997c, 1997a). The highest proportion of accidents involve passenger cars and trucks followed by buses and motorcycles (Figs. 3.10 to 3.13).

Independent studies have shown that around 500,000 persons are killed and around 15 million persons are injured each year in road accidents around the world. Of these deaths and injuries around 70 percent occur in the developing world. Studies show that in the ESCAP countries around 235,000 deaths occur each year. This is over half the total deaths taking place globally.

Table 3.12 Percentage of accidents by vehicle type in some ESCAP member countries

Vehicle type	Indonesia	Philippines	Thailand
Passenger car	32	31	33
Truck	21	37	28
Buses	11	15	9
Motorcycles	37	7	26
Others	-	10	-

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

Apart from the humanitarian aspects of safety, road accidents are responsible for economic losses in developing countries. Studies estimate that in the ESCAP countries over US$63 billion dollars are lost through road accidents each year. This is about 2.5 times as much as World Bank lends globally each year. Thus, even if the reduction in the substantial pain, grief and suffering caused by road accidents is not in itself sufficient motivation to attempt to improve the situation, there is also a very strong economic case to be made in the significant losses to economies of countries in the ESCAP region each year due to the road accident problem.

According to the findings of World Bank, Asian Development Bank and ESCAP, road accidents cost most countries between 1 percent and 2 percent of their annual GDP (ESCAP 1995d) which is higher than annual road budgets in many countries. Much of this is often in foreign exchange. ESCAP region alone incurs costs of around US$63 billion per year and loses around 235,000 persons who are killed each year. No region in the world can afford to lose these sorts of sums or have such large numbers of its citizens killed year after year. Action therefore should be taken to reduce the recurring costs and social consequences of road accidents.

Traffic congestion: Traffic congestion is a significant problem in many cities of the ESCAP region. Road traffic congestion is not simply a problem confined to commuter trips in large cities or urban areas. Congestion affects the work trips and the non-work trips. It affects the movement of people and the flow of goods. In non-urban (rural) areas and inter city corridors, traffic is disrupted by incidents, maintenance operations, detours, over-loaded tourist routes, and other causes. From the road traveller's point-of-view, traffic delays are substantial and growing in the region. From the employers point-of-view, congestion takes its toll in lost worker productivity, delivery delays, and cost. Speed, reliability, and cost of urban and intercity freight movements are increasingly affected by congestion in many cities in the region (ESCAP 1993a, Hook 1995).

Road traffic congestion is largely due to the result of unrestricted growth in private motor vehicle ownership and usage. The number of automobiles in the ESCAP region is growing at an alarming rate, well over 10 percent per year in the higher income cities. The main effects of traffic congestion in the region are time delays, fuel wastage, pollution, noise and accidents. Average travel speed has slowed considerably in many cities of the region. The wasted time causes productivity losses amounting to 5 to 10 percent of the economic turnover of the local economy. It is estimated that for every one third drop in average vehicle speed, fuel efficiency drops by around 15 percent. Petroleum fuelled vehicles emit carbon monoxide, carbon dioxide,

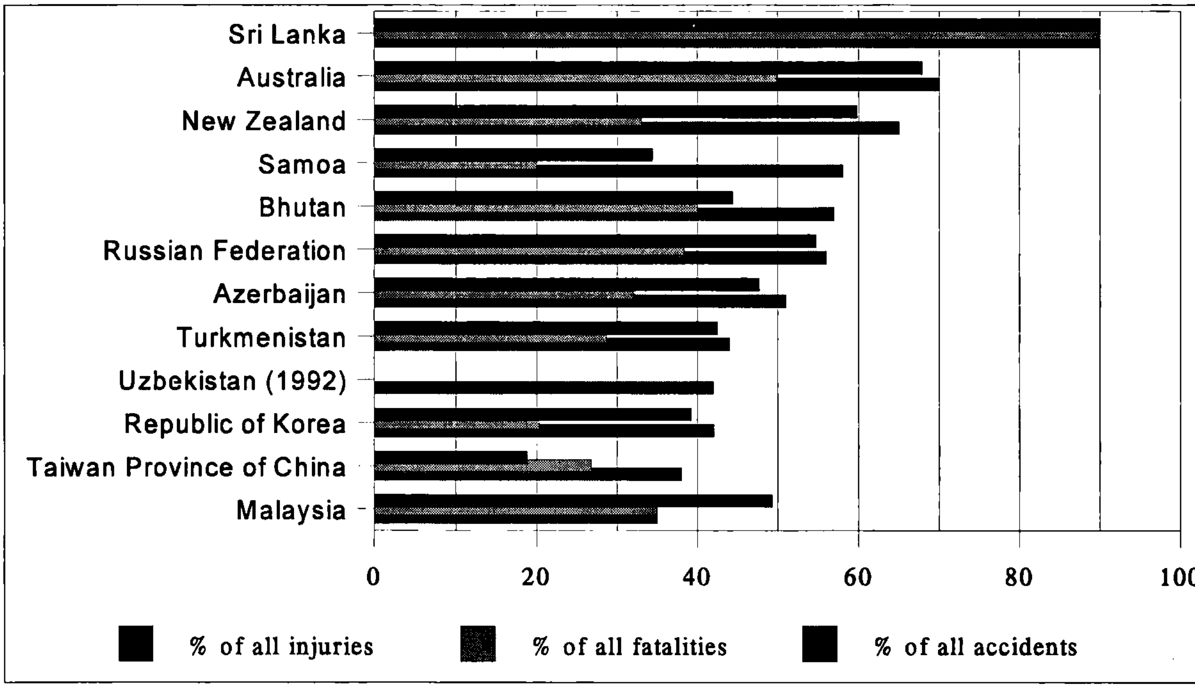


Fig.3.10: Percentage of road accidents in some ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

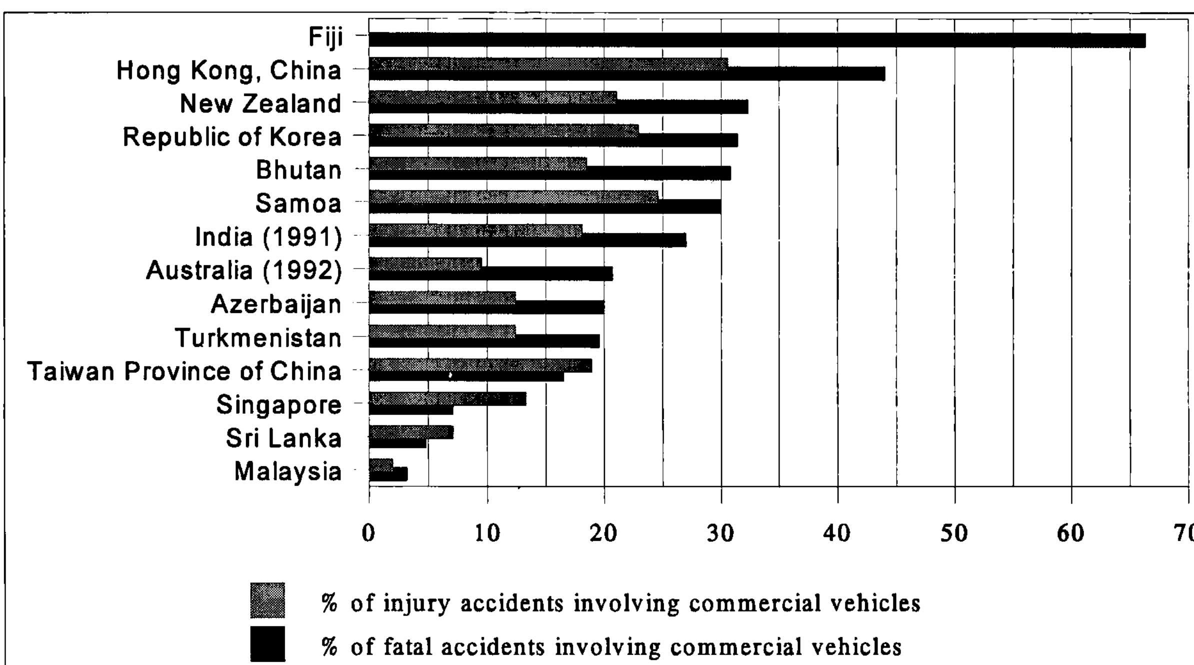


Fig. 3.11: Commercial vehicle involvement in road accidents in some ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

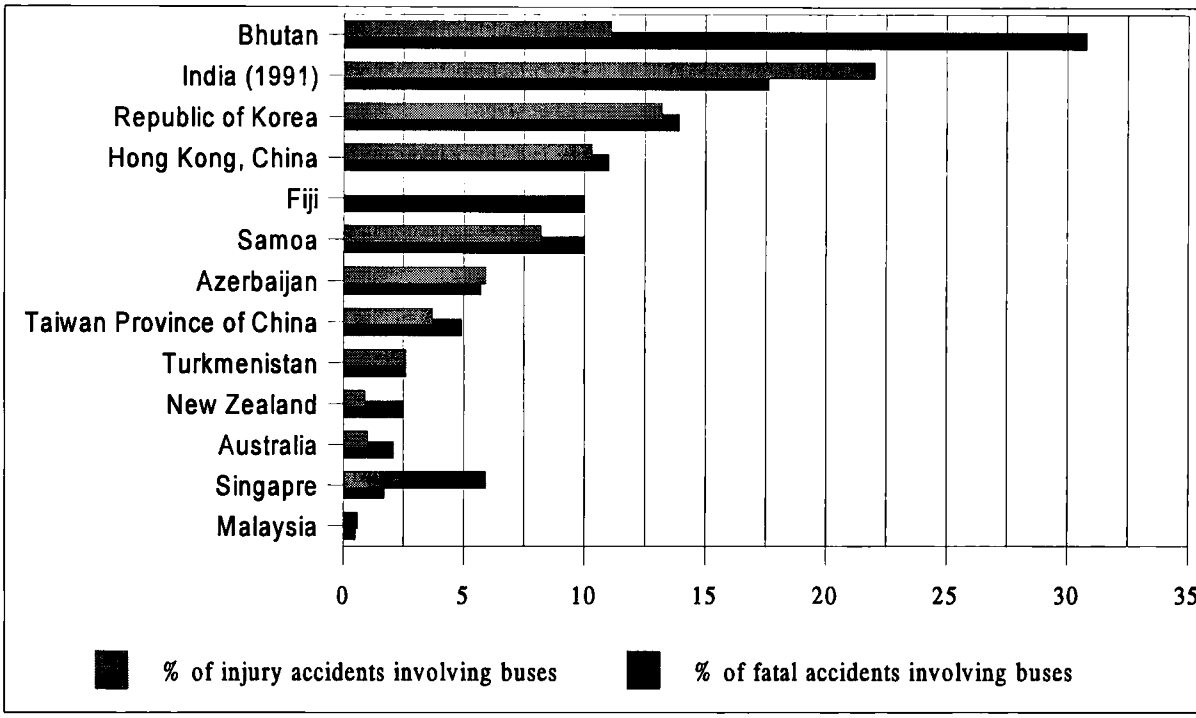


Fig. 3.12: Bus involvement in road accident in some ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

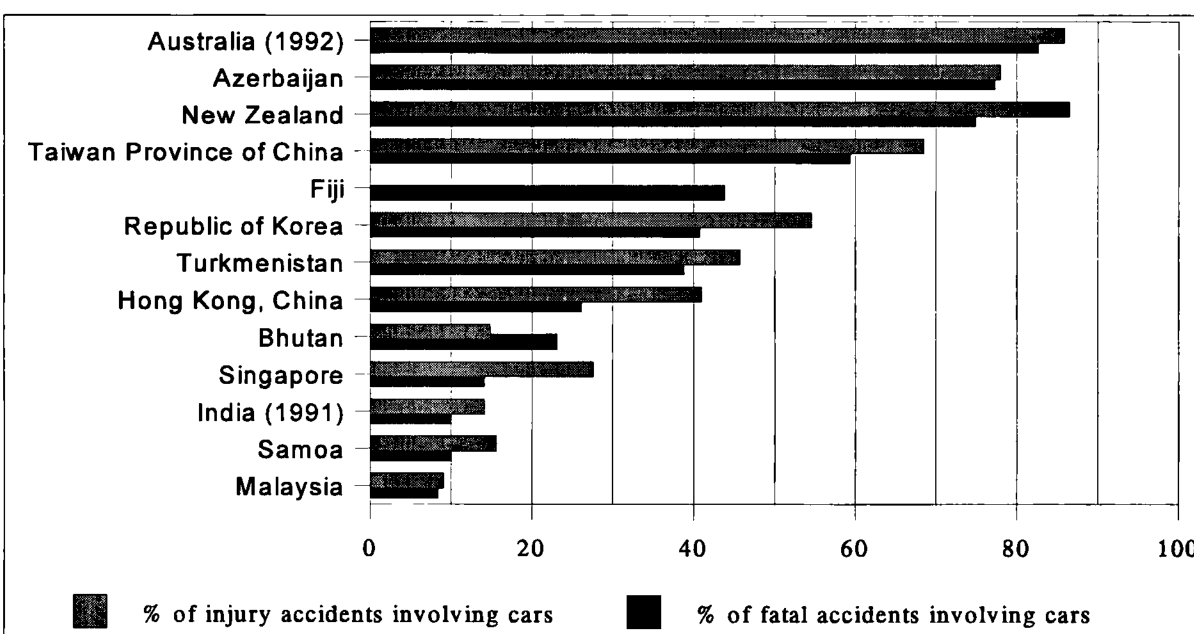


Fig. 3.13: Car involvement in road accident in some ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

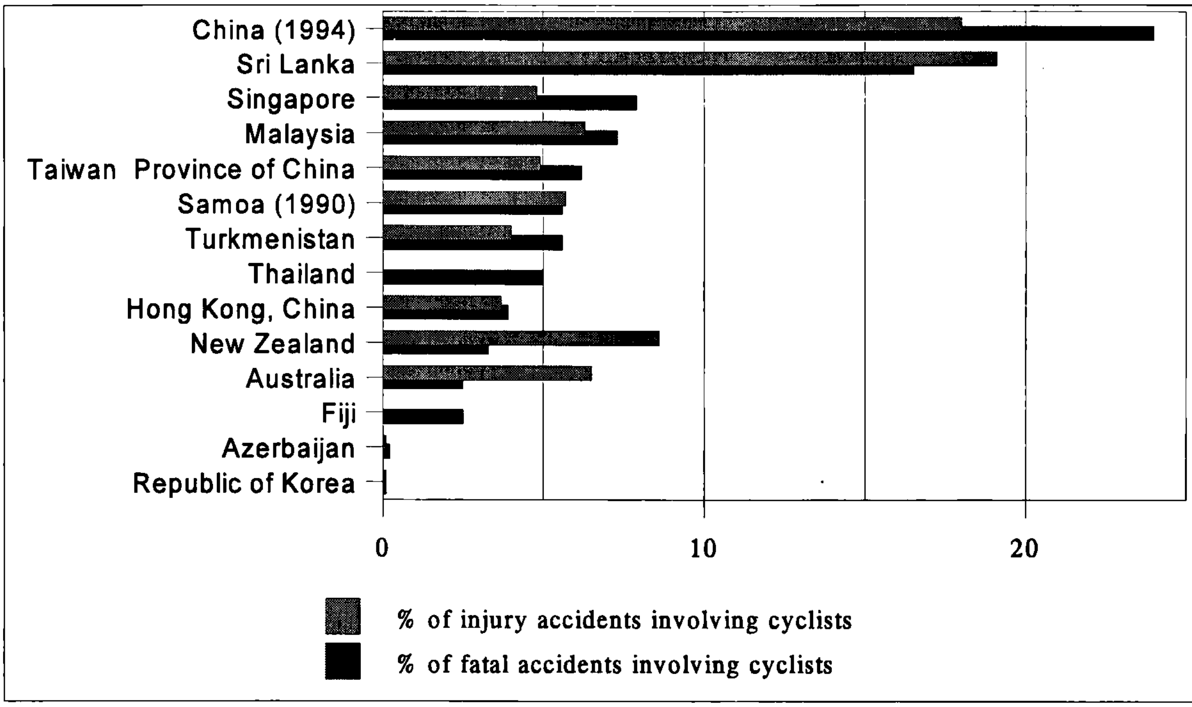


Fig. 3.14 Cyclist involvement in road accident in some ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

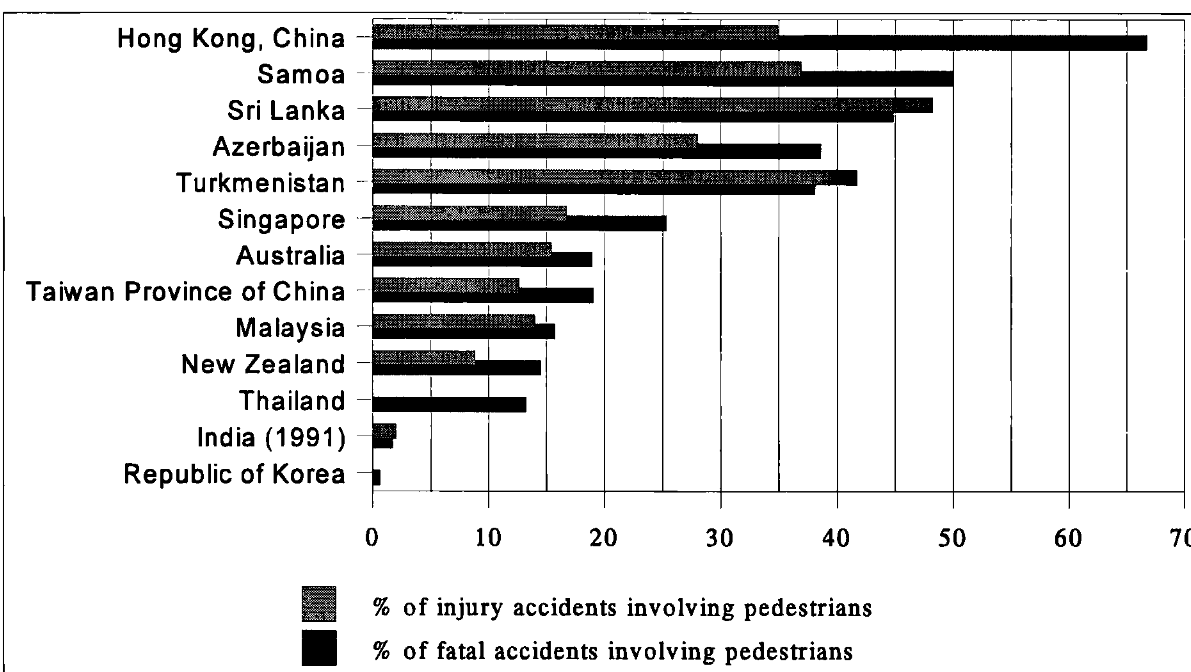


Fig. 3.15: Pedestrian involvement in road accident in some ESCAP countries

Source: ESCAP (19975). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

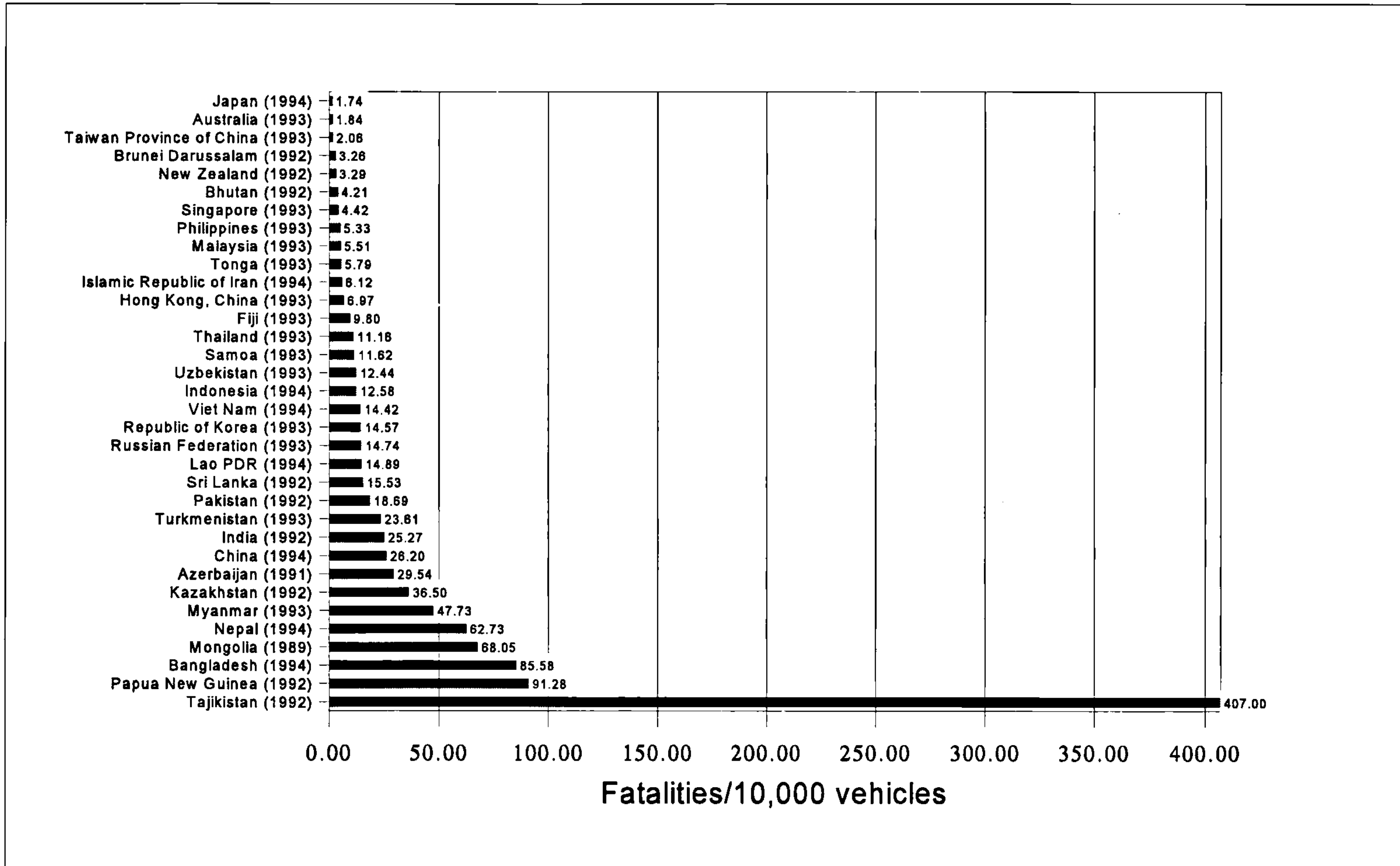


Fig. 3.16: Fatalities per 10,000 vehicles in selected ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

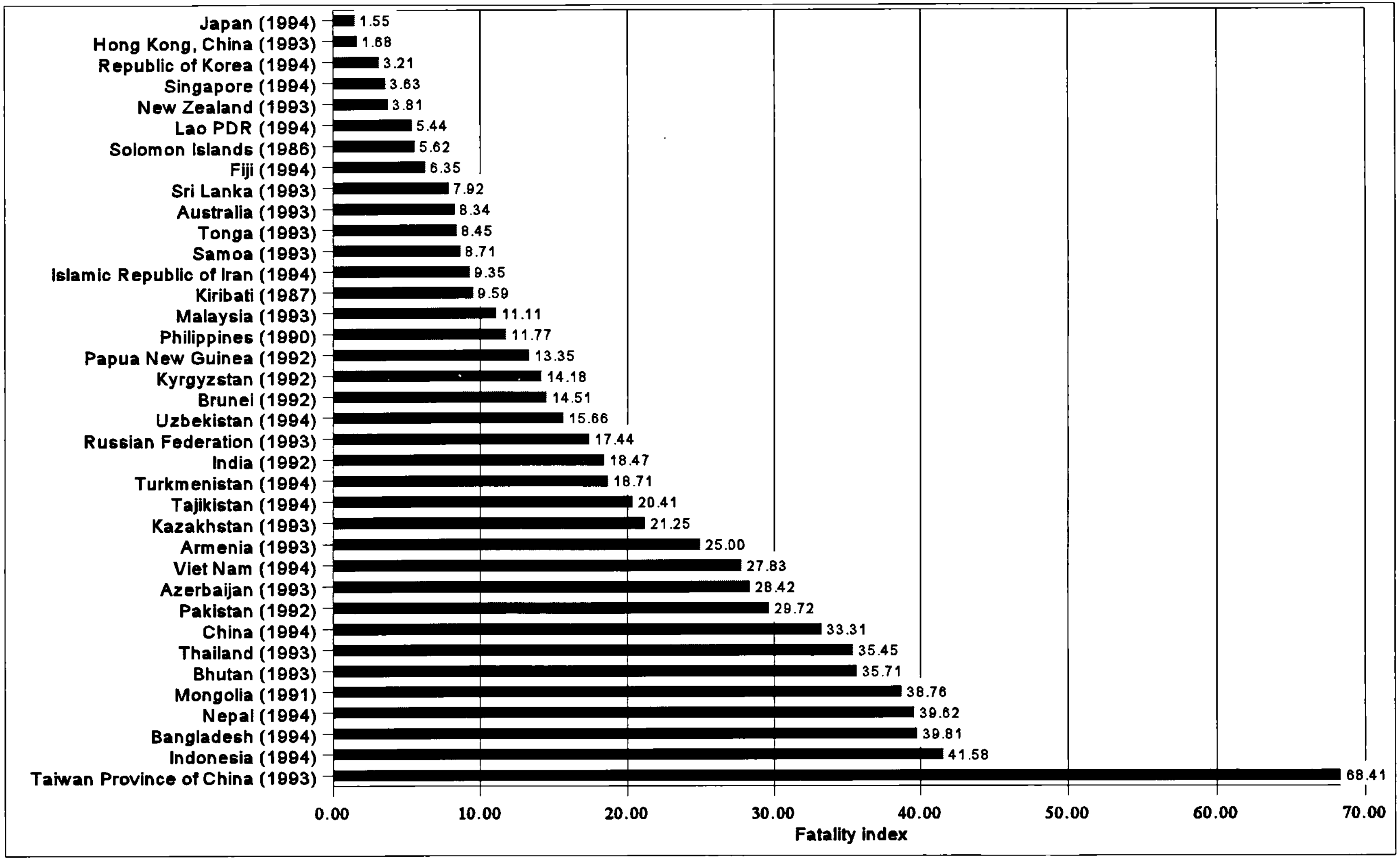


Fig. 3.17: Fatality index (deaths/total casualties as percentage) in selected ESCAP countries

Source: ESCAP (1995). *Review of Road Safety in Asia and the Pacific* (ST/ESCAP/1633). United Nations, New York.

sulphur and nitrogen oxides, hydrocarbons, and particulates, as well as more toxic chemicals such as lead, benzene and other fuel additives. The noise created is also a problem. These problems are compounded in cities where vehicles are poorly maintained, particularly diesel powered vehicles. The results include widespread respiratory illnesses and lead poisoning. Road accidents also occur due to traffic congestion and it ranks among the ten most common causes of death in ESCAP countries (ESCAP 1993a, 1995c).

In big cities such as Bangkok, Bombay, Jakarta and Manila, traffic congestion has become so aggravated that the economy suffers losses due to the productive time wasted in commuting. In the city centres, traffic speeds average less than 10 km/hr (Hook 1995). The congestion is often severe outside the city centres also. Due to the lack of alternative options to road transport and because of rapid suburban development, congestion over a radius of 20 to 30 km of the city core. Traffic congestion in many cities in the region has worsened steadily. The speed of traffic flow on the main streets fell from 13 to 15 kilometers per hour in 1984 to 8 to 10 kilometers per hour in 1994, with the prospect that the pace will soon be slower than that of walking. The worsening traffic congestion is costing Bangkok a huge sum of money a year in fuel bills. In addition, Bangkok automobile drivers are being forced to spend the equivalent of an average of 44 days a year stick in traffic jams (Bodell 1995). The amount of losses in business opportunities and other conveniences as a result of the worsening traffic snarls could be much higher. Air and noise pollution rise alarmingly on numerous thoroughfares, causing health hazards to passerby. Businesses have also been hurt, foremost among them being tourism. Traffic congestion is already discouraging tourists from visiting Manila, Jakarta and Bangkok. Worsening traffic congestion and infrastructure shortages also pose an obstacle to foreign investment.

A huge amount of fuel is squandered daily by vehicles idling in traffic jams (Hook 1995). In addition, a study has shown that workers spend an average of 44 working days in traffic each year (OECD 1994b). In addition to such a huge economic cost, the congestion results in greater incidence of incomplete combustion of fuels in the engine causing higher emissions of CO, SPM and black and white smoke. In recent years, more than one million Bangkok residents received treatment for various respiratory infectious diseases linked to air pollution. Bangkok reportedly has cancer rates three times higher than the rest of Thailand.

Spillage of hazardous goods: The volume of freighting hazardous goods by road has been increasing rapidly in ESCAP region. The road transport of hazardous goods if not well managed, could pose serious threat to the environment as well as to human safety. Most common violations found during road transportation of hazardous materials are: (i) failure to display the correct labels and placards, (ii) failure to block or brace hazardous materials containers, (iii) leaking discharge valves on cargo tanks, (iv) improperly described hazardous materials, and (v) inaccurate or missing papers/documents (Aziz 1996, Christmas 1996, ESCAP 1996c).

In many countries of the region, there is a lack of proper guidelines for road transport of dangerous goods (OTA 1986). Although accidental spillages may occur anywhere, there are some situations where their consequences can be particularly serious. A spill on certain sections of a road, for instance, could end up in soil and water contamination. In some cases, the spills cause fire resulting in injuries, deaths and property damage. There is no specific safety devices for the transport of hazardous goods by roads in many countries except Australia, Indonesia, Malaysia, New Zealand, Phillippines, Republic of Korea, Singapore and Thailand where exist reasonable codes regarding the road transport of hazardous goods exist (ESCAP 1994a, Aziz 1996).

Road safety: Road safety is now a serious problem in the Asia-Pacific region. Each year over 235,000 persons are killed and several millions more are crippled or injured in road accidents in the region. Fatality rates in the region's developing countries are anything from 10 to 25 times higher than in developed countries. Accidents are rapidly increasing in developing countries of the Asia-Pacific region, whereas they are now declining or at worst stabilising/growing very slowly in most developed countries. Road accidents are now one of the most important causes of death for the economically active population of Asia-Pacific region and the problem is now considered to be of epidemic proportions by WHO. Road accidents cost the developing countries of the Asia-Pacific region over US$ 20 billion per year and this clearly inhibits the social and economic development of the region (ESCAP 1996d, 1995d).

Major constraints inhibiting road safety improvement are as follows:

- Fragmentation of responsibility for road safety issues.
- General absence of accurate information on the scale, nature and characteristics of the problem.
- Inadequate resources and activities to coordinate and implement road safety counter measures in all sectors which require improvement.
- Inadequate efforts being made to improve known-hazardous locations or to have more road safety conscious planning and design of road schemes.
- Insufficient technical and financial resources being allocated to tackle the problem.

Road safety problems require multidisciplinary approaches with activity undertaken in a wide range of sectors. Such activities are best undertaken under an effective National Road Safety Council or similar entity. Road safety improvements need to be undertaken in a number of phases which gradually build up institutional capability and technical skills to tackle the problem.

3.4.4 Roadway impacts

These impacts are mainly associated with the construction of new road transport systems (especially expressways) rather than with the traffic generated by other types of developments. However, the latter may require the construction of new road transport systems.

Visual intrusion and aesthetics: The most significant visual impacts include the following:

- Scenic incompatibility, which may occur either in an urban or in a rural area
- Obscuring of existing views
- Creation of gaps in the urban fabric
- Loss of sunlight
- Loss of privacy

Depending on the viewpoint of the observer, these impacts may vary. Consequently three different viewpoints must be considered: that of the adjacent property occupiers, that of the community or users of the area and that of drivers. The above impacts are usually assessed separately for each group. The impact on the adjacent property occupiers is usually considered the most significant.

Severance: Severance occurs when a new road development forms either a physical or a psychological boundary between different areas. It is primarily associated with large road transport systems such as expressways but can also result from increased speeds or traffic volumes on existing roads. Apart from those whose lands or properties are directly effected, severance can have a major impact on communities, for example the separation of residents from facilities and services, from their place of employment or from friends and relatives. It is most directly felt by pedestrians in built-up areas. However, severance can occasionally be beneficial, for instance by providing a boundary between areas of different land use. In urban areas, particular attention is focused on the facilities used by vulnerable groups in society. Severance is a complex impact, in which a bundle of negative aspects of trafficked roads are linked together, including pedestrian delay, trip diversion and trip suppression, noise pollution, perceived danger and general unpleasantness. Detailed studies have shown that the overall impact of this bundle of aspects is substantial and that the public is significantly concerned by these impacts (Kiely 1997).

Land consumption and loss of property: The number of properties demolished is usually an important measure of the impact of a proposed road transport development, especially where there are employment implications. However, other impacts such as the displacement and relocation of people, the loss of recreational areas or wetlands, even the loss of parking, may also be significant and should be quantified. Frequently, new road construction through urban areas results in awkwardly shaped underdeveloped sites adjoining the road.

Changes in land access and land values: Road transport improvements may result in either increased or decreased access to adjacent properties. Normally increased access occurs which may stimulate development and lead to increased land values. Local businesses and retailers usually benefit from increased access. However, increased access can sometimes lead to undesirable developments and decreased land values (e.g. where a new road is constructed through an established housing area). Also some businesses may suffer from increased levels of passing traffic due to parking difficulties or traffic congestion. Decreased access can cause problems for emergency and service vehicles and may lead to other detrimental effects, particularly for commercial properties. When a new road bypasses an area, local businesses can suffer trade losses.

Planning blight: The announcement of a proposed new road transport development can lead to the gradual rundown of the directly affected properties since little or no maintenance of these properties is likely to be undertaken. Consequently, unless the development takes place within a relatively short time, planning blight may follow.

Impacts on wildlife, plants and the aquatic ecosystem; historic and cultural resources; utilities and drainage: These can largely occur over a wider area. Pollution of water courses adjacent to roads can result from the concentrated runoff during periods of heavy rain. Even at low concentrations there can be long-term impacts on the surrounding environment. However, spillages of toxic materials in accidents are usually much more significant.

Employment and business impacts: The construction of a new road may have severe impacts on existing retail businesses over a wide area. Changes in employment and business activities are usually consequences of previously considered roadway impacts such as severance, changes in land access or demolition of property, but should be considered separately because of their importance. Road transport developments can stimulate employment and business activity but the contrary can also occur; e.g. the construction of a new expressway can lead to a reduction in distribution sector jobs because a larger area can be served in the same time compared with the expressways situation.

3.4.5 Construction Impacts

The traffic generation by the construction of a new road transport system can cause major impacts, particularly for those living along the routes used by this traffic. Since construction is labour intensive, large numbers of cars access construction sites at the start and end of the working day. However, heavy vehicles carrying materials to and from the site and the movement of large earthmoving equipment usually cause the principal problems. The noise and vibration from these vehicles disturb roadside residents, traffic delays occur, mud is deposited on the roads and the road pavements and verges may be physically damaged.

3.5 Summary of Various Impacts

Various environmental impacts of road transport include the impacts on natural environment, man-made environment, human welfare, and socio-economic aspects.

3.5.1 Impacts on natural environment

In a road transport infrastructure development, in addition to land, large scale natural resources and energy are used. The main ecological impacts are the loss of farmland and biodiversity, changes in hydrology and drainage pattern, soil erosion and sedimentation, water pollution, changes in landscape and ecosystems. In addition, the road transport project have impacts on wetlands, floodplains, rivers, reservoirs and coastal waters. Documentary evidences of these impacts do exist in the ESCAP region.

From road transport operations, the emission of various gases and particles from transportation activities into the atmosphere creates some severe problems of environmental degradation due to air pollution. In many countries of the region, there exists severe air pollution problems due to vehicle emission. In addition, there is a disturbance to roadside habitats, and also to animals through light and sound.

3.5.2 Impacts on man-made environment

In addition to the impacts on road transportation systems on the natural environment, there is also an impact on the uses of land and on land values. Perhaps the most obvious of these impacts is the taking of land for rights-of-way for road transportation facilities thereby changing the existing land usage to a transportation usage. Also, road transport development in an area induces a change of certain types which would not have occurred otherwise. This has the potential effect of changing not only the spatial pattern of land uses but also through such changes, the overall quality of life in an area and, closely related, the values of land which result from altered demands for land adjacent to roads and highways. There exists many examples of such changes in ESCAP region resulting in new land-use with higher land value.

When major roads and/or highways run through a major city or through a rural area, large numbers of people and many businesses are displaced. Sometimes, the roads and/or highways are frequently routed through the least desirable sections of the city, and those who are displaced are the poor, the aged, and those who are least able to take care of themselves, and there is little likelihood that many of them will use the road that displaces them. Relocation has created many problems in the region because it is difficult, complicated and time-consuming. Frequently, successful relocation depends upon solving problems, both financial and social, of the people and the business displaced in addition to finding replacement property. Furthermore, public properties like schools, hospitals, market places, recreational centres, parks, etc. are also displaced.

3.5.3 Impacts on human welfare

Communities are often divided by major road infrastructure developments, especially in residential and urban areas which can result in social fragmentation. Community severance has often significant social implications in terms of the quality of life which segmented communities can enjoy. It is difficult for members of the segmented communities to interact and participate fully in various welfare activities.

Traffic noise is generally disturbing to humans. Other direct impacts on humans are those caused by air pollution, traffic congestion, and road accidents.

Visual intrusion and aesthetics embrace such things as blocking out of light or pleasant views and as eyesores often associated with the disposal of waste materials and abandoned vehicles. There are cases of severe impacts of road transport system in the ESCAP region on human welfare.

3.5.4 Socio-economic impacts

Social impacts of road transport system can be quite significant. Some social effects are easily understood and can be quantified. A change of any kind due to road transport development brings social costs to some and benefits to others. Evaluation of social impact relates particularly to the effects of a road project on the elderly, handicapped, non-drivers, and minority/ethnic groups. The economic impacts are many and varied. It is difficult to quantify such impacts. There are examples of major socio-economic impacts of road transport in the ESCAP region.

3.6 Environmental Impact Assessment of Proposed Road Transport Developments

Environmental impact assessment (EIA) consists of a systematic investigation into the effects of a proposed road transport development on the environment. Such assessments are now required as an integral part of the evaluation process for all large road transportation proposals. Traditionally, the evaluation of proposed road schemes is largely based on cost-benefit analysis which consists of estimating the likely construction costs and assigning monetary values to the predicted benefits such as savings in travel time and accidents. Environmental impacts tended to be omitted since it is difficult to determine their monetary values. This frequently results in public opposition to proposed road schemes and results in the inclusion of environmental impacts in the evaluation procedures. Under the 1985 EU Directive on the Environment at Impact Assessment, large road transport projects must be subjected to an EIA (OECD 1994a). The EU legislation does not specify detailed assessment methods and, in general, the various national regulations incorporating the EU Directive allow considerable latitude in the methods used. This is probably because of the subjective nature of many environmental impacts and disagreement on how they should be quantified (Kiely 1997).

3.6.1 Contents of a road transport environmental impact assessment

A typical environmental impact assessment for a proposed road would include the following:

- A summary of the proposed road development and of the principal environmental impacts
- General project description and a description of the alternatives considered
- A baseline survey of the existing environment
- Assessment of the environmental impacts
- Implications for the land use and development plans for the affected area
- Financial implications
- Mitigation measures proposed to reduce the negative impacts
- A synoptic table summarizing the individual impacts and costs for each of the alternatives considered
- Conclusions

3.6.2 Impact identification

Checklists are commonly used to ensure that all relevant impacts are identified. Table 3.13 shows an example of a generic checklist (WB 1994c).

3.6.3 Impact prediction/assessment

As previously discussed, it is difficult to assess many of the impacts shown in Table 3.13 in quantitative terms. Table 3.14 gives an indication of the level of assessment typically used for each individual impact (WB 1994c).

3.7 Sources of Road Transport Related Environmental Problems

The sources to the various environmental problems caused by road transport development can be classified into four general categories: vehicle related, road related, user related and policy related (ESCAP 1990, 1991a). A good understanding of the relationship between the sources and the problems is essential for developing effective mitigating measures to reduce adverse environmental impacts.

Table 3.13 Generic checklist of impacts

Impact group	Impacts
Road users	- Time savings/delays - Vehicle operating costs - Accident costs - Driver comfort and convenience - View from road
Physical environment	- Landscape - Infrastructure - Air quality - Nature conservation
Social environment	- Community severance - Employment - Aesthetics (intrusion) - Culture and heritage
Occupiers of property	- Demolition - Severance (land) - Noise - Visual obstruction

3.7.1 Vehicle related problems

Traffic noise and vehicle emissions are the two most commonly known environmental problems that are directly related to the operations of individual vehicles. For example, an important factor that determines the amount of vehicle emissions is the fuel economy of vehicles. Traffic noise, air pollution and road accidents can be reduced by improving vehicle designs or developing new engine technology. The use of CFC in the air-conditioning systems of motor vehicles contributes to the depletion process of the ozone layer. Other vehicle related environmental problems include disposal of used batteries and scrap tyres. There are several major vehicle exporting nations in Group 1 countries, the most important of which is Japan, followed by Republic of Korea, and Australia. Malaysia is a Group 2 country which is actively developing its car and two wheeler manufacturing industry using Japanese technology, and has enjoyed some success in capturing overseas market. There are also countries in Group 2 and 3 with vehicle manufacturing facilities (such as China and India) and assembling capability (such as Thailand, Philippines and Indonesia) mainly for the domestic markets. There is considerable scope for technology improvement of the domestically manufactured vehicles in Group 2 and 3 countries. For instance, cars manufactured in China and India could only achieve half the fuel efficiency of Japanese manufactured cars (Midgley 1994). However, the technology is being rapidly updated especially with collaborative efforts.

Table 3.14 Typical assessment techniques for environmental impacts

Impact areas	Effects	Unit of measurement
Road users	- Time savings - Vehicle operating costs - Accident costs - Comfort and convenience - View from the road	- Monetary - Monetary - Monetary - Scaled (low, moderate or high driver stress) - Scaled (no view, restricted, intermittent, open view)
Physical environment	- Landscape - Infrastructure - Air quality - Nature conservation	- Descriptive - Descriptive - Ceiling levels - Descriptive (initial and final appraisal)
Social environment	- Community severance - Employment - Aesthetic (intrusion) - Culture and heritage	- Scaled (none, slight, moderate, severe) - Descriptive - Scaled (slight, moderate, severe) - Descriptive
Occupiers of property	- Noise - Visual obstruction - Severance of land - Demolition	- Scaled (increase of 3-5, 5-10, 10-15 dBA, etc) - Scaled: >150 steradian-high 50-150 steradian-moderate 25-50 steradian-light - Number of properties severed, plus description of quality of land - Number of properties demolished

Source: World Bank (1994). *Roads and the Environment - A Handbook.* Report TWU 13, World Bank, Washington DC.

3.7.2 Road related problems

Road construction and maintenance involves consumption of natural resources, disfiguration of natural landscape, destruction of area drainage pattern, disruption of natural wildlife and eco-environmental system, and relocation of communities and human settlements. Road construction and maintenance creates inconvenience and travel delay, as well as environmental nuisance such as noise and dust. Poorly designed, constructed or maintained roads are considered by many to be a factor leading to higher accident rates in developing countries.

Efforts have been made to introduce environmentally conscious practices to reduce the adverse environmental impacts of road construction and maintenance (Menon 1995). Such practices are currently not in full enforcement even in Group 1 countries, and have been ignored largely in Group 2, 3 and 4 countries. For instance, as an effort to preserve the natural resources of construction materials, the recycling technique of road construction and maintenance has become very much a priority consideration in environmentally conscious countries in Europe and North America. Besides probably for some applications in Japan and Australia, road recycling has not been considered routinely as an option at all in other Group 1 countries, not to mention the less developed countries of Group 2, 3 and 4 countries.

3.7.3 User related problems

User related problems refer to road transport and environmental problems caused by poor attitude and behaviour, and weak environmental consciousness of road transport users. Bad driver attitudes such as drunk driving, speeding, and ignoring of traffic regulations are among the major causes of road accidents. Poor driving habits and behaviour can account for up to 30 percent increase in fuel consumption. The human factor, including drivers passengers and pedestrians, are responsible for about every second road accident (ESCAP 1996b). It is believed that driver training and education would be an important element in the effort to reduce the high road accident rates in Group 2, 3 and 4 countries in the ESCAP region.

Weak environmental consciousness of road transport users is an area where there is a considerable scope for improvement in the ESCAP region as a whole. With the exception of Japan and Australia, generally there seems to be a lack of public awareness of the environmental impacts caused by private cars. In some European countries where the general environmental awareness is high, road transport users consciously avoid using private cars for short trips within urban areas.

3.7.4 Policy and management related problems

The importance of having environmentally friendly road transport policies cannot be over-emphasised. Good and firm policies are probably all it needs to keep road transport generated environmental problems under control. Practically all the vehicle related, user related and road related problems described in the preceding sections could be resolved by instituting positive policies that are enforced strictly by all relevant authorities. The road transport achievements in Singapore offer a classic example of how strict enforcement of well planned road transport policies could lead to positive results in environment protection (Birk et al 1993). On the other hand, poorly planned policies, badly coordinated implementation, weak enforcement and lack of institutional commitment are to be blamed for the poor state of road transport and environmental conditions in most Group 2, 3 and 4 countries.

3.8 Issues and Problems in Road Transport Policy and Management

In the ESCAP region, the main road transport management related problems are institutional and financial. But there are also a number of technical, organizational and human resource problems which contribute to poor road transport management policies. Specific problems include lack of integrated approach to policy formulation, inefficient policy implementation, lack of integrated multi-modal road transport system, lack of technological capabilities, lack of trained manpower, and lack of adequate information (ESCAP 1993a, 1993b, 1995b).

3.8.1 Institutional and financial problems

The causes of the institutional and financial problems in the region are found related to the way road transport systems are managed and to the hostile enabling environment both of which undermine incentives and staff motivation. Roads are not managed in the pro-active manner common to most commercial organisations. The road transport authority simply delivers road services based on spending allocations which bear little relationship to either the volume or importance of the traffic using the roads. Since the road transport authority invariably operates as a government department, managerial responsibilities are unclear, staff terms and conditions of employment are poor. The road transport authority enjoys little managerial autonomy, keeps accounts on a cash basis (to ensure it does not over-spend its budget allocation), has no independent source of revenue and is not subject to an independent external audit. This has resulted in several undesirable consequences in the region. First, there are no clear lines of responsibility for managing different parts of the road network or intervening to control congestion, improve road safety and reduce the adverse environmental impacts associated with road traffic. It is common place, in many countries of the region, to come across road transport authorities without clearly defined responsibilities. Second, government terms and conditions of employment are woefully out of line with the private sector in most countries. Road departments paying qualified staff a fraction of the on-going market wage end up with high vacancy rates, employing expatriate staffs paid through donor - financial assistance programme and/or with part-time staff forced to supplement their salaries by other means. Third, there is no simple mechanism for holding the road transport authority accountable for its performance, other than in the context of the government audit process which is more concerned with consistent application of procedures than with efficient use of resources. Road users have few ways of influencing the road transport authority's performance. Indeed, most road transport authorities in the region produce few indicators to measure their performance. Their financial accounting systems likewise lack transparency, expenditures are poorly controlled, and funds are often diverted and spent on other programmes. Fourth, financing arrangements are unsatisfactory. Road transport related expenditures in many ESCAP countries are well below the levels needed to keep the road network in a stable long-term condition. Furthermore, the flow of funds is erratic. Budget allocations are cut at a short notice in response to difficult fiscal conditions. Funds are rarely released on time and actual expenditures are often well below agreed budget allocations. As a result, roads in many Group 2, 3 and 4 has been deteriorating steadily; rural roads regularly become impassable during the rainy season and the large backlog of road rehabilitation continues to increase. Between a quarter and a half of the road networks in many ESCAP countries are classified as being in poor condition.

The main reason why road transport is under-funded in many ESCAP countries, is that road users are very highly subsidized for use of the road network. Most road expenditures are financed through general tax revenues allocated as part of the annual budgetary process. The budget allocation process is furthermore flawed and politicized. Transport ministries, particularly those spending large sums on road transport nearly always loose out in the budget debate. Road transport allocations nearly always end up getting cut or deferred.

3.8.2 Technical, organizational, and human resource problems

Almost all these problems mentioned in the preceding section reflect that managing road transport in the ESCAP region needs to be improved. Most road transport expenditures are poorly planned and badly managed. Few road transport authorities establish consistent spending priorities, based on a detailed analysis of individual spending programmes within a consolidated budget framework. Few compare recurrent and development expenditures, new construction with maintenance and routine maintenance. Around 10 percent compile basic road transport inventory data or have functioning maintenance and pavement management systems to determine road network-wide management priorities (ESCAP 1995c).

Government-owned plant and equipment pools for road transport also pose problems in the region. Most governments own heavy construction and maintenance equipment worth millions of dollars, much of it procured under loans or furnished on a grant basis by well-meaning bilateral donors. Availability and utilization rates for these equipment are low with net utilization rates often as low as 20 to 30 percent compared with 80 to 90 percent in the private sector. The main problems are that much of the equipment is out-of-order and that equipment in working order lacks fuel and/or trained equipment operators. There are several reasons: lack of standardization; shortage of foreign exchange to purchase spare parts; and poor terms and conditions of employment (hence no equipment operators). Moreover, management systems are not transparent. There are no cost accounts and there is a lack of managerial accountability.

In addition, most road transport authorities in the region suffer from an acute shortage of skilled manpower. Human resource development is inadequate. However, without adequate terms and conditions of employment, the standard prescriptions of training and technical assistance simply do not work. Staff show little interest in training geared to their task in the road transport sector when they spend half of their time for doing another job. Technical assistance cannot transfer skills when staff are under paid or do not see changes for promotion.

3.8.3 Lack of integrated approach to policy formulation and ineffective policy implementation

The lack of an integrated approach to policy formulation in countries of the region disregards environmental considerations and fails to enforce laws and regulations. In certain cases, the regulations are inadequate. For example, in countries such as Bangladesh, Malaysia and India, the penalties for the infringement of environmental regulations are, in many cases, insufficient to deter violations. In Thailand, while a legal framework for environmental protection exists, its enforcement has been observed to be tardy owing to weak institutional arrangements permitting inter-agency conflicts (ESCAP 1995b). A related factor which detracts from the effectiveness of implementation and also affects policy evolution is inadequate environmental awareness among politicians, policy makers, bureaucrats and the general public.

3.8.4 Lack of integrated multi-modal transport system

There is a lack of initiatives in many countries in the region to take into consideration of multi-modal transport system. It is widely recognized that the most effective way of overcoming the road transport problems is the transport mix. Yet in most countries of the ESCAP region, little headway is being made with respect to multi-modal transport systems (ESCAP 1995a).

3.8.5 Lack of technological capability and trained manpower

There is a lack of technological capability and trained manpower in road transport sector in many ESCAP countries (ESCAP 1995b, 1996a, 1996c). In many cases, technology is not properly selected for road transport systems. Often, it is selected without prior evaluation of other available alternatives. Sometimes, technology choices are dictated by donor countries as part of tied aid or tied loans. These acquired technologies are often simply transplanted to the recipient countries of the region without modifications. There is often little attention to develop local skills required for managing the technology or making modifications in order to meet changing demands in the region.

3.8.6 Lack of adequate information system

A major constraint on the road transport strategies in most countries in the ESCAP region is a lack of adequate information and data for assessing the implications of road transport on the environment (ESCAP 1995a, 1997b). Data collection and processing techniques are limited in terms of both geographical coverage and the quantification of the range and extent of environmental degradation due to road transport.

3.9 Summary

The aim of this chapter has been to highlight the role which the road transport plays in causing environmental degradation in the ESCAP region. Adverse environmental impacts of road transport have been found to affect natural environment, man-made environment, human welfare, and socio-economic aspects. The kinds of adverse impacts that road transport activities have on the environment of the ESCAP region and their importance depend on infrastructure development and operation, production of vehicles and their regular servicing and maintenance.

Adverse environmental impacts of road transport activities were found to originate from the construction of infrastructure, production of vehicles, and the operation and maintenance of transport facilities and vehicles in the region. These impacts include air pollution, noise, congestion, accidents, energy consumption and consumption of land and other natural resources. Major environmental consequences of transport activities in the region can be summarised and structured along the following lines:

- Pollution problems are mainly concerned with air pollutants (CO, NO_x, HC, particulates, lead and so on) and their associated health risks and ecological impacts. Unpleasant odours and soiling are evident and widespread sources of annoyance. The pollution of the environment by the accidental spills of hazardous goods is also a cause for concern in the ESCAP region.
- Noise disturbance due to road traffic is an increasingly common nuisance in cities in the region.
- Land consumption by road transport infrastructure development is not only in conflict with other land uses but also influences access and property values in the region
- Road accident have been in rise in ESCAP countries. Although disastrous accidents in the air, sea and rail modes occasionally result in heavy tolls, taken together, these generally represent only a small fraction of the deaths, injuries and property damage attributable to road transport activities. Accidents caused by the transport of hazardous goods represent an increasing cause of concern in the ESCAP region because of the potential scale and intensity of injuries and damages.
- Consumption of energy resources by the road transport sector have been found to be a major concern in the region because of its high dependence on petroleum. The consumption of metals and other non-fuel minerals for the construction of road transport infrastructures and mobile vehicles raises long-term issues of resource utilisation and recycling in the region.
- Traffic congestion has been found to result in loss of time that might otherwise be spent in more useful or productive activities.

Although other modes of transport have some adverse impacts on the environment, the road transport has been found to be responsible for much of the impacts on the environment in almost every aspect in the region. In addition, there have been some serious road transport management-related problems in the ESCAP region. These are mainly institutional and financial, although there are also a number of technical, organisational and human resource problems which contribute to poor road transport management policies. Specific problems include lack of integrated approach to policy formulation, inefficient policy implementation, lack of integrated multi-modal road transport system, lack of technological capabilities, lack of trained manpower, and lack of adequate information.

From the critical review of the current situation in the ESCAP region, all the road transport problems are classified into road related, vehicle related, user related and policy related. The mitigative measures of these problems require careful survey and judicious classification in order to prioritize programme activities for short-term, medium-term and long-term planning and implementation.

4. MEASURES TO REDUCE ADVERSE ENVIRONMENTAL IMPACTS

The preceding chapters have identified the trends and development in the ESCAP region, and the major areas of road transport and environmental concerns of the four different groups of countries. This chapter describes various preventive and corrective measures which have been applied or experimented in different parts of the world. In accordance with the main road transport related environmental problems they address, these measures may be classified as follows:

(A) Measures to combat problems associated with urban traffic congestion

- Traffic management systems
- Traffic demand management
- Promoting use of public transport system
- Integrated multimodal passenger transport system
- Comprehensive transportation and socio-economic planning

(B) Measures to combat traffic-generated pollution problems

- Adoption of zero emission vehicles
- Use of environmentally friendly fuels
- Regular and effective vehicle inspection and maintenance programme
- Noise abatement measures

(C) Measures to relieve inconvenience and suffering of human beings

- Measures to enhance road safety
- Safe transportation of hazardous goods
- Participation citizens and non-governmental organisations
- Incorporation of EIA in transportation planning and project evaluation

(D) Measures to reduce wasteful use of natural and human resources

- Raising environmental awareness of policy makers, road users and the general public
- Efficient road construction and maintenance
- Effective financing mechanisms and participation of private sector
- Strengthening of institutional roles

The above classification serves to highlight the key benefits of the various measures. It must be mentioned, however, that as explained in earlier chapters, there are overlapping effects. Without exception each of the measures would bring about other benefits than that indicated in the classification. For instance, all the traffic congestion relieving measures will, besides reducing travel delay and fuel consumption, also lead to substantial reduction in vehicle emissions and the associated environmental pollution.

4.1 Traffic Management Systems

Traffic management techniques are adopted by transportation authorities to improve the speed of traffic flow, thereby enhancing environment protection through reduced congestion, improved fuel efficiency, shorter travelling times, and lower emission. The techniques that have been adopted are area traffic control measures, and traffic restraint schemes.

4.1.1 Area traffic control

Area Traffic Control (ATC) generally refers to coordinated computerized controlling of traffic signals of all or a selected group of road junctions along main traffic corridors or within an urban area. An effective ATC system can reduce traffic congestion and fuel consumption. For example, the first ATC scheme in Bangkok increased total flows by about 8 percent, reduced travel times by 27 percent, and fuel consumption by 18 percent although the area covered by ATC was only 3 km across (Jones et al 1982). In Singapore, an ATC implemented in 1981 improved the average travel speed by 15 percent to 23 percent within the Central Business District (Lee 1996).

ATC systems are not uncommon in the major cities of the Asia-Pacific countries, although their uses are restricted essentially within Groups 1 and 2 countries. Japan has the highest density of ATC systems in the region with a total of 34,500 intersections under area traffic control in 74 cities (Midgley 1994). The most advanced ATC systems are found in a number of major cities of Group 1 countries where continuous real-time monitoring of traffic flows and signal timing adjustments are practised. These include the systems in Tokyo, Osaka, Sydney and Singapore. It should be noted that some forms of ATC systems are also being employed in some big cities in Groups 2 and 3 countries. They include Bangkok, Jakarta, Kuala Lumpur, Bombay, Beijing, Shanghai and Manila.

Tokyo probably has the most sophisticated high-technology traffic control system in the region. In February 1995, the Traffic Bureau of Tokyo's Metropolitan Police Department (MPD) launched a multi-million dollar 24-hour Traffic Control Centre in Shinbashi which was equipped with the latest state-of-the-art computers and traffic monitoring equipment. To adjust and guide vehicular flow in the metropolitan areas and neighbouring prefectures, the Centre processed information gathered from a wide range of facilities: 134 television cameras, 13,199 electronic vehicle sensors suspended above crowded roads at more than 6,000 locations, and a fleet of 11 observation helicopters. Information is also provided by police patrols and members of the public through phone calls. There are a total of 119 computers in the Centre. The processed data is displayed on a huge digital information board that measures 25 m wide and 5 m high. A group of 21 television monitors below the board shows scenes from the roadside cameras. The computers control the signal timing of 6,831 automatic signals. They also edit information for display on 163 electronic bulletin boards, 907 intersection display boards, and 82 roadside radio rebroadcast systems.

It is foreseeable that more and more cities in the region will be adopting the technology-intensive ATC as one of the means to ease the problem of urban traffic congestion. It is to be noted that with the exception of Japan and Australia, all other countries have to rely on assistance in staff training, and imported hardware and software to implement an ATC system.

4.1.2 Traffic restraint measures

Area Licensing Scheme

Different forms of traffic restraint measures have been employed by road transport authorities over the world to reduce traffic congestion by decreasing the volume of traffic within controlled areas. The Area Licensing Scheme (ALS) in Singapore has been widely quoted as the most outstanding example on how traffic restraint measures could be effectively used to reduce traffic congestion. Today, 20 years after the ALS was implemented in 1975, the total number of vehicles entering the restricted zone of the Central Business District (CBD) during the morning peak period (7.30 am to 10.15 am) was still less the 1975 pre-ALS level of 74,000. This is impressive because during this 20 year period, employment within the ALS restricted zone had grown by more than 35 percent, and the vehicle population in Singapore has increased by more than double (Menon 1995).

Some of the important factors that contribute to the successful implementation and sustained effectiveness of the Singapore ALS are: (a) strict enforcement of well planned policy, (b) efficient public transport system to support the imposition of ALS by providing easy access to the CBD, (c) effective road network surrounding the CBD with adequate capacity to offer alternative routes for original through-CBD traffic that have avoided the CBD after the imposition of the ALS, (d) the authority had conveyed to the public effectively the need for the system, and (e) coordinated complementary policies by other government authorities and ministries, a reflection of the strong political will of the Singapore Government in making the scheme a success.

Singapore's success in keeping its urban areas almost congestion free for more than 20 years has demonstrated that multi-pronged coordinated approaches are required to achieve the desired results. The main strategies have been strict enforcement of vehicle use controls, restraining of vehicle ownership, and providing of efficient and affordable public transport system. Singapore has been able to reap the full benefits of these strategies through strong political consensus and commitment in policy execution. It is interesting to note that several cities in China are experimenting with similar schemes by learning from Singapore's experience (ST 28/4/96).

In December 1995 the Philippines implemented a scheme under which private vehicles had restricted access to 10 heavily-used roads in Manila during peak hours (ST 29/11/1995). Vehicles with plates ending in even numbers are allowed on them on Tuesday, Thursday and Saturdays. Those with plates ending in odd numbers are allowed to ply on Mondays, Wednesdays and Fridays. Any vehicle with three or more passengers can use the roads at any time, on any day. The effectiveness of this project is not available at the time of writing this report. A similar car pooling requirement is also imposed in Jakarta for access to the central business district. This policy helps to restrict the number of cars into the city, and encourages better usage of passenger cars.

Seoul authority proposed to impose a rotating ban to ease its growing traffic congestion by keeping 10 percent of passenger cars off its streets on weekdays (ST 28/12/1994). The plan was not implemented after a six-month trial in 1995. Under this plan, license numbers will determine which cars are not allowed on the roads. On any day of a month, cars with the last digit of their license number coincides with the last number of the day must stay off the roads. For example, a car with a license number ending with 3 cannot be on the road on the 3rd, 13th and 23rd of any month.

Electronic Road Pricing

Hong Kong China was the first city in the world to try out an Electronic Road Pricing (ERP) system in an actual road network. It was implemented in part of the city road network in 1983 and was found effective in reducing traffic congestion during the targeted time of the day and location. However, it was abandoned in 1985 due to the following reasons (Midgley 1994): (a) objections from car drivers, (b) public opinion against invasion of privacy, (c) ineffective publicity concerning the purpose and benefits of the system, and (d) perception by the public that the system was a tool by the Government to raise revenue.

Singapore replaced the current manually enforced ALS by an ERP system in 1997. The ERP system will be eventually extended to the entire island. The current manual ALS system only has two level of entrance permit fees - S$3 during the morning peak period of 7.30 am to 10.15 am and the evening peak period of 4.30 pm to 6.30 pm, and S$2 during the period from 10.15 am to 4.30 pm. The ERP system is expected to permit more flexible graduated restricted zone entrance charges according to the time of day and traffic condition. Being more responsive to traffic level of service, the ERP system may offer a more effective means of controlling peak hour traffic volume and congestion. It is interesting to note that in a survey conducted in early 1996 (ST 2/1/1996), 64 percent of the respondents knew that vehicle owners would soon have to pay for using the roads. Of these, 55 percent said the scheme would lead to smoother traffic, while 44 percent were sure it would not.

The Singapore ERP project has been awarded and it costs S$197 million to install the system to replace the manual ALS and another S$39.3 million to maintain over the first 5 years of operation. In the case of Hong Kong China, a full system would have cost US$30 million in 1985, plus a recurrent cost of around US$2.5 million annually. The magnitude of financial investment and recurrent commitment of the area-wide system obviously will restrict its application in most cities in Group 2, 3 and 4 countries.

4.1.3 Measures to increase road capacity

A large number of traffic management measures have been used by road transport authorities to improve traffic flow by increasing the capacity of existing road network. Depending on the travel and traffic flow characteristics of a city, some of the measures described in this section can be adopted to an advantage without having to resort to road widening or constructing new roads.

Reversible Lanes for Tidal Flows

In urban expressways or major arterials where there is a large imbalance of directional traffic flow during peak periods, the concept of reversible lanes may be adopted. For example, for most cities the inbound traffic towards CBD tends to be much higher than outbound traffic during the morning peak period, while the reverse is true for the evening peak period. On expressways or arterials that have such imbalance of flow, one or more lanes may be made reversible so that more lanes will be assigned to the direction that carries the high traffic flow. Special equipment may be used to shift movable road divider mechanically. A good example is found in Bangkok where a 5-lane major arterial of about 20 km has its 3 central lanes made reversible to handle the morning peak traffic in the in-bound direction, and the evening peak traffic in the out-bound direction.

Parking Management

Kerb side parking has been a common problem in many busy city streets in the region. Allowing such practice would effectively reduce by one lane the capacity of the street affected. Strict prohibition of kerb side parking has been enforced in cities like Singapore to ensure full road capacity available for the traffic. The strict enforcement of parking regulation in Singapore has been possible because of the availability of relatively large number of basement parking garages in the buildings within the city area.

In some busy city centres like those in some Japanese cities, vehicles searching for parking place could contribute significantly to traffic congestion. Street side information systems that provide directions to available parking garages would help to relieve this problem. Such information system should be provided on a real-time basis in order to be useful to drivers.

Real Time Traveller Information

Real-time traveller information by various means such as road side display boards, radio broadcast, or intelligent vehicle-highway systems would help motorists to select routes that are less congested would contribute to more effective utilisation of the total road capacity of the entire road network. Although such route guidance information systems would not be of any help for vehicles already caught in the traffic jam if the entire road network is congested. However, it helps to prevent the congestion from getting worse by cautioning would be travelling drivers not to make trip by cars.

Reducing Delays Caused by Non-Recurrent Incidents

Accidents or incidents that immobilise one of the lanes of a busy roads operating at or near its capacity would cause serious traffic delays. It is also a common phenomenon that an accident or incident in one direction of a road would also cause delay in the opposite direction due to curious motorists who slow down to have a quick look at the accident or incident. Quick actions to remove broken-down vehicles or vehicles involved in an accident would save time loss caused by non-recurrent incidents.

Auto Drive Vehicle Highway System

The capacity of expressways and other high-speed highways can be increased substantially if the safe distance between vehicles can be reduced. One possible way of achieving this in the future is by means of the so-called automatic vehicle-highway system where the intelligent highway will take over the driving when a vehicle enters it. This will enable a large number of vehicles to be carried at a uniform high speed with very small gaps between vehicles. It has been estimated that such a system will be able to transport up to 4,500 cars per lane per hour as compared with the normal 2,400 cars per hour per lane in today's highway (ST 20/4/96).

4.2 Demand Management in Road Transport

Demand management in road transport makes use of various forms of measures to rationalize and minimize travel needs. It represents one of the most direct ways to cut down traffic congestion and reduce the total number of trips on the roads. This would lead to lessening of environmental impacts by vehicles, and reduced consumption of fuels and other natural resources.

4.2.1 Road transport pricing measures

Pricing mechanisms such as fuel taxes, registration fees and road taxes have been used traditionally to influence road users' choices of transport. Such mechanisms can be used as an effective instrument of demand management approach to environment protection in road transport. For example, differential pricing of fuel taxes on diesel and petrol, and on leaded and unleaded petrol have been commonly used in the ESCAP region to promote the use of environmentally friendly fuels. Similar pricing mechanisms could be employed to encourage the use of environmentally friendly alternative fuels.

Road pricing is often cited as a promising tool of demand management to control vehicle use and reduce traffic congestion. Toll highways in many cities in the ESCAP countries such as Malaysia, Philippines, Indonesia and China are examples of such pricing measures that have already been practised in the region. In Singapore, there is plan to move towards a city-wide road pricing system where differential road use charges may be imposed on motorist for road use according to the congestion level of the road sections.

4.2.2 Vehicle ownership restraint measures

Uncontrolled growth of vehicle population has led to serious traffic congestion in many Asia-Pacific cities. A number of Asia-Pacific countries have resorted to vehicle ownership restraint measures. The common forms of such measures include increasing the costs of owning a vehicle (such as high vehicle registration fees, high road tax, high petroleum taxes, etc). In Japan, it is required to acquire a car-parking space first before one is allowed to purchase a car. Singapore has gone to the extreme of instituting in 1990 a Vehicle Quota System (VQS) which caps the maximum number of new vehicles to be registered each month. In this system, prior to registering a new vehicle one must first secure a Certificate of Entitlement (COE) through an open bidding system administered by the Government. VQS has enabled Singapore to control its total vehicle growth rate to about 3 percent per annum for the last 5 years.

In February 1995, the Hong Kong China government announced a proposal to introduce a vehicle quota system modelled on Singapore's VQS (ST 11/2/1995). Under the proposed scheme, prospective buyers of new cars have to obtain a Certificate of Entitlement, either through balloting or bidding. The annual quota would allow for the replacement of old cars (numbering between 15,000 and 18,000) and a 2 to 3 percent growth (5,000 to 6,000 vehicles) in the private car population each year. As in the Singapore system, the entitlement would be valid for 10 years.

4.2.3 Decentralisation of commercial centres

To avoid further increase of traffic volume in the city area and deterioration of productivity, many major cities in the world have resorted to decentralisation of commercial centres. In the Asia-Pacific region, Singapore is an outstanding example of sound urban planning that has created regional commercial centres away from CBD. Each regional centre will provide the necessary financial and social services to satisfy the needs of residents around the regional centre, thereby reducing the travel needs to the CBD.

4.2.4 Measures to reduce work trips

Travel trips to work and from work place to home are the main reason for the peak traffic flows during the morning and evening peak periods in all cities. A logical approach to reduce travel demand is to cut down the need to travel to work place and back. This can be achieved by a number of ways. One way is to work from home, and by doing so eliminate the need to travel to work. This can be achieved by teleworking using telephone or other more advanced telecommunications means.

4.3 Promoting the Use of Public Transport System

Increasing the use of public transport is probably the most practical solution available to virtually all Asia-Pacific cities to reduce congestion, decrease environmental pollution, and improve the energy efficiency of urban transport. Rail based mass transport system, bus system and paratransit are three major modes of public transport in the cities of Asia-Pacific countries. This section first addresses the choice of mass transit system in the region, followed by a discussion of the bus service, and finally the role of paratransit.

4.3.1 Mass transit options

Rail Mass Rapid Transit

There are currently at least 37 rail mass transit systems carrying 27 million passengers per day in 27 cities in Asia, as shown in Table 4.1 (Midgley 1994). The intensive rail mass rapid transit (MRT) systems are found in major cities of Group 1 countries such as Japan, Australia, Republic of Korea and Singapore. Some major cities in Group 2 and 3 countries already have (eg. Beijing, Tianjin and Calcutta) or are planning to have (eg. Bangkok, Jakarta and New Delhi) urban rail based public transport. Kuala Lumpur's LRT will be operational in 1996. Unfortunately, while rail MRT systems provide high capacity able to satisfy the passenger travel demands in large cities, they are extremely costly. The experience with the performance of such systems in various parts of the world has indicated that they are usually not financially self-supporting. Heavy government subsidy is often required to sustain their operations, with Hong Kong China and Singapore being the only two exceptions so far. The Hong Kong China three-line MTR metro system carries about 2 million passengers a day with 8-car trains operating at up to two-minute intervals in the peak periods. Singapore's MRT operates with 6-car trains at up to 2.5-minute intervals during the peak periods, and carries about 1 million passengers a day.

Another variation is the Automated People Movers (AMP) which consist of automated, electric-powered, driverless vehicles operated as a single unit or multi-car trains on steel or concrete guideways. The vehicles are typically the size of a bus and able to operate in an on-demand mode during off-peak hours to minimize energy consumption (Aitken and Barter 1989). AMP can carry 2,000 to 25,000 passengers per hour per direction with headways as short as 60 seconds. Travel speeds up to 80 km per hour can be achieved. Shen (1997) reported that the average capital cost of the AMP systems of US$30 million per km was between those of MRT (US$50 million per km) and LRT (US$20 million per km). In terms of operating costs, the AMP does not have advantage over MRT or LRT due to its high technological nature and the higher labour costs for system maintenance.

Busway System

Out of the various options of public transport upgrading for developing countries in the region, the lowest-cost option is to increase the capacity of the bus services which are already in place in practically every Asia-Pacific city. This option ultimately leads to the use of exclusive busways as the demand increases. The full capacity of the road-based bus transport system is about 16,000 passengers per hour per direction in the main corridors (Allport 1990). This level of travel demand provides an indication that urban development may have reached a threshold at which one would like to consider building a rail based mass transit system. Under this consideration, Asia-Pacific cities with populations in excess of 5 million such as Bangkok, Bombay, Delhi, Jakarta, Karachi and Shanghai are already having travel demand past the threshold wherein conventional bus systems can no longer cope with travel demands for public transport.

Table 4.1 Urban mass transit systems in Asia

Country/Territory	City	MRT	LRT	GRT	Total
Low Income	6	4	3	0	7
China	Anshan	-	1	-	1
	Beijing	1	-	-	1
	Dalian	-	1	-	1
	Tianjin	1	-	-	1
India	Calcutta	1	1	-	2
Democratic People's Republic of Korea	Pyongyang	1	-	-	1
Middle Income	3	2	1	0	3
Republic of Korea	Pusan	1	-	-	1
	Seoul	1	-	-	1
Philippines	Manila	-	1	-	1
High Income	16	9	8	10	27
Australia	Adelaide	-	-	1	1
	Melbourne	-	1	-	1
	Sydney	-	-	1	1
Hong Kong, China	Hong Kong, China	1	2	-	3
Japan	Chiba	-	-	1	1
	Ina	-	-	1	1
	Kitakyushu	-	1	1	2
	Kobe	1	-	1	2
	Kyoto	1	1	-	2
	Nagoya	1	-	-	1
	Osaka	1	-	1	2
	Sapporo	1	1	-	2
	Tokyo	2	2	1	5
	Yokohama	-	-	1	1
	Yukarigaoka	-	-	1	1
Singapore	Singapore	1	-	-	1
Total	25	15	12	10	37

Note : MRT = Mass Rapid Transit • LRT = Light Rail Transit
GRT = Guided Rapid Transit.

Source: P. Midgley (1994). Urban transport in Asia - an operational agenda for the 1990s. World Bank Technical Paper No. 224. Washington DC.

Although exclusive busway systems have not been used by any Asia-Pacific cities, these less costly systems appears to be a viable option for many medium size cities in the region where the urban travel demands for public transport are still below the threshold. Midgley (1994) reported the experience in Brazil where an extensive and often high capacity system of busways has been developed in nearly all metropolitan areas. Most of these busway systems have been designed and constructed as a first stage in moving toward rail-based mass transit.

It is noted that upon reviewing the need for mass transit in Karachi, a proposal of transitways for buses that can be converted into a rail system was made in the early 1990s (Soomro and McBrayer 1991). It reasons that a busway system avoids commitment of impractical investment levels, and allows immediate and extensive integration of routes and is far more flexible in the way it is initially used than is possible with a rail network. It also argued that the availability to convert transitways from bus to rail use allows the investment in busways not to be wasted when later circumstances encourage or require conversion to rail.

In Adelaide, the world's first high-speed guided busway system (6 km long) began operation in 1986 (Wayte 1987). The problems faced were an environmentally sensitive corridor, congested CBD, low density suburbs and high car ownership producing low transport patronage. A LRT was initially chosen as being environmentally more acceptable and safer than a busway. However, the LRT would have required expensive tunnel construction and feeder bus services in the CBD. The guided busway portion was finally adopted for the following advantages: (a) it was 50 percent cheaper than LRT; (b) no construction was required in the CBD as the buses could operate like normal buses once they left the guide track; (c) it allowed the majority of the commuters to complete their journey without transfer; (d) it used economical existing bus technology; (e) it had equivalent travel times; (f) it allowed high ride quality to be retained with minimal track maintenance; and (g) it had a narrow right of way similar to that of LRT.

4.3.2 Efficient management of bus service

It is interesting to note that urban bus services in the major cities of Group 1 countries and territories (Republic of Korea, Hong Kong China and Singapore) are mostly privately owned, and operating with some profit without subsidy. On the other hand, bus services in the cities of most Group 3 and 4 countries are run by the public sector under heavy subsidy. The relatively poor management efficiency of bus companies in Group 3 and 4 countries can be seen from Fig. 4.1 which shows the staff per bus ratios in selected city bus companies (Midgley 1994).

The experience of Seoul, Pusan, Hong Kong China and Singapore provide good examples and varieties of systems that work. It can be of use to other cities in the region seeking improvements to their bus services. In Seoul and Pusan, private bus companies operate as a cooperative under franchises issued by the transport authority. The cooperative in Seoul has a fleet of more than 8,000 buses operating efficiently without subsidy by about 90 companies, while the one in Pusan comprising 65 companies operating about 2,300 buses (Midgley 1994).

In Hong Kong China, the legislation regulating bus operations is based on individual route franchises and provides for the replacement of an operator, or the admission of a new operator. Although two large private bus companies, China Motor Bus (CMB) and Kowloon Motor Bus (KMB) are given exclusive rights to their routes, the government has control over routes, frequencies, fares, forward planning and service quality (Meakin 1991). In 1991, there were altogether 385 franchised bus routes operated by 3,950 buses most of which were double deckers (Chen 1991). There is a also a profit control scheme that limits the return to the operators to about 15 percent per annum of their net fixed assets, with excess profit transferred to a development fund for purchasing future assets. Grants are provided by government for student travel concessions which amounted to about 5.5 percent of bus operating costs in 1988 (Midgley 1994).

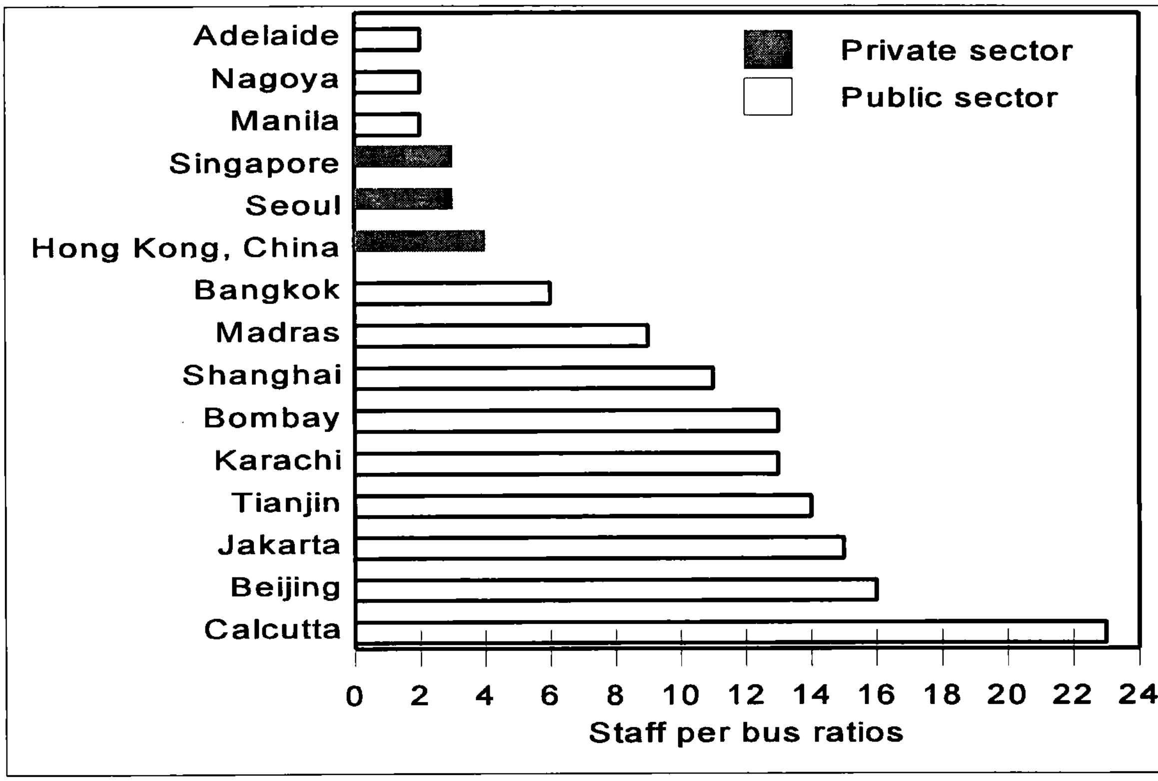


Fig. 4.1: Staff per bus ratios in selected Asian and the Pacific city bus companies

Source: P. Midgley (1994). Urban transport in Asia - an operational agenda for the 1990s. World Bank Technical Paper No. 224. Washington DC.

To maintain a high standard of bus service in Singapore in terms of convenience, reliability and comfort, the Ministry of Communications requires bus companies to comply with a guidelines consisting of 22-point standards. The significant requirements are: (a) every commuter should have a bus service within 400 m of his home to connect with public transport services; (b) at least 95 percent of all journeys should involve no more than one transfer, excluding rides on feeder buses; (c) 70 percent of trunk services and all residential feeder services shall have intervals below 10 minutes during peak hours. For the less profitable services, the maximum limit is 12 minutes.

Based on the success of bus services in the cities mentioned, it is possible to single out as follows some elements that could contribute to the viability of a bus system and its capability to expand and cope with increasing demand for public transport of a growing economy:

- Bus services are owned by private operators that follow sound commercial practices.
- Bus services are owned by public corporations that operate on a self-financing basis.
- Positive competitions exist among different public transport services, monitored and moderated by a body with representatives from the transport authority and all interest parties.
- Active role by the transport authority in setting and enforcing service quality, affordable (to passengers) and profitable (to operators) fare structures, and safety standards.

4.3.3 Roles of paratransit

Paratransit services by the private sectors in many cities of Group 3 and 4 countries are playing key roles in offering personal mobility in the urban areas. This situation is resulted mainly from the inadequacy of bus services which are often in the control of the public sector. For example, it has been reported that the average number of buses operated per 100,000 population in the developing cities of Asia was 48 compared to 90 in cities of developed countries, and the route kilometres operated per 100,000 population in Asian cities was 54 compared to 100 in developed cities (Heraty 1987).

Paratransit as Low Cost Solutions to Travel Needs

The "jeepneys" in Manila, the "tuk-tuk" (3-seat 3-wheeled vehicles) and "silors" (6-seater converted from light truck) in Bangkok are well-known examples of paratransit. The Jeepneys is the most popular mode of public transport in Manila because of its cheap fare and the convenience afforded to passengers to board and alight anywhere they want. Together with tricycles, jeepneys accounted for 44 percent of the total passenger movements in Manila in 1990, while the shares of buses, LRT and passenger cars were 24 percent, 2 percent and 30 percent respectively (NCTS 1995). A study by Midgley (1994) found that the greatest variety of paratransit modes generally existed in places with the least amount of road capacity per capita, and although such services provided an affordable public transport service at no cost to governments, they were inefficient users of road space.

Paratransit as Complimentary Services to Scheduled Buses

Paratransit has been a quick low-cost solution to meet public transport demand in many developing countries. It requires little or no capital investment from the government. In Sri Lanka, paratransit emerged in 1979 when the monopoly of the state-owned public bus services ended. With little government regulation and more or less unrestricted competition initially, paratransit in the form minibuses grew rapidly. Their presence has been highly pronounced in the urban sector, capturing as much as 80 percent of the passengers on some city routes although their share in the country's total market is less than 30 percent. Sahabandu (1987) reported that their early rapid growth led to a fragmented, uncoordinated, unorganised paratransit sector that was unconcerned with system issues. The operation was marred by such malpractices as crush loads, excessive speeds, safety violations and unhealthy competition. As a result, the government imposed regulations to protect public welfare and paratransit operators were organised into a Federation of District Association for joint planning, operation and distribution of the services. This has brought about a significant improvement in safety that saw reduction of accidents varying from 17 percent to 54 percent. Sahabandu concluded that the benefits of introducing paratransit was the substantial increase in the overall capacity of public transport, and more frequent bus services with reduced passenger waiting time. The disadvantages were its contribution to time-related congestion costs, travel-related environmental pollution, noise, accidents, non-optimal use of facilities and resources.

In Hong Kong China in the 1960s, a large number of minibus operated passenger services illegally by taking advantage of the deficiency of regular bus services. When these paratransit services were legalized in 1969 and known as Public Light Buses (PLBs), there were more than 2,000 minibuses in operation, carrying more than a million passengers a day (Meakin 1991). The legalisation imposed safety regulations on the PLBs, but they continued to enjoy freedom from government controls on their routes and fares. PLBs are flexible in their operation - stopping on demand and queuing for passengers at busy intersections. This mode of operation has caused congestion and they have been prohibited from entering or stopping at some congested locations. In 1976, the government limited the number of PLBs at 4,350. A growing number of PLBs have been granted franchises to operate fixed routes at frequencies and fares set by the government, while enjoying partial protection from competition. In 1989, about 25 percent of the PLBs was controlled this way.

Hong Kong China has more than 25 years of experience in administering the operation of paratransit services to supplement franchised buses and to foster certain degree of competition. Lee (1990) reported that paratransit services in Hong Kong China carried a total of 3 million passengers per day (30 percent market share) in 1989. The major paratransit modes included 4,350 PLBs, 3,000 non-franchised public buses and about 17,000 taxis. They competed with formal modes of public transport comprising franchised buses, underground and overground railways, light rails, trams and commuter ferries. Lee (1990) identified the following common features of the various paratransit services in Hong Kong China:

- They have a clear role to supplement the franchised modes.
- They are licensed and regulated with *modus operandi* controlled through an operator's license known as Passenger Service License (PSL).
- They enjoy freedom on entry and exit in the market.
- Within the licensing framework, they have commercial freedom to exploit the market.
- Their vehicles are individually owned or owned by small firms.
- Vehicle owners are free to join trade associations which represent them when bargaining with the government.

The PLBs in Hong Kong China are welcomed by passengers. Through competition, their quality of service has been improving and they survive competition by being innovative and responsive to changes in market demand.

In Singapore where the well coordinated public transport system formed by MRT and the regular scheduled bus services provided by two privately-owned bus companies is providing efficient mode of transport covering all parts of the island. Paratransit also has an important role to play in two ways: (a) helping to meet the high demand during the peak periods, and (b) to bridge the gap between public buses and taxis or private cars. For (a), private buses are allowed to operate under a Scheme B to ply along routes that supplement the regular bus services during peak hours. As for (b), a minibus service known as Bus-Plus Services was launched in August 1994 to provide an up-market public transport as an alternative for car drivers. It offered high quality, luxurious and comfortable scheduled bus service from housing estates to CBD and MRT stations, charging each passenger about 3 to 5 times the fare of regular scheduled buses plying along similar routes. Although the total demand for such service is not large, the success of the service has since attracted two other operators to launch similar services in 1995. The total daily volume of passengers carried was about 2,000 in 1996.

4.4 Transportation and Socio-Economic Planning

It is important that transportation planning should be integrated with socio-economic planning, and accommodate the needs for all modes of transport. The experience of Singapore provides a sound example of how an integrated land use and transportation planning process has been effectively applied to tackle the traffic congestion problem. Shortly after its independence in 1965, Singapore initiated a 4-year comprehensive land use and transportation study under a UNDP assistance programme. This study led to the Concept Plan that called for a ring of new towns away from the CBD to achieve suburbanisation of population. This land use plan was supported by a land transport network that allowed for the eventual development of a MRT system and an island-wide expressway system. When the construction of the MRT system was completed and the expressway network was near completion in 1991, a refinement of the Concept Plan was formulated for further land use and transport network development. The Revised Concept Plan (also known as the Constellation Plan) will see the development of new regional commercial centres to decentralise commercial activities from the CBD. The MRT will be extended to serve the regional centres, and a LRT system will be built to complement the MRT. New roads and expressways will be added to link up these regional centres. This revised plan represents steps taken by the Singapore government to prevent the degenerative process of urban areas in many major cities which are paralysed by over-crowded streets.

4.5 Zero-emission Vehicles

The approaches that have been adopted to either reduce or control vehicle emissions can be classified into four categories: (a) vehicle technology based approach to improve engine design and operation to reduce vehicle emission; (b) exhaust after-treatment such as traps, trap oxidizers and catalysts; (c) adoption of vehicles that do not produce any emission; and (d) use of alternative fuels. While all four approaches should be actively employed to reduce environmental pollution, approaches (c) and (d) appear to be more promising for significant overall reduction of emission in the Asia-Pacific region.

The use of vehicles that do not produce any emission would be ideal in eliminating the ground level pollution problem in urban areas. This section describes electric vehicles and non-motorized vehicles which are the two major forms of zero-emission vehicles that are of practical significance today.

4.5.1 Electric vehicles

Electric vehicles do not produce any emissions at all (Leembruggen 1990). However, since pollutants may form when electricity is generated, the overall pollution potential of using electric vehicles should be assessed with consideration of how the electricity is generated. Johansson (1992) estimated that if 50 percent of the electricity is produced from coal, 20 percent from natural gas, and the remaining 30 percent from nuclear and renewable sources such as hydroelectric power and solar power, the emission reductions that would be achieved by substituting electric vehicles for gasoline-engined vehicles are as follows: 99 percent less hydrocarbons (HC), 99 percent less carbon monoxide (CO), and 60 percent less nitrogen oxides (NO_x). However, sulphur oxides (SO_x) would increase by almost 500 percent and particulates by 570 percent. This shows that introducing electric vehicles would not eliminate air pollution if a large part of the electricity is generated from fossil fuels, although it would remove them from pollution sensitive built-up areas and solve major ground level pollution problem. The greatest reduction in environmental pollution would be achieved if the electricity is generated from non-fossil fuels.

Electric Taxis

A Hong Kong China taxi company put the world's first electric taxi on a 3-month trial in 1994 and announced its plan to convert a fleet of 1,000 into electric taxis gradually (ST 3/7/1994). The plan won the support of the Hong Kong China government which granted exemption of first-time registration tax to electric taxis. The conversion of the trial vehicle cost about HK$60,000. Power was supplied by three units of rechargeable batteries, one installed at the front of the vehicle and two at the back. Each charging of the battery allows 4 to 5 hours or about 80 to 100 km of travel. It was also reported that the energy and operational costs were close to that of diesel, but lower than petrol.

Tramway Systems

Tramways, or street railways, have been used in about 300 cities in the world (Leembruggen 1990). This mode of public transport, however, is not common in Asia-Pacific cities. Hong Kong China has a double-deck tram system with about 163 cars. The tramway started operation in 1904 with an average speed of less than 10 km/h. It is interesting to note that when the MRT Island Line began to run directly under the surface tram line in 1979, a decision was made to retain the service of the old tram cars. These cars have since been refurbished and continue to provide a cheap and useful service (Meakin 1991).

Electric Buses

It is unfortunate that diesel bus has been accepted as the major public transport for cities and towns worldwide for more than 50 years. While many densely populated cities have adopted rail based electric trains for mass transportation, diesel bus services remain the backbone of public transport in these cities. The high construction and operating costs of the rail based mass transit modes also preclude their adoption in the major cities of developing countries, and smaller cities around the world. In this regard, electric buses offer an economical version of clean and silent transit mode. They have the flexibility of operation on normal roads like the diesel buses, and they do not require expensive tracks of rail based transit and tramways (Leembruggen 1990)..

The most common form of electric bus is the `trolley bus' which draws electric energy from wires suspended above the roadway. Leembruggen (1990) reported that about 300 cities in the world were using electric bus systems. China has the most extensive trolley bus networks, and by the year 2000, the number of trolley bus would double to reach 12,000. Articulated trolley buses are playing a key role in the public transport sector of more than 310 cities in China. The trolley buses in Shengyang accounts for 42.5 percent of the total bus fleet and carried 47.1 percent of the total passenger-trips; and in Shanghai, the corresponding percentages are 16.4 percent and 33.3 percent (Cai 1988). The experience in Mexico City during an earthquake indicated that the wires could be transferred to other streets within a day, thereby offering flexibility in route change equivalent to that of diesel buses.

Battery Vehicles

Leembruggen (1990) pointed out that battery bus in which lead-acid or other battery packs store energy for up to 4 hours' operation was a environmentally friendly and energy saving alternative for diesel bus. Battery packs can be quickly exchanged or recharged without much disruption to normal service. He claimed that electric bus (either a trolley or a battery bus) had the following advantages:

- Electric motor is simpler, lighter and has overall efficiency of 90 percent. It minimizes maintenance and energy costs.
- Electric buses are quieter than electric trains, trams and diesel buses. It is also much cleaner than diesel buses. In Seattle in 1980-82 when diesel buses replaced the trolley bus system during system renewal, the residents were outraged by the noise, smoke and smell of the diesel buses.
- The overall costs per passenger kilometre of electric bus is 30 percent less than diesel buses. Its life cycle of 30 years is also much longer than the 15 years of diesel buses.
- Electric bus is more versatile than rail based public transport in responding to changes in route service demand.

Compared to gasoline-engined vehicles, battery vehicles are heavier, have a poorer acceleration and a shorter drive range, due mainly to the lower energy capacity of batteries. Lee (1996) estimated that the total operating cost per unit travel distance of battery vehicles is about the same as gasoline-engined vehicles at approximately US$0.054 per mile (or US$0.034 per km). The costs of running electric vehicles will drop when infrastructure supports are widely available. It has been suggested that a systems approach could be adopted in which vehicle owners can exchange their used batteries with fully charged ones at the battery stations (Doctors 1995).

The use of battery vehicles can lead to environmental pollution caused by increased production of batteries and recycling of spent batteries. This would be the case if lead acid batteries are used. There are, however, other alternative electrochemical systems which have better performance than lead acids and which are also environmentally friendly. Some of such systems have reached the final stage of commercialisation (Doctors 1995, Lee 1996).

4.5.2 Non-motorized vehicles

From the stand point of environmental impact, non-motorized vehicles (NMVs) are a desirable form of transport (ESCAP 1997c). They use renewable energy and are non-polluting. Another advantage is their low-cost operations. In spite of their limitations due to the low speed of travel, low capacity and their potential to obstruct motor-vehicle traffic and provoke congestion and accidents, NMVs can be an effective transport mode for short urban trips. The general situation in the region is that there are insufficient use of NMVs in the cities of Group 1 and 2 countries, while the wide-spread use of NMVs in the cities of Group 3 and 4 countries. However, the NMVs are being threatened by increasing motorization and use of motorcycles.

In many Indian cities such as Madurai, Coimbatore and even Madras, congestion has been caused not by lines of motor vehicles but by a disorderly mass of pedestrians, bicycles, tricycles, handcarts, oxcarts, rickshaws, buses and trucks, with only an occasional car and motorcycles (Parker 1991). However, this is changing due to the economic growth in recent years. In 1984, car and motorcycle travel only accounted for 1.5 percent and 3.2 percent respectively of the total daily trips dominated by buses (45.5 percent), walking (28 percent), pedal cycles (10 percent), and trains (9 percent). But there was a threefold increase in the number of motor vehicles from 1984 to 1989 at an average growth rate of 25 percent per annum.

Bicycle is a major mode of transport in the cities in China. In 1986, 200 million people in China owned bicycles, 47 percent of which were in the cities (Wang 1990). It was estimated that by the year 2000, there will be 500 million bicycles in China. Bicycles are mainly used for work trips, school trips and for shopping trips. A survey in China shows that bicycle are the predominant form of transport with trip lengths averaging about 5 km and travel times less than 30 minutes. Bicycles are popular in China because (a) their costs are low and affordable to most people, (b) workers and teachers who ride cycles to work can receive a transport allowance, and (c) during peak hours in a typical city, it takes about 30 minutes by bicycle to travel 5 or 6 kilometres, while a bus trip over the same distance will last longer than 40 minutes.

In the Netherlands, 10 percent of the surface transport budget is spent on infrastructure support for bicycle facilities (Hook 1995). Today more than 30 percent of all trips in the Netherlands, and 25 percent of trips to railroad stations are by bicycle. Similar measures have been implemented in Denmark. In Copenhagen, 30 percent of all trips are by bicycles. In the ESCAP region, Japan is probably the only Group 1 country where bicycles are used commonly for short urban trips. In Tokyo, only 15 percent of the population commutes by car (Hook 1995). Many rail stations are providing sophisticated secured bicycle parking facilities to encourage the use of bicycles. In Singapore, for example, where the terrain is generally flat and ideal for cycling as the means for short distance trips, the bicycle as a mode of transport has been neglected and is only promoted as a leisure sport within the parks. No allowance has been given to bicycles in the total land transportation plan, and no bicycle facilities are planned for in any MRT stations or bus terminals. There are, however, some major drawbacks of bicycle as a main-stream mode of urban transport. For example, eight bicycles will take up as much road space as a bus that could carry up to 100 passengers. Compared to buses, bicycles are therefore an inefficient transport mode in respect of road space requirement and passenger load. Their travel speeds are relatively low (15 to 20 km/h in urban areas), and they are normally not used when trip distance exceeds about 8 kilometres. In urban areas for safe and convenient travel, cyclists must be provided with special bicycle lanes and parking facilities at strategic locations.

There exist two different views concerning the role of bicycles in Chinese cities. One view advocates restraining the volume of bicycle traffic in order to encourage the use of public transport, thereby relieving traffic congestion and making more effective use of road space. The other view argues that the advantages of using bicycles out-weigh its limitations. With proper planning that caters for the needs of bicycle traffic, the pressure on public transport can be reduced and it helps to save energy and decrease environmental pollution.

4.6 Use of Environmentally Friendly Fuels

Currently available technology to reduce the environmental impacts of vehicle emissions include improving vehicle technology and fuel efficiency, increasing the use of non-fossil alternative fuels or secondary fuels derived from non-fossil fuels (ESCAP 1989, UNDP/ESCAP 1994a, 1994b). This section describes a few important developments in this aspect.

4.6.1 Unleaded petrol

Lead has long been known to be a neurotoxin in human. Use of unleaded petrol helps to reduce the direct effects of vehicle emission on human health. It also facilitates the introduction of advanced pollution control technologies. However, as it incurs additional costs in producing unleaded fuel, government subsidy is required to introduce differential fuel taxation in order to promote the use of unleaded fuel. Midgley (1994) pointed out that the use of unleaded fuel allows for the introduction of closed loop three-way catalysts and oxidation catalysts which have the potential to substantially reduce petrol car emissions in a cost effective manner. These technologies would also improve vehicle performance and driveability, reduce maintenance and lead to improved fuel economy.

4.6.2 Alcohol fuels

Methanol and ethanol are alternative fuels that can be obtained from biomass. The production costs of these alcohol fuels are, unfortunately, are high and not competitive enough commercially against gasoline. For instance, research in China has found that methanol M15 indicated that with a price of 108 percent of that of gasoline and a calorific value of only 45 percent, it was impractical to popularize its use (ESCAP 1989). Studies in USA have shown that the energy efficiency of methanol engine is equivalent to that of diesel engines calibrated to meet future NO_x standards, and that methanol bus engines provide significant reductions in SO_x and particulate emissions (Alson et al. 1989).

The technology for converting sugar and starch crops to ethanol has already been applied commercially in Brazil and USA. It has the advantage of being renewable, but they also have limitations relating to supply and collection problems. The resource base for ethanol includes wood and herbaceous plants which may not be desirable because of the serious problem of deforestation worldwide. Trindade and Carvalho (1989) reports that the use of ethanol as transportation fuel in Brazil has become a significant and durable feature, accounting for about 30 percent of the fuels used for land transportation. The production of ethanol was competitive only if crude oil prices exceeded US$30 per barrel (1988 values) and the Brazilian government had to provide incentive by ensuring that ethanol would not cost more than 65 percent of gasoline price. This subsidy has cost the Brazilian government about US$2 billion in 1987 (Bleviss 1988).

Ethanol is also used in several African countries, including Zimbabwe, Kenya and Malawi (Bhagavan 1996). The technology of using molasses from sugar factories as feedstock for fuel grade alcohol production has been applied to produce ethanol for blending with petrol, thereby reducing costly imports of petroleum products. The technology provides for blending up to 15% ethanol with petrol to produce gashol, without requiring modifications of the carburettors, compression gaskets and the exhaust system (Otiti 1997). However, no information is available concerning the resulted changes in emission composition and net energy savings in the production consumption process.

4.6.3 Natural gas (LPG and CNG)

Natural gas is relatively clean-burning due to their high burning efficiency. Compared to gasoline, they present a good solution for reducing urban vehicle emission problems. Approximately one million natural gas driven buses, trucks, delivery cars, forklifts private cars are in use worldwide. Natural gas can be used in normal four-stroke spark ignition engines without any technical problems. For diesel-driven vehicles, however, the engine has to be converted to a spark ignition engine before they can run on natural gas. Natural gas has relatively low volumetric energy content as compared with diesel and gasoline. It has to be processed to a fuel with higher volumetric energy content before it can be practically applied as a transport fuel.

Liquefied petroleum gas (LPG) is a mixture of propane and butane and is currently the most widely used alternative vehicle fuel because gasoline-engined cars can be converted to run on LPG without engine modifications. The emissions from these LPG vehicles are comparable to those running on gasoline. The number of LPG-powered vehicles is estimated to be about 4 million worldwide (Johansson 1992). In Asia-Pacific countries, Japan and Australia each has about 2 percent LPG-powered vehicles on the road (Verloop 1992). A study conducted by the Australian Liquefied Petroleum Gas Association (ALPGA) claimed that when a sophisticated closed-loop LPG fuel system is professionally installed and maintained in a post-1986 motor vehicle, the emissions were cleaner and performance was enhanced when compared to unleaded petrol. The LPG emissions were found to have lower average values of HC and NO_x, with a reduction 34 percent reduction in NO_x and 13.3 percent reduction in CO_2. The use of LPG reduced evaporative emissions of HC virtually to zero due to a sealed system (UNDP/ESCAP 1994a).

LPG has less potential as an alternative fuel worldwide because it constitutes only a small percentage of oil and gas production as compared to compressed natural gas (CNG). CNG consists primarily of methane (CH4), a hydrocarbon with a high share of hydrogen and a relatively low carbon content. It is an energy source widely available in most parts of the world, including many ESCAP member countries. Table 4.2 shows that, in comparison with other available fuels, CNG is the most attractive on the basis of safety and health consideration. In Table 4.3, the advantages and disadvantages of CNG against gasoline are listed. In general, the combustion of CNG in an engine leads to lower overall toxic emission. It is noted that the 3-way catalytic converter designed for gasoline engine is ineffective for the degradation of nitrogen oxides and methane in CNG. Special purpose catalytic converters can be designed to achieve further improvements in this aspect.

Table 4.2 Relative concern of health and safety related factors for different fuels

	Flame Luminosity	Combustion of vapours in tank	Potential damage from detonation	Toxicity	Ground water pollution	Air pollution
Ethanol	1	2	2	1	1	2
Methanol	3	2	2	3	3	2
CNG	0	0	1	0	0	1
Propane	0	0	3	1	1	1
Gasoline	0	0	3	2	2	3

Degree of concern: 0 = No concern
1 = Some concern
2 = Moderate concern
3 = High concern

Source: ESCAP (1994). *Compressed Natural Gas (CNG) Technologies for Road Transport: Proc. Seminar-cum-Study Tour* (ST/ESCAP/1460). United Nations, New York.

A comparison of the emissions of different diesel and CNG engines is presented in Table 4.4 (ESCAP 1994c). It is seen that significant reductions in NO_x, CO and particulates are achieved using CNG engines, against an increase of HC emission, which includes non-toxic methane. Two other benefits with the use of CNG engines are the much reduced smell from unburnt non-methane HC and engine noise. Figure 4.2 compares the relative attractiveness of various vehicle types for conversion to CNG driven engines, and their accessibility to CNG refuelling facilities. Urban trucks and buses are clearly the most attractive groups in view of their high specific fuel consumption and the relative ease of setting up refuelling stations at their operation bases. Use of CNG engines on inter-urban trucks and buses would also lead to significant reductions in undesired emissions due to their high annual mileage of travel. However, refuelling could present an operational problem.

Table 4.3 Comparison of emissions of diesel and CNG engines

CNG	
Advantages	Disadvantages
- 20 to 25 percent less carbon dioxide - Up to 90 percent less carbon monoxide - 75 to 90 percent less non-methane hydrocarbons - Approximately 80 percent less ozone-generating potential - No acrid smell from exhaust gases - No heavy metal additives necessary to increase knock rating - No losses through vaporization from the tank and/or while refuelling - No carcinogenic substances - No transport by road because natural gas is normally supplied via pipelines	- Methane emission - Approximately 50 to 100 percent more nitrogen oxides in comparison with gasoline (with regulated 3-way catalytic converter) - 10 to 20 percent less power output with existing engines (which have been optimized for gasoline and not for CNG operation) - Additional fuel station network necessary - Weight and space requirements for gas cylinders in a vehicle - Shorter operating range of vehicles

Source: ESCAP (1994). *Compressed Natural Gas (CNG) Technologies for Road Transport: Proc. Seminar-cum-Study Tour* (ST/ESCAP/1460). United Nations, New York.

4.6.4 Hydrogen

Hydrogen is an alternative fuel with excellent long-term potential from an environmental point of view. Stored as hydrides, as a cryogenic liquid or as compressed gas, it can be used in an internal combustion engine with the main product being water. Hydrogen vehicles would not emit significant amounts of CO, HCs, particulates and CO_2, and it would not contribute to the formation of ozone. It is estimated their NO_x emissions from can be 60 percent lower than gasoline vehicles (DeLuchi 1989). However, as in the case of electric vehicles, the overall impact of hydrogen vehicles has to be assessed with consideration of how hydrogen is produced. There is a recent promising development in the use of hydrogen battery for motor vehicles in Germany (Lianhe Zao Pao 27 April 1996). This form of battery will not have the environmental problem caused by production and disposal of electric batteries as described in Sec. 4.5.

Table 4.4 Average emission values of different diesel and CNG engine concepts

Engines	NO_x (g/kWh)	HC (g/kWh)	CO (g/kWh)	Particulates (g/kWh)
Diesel				
Naturally aspirated engine	14.0	1.2	4.0	0.55
Turbocharged engine	14.0	0.4	1.4	0.40
Turbocharged engine with intercooler	8.0	0.4	0.9	0.20
Turbocharged engine with intercooler and soot filter	8.0	0.3	0.9	0.08
CNG (with catalytic converter)				
Naturally aspirated engine, lean mixture	0.3	2.3	0.2	<0.05
Turbocharged engine, lean mixture	4.5	2.0	0.8	<0.05
Naturally aspirated engine, lambda=1 mixture	0.5	0.5	2.8	<0.05
Turbocharged engine with intercooler, lambda-1 mixture	0.7	0.4	0.4	<0.05

Source: ESCAP (1994). *Compressed Natural Gas (CNG) Technologies for Road Transport: Proc. Senimar-cum-Study Tour* (ST/ESCAP/1460). United Nations, New York.

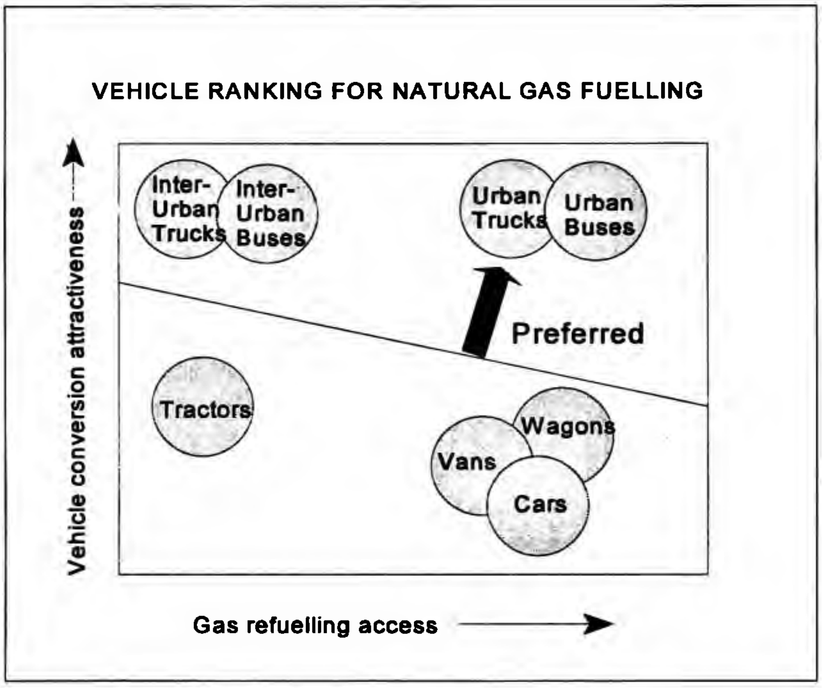


Fig. 4.2: Vehicle ranking for natural gas fuelling

Source: ESCAP (1993). *Guidelines for Conversion of Diesel Buses to Compressed Natural Gas.* United Nations, New York.

4.7 Regular and Effective Vehicle Inspection and Maintenance Programme

The benefits of emission control strategies such as improved vehicle technologies, use of alternative fuels, and fuel saving traffic control measures can be fully received only when there are effective vehicle inspection schemes and maintenance programmes. In many developing countries where the standards of vehicle maintenance are low, strict enforcement of vehicle inspection can be an effective means of vehicle emission control. The benefits of a regular and effective vehicle inspection and maintenance programme include (a) enhanced road worthiness of vehicles which in turns helps to reduce road accidents caused by mechanical deficiencies; (b) decreased environmental impacts due to lower emission levels of vehicles; and (c) lesser traffic delays caused by stalled vehicles on the road.

An effective vehicle inspection programme can be achieved by adopting appropriate test procedures, periodic evaluation and review, and maintaining a high inspection standards through qualified inspectors. Good vehicle maintenance can be attained by adhering to proper repair procedures and training of vehicle mechanics. In Group 3 and 4 countries where the average age of vehicles is high and the standard of vehicle maintenance is relatively poor, the implementation of inspection and maintenance programmes that gradually tighten the control emission levels can achieve significant improvement in air quality.

4.8 Noise Abatement Measures

Road traffic noise abatement measures can be classified into the following categories: (a) controlling of noise at the source with measures that reduce noise emission from motor vehicle engine and vehicle-road interaction; (b) regulating of traffic flow to reduce vehicle operation noise; (c) limiting the transmission of traffic noise to receivers by the use of noise barriers or sound insulation; and (d) avoiding the noise problem by means of sound town/country planning and road geometric design.

4.8.1 Reducing vehicle noise at the source

Noise a major factor in dissatisfaction with the environment in residential areas. Due to the lack of town/country planning and proper consideration for noise pollution in road construction, road traffic noise is a widespread problem faced by all Asia-Pacific countries. The most ideal method of reducing traffic noise is undoubtedly to curb it at the source. Technologically, there are no difficulties in design and manufacture gasoline-engined vehicles with noise level as low as 75 dBA. However, such vehicles are costly and it requires incentives and economically unpopular policies by the relevant authority. This problem of implementation also applies to the use of electric vehicles which would practically eliminate the noise pollution problem by reducing vehicle noise to a very low level.

Another source of road vehicle noise is the interaction between wheels and pavement. This source of noise becomes more significant compared to vehicle engine and exhaust noise for vehicles travelling at high speed of about 70 km/h or higher. Studies have shown that the use of special low-noise tyre could achieve a noise reduction of about 10 dBA. On the hand, road surface could be constructed with low noise materials such as porous asphalt that could achieve 2 to 4 dBA reduction in tyre-pavement interaction noise (WB 1994c, Kiely 1997).

MRT noise in heavily built-up urban areas has also been a common target of complaints. The major sources of noise from a moving train are engine noise, wheel-rail contact noise and aerodynamic noise. For MRT, the most important source of noise is the wheel-rail contact noise. Studies have shown that noise from the wheel is only relevant at frequencies above 1 kHz whereas the rail is a significant source for all frequencies (Sy 1993). In Hong Kong China, after the experience with the initial MIS line which was laid without acoustic reduction consideration, acoustic rubber pads were laid in station track foundation of the lines constructed subsequently. Correct carriage wheel contact to prevent wheel frets and side wear is also important in minimising travelling friction noise (SMA 1994).

4.8.2 Noise reduction by regulating traffic flow

Road traffic noise can be reduced by controlling the volume of traffic flow, limiting the vehicle running speeds, and restricting heavy vehicle traffic to certain routes away from residential districts. Improvements in road alignments (such as re-alignment to reduce road gradients and sharp turning) that reduce the number of speed changes and acceleration help cutting down traffic noise. Traffic management schemes that smoothen vehicular flow would reduce vehicle noise caused by minimising stop-and-go traffic.

In residential areas in Singapore, road humps are commonly constructed at strategic locations to restrict traffic speeds to below 40 km/h for the dual purpose of safety and noise control.

4.8.3 Noise barriers and insulation

A noise barrier is a structure that prevents the direct propagation of noise between the source and the receiver. By appropriate placement of a suitable barrier, substantial reduction of traffic noise levels can be achieved. A good sound barrier must be acoustically effective, structurally reliable, visually acceptable, adaptable to site variability, durable and economical. Noise reduction of 12 dBA or more can be achieved in communities adjacent to a roadway by the use of an effective barrier (WB 1994c). A number of diverse barriers have been constructed in Japan and Australia using a variety of materials. However, for many built-up urban areas in the region that are already badly affected by traffic noise, the erection of noise barrier is often an aesthetically and financially unacceptable solution beyond the means of most road authorities.

4.8.4 Traffic noise control through integrated transportation planning and road design

To avoid the problem of traffic noise, transportation and land use planning could include consideration for traffic noise impact as part of the EIA process. This is strongly recommended for new towns and small cities that have not yet developed to the stage where re-development would pose a major disruption to business and problems in re-settlement of residents. Singapore urban renewal and new residential town development are excellent examples

There are several road design parameters which can be manipulated to minimise problems associated with traffic noise. The significant parameters include distance from the roadway, gradients in the roadway, and the relative elevations between the roadway and the receiving point. The effect of distance from the roadway on the noise levels received from road traffic is to decrease the levels from between 3 dBA and 6 dBA for each doubling of distance. Where it is not possible to separate buildings from roadway by a sufficient distance, interrupting the line of sight between them by suitable design features is probably the next most effective noise control procedure available. This can be accomplished by creating berms, constructing earthen mounds, elevating or depressing the roadway.

4.9 Air Pollution Mitigation Measures

The basic objective of road transport policy is to keep traffic on the roads free-flowing for the easy movement of people and goods. Countries of the region need an efficient transportation system to serve their dynamic economy. There are other benefits, perhaps less apparent, from having uncongested roads - such as a healthier environment and a better quality of life. Smooth driving makes for more efficient fuel use and therefore less waste of energy, less noise and air pollution. Uninterrupted travel also allows commuters more time for other activities. Traffic jams put undue stress on road users, running down their health and productivity in the long term. While this objective is simple, it is a challenge for some countries like Singapore and Japan in view of various constraints such as limited space and high population density (Tong 1993). To meet the challenge, each national government should adopt a comprehensive approach based on the principle of increasing road network capacity while containing road traffic and optimizing road use (Tong 1993 and WB 1994c).

4.9.1 Increasing Road Capacity

This involves intelligent network planning to augment road building so as to maximize the overall carrying capacity of the road network. Function interchanges, flyovers and underpasses need to be incorporated into major roads to smooth traffic flow. These intelligent infrastructural traffic management techniques enhance the carrying capacity of many major roads.

4.9.2 Integrating land use planning

Systematic land use planning especially town planning is essential to bring schools, factories and offices, shops, and recreational and other facilities into or near housing estates in order to minimize the need to travel far or frequently for work and other activities (Mohammad 1995, Koh 1997).

4.9.3 Promoting public transport

Buses and urban rails are efficient people-movers compared with cars, as they occupy much less road space for the same number of passengers. These are also more energy-efficient and less polluting than cars for each passenger carried. Each national government should promote the development of a public transport system that is extensive, efficient, comfortable and affordable. Special lanes are to be designated for exclusive use by buses during peak hours. Integration of the urban rails and bus services is required so that commuters can enjoy a more efficient, cost-effective and comprehensive system. To achieve maximum impact, integration is to be carried out on all fronts: routes, infrastructure, fares and information (Heraty 1987, Cai 1988).

4.9.4 Management of vehicle ownership and use

To minimize congestion, each national government should control both the ownership and use of vehicles. Firstly, the vehicle population must be contained within levels that will not result in general congestion across the entire road network. Other measures like **Vehicle Quota System (VQS)**, **Area Licensing Scheme (ALS)**, and **Electronic Road Pricing (ERP)** may be introduced.

4.9.5 Controlling the quality of vehicles

Minimizing congestion and the number of vehicles on the roads is just one aspect of limiting air pollution. There is also a need to control pollution at the source - the vehicles.

4.9.6 Exhaust/emission standards

New vehicle should meet defined emission standards before they are allowed to be registered. In this respect, every opportunity should be taken to upgrade emission standards for new vehicles as soon as improvement in vehicle technology allows, and when major vehicle exporting countries upgrade their emission standards. All petrol driven vehicles to be registered must be able to use unloaded petrol. Motor cycles and scooters are required to meet exhaust emission standards. All diesel engine driven vehicles must satisfy emission standards too.

For in-use vehicles, each national government should impose compulsory periodic inspections including test items on exhaust. This is to ensure that in-use vehicles continue to meet basic standards of road worthiness and emission cleanliness. Active enforcement should be carried out on the roads, particularly in the case of diesel-powered vehicles, e.g. trucks and buses.

4.9.7 Revitalizing the vehicle population

Despite proper maintenance, vehicles will inevitably become more polluting and less road worthy over time due to wear and tear. Older vehicles are more likely to break down on the road, thereby causing congestion and posing danger to other road users. Therefore, each national government should discourage keeping old vehicles and encourage their early replacement.

4.9.8 Legislations and regulations

These are an important component of an integrated air pollution control strategy; they should in time address emissions standards of new and in-use vehicles, vehicle inspection and maintenance requirements, and fuel quality.

4.9.9 Other measures

Impacts of air pollution from motor vehicles can be avoided to some extent by routing traffic away from populated areas and reducing traffic growth. Other mitigative measures are given below (Claus et al 1993).

Measures	Effectiveness
Vehicle emissions control and maintenance	Reduces emissions of vehicles on the road
Traffic management	Optimizes speed and flow to reduce emissions
Demand management	Reduces growth of traffic
Vegetation screens	50 percent retention of particles for a width of 15 to 20 metres using resistant species

4.9.10 Policy instruments

In order to abate or to mitigate or to reduce air pollution from road transport, one or more of the following measures can be used (Claus et al 1993):

1. **Energy economy**: increased energy efficiency, smaller cars and better driving habits.

2. **Standard norms for emissions**: vehicles change to gasoline and catalytic converters.

3. **Speed limits**: lower speed limits and improved enforcement of these limits.

4. **Electronic traffic control**: use of new technology to coordinate traffic lights, control and provide information of actual traffic situation and available parking spaces.

5. **Car pooling**: for home-workplace trips in particular, joint transport needs to be encouraged, resulting in increased load factors for passenger cars.

6. **Load factor for trucks**: increasing the average load factor for trucks by route planning, joint distribution and similar measures.

7. **Public transport**: modal shift from private cars to public transport.

8. **Walking and cycling**: modal shift from private cars to walking/cycling for the short trip segment of the transport demand.

9. **Freight trains**: modal shift from trucks to trains.

10. **Electric vehicles**: shift in fuel to electric power for cars used in urban transport.

11. **Trolley buses**: shift in fuel to electric power for buses.

12. **Methane as propellant**: shift in fuel for part of passenger cars, vans, buses and trucks.

13. **Alcohol as propellant**: shift in fuel for part of passenger cars, vans, buses and trucks.

4.9.11 Overall strategies for road transport related air pollution mitigation measures

The overall strategies for road transport related air pollution mitigation measures are given in Table 4.5 (Claus et al 1993).

Table 4.5 Overall strategies for road transport related air pollution mitigation measures

1. **Improving traffic flow conditions through road improvements and better utilization of existing capacity**
   - new roads, added lanes
   - intersection widenings, over- or underpasses
   - provision of left- and right-turn lanes
   - peak period on-street parking bans
   - efficient signal timing
   - freeway ramp metering and flow metering
   - timely accident removal

2. **Shifting trips to less congested routes**
   - route guidance
   - route restrictions
   - corridor management

3. **Shifting trips to less congested times of day/days of week**
   - flexitime programmes
   - staggered work hours, staggered work weeks
   - congestion pricing
   - peak period restrictions on travel, deliveries, etc.

4. **Shifting travel to less polluting modes**
   a. provision of/improvements to commute alternatives
      - better transit: denser networks. increased frequency, direct service, express service, timed transfers
      - specialized services (shuttles, club buses, shared taxis)
      - programmes to market, promote, and assist carpooling, vanpooling, bicycling, walking

   b. provision of related facilities
      - special lanes, bypasses on freeways and local streets
      - signal on on-ramps, major intersections
      - improved transit stops, shelters, stations
      - park-and-ride lots
      - parking facilities for carpools, vanpools
      - bike paths and parking
      - walking paths and sidewalks

   c. subsidies/other incentives
      - transit passes, employer provided or subsidized vehicles for pooling, mileage payments for bike, walk use
      - preferential parking allocation, location.
      - guaranteed rides home; midday transportation; short-term auto rentals

5. **Reducing auto use and removing auto subsidies**
   - promotion of voluntary no-drive days; vehicle-free zones; transit malls
   - area entry licenses
   - parking by permit only
   - congestion tolls, entry tolls
   - parking pricing
   - control of parking supply, location, use, rates
   - no free employee parking for solo commuters

6. **Eliminating some trips altogether**
   - telecommuting
   - teleconferencing
   - delivery services
   - automatic payroll deposits

7. **Technology substitutions**
   - new emissions control devices
   - clean fuels
   - clean engines

8. **Others**
   - restrictions on idling
   - retirement of older vehicles

4.10 Road Safety

4.10.1 Mitigation measures

Site-specific measures: There are many features of a road and its surroundings which influence the risk of a road accident or the severity of accidents when they do occur. Examples include:

- Pavement and shoulder condition
- Presence of roadside poles, trees, ditches, steep slopes, and barriers
- Signs, markings, intersection layout and control
- Roadside access, parking, and bus stop arrangements
- Provisions for pedestrians, cyclists and nonmotorized road users (Table 4.6)

Important steps to ensure that these factors are adequately addressed can be categorized as preventive measures, which reduce the likelihood of future accidents, and remedial actions, which attempt to resolve existing problems. They include:

1. Road design standards, safety equipment specifications, and training to ensure that design detail takes account of safety concerns and that specific safety features such as guard fences are correctly designed and installed. Effects of some design alternatives are compared in Table 4.7 (ESCAP 1995d).

2. Road design audits, at preliminary and final design stages, by specialists in road safety and traffic operations. Account should be taken of any inconsistencies between improved road sections and adjacent roads and of possible conflicts with pedestrians and crossing traffic.

3. Traffic management plans, including details of signs, markings, intersection layouts, channelization of flows, access restrictions, footpaths, bus stops, and crossings. These should be incorporated with road designs, while separate traffic plans should be developed by contractors for execution of road works and temporary detours. Some examples are discussed in Table 4.8 (ESCAP 1995d).

4. Blackspot programmes, which set aside funds for low-cost improvements targeting known high-fatality accident locations. It is important that these programmes include: evidence of actual accident history; proven remedial measures; rigorous analysis of expected benefits; and follow-up monitoring of accident experience.

   Failure to consider road safety in road projects can sometimes result in "improvements" which lead to higher accident rates. For example, higher design speeds can contribute to changes in driver perception of road standards and increased conflicts at intersections or pedestrian crossings, as well as more single-vehicle loss of control accidents. On the other hand, safety improvements can also provide other benefits to road users, such as better bus stops, parking, footpaths, and rest areas.

Table 4.6 Types, causes and countermeasures of pedestrian accidents

Types

- Pedestrians walking along the road in direction of or towards traffic
- Pedestrians crossing the road
- Pedestrians standing on or by the road

Causes

- Negligent crossing or walking
- Undefined crossing sites
- Narrow roads
- Poor visibility
- High speed
- Rushing into the roadway
- Lack of footpaths

Countermeasures

- Improvement of pedestrian and cyclist facilities
    - Widening or construction of shoulders
    - Construction of separate footpaths
    - Painting of edgelines in order to separate shoulders
- Speed-limiting measures
    - Speed limit signs
    - Constructive speed limiting measures
    - Active police enforcement
- Improvement of visibility
    - Parking prohibition
    - Removal of sight limiting obstacles, plants, etc.
    - Construction of pedestrian bay within street parking
    - Lighting (especially of crossing sites)
    - Use of pedestrian reflectors
- Limiting of pedestrian movements by fences or guardrails
- Improvement of crossing sites
    - (Re)paint zebra crossing and provide signs
    - Provide rumble strips on both sides of zebra crossing
    - Erect warning signs for a pedestrian crossing
    - Construct pedestrian refuge with road signs
    - Provide a line of reflective studs on both side of a zebra crossing
    - Construct raised zebra crossing (with warning signs)
    - Construct level-separated crossing
- Regulations, education and training

Table 4.7 Effects of physical safety countermeasures on accessibility and environment

Countermeasure	Effect on accessibility	Effect on environment
Footpaths and bikeways	Positive	Positive
Motorways	Positive	Negative
Bypasses	Positive	Positive
Arterial routes in urban areas	Positive	Variable
Junction improvements	None	None
Roundabouts	Positive	Positive
Split level interchange	Positive	Variable
Improved cross-section	Positive	Variable
Improved geometric design	Positive	Variable
Guardrails	None	None
Improved road friction	Positive	Positive
Street lighting	None	Positive
Bus laybys	Positive	Positive

5. Integrated or comprehensive road safety programmes: Apart from physical road features, road accidents are also affected by policies, regulations, and other actions beyond the scope of a specific road project. Seat belt legislation, drunk-driving programme, speed regulation, and vehicle safety standards are typical examples. These can not be dealt with at the level of individual projects; they require coordinated actions from a number of government departments, possibly supported by nongovernment organizations. They are included briefly here because only a proportion of road accident reductions can be achieved through road engineering interventions.

A comprehensive approach to road safety generally requires the establishment of a national road safety council or similar body to coordinate the activities of numerous ministries and agencies with responsibility for various aspects of road safety, including:

- National road safety plan
- Road safety studies
- Accident data system
- Physical engineering improvements
- Traffic police enforcement
- Road safety legislations
- Publicity and advertising
- Traffic education of children
- Driver training and testing
- Vehicle testing and inspection
- Post-accident emergency assistance and medical care
- Road safety research and monitoring.

Table 4.8 Effects of traffic safety management countermeasures on accessibility and environment

Countermeasure	Effect on accessibility	Effect on environment
Traffic calming	Negative/no effect	Positive
Environmental priority for roads through urban areas	Negative	Positive
Pedestrian streets	Negative	Positive
Access control	Depends on measure	Positive
Priority routes	Slightly positive	Not known
Stop and give-way signs junctions	Depends on traffic distribution	Positive
Traffic signal control of junctions	Positive/negative (depends on traffic)	No effect
Traffic signal control of pedestrian crossings	Negative (vehicles) Positive (pedestrians)	Neutral/negative
Speed limits	Negative	Positive
Physical speed-reducing measures	Negative	Positive
Road marking	No effect/positive	No effect
Sidewalks	Negative (vehicles)	No effect
Bikeways	Positive (pedestrians/bikers)	No effect
One-way street measures	Positive	Not known
Traffic control of road works	Negative	Not known
Improved railway crossings	Negative	Positive

In many cases, the national road safety body consists of a secretariat providing technical support, especially in the areas of policy development, programme evaluation, data quality control, and oversight of special programmes. Development of these capabilities requires a long-term commitment to institution-building, training, and funding.

4.10.2 Traffic safety action programme

Studies have shown that the patterns of road accidents and casualties are not uniform in all countries because of differences in the following aspects: degree of motorisation, composition of traffic stream by vehicle type, standard and quality of road infrastructure design and construction, cultural and social values, and driver behaviour (Vaughan 1992). In Singapore, the fatality rate of motorcyclists is about 7 times that of car occupants. Special efforts such as imposing of day-time headlight requirement, traffic regulations enforcement, safe driving incentive schemes, raising of legal age limit for motorcyclists, and speed limit enforcement etc have been made to cut down the number of traffic accidents involving motorcycles.

Motorcycle accidents also feature very prominently in other Group 2, 3 and 4 countries (Vaughan 1992). The Malaysian government has required that from 1996 all new highways and federal roads to have motorcycle lanes to reduce the number of accidents involving motorcycles and allow smooth traffic flow (ST 9/4/1996). In strong contrast to the city state of Singapore, the nature of overall accident pattern in Group 2 countries like Malaysia is different in that the fatality rate of car occupants is about 3 to 4 times that of Singapore and other developed countries. There is still considerable effort needed to improve road safety of passenger car traffic.

The World Bank has significant experience in traffic safety improvement programmes around the world. It identifies four broad categories of "awareness" according to a country's need for and readiness to adopt a systematic road safety action programme. Most Group 3 and 4 countries in the ESCAP region are at awareness level 1 where there is little safety awareness activity. In these countries, there is an urgent need for a comprehensive road safety action programme that covers all major elements of road safety programme. Such a programme consists of a mixture of technical cooperation, training, equipment purchases etc. Governments need to be made aware of the high recurring economic and social costs of road accidents, and be motivated to allocate sufficient resources to tackle the problem (ESCAP 1995d). The entire process of institution building may take 5 to 7 years. A number of countries in the ESCAP region have benefitted from these programmes funded by the World Bank and the Asian Development Bank.

4.10.3 Coordinated road safety policies

For the road safety action programme to be successful, the need for coordinated activities in the various government and non-government agencies cannot be over-emphasised. For example, coordination among land use planning department, road design and construction authorities and the traffic police is often lacking in many countries (including Group 1 and 2 countries) in the ESCAP region. This is because in most cases these different authorities do not come under the same ministry in the administrative structure. Problems can arise with regard to road geometric design, safe sight distance requirements, design speed level, traffic signs and road markings that present design and traffic law enforcement difficulties.

4.10.4 Road infrastructure improvement

Poor state of road infrastructure and vehicles has been identified as a major factor contributing to road accidents in Group 3 and 4 countries. A satisfactory road worthiness level of vehicles can be attained by means of effective regular vehicle inspection and maintenance programme. Improvements in the level of service of the general road infrastructure can be realised through the incorporation of a safety audit plans for new roads and for the revision or upgrading of design standards. The safety audit will cover safety requirements for road alignment and layout, geometric design of road element, installation of guardrails, road signs and markings design, and road pavement design.

The construction of expressways which requires a large amount of investments, are effective in reducing road accidents. On the other hand, low-cost road improvement programmes like re-alignment, road widening, skid-resistant road surface treatment, and re-design of road intersections to resolve traffic conflicts etc. at frequent accident locations (or black spots) can be equally effective. A sound network level road maintenance and rehabilitation management system would also contribute to reducing road accidents by maintaining the overall road serviceability level at a sufficiently high level. Considerations of traffic accident costs and savings should be carried out to prioritise all these infrastructure improvement measures for road safety enhancement.

4.10.5 Training to inculcate good road use behaviour

All road users, including pedestrians, cyclists, motorcyclists, car drivers, truck drivers, bus drivers, and passengers, should be given instructions and/or training on the proper road use behaviour. It has been recommended that a separate instruction programme must be developed for each group of road users to enhance the safety consciousness of various groups of road users (OECD 1994a). Offering of regular training courses, provision of guidelines, teaching materials and manuals would contribute to sustainability in road safety efforts. The effectiveness of driver training and driving tests in many Group 3 and 4 countries has much room for improvement. Even in Group 2 and 1 countries, re-training or refreshment courses for errant drivers are found necessary.

4.10.6 Road safety database and analysis capability

Road safety database and analysis capability must be established so that an effective mechanism can be implemented to chart the management strategy for the road safety programme. This is essential for development and assessment of appropriate road safety measures. As a whole, adequate accident data systems and associated analysis provide the basis for rational decision making. At local level such data can be used to locate accident black spots, to identify possible causes of the accidents, and to formulate appropriate accident reduction measures.

Studies have shown that most ESCAP member countries do collect some form of accident data (ESCAP 1995d). However, the data collected are often very limited in terms of useful information that are suitable for further analysis. Most of the data collected provide very basic information meant for in-house administrative use within the Traffic Police. Almost without exception, there has been little or no effort applied to understand the nature or causes of the accidents. To ensure that the data collected provide adequate information for road accident analysis, a comprehensive accident data form must be devised, and a traffic accident analysis unit must be set up (ESCAP 1995d). The unit must be capable of handling the data submitted in the accident data forms, managing the traffic accident database, performing accident analysis, and producing and disseminating to all relevant agencies and institutions a comprehensive annual accident statistics report.

4.11 Integrated Multimodal Passenger Transport System

Besides the basic general classification of transportation modes as land, sea and air transport, there also exist a large number of different modes of transport within each basic mode. For example, in land transport, there are railway trains, trucks, buses, passenger cars, non-motorised transport etc. Each mode of transport has its strengths and weaknesses in the passenger and freight transport markets. By adopting the multimodal concept, the advantages offered by the various modes can be optimised. The benefits that can be derived from such multimodal systems include reduced overall transport costs, savings of time and energy, and optimal utilisation of natural resources.

Although multimodal integrity is a fundamental requirement of a comprehensive transportation system, road transport in many Asia-Pacific countries has been developed independently with no consideration given to an integrated multi-modal system involving various modes of rail, water and air transport. The unique techno-economic characteristics of different transport modes often lead transportation planners to focus on a single mode. Furthermore, the traditional governmental administration structure is such that road, air and water transportation are handled independently by different divisions. The end results are that the inter-dependencies between the various modes or subsystems are not given adequate attention.

Integrated multimodal systems within the land transport are more common. For instance, the so-called park-and-ride scheme has been successfully used in many major cities in the world that allows car drivers to drive from their homes to train stations, park their cars at dedicated carparks at the stations and travel by commuter trains to their work place. This scheme optimises the high passenger capacity of commuter trains for the main corridor, reduces the traffic congestion within the city centres, and cuts down the total travel time of commuters. In many cities in Japan and some cities in China, bicycles are widely used as the transport mode to train stations. Bicycle parks are commonly found at train stations to accommodate the large number of cyclists.

A fully integrated multimodal passenger system is a necessity to achieve an ideal seamless transportation for the commuters. This is because the travel demand patterns for low and high population density areas are different, so are those of areas with different functional activities such as commercial districts, shopping centres and recreation hubs. Each of these areas requires different modes of transport for optimal commuting operation. Such a system will reduce traffic congestion, travel delay, energy consumption and hence environmental pollution.

4.12 Environmental Awareness

Environmental awareness is the driving force behind all moves to reduce or eliminate adverse environmental impacts in the implementation of transportation policies. Many industrialised nations in their relentless effort to push for higher economic growth and better living standard have come to realise the importance of environment protection to safeguard sustainable development. Developments that have taken place at the expense of natural environment would retard further developments in the long run. It is this environmental awareness of the policy makers in the industrialised nations in North America and Europe that have led to legislative requirements to include environmental consideration and impact analysis in transportation infrastructure development projects.

The successful implementation of many environmentally friendly transportation policies would not be possible without the understanding and support of the general citizens and the travelling public. It is also true, however, that even in the industrialised countries in North America and Europe there are environmentally sound measures which politicians would not consider at all for fear of loss of citizen support.

National interest and economic considerations are also common reasons in many instances that countries ignore environmentally justifiable transportation strategies. There is also resistance, because of cost and profit considerations from manufacturers, energy suppliers and transport operators to switching from existing technology to an alternative technology that is more environment-friendly. It appears that the only effective way to overcome such resistance is to promote higher environment consciousness among the policy makers in the public and private sectors, as well as of the general public.

4.13 Participation of Citizens and Non-Government Organisations

As one of the main functions of transport infrastructure development is to provide speedy, efficient, affordable, safe and comfortable transport facilities and services to the public, it only make sense that the opinions and comments of the general public and the affected private sector be given due consideration in the various phases of the development, including planning, design, construction and management. Participation of citizens and non-governmental organisations (NGOs) has a definite positive role to play in the transport infrastructure development process. It is particularly so as far as environment protection is concerned.

Public demonstration, complaints by means of telephone or letters, and articles in the mass media have been found to have led to changes in transport matters in the direction favouring environment protection. This confrontary mode of participation is commonly found in industrialised nations, and to some extent also in countries of the Asia Pacific region. On the other hand, there is a tendency, though a rather slow one due to the difficulties in implementation, for the transport authorities in the world to adopt a participatory approach to formally include citizen and NGO participation in the transport infrastructure development process.

In many industrialised countries in North America and Europe, public involvement is an integral component of transportation planning process. For instance, in the United States, there are federal requirements that provide the public input throughout the transportation development decision making process, starting with planning and continuing through programming and the project development phase. In the cities, metropolitan planning organisations and other relevant state organisations, prior to obtaining approval for long range transportation development plans and transportation improvement programmes, are required to consider input from citizens, affected public agencies, representatives of transportation agency employees, private transportation providers, affected segments of the community and any other interested parties (TRB 1994, 1997).

4.14 Environmental Impact Assessment of Road Transport Systems

The severe impacts of road construction and road transport on the environment can be contained by adopting a systematic approach and appropriate measures which can be professionally accomplished by the Environmental Impact Assessment (EIA) technique.

In the ESCAP region, the EIA was first introduced in the 1970s. Australia, Papua New Guinea, the Philippines, and Thailand have specific laws on EIA. Some of the other countries of the region such as Malaysia, Indonesia, India, Japan, Republic of Korea and Pakistan have administrative measures to require EIAs for many development projects including road transport (ESCAP 1990b). In Myanmar and Hong Kong China, EIA has been introduced on an ad-hoc basis and there seems to be no particular list of projects requiring EIA. In Australia, only the general criteria guidelines for the selection of projects require EIA, while most countries require EIA for sectoral projects such as industrial development and land transport that may have significant implications for the urban development projects.

In some ESCAP member countries, Environmental Impact Assessment (EIA) has been compulsory for road projects for the last decade and today, these countries have at least some experience with EIA. The responsibility to carry out EIA studies lies generally with the authority or the company that initiates the project proposal.

Approaches to integrate environmental impact assessment into the general road transport planning process are rare not only in the ESCAP member countries but also in European and North American countries. The few countries which conduct both Environmental Impact Assessment (EIA) and Strategic Environmental Impact Assessment (SEIA) are the Netherlands, the United States and Sweden. Some other countries in Europe are beginning to consider both EIA and SEIA (WB 1994c).

In some countries, EIA reports are prepared in continuous, open interaction between different interests. As a consequence, the resulting report is appropriate for the users. In other countries, EIA is a formal procedure and interaction with the public is insufficient. The EC Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment states that the information provided by the developer/promoter shall include the following as a minimum:

- description of the road transport project comprising information on the site, design and size of the project
- description of the measures envisaged in order to avoid, reduce and if possible, remedy significant adverse impacts.
- data required to identify and assess the major impacts which the project is likely to have.

In most recent cases, EIA reports include the following:

- description of the initial environmental and social conditions and a listing of the natural resources in the area which is affected by the proposal.
- description of the environmental changes which are likely to occur
- description of land use and the proposed scheme's relationship to national and local plans and programmes.
- description of the project and any alternative solutions
- evaluation and comparison of alternative solutions
- listing of needs for public consultations
- description of the impacts on the environment, natural resources and social conditions (for road transport scheme itself and construction operations).
- description of proposed mitigation and compensation measures and how they should be carried out.
- proposed investigation of impacts after compensation and mitigation measures have been carried out, and a proposal for longer-term follow-up studies of the impacts of the road transport project

An EIA document containing these information is presented to different public agencies and private agencies and NGOs for their reviews. Figures 4.3 and 4.4 describes the main interaction between environmental assessment and road transport decision processes in the most common cases and in complete interaction respectively (OECD 1994c).

4.14.1 Evaluation practices

There are many gaps in current practices, including EIA methods which relate to the evaluation of landscape, cultural and natural heritage and their interaction in the design process. At the moment, multicriteria presentation is used for environmental evaluations. Very occasionally, some weighting of the evaluation factors or some similar technical analyses are included. Cost/benefit analysis incorporating environmental impacts is often discussed but seldom used in a real case. It cannot be said that a consensus exists in regard to the relationship between cost/benefit analysis and EIA. The principles of EIA are based fundamentally on a disaggregated method responding to the important role of open discussions and public (non expert) involvement as well as the plurality of goals and interests. In general, the inclusion of cost/benefit analysis into Environmental Impact Assessment, or expressing such an assessment in cost/benefit terms, presents risks of endangering the proper consideration of environmental concerns.

Non-monetary techniques for road transport project evaluation are not yet fully developed. Appraisal methods need to make proper provision for the involvement of large number of people. Another concern is the need for sensitivity analyses, checking the stability of the calculated results for those methods which use weighting of criteria against possible changes in the values of the weights. Nuisance during road construction is rarely mentioned. EIA procedures need to consider this sensitive period in the course of a road transport scheme adequately. Some countries do not always carry out the post-construction monitoring and follow-up studies that are advisable. These are necessary for three reasons:

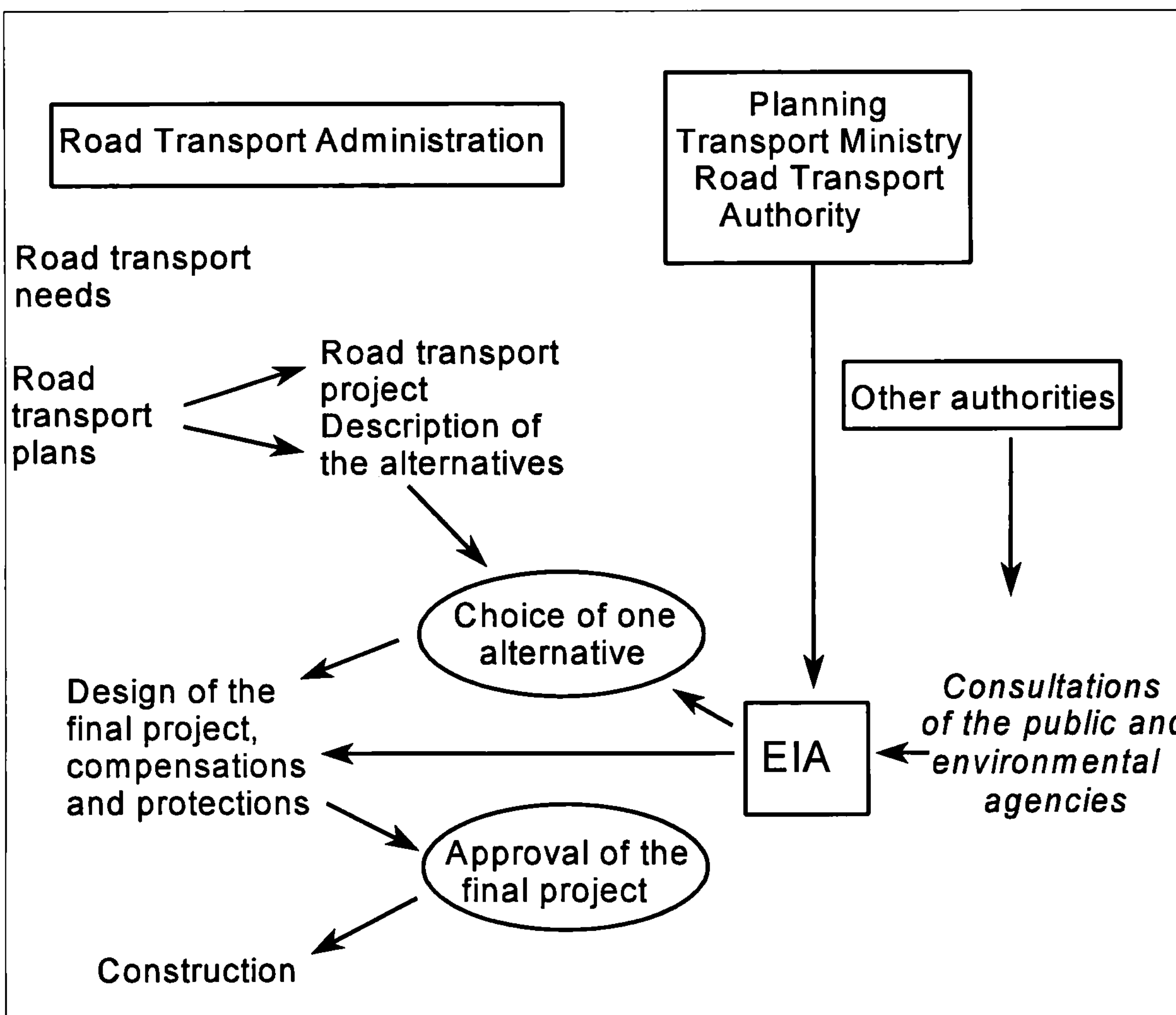


Fig. 4.3: Environmental impact assessment of a road project - common situation

Source: OECD (1994). *Environmental Impact Assessment of Roads.* OECD Report, Paris.

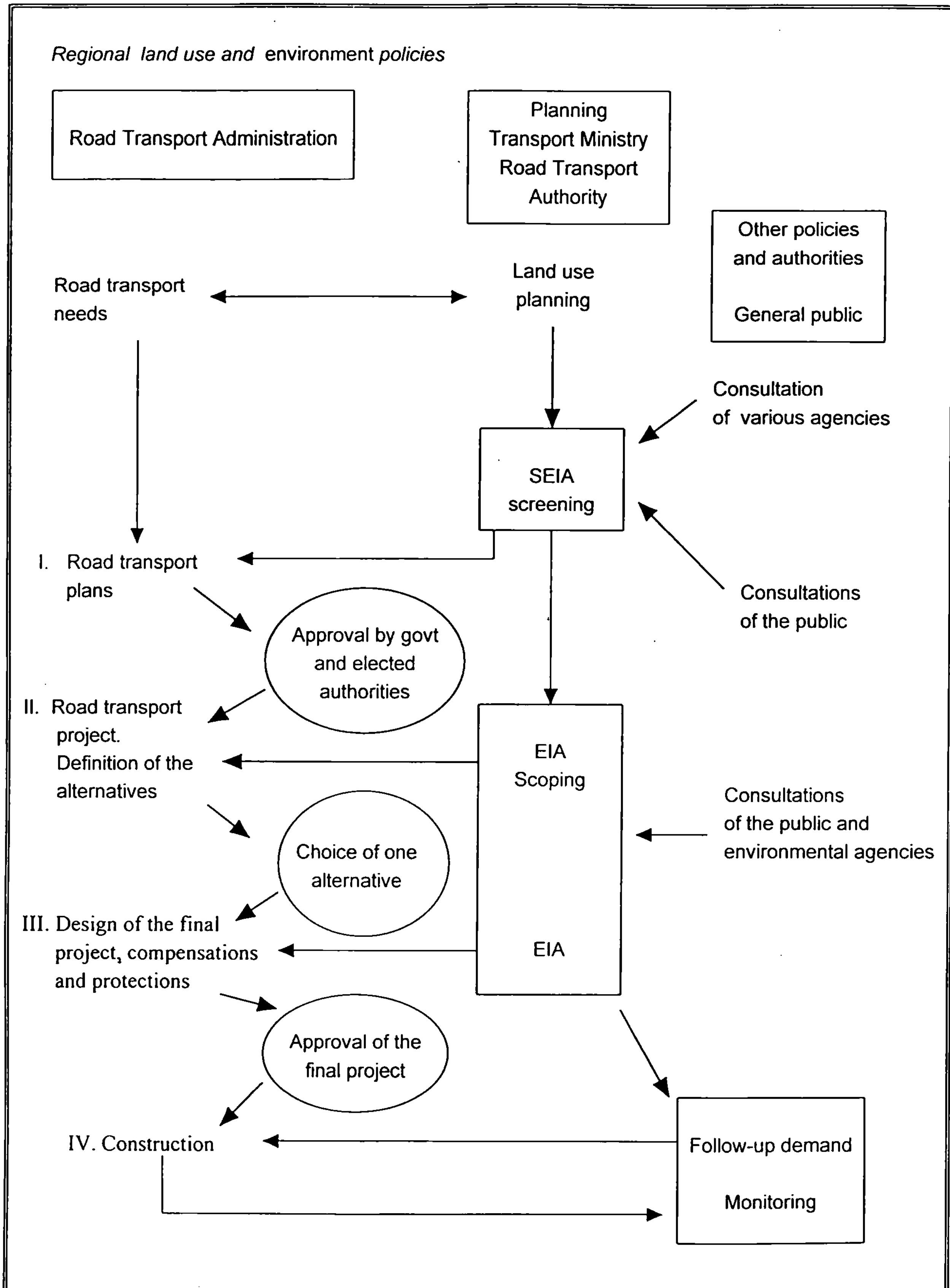


Fig. 4.4 Environmental impact assessment of a road transport project - full integration

Source: OECD (1994), Environmental impact assessment of roads, OECD Report, Paris.

- to ensure that the EIA post-construction commitments are properly implemented
- to check the assessment methodology
- to monitor evolution of impacts in the long-term.

Some ESCAP member countries are, to varying extents, involved in some forms of monitoring and follow-up studies.

4.14.2 Activities of environmental impact studies

Environmental impact studies must include the following activities:

- identification of road transport project objectives and of links with related policies, plans and programmes
- verification that the road transport project conforms with environmental legislation and planning
- generation and selection of alternative studies
- selection of the significant environmental impacts of the proposed road transport project
- inter-agency cooperation and coordination
- identification of various environmental impacts by target group and/or social group
- public involvement
- identification of associated projects
- negotiation and identification of any necessary compensation
- design of any mitigation measures.

The final content of the Environmental Impact Assessment study report has to be determined on the basis of the preliminary stage report and the results of the subsequent consultation process.

The EIA procedure identifies the possible positive and negative environmental impacts over the life of the road transport project including its construction, maintenance and operational phases. Through the EIA, alternative routings, construction techniques, materials, operating and management technologies as well as other factors can be evaluated and quantified to assist road transport policy makers and planners in seeking appropriate and cost-effective solutions which for the greatest overall benefits. EIA provides the opportunity to evaluate possible long-term and short-term impacts of road transport developments and operations over the full life of the project.

4.15 Road Construction and Maintenance

The various aspects of incorporating EIA in road planning and design have been covered in Section 4.14. This section describes the additional environmental considerations needed during the construction and maintenance phases of road development.

4.15.1 Environmental considerations in road construction

Traditional road construction practice calls for the use of high quality crushed rocks the supply of which is becoming more and more difficult to meet the demand of worldwide road development programmes. Rock quarries create serious disfiguration of natural landscape and objectionable dust pollution. There has also been concerted effort in most industrialized countries to use industrial waste, such as steel slag, incinerator ash and scrapped rubber, in road construction.

In many parts of the world, especially where the supply of crushed stones is limited, revised road design and construction practice have been developed to make use of locally available materials and marginal materials. Special treatment or stabilisation of the otherwise un-usable materials helps reduce the volume of dumping and the reliance on quarried rocks. The use of geofabric, for instance, reduces the required total thickness and hence the volume of construction materials needed.

Modern improved construction techniques have made it possible to build roads through areas formerly considered unsuitable for road construction. This include swampy land and other deserted areas. This added flexibility in route location makes it possible to avoid massive destruction of natural environment in road building, and encourages creative location and alignment design to blend with the surrounding environment.

Recycling is an important environment-friendly way of road construction. This is especially applicable to rehabilitation or reconstruction projects where part or all of the materials in the existing road is recycled and used. On-site recycling techniques and machinery are currently available. Recycled materials may be stick-piled centrally and used for new road construction.

4.15.2 Environmental consideration in road maintenance

A good maintenance management programme is needed to keep roads in good service condition and this has important implications with regard to environmental protection. The direct benefits of a well maintained road network are low vehicle operation costs (including fuel costs, vehicle maintenance costs, and vehicle parts replacement costs etc), longer vehicle service lives, smooth traffic flow, and safe road operations. For instance, it is estimated that for each US dollar spent on road maintenance, there is a saving of about 2 to 3 US dollars in vehicle operation cost. Good maintenance would also leads to more economical use of road materials and less construction activities in the long run.

Experience in industrialised nations has shown that delaying needed road maintenance would only lead to more expensive repair and rehabilitation subsequently. The cost of deferred maintenance and rehabilitation is many times higher than timely regular maintenance. Road building programmes in many developing countries have also highlighted the risk of losing the main bulk of initial investments if proper maintenance is not carried out. It is estimated that over US$50 billion invested in main roads worldwide has been eroded due to lack of maintenance (ESCAP 1994b). Internal rates of return of road maintenance projects often exceed 40 percent (WB 1994c). A sound road maintenance management system is therefore an integral part of an effective overall environment protection programme of road infrastructure development.

4.16 Road Transportation of Dangerous Goods

4.16.1 Present situation

As the countries of the Asia-Pacific region become more industrially oriented, larger quantities of dangerous goods are transported across national borders and through inland road networks (ESCAP 1994b, ESCAP 1996c). The transportation of dangerous goods often poses a greater threat to the community and environment than when they are stored at their eventual industrial destination, even though the quantities that are transported may be smaller. The problems are magnified since a whole range of dangerous goods, sometimes in one shipment, have to transit corridors which often pass through population centres. Moreover, the transport sector, by its nature, is not specially geared to the handling of dangerous goods. Due to these limitations, incidents and accidents involving dangerous goods occur frequently. Studies have shown that 60 percent of accidents involving dangerous goods occur during transportation (Borig 1996, ESCAP 1995c, 1996c).

Improving the safety of the road transport of dangerous goods is difficult because in most countries, a large number of government ministries and agencies have varying levels of responsibility. This splits the line of command and brings into play a number of laws and regulations, not all of which are complementary. The related administrative procedures in terms of documentation, information transfer between agencies and coordination is also overly complex (Blum 1995, OTA 1997).

An example drawn from Thailand provides an indication of the scale of problems that can be caused by accidents involving the transport of dangerous goods. On 24 September 1990, a liquid gas tanker, coming off the Expressway at New Petchburi Road, in the heart of Bangkok, Thailand, overturned and caught fire killing 73 people, injuring 113, and totally destroying 17 cars, 4 motorcycles and 40 houses and shops in the vicinity. The damage to property alone was assessed at about US$5 million (ESCAP 1995c). The social costs of the accident were considerably higher.

An analysis of the accident and its causes revealed a state of affairs common to most countries of the ESCAP region. Provisions for the carriage of LPG-gas and fuels have been made by the Ministry of Interior and Ministry of Industry, Thailand. However, neither the Land Transport Act of the Ministry of Transport and Communications, nor the Land Traffic Act of the Ministry of Interior has any specific mention of the transport of dangerous goods by roads. There are no laws or regulations prescribing what should be done in case of an emergency. As in many other countries in the region, the transport department is not involved until an accident occurs. Due to the lack of specific provisions, neither enforcement bodies nor enforcement procedures have been defined (ESCAP 1996c).

An ESCAP survey has found that this situation is common to many countries of the region, both in terms of legislative and regulatory control of domestic movement of dangerous goods (ESCAP 1995c). In addition, there is a lack of harmonization of legislation and regulations between the regional countries or with internationally recognized model regulations. This is already creating difficulties in the movement of dangerous goods across borders and frustrating cooperative efforts (Aziz 1996, Christmas 1996).

4.16.2 Stakeholders

Land transportation of dangerous goods contributes to the extent of loss of life, injuries, property and environmental damage in the region. The prime cause may be spills, or mechanical breakdown which may be either design or maintenance related, infrastructure failure (signals and other form of traffic control) or inadequate traffic control systems or failure to comply with the systems. In land transportation of dangerous goods, there is surprisingly a large number of people whose activities impact on the safe transport of dangerous goods by roads. These include manufacturer/generator, packer, importer, consolidator, bulk consignor, consignor, freight yard operator and driver (OTA 1997).

A failure by any of the above to do their task properly can result in either an incident or an inadequate response once an incident is underway. To be effective therefore, regulations need to cover every one of these functions (Blum 1995, Fitzgerald 1996 and Grainer 1996). This approach not only clearly defines who has what responsibilities but also permits penalties to be imposed on the person or persons primarily responsible for inadequate safety.

4.16.3 Responsibilities of all parties involved

If dangerous goods are to be road transported, then the manufacturer/generator must ensure that all parties involved clearly understand their responsibilities under the relevant statutory legislation. Safety in the **Logistics Supply Chain** is the responsibility of all concerned (OTA 1986, Kuhre 1995 and Boring 1996). The most important aspect must be the safety of movement when the dangerous goods are in the public domain. The manufacturer/generator must set the standards of training, communication, etc. and the transporter must also fully understand and accept their individual responsibilities. Typical guidance is detailed below (ESCAP 1993c, 1996c and Grainer 1996).

Consignor

The **consignor** of dangerous goods must ensure that:

a. information is available about the physical, chemical and dangerous properties of the materials and potential environmental dangers. The most acceptable form of this information as **Material Safety Data Sheet**.

b. personnel involved in all aspects of the operation are competent and properly trained.

c. hauliers are committed to safe operations in accordance to the **Land Transport Guidelines** and are prepared to be audited on a periodic basis.

d. information is provided with respect to labelling and packaging of dangerous goods and type of vehicle to be used, personnel protective equipment to be selected, and information supplied to the driver.

e. information in writing about the hazards of the materials, action to be taken in the case of emergency and a telephone number provided which can supply proper advice at all times.

f. written loading procedures should exist.

g. special instructions are provided, if necessary, on vehicle routing, parking or special delivery instructions.

Haulier

The **Haulier** must provide safe systems of work which ensure:

a. information is obtained from consignor to allow the haulier to select the correct equipment, labels and placards for the vehicle and to instruct the driver.

b. all personnel are properly trained.

c. suitable personal protective equipment for the driver is provided for the goods carried.

d. vehicles, tanks, pumps and hoses are maintained and tested in line with regulations

e. information in writing in appropriate languages about the hazards of the materials obtained from the consignor and given to the driver.

f. any special instructions regarding routing, parking and delivery are given to the driver.

g. sub-contracting must not happen without prior agreement from the consignor.

h. consignor is informed of any abnormal occurrence which happens during the transport operation.

Customer

The customer must ensure:

a. there are written procedures for discharge and if the driver is involved, adequate training should be given.

b. if required, the driver will wear the appropriate personal protective equipment.

c. that any emergency equipment needed during the discharge is available and in good working order.

d. a predelivery inspection of the "**Customer Stock Tanks**" before a first delivery should be conducted to ensure that safety standards are in place to prevent any accident during discharge.

4.16.4 Selection and monitoring of transport companies

The transportation of dangerous goods is a specialist business and demands that the haulage companies involved are of the highest possible calibre with a management attitude that puts safety at the top of the priority list.

Before any transport company is used to carry dangerous goods, a full safety audit of their operations should be conducted and it is accepted that repeat audits should take place every 24 to 36 months depending on the type of dangerous goods carried.

The audit is, in fact, an in-depth examination of the carriers activities covering safety. quality practice and management controls. It looks at the key people in the management structure and checks their experience and qualifications with regards to their position in the organization. It looks for evidence that there are written instructions for critical activities and that these are not only understood by all personnel but are applied.

The procedures should cover maintenance, vehicle selection, routing requirements and special instructions relating to the **Customer** and an **Emergency Response Plan**.

Physical check should also be carried out on tanks, hoses etc., during the audit process. Only after a carrier has undergone such an audit and there is an evidence of a higher degree of compliance should the carrier be used to transport dangerous goods.

4.16.5 Design and specification of equipment

All equipment used in the transportation of dangerous goods must be fit for the purpose. High standards should be set for the design and construction of tanks. However, it is also important to ensure that appropriate maintenance programme is in place which covers not only the tank but all the auxiliary items such as hoses, pumps, relief valves, tyres and safety equipment. Maintenance checks should be carried out at regular intervals.

4.16.6 Selection criteria for containers

Criteria governing the selection and use of containers for transporting dangerous goods are stringent. Dangerous goods are transported in bulk by vessels, tank cars, tank trucks, and intermodal portable tanks and in smaller lots in containers such as cylinders, drums, barrels, cans, boxes, bottles, and casks. Selection criteria of containers are many and varied depending upon country specific regulations. The US-DOT (OTA 1986) requires that containers used for road transport of dangerous goods be so designed and constructed that if an incident occurs under normal transportation conditions:

a. there will be no significant release of the dangerous goods to the environment;

b. effectiveness of the packaging will not be substantially reduced during transport;

c. there will be no mixture of gases or vapours in the packaging that could, through any spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging;

d. there will be no significant chemical reaction among any of the materials in the packaging. Closures must prevent leakage and gaskets must not be significantly deteriorated by the contents of the container.

4.16.7 Recruitment and training of drivers

The driver is the most important person during the transport of dangerous goods. He is often alone or unsupervised for extended periods. In addition to the ability to drive a heavy goods vehicle, the driver must have knowledge of the properties of the goods carried and how to react in an emergency. Detailed procedures should be followed in the recruitment and training of drivers. Typically, a potential driver should meet the following criteria:

a. be physically fit.

b. be reliable.

c. has a proven record of driving vehicles safely.

d. must be able to understand written procedures and information relating to dangerous goods.

e. must be able to calculate quantities of goods to be loaded into the tank.

f. must be fully trained in all auxiliary equipment on the vehicle.

g. must have completed a **Hazardous Chemicals/Materials Driver Training Course**.

h. be aware of what actions to take in an emergency.

Many of the above criteria can be achieved by the driver either in-house or by recognised training centres. It is also important that records of all driver training courses are maintained, so that refresher training can be carried out at the appropriate time.

4.16.8 Control of all operations

There must be proper control of both driver and vehicles whilst in transit. The driver is normally in sole charge and therefore must have clear instructions about the journey and the actions to be taken in an emergency situation. Procedures should cover the following areas (ESCAP 1993c and Boring 1996).

Route

The routing of vehicles should be selected to minimise risk. The consignor and the haulier should agree the route especially for materials with high risk and the driver made aware of the route. It may be necessary to involve local authorities or emergency services along the designated route so that risks are minimised.

Parking

When covering a long distance, it is important to park the vehicle in a safe place away from population if feasibly possible. Overnight parking areas should, whenever possible, be agreed between the consignor and the haulier.

Bad weather

Extra caution is needed when very bad weather conditions occur during transport of dangerous goods. It may be necessary to delay the departure of loaded vehicles if bad weather is forecast for the duration of the journey.

Vehicle checks during the journey

It is particular relevant during very long journeys that the driver carries out checks on the vehicle to ensure that valves, gaskets etc., are still tight and have not become loose due to vehicle vibration. Tyres, vehicle lights and tank externals should also be examined together with tank pressure and temperature gauges if fitted. Any problem on route should be reported by the driver to both the Transport Company Management and the Consignor.

4.16.9 Emergency response

In the event of an incident, an efficient and well planned **Emergency Response Procedure** can often minimise risk and adverse comments by the media. **Emergency Response Plans** should be drawn up by both the Consignor and the Transporter, communicated to the **Driver** and **Emergency Response Personnel** and wherever possible, **emergency exercises** should be carried out.

4.16.10 Common violations

Most common violations found during road transportation of dangerous goods are: failure to display the correct labels and placards; failure to block or brace dangerous goods containers; leaking discharge valves on cargo tanks; improperly described dangerous goods; inaccurate or missing papers/documents and excessive radiation levels (in case of radioactive materials) in the transport vehicle.

In addition, there are number of other reasons for noncompliance with regulations for road transportation of dangerous goods. These reasons include the complexity of the regulations, lack of available training for inexperienced personnel, and the fact that the personnel involved in road transport of dangerous goods are often unaware of the regulations.

4.16.11 General regulations governing land transportation of dangerous goods

Land transportation of dangerous goods should follow a set of regulations. The regulations applicable to land transport include packaging requirements, labelling and placarding requirements, marking requirements, notification requirements, routing requirements, manifest requirements, rules governing record keeping, and cleanup regulations. In the Asia-Pacific region, some countries have developed their own permit and registration programmes for transporters of dangerous goods by rails and roads (ESCAP 1993c and Blum 1995). All transporters of dangerous goods are required to obtain an identification number and to follow regulations governing hazard communication. The land transport regulations prohibit all transporters from accepting dangerous goods that have not been properly identified, packaged, marked, labelled and placarded. Special requirements for leaking containers have been established in some countries for rail and road transport of dangerous goods (ESCAP 1996c, Grainer 1996).

Growing environmental awareness has, in most jurisdictions in Asia and the Pacific region, pushed environmental issues to priority status for both governments and industry in general. Governments in this region are becoming increasingly aware of the need of guidelines for land transporting dangerous goods in their countries, from the stand-point of public health and safety, as well as protection of the environment. To accomplish this, legislative bodies throughout the region have had to grapple with the issues of transport of dangerous goods along with administrative matters relating to national, territorial and jurisdictional boundaries and the enforcement of compliance with environmental laws. Many jurisdictions have new or overhauled legislations for the efficient transport of dangerous goods. Among the countries of this region, no separate laws were identified which specifically deal with the land transport of dangerous goods. Legislative mandates that require these forms of regulations most often are embodied in broader statutes covering the public health, environment, transport and/or other issues. Although many countries statutes follow US-DOT regulations (OTA 1996), and British Road Transport regulations, there are some distinctions (Blum 1995, ESCAP 1993c, Borig 1996 and Fitzerald 1996). Table 4.9 shows the current status of regulations related to land transport of dangerous goods of some selected countries of the region (ESCAP 1993c, 1995c and Blum 1995).

Table 4.9 Current status of legislation/regulations, institutions, and manpower Capabilities for land transportation of dangerous goods in selected countries of the Asia-Pacific region

Country	Legislation/Regulations	Institutions	Manpower Capabilities
Australia	•••	•••	•••
Bangladesh	••	•	•
Brunei Darussalam	•••	•••	••
Cambodia	•	•	•
China	•••	••	••
Fiji	••	•	•
India	•••	••	••
Indonesia	•••	••	••
Japan	•••	•••	•••
Lao PDR	•	•	•
Malaysia	•••	•••	••
Myanmar	•	•	•
Nepal	•	•	•
New Zealand	•••	•••	•••
Pakistan	•••	••	••
Philippines	•••	•••	••
Papua New Guinea	••	•	•
Republic of Korea	•••	•••	•••
Singapore	•••	•••	•••
Sri Lanka	••	•	•
Thailand	•••	•••	••
Viet Nam	••	••	•

Key ••• Extensive coverage
•• Moderate coverage
• Minimal coverage

4.17 Effective Financing Mechanisms

4.17.1 Private financing and public/private partnership (PPP)

The scale of transport infrastructural development is much larger than the financial and human resources that the public sector could handle. Private financing can be relied upon to undertake public transportation projects which are commercially attractive to the private sector. Public/private partnership would allow the expertise of private sector to be tapped for the benefits of the general transport facility users. The partnership scheme can be selective in awarding contracts to only those private companies which are efficient and well-managed. The government and relevant authorities are in a position to prioritize projects, in accordance with the environmental soundness of the projects, for private financing or to be taken up under public/private partnership.

There are, however, potential problems that could offset the advantages of private financing. Awarding monopolies to private companies presents complex regulatory challenges to protect the consumer. Participation of private companies in large transport projects may give rise to powerful lobby groups that can pressure government for changes that allow the appropriation of socially disadvantageous pricing and accumulation of excess surpluses (ESCAP 1997a). There exist many transportation projects with considerable commercial and policy risks that call for substantial government guarantees. Government guarantees against risks is a major issue in private financing and public/private partnership. Care must be taken not to offer guarantees that may work against the major environmental protection effort. For instance, private toll road operators have been offered guarantees of traffic volume level and against competition of public transit. This could be counter-productive as it encourages increased use of passenger cars and creates problems to public transit operations.

4.17.2 Public/private cooperation and joint ventures

Cooperation between the public and private sectors in transportation projects in the form of joint venture can be a successful formula that benefits both sectors as well as the general public. The following are some examples of the benefits of such cooperation:

- Viable transit operations by coordinating private development and state transit projects to increase transit ridership
- Transportation improvement undertaken by the state to enhance the value of private sector projects
- Opportunity for value capture on public property due to private development
- Enhanced environment of a public transport facility with amenities provided by private sector.

The public sector can exercise its planning function to affect local land use and zoning decision in order to assure a better environment, a safer transportation system, and a sharing of project benefits. The relevant authorities must provide suitable incentives to encourage the commercial sector to adopt environmentally sound technology, and to embark on transportation infrastructural developments which will promote environmental protection.

4.17.3 Innovative approaches to user charges

The traditional user charges of motor fuel taxes, registration fees and road taxes have failed to meet the costs of providing and maintaining roads. To generate an adequate and stable flow of funds, road and traffic management expenditures can met with revenues raised on fee-for-services basis. This creates direct link between those who benefit and those who pay, thereby building more transparency and accountability in the system of financing. The various forms of charges levied on users according to this principle include (a) road access charges such as area licence fee and toll fee, (b) charges for road capacity use as road tax, registration fees and those based on passenger-car equivalencies of vehicles, (c) charges for road distance use in the form of gasoline tax, (d) charges for road damage such as vehicle weight charges, and weight-distance charges.

While the user charges mentioned in the preceding paragraph help to create awareness of road users of the value or cost of the service they receive, there are other possible forms of user charges which have direct links with environment protection and convey a direct message to the users on the importance of a sustainable transportation system. In industrialised countries, there appears to be increasing convergence towards pricing and imposing charges on vehicles for their shares in causing environmental pollution and community disturbances. Congestion pricing, higher taxes on `dirty' fuels, heavier road tax and registration fees for older vehicles are examples of charges that impose penalties for generating adverse impacts on the environment. For example, Germany, United Kingdom and the Netherlands have imposed a pollution tax on leaded petrol. Road pricing could also be considered as a mechanism for degradation charges.

4.18 Institutional Roles

4.18.1 Rational motorisation and road development policy

Road building is expensive and it tends to encourage higher rate of motorization. While road building is necessary to support economic growth in many cities in Group 3 and 4 countries, an effective measure to mitigate traffic congestion and environmental damage is to make the best use of existing roads by rationalizing road use, imposing parking control and improve the efficiency and productivity of public transport, bus service in particular. For example, Singapore adopts the concept of semi-expressway to improve road capacity by removing traffic lights at key junctions and building flyovers and underpasses. This could increase the capacity of a major arterial from 4,500 cars an hour by 60 percent to 7,200 cars an hour. In Tokyo, much work has also been done to construct flyovers and underpasses to improve traffic flow.

Building more roads in an urban area often does not solve the traffic congestion problem. In Kuala Lumpur, there are two ring roads and 13 radial roads. Both the ring roads and radial roads experienced over-saturation condition even during off-peak hours. The severe congestion has often resulted in a grid-lock situation at many of the intersections. This has prompted reactive remedial measures to build another ring road and other bypasses. Such measures, however, are not expected to bring much relief in the traffic congestion problem if car population is allowed to grow uncontrolled (Muhammad 1995).

4.18.2 Environmentally conscious transport policies

Environmental Consciousness of Policy Makers

In many countries in the world, including many ESCAP members countries, transport policies have been formulated by politicians and administrators who may not have the benefits of having been trained in transportation professionally. In most cases, these policy makers received assistance and advice from transportation experts and professionals within the ministries or from the private sector. It is unfortunate that in developing countries economic issues usually take the top priority and received the most attention in formulating transport-related policies.

This situation is rather common in Group 2, 3 and 4 countries. The importance of the need to increase the awareness of policy makers as well as transportation professionals and experts cannot be over-emphasised.

Safe and healthy environment is high on the national agenda of practically all developed countries where laws are enacted and policies formulated to protect the environment. For example, stringent vehicle safety and emission standards are already in place in the developed countries, and these standards are constantly being tightened and enhanced as newer technology develops. As has been pointed out by many, it is sad to note that in developing countries such as most of the Group 2, 3 and 4 countries, there is a high degree of unhealthy freedom in this regard and the governments in these countries have not shown strong signs of valuing the environment and striving for enforcement of environmentally standards and policies (Hart 1995). A great deal of effort is required to increase environmental awareness in the region as a whole.

Policies made by government authorities other than the road or transportation authority would often have either direct or indirect impacts on the transport sector. Environmental awareness programmes must also direct effort to educate all government policy makers and officials, besides the usual target of the general public in most awareness campaigns. For example, support is needed from all public and private sectors, and the general public to promote the use of public transport and limit car use to only those necessary trips; and incentives could be given to encourage environment protection actions.

Strategies for Promoting Environmentally Efficient Transport

Historically most transport-related policies have been formulated and implemented without giving due consideration to impacts on the environment. Changes to these conventional policies can be introduced to promote protection of the environment and preservation of natural resources. Listed below are some of the strategies that have been proposed:

(a) Offer subsidy to environmentally efficient transport modes - The most commonly known form of subsidy is that for the public buses to encourage more urban travellers to switch from car driving to taking public transport. Subsidies may be offered to environmentally efficient fuels to reduce air pollution.

(b) Imposition of environmental degradation charges - Instead of offering subsidies, environmental degradation charges may be imposed selectively to discourage the use of environmentally inefficient transport modes. For example, as mentioned in section 4.17.3, Germany, United Kingdom and the Netherlands impose a pollution tax on leaded petrol. Road pricing could also be considered as a mechanism for degradation charges.

4.18.3 Coordinated government agency involvement

Poorly coordinated transportation planning process has been cited as the single most important factor that has led to Bangkok's traffic congestion. There exist different agencies under several different ministries that are involved in transportation planning, construction and management. Each of these agencies carry out their own planning and feasibility studies, often independently from each other (Bodell 1995). The lack of coordinated policies of different agencies is one of the factors responsible for poor environmental achievements in Group 2, 3 and 4 countries. The effort of an environmental protection measure by one agency can be easily nullified by another uncoordinated policy by another agency.

4.18.4 Effective policy implementation and enforcement

Effective regulation enforcement and control are important to contain the negative environmental impacts of transport development and operations. The failure of the authority to enforce transportation laws and regulations is a major tumbling block towards effective implementation of environmental protection policies. The quality and integrity of enforcement personnel at the lower levels, and their relatively low wages have been cited as reasons in some cases. In other cases, the penalties for the infringement of environmental regulations are insufficient to deter violations. Alternatively, incentive schemes may be used in lieu of legislation and enforcement. In Singapore, drivers who have not committed any traffic offences for a period of 3 years are entitled to 5 percent discount in their annual renewal fees of vehicle insurance. There is also an annual campaign to encourage good driving behaviour during which good drivers identified by traffic police are presented with gifts.

Due to the constraints of manpower and resources, reliance on the enforcing units alone would not be effective. Enforcement policies that encourage participation of the general public and non-governmental organisation would be a long-term solution to the environment protection problem. For example, enforcing vehicle emission standards is no easy matter as traffic police or vehicle inspectors cannot be around all the time to nab violators. One of the ways to overcome this enforcement difficulty is to adopt the practice of citizen participation in which citizens report sightings of smoky or noisy vehicles to the authority for action (ST 10/4/96). The alert eyes of every motorist on the road would be more effective than the occasional patrol car or traffic police on motorcycles. If the public were assured that their reports will be taken seriously, much of the enforcement load of the authorities would be relieved.

4.18.5 Development of information system and database

A common problem that works against developing countries' effort to implement environmental protection policy is the lack of relevant local data and technical information to formulate effective strategies. A database system should be developed and continuously updated to provide the required information on various aspects of environmental impacts by road transport. Such a system would also help policy makers of relevant authorities to formulate more effective strategies to enhance environment protection.

4.19 Summary

This chapter has described various ways by which the adverse environmental impacts of road transport development can be reduced or eliminated. The appropriateness of each mitigation measure has been discussed with respect to the stage of economic development of the countries in the region in terms of four economic groupings. Table 4.10 highlights the aspects of road transport improvement achievable by each measure, the expected environmental benefits, and the respective urgency of needs for this measure by the four groups of countries.

Table 4.10 Need for environmental protection measures in road transport in the ESCAP region

Measure	Effect on road transport	Benefits to environment	Urgency of needs											
			Group 1 countries			Group 2 countries			Group 3 countries			Group 4 countries		
			A	B	C	A	B	C	A	B	C	A	B	C
Traffic management technologies	1. Smoother traffic flow 2. Increased road capacity 3. Higher travel speed 4. Lower vehicle operating and maintenance costs	1. Lower vehicle emissions 2. Less traffic noise 3. Shorter travel time 4. Less fuel consumption	x			x				x				x
Traffic demand management	1. Smoother traffic flow 2. Reduced traffic congestion 3. Higher travel speed 4. Increased use of public transport	1. Lower vehicle emissions 2. Less traffic noise 3. Shorter travel time 4. Less fuel consumption	x			x				x				x
Promoting use of public transport system	1. Reduced traffic congestion 2. Increased use of public transport	1. Lower vehicle emissions 2. Less fuel consumption 3. Less traffic noise	x			x			x			x		
Mass transit options analysis	1. Cost-effective public transport system	1. Beneficial if EIA is included in the analysis	x			x				x				x
Efficient management of bus services	1. Reduced traffic congestion 2. Better bus service 3. Increased use of public transport	1. Lower vehicle emissions 2. Less fuel consumption 3. Less traffic noise 4. Shorter travel time	x			x			x			x		

Table 4.10 (Cont'd)

Measure	Effect on road transport	Benefits to environment	Urgency of needs											
			Group 1 countries			Group 2 countries			Group 3 countries			Group 4 countries		
			A	B	C	A	B	C	A	B	C	A	B	C
Complimentary roles of paratransit	1. Improved public transport capacity and service 2. Lower overall investment	1. Shorter travel time		x		x			x			x		
Integration of transportation, land use and socio-economic planning	1. Efficient road network 2. Reduced traffic congestion 3. Good accessibility 4. Less travel needs	1. Less traffic noise 2. Shorter travel time 3. Less air pollution 4. Enhanced social and community life	x			x			x				x	
Use of electric vehicles	1. Less vehicle maintenance	1. Less traffic noise 2. Zero vehicle emission			x		x			x				x
Use of non-motorised vehicles	1. Less vehicle maintenance 2. Reduced road capacity 3. Lower travel speed 4. Lower operating costs	1. Less traffic noise 2. Zero vehicle emission			x			x	x			x		
Use of environmentally friendly fuels	1. Effect depending on type of fuel	1. Less air pollution		x			x			x				x
Regular and effective vehicle inspection and maintenance programme	1. Less vehicle breakdown and traffic delays	1. Less road accidents 2. Less air pollution	x			x			x				x	
Noise abatement measures	No direct effect	1. Less traffic noise	x			x			x				x	

Table 4.10 (Cont'd)

Measure	Effect on road transport	Benefits to environment	Urgency of needs											
			Group 1 countries			Group 2 countries			Group 3 countries			Group 4 countries		
			A	B	C	A	B	C	A	B	C	A	B	C
Road safety programme	1. Less traffic delays	1. Less road accidents	x			x			x				x	
Coordination of different transport modes	1. Less traffic congestion 2. Increased overall road capacity 3. Improved traffic flow 4. Lower operating costs	1. Less fuel consumption 2. Shorter travel time		x			x		x				x	
Environmental awareness programmes	1. Increased use of public transport 2. Increased use of environmentally friendly fuels	1. Less fuel consumption 2. Less air pollution 3. Less traffic noise	x			x			x				x	
Participation of non-governmental organisations	1. Increased use of public transport 2. Increased use of environmentally friendly fuels	1. Less fuel consumption 2. Less air pollution 3. Less traffic noise 4. Less destruction to natural environment	x			x			x				x	
Incorporating EIA in transportation planning and project evaluation	1. Impacts depending on nature of projects	1. Less destruction to natural environment 2. Less fuel consumption 3. Less air pollution 4. Less traffic noise	x			x			x			x		
Environmentally friendly technologies for road construction and maintenance	1. Impacts depending on nature of projects	1. Less destruction to natural environment 2. Less consumption of natural resources	x			x			x			x		

Table 4.10 (Cont'd)

Measure	Effect on road transport	Benefits to environment	Urgency of needs											
			Group 1 countries			Group 2 countries			Group 3 countries			Group 4 countries		
			A	B	C	A	B	C	A	B	C	A	B	C
Transport of dangerous goods	No direct impacts	1. Safer road environment 2. Lower risk of contamination to environment	x			x				x			x	
Institutional roles inroad transport development and environmental protection	1. Impacts depending on nature of policy	1. Overall improvements in environment protection	x			x			x			x		

Note: Mitigation measures are classified according to their urgency of needs by different groups of countries as follows:
A - urgently required to relieve severe environmental impacts or to avoid serious environmental problems.
B - required as measures to address environmental issues that are causing concerns to the authority or the public.
C - required as measures for enhancing environment protection in the long term.

5. RECOMMENDED PRIORITY ACTIONS AND REGIONAL IMPLEMENTATION POTENTIALS OF ENVIRONMENTAL PROTECTION MEASURES

Chapter 4 has presented technology and measures which are available to reduce adverse environmental impacts of road transport operations and infrastructural developments. However, due to the different socio-economic situations in individual countries, not all technology and measures are suitable for implementation in every country. This chapter describes various recommended priority actions with respect to their implementation potential in the Asia-Pacific region. Since the major concerns of adverse environmental impacts related to road transport in the Asia Pacific region are mostly found in Groups 2, 3 and 4 countries, the discussion will focus mainly on the implementation potential in these countries.

Recommended Priority Actions

1. Traffic Management Measures
2. Traffic Demand Management Measures
3. Measures to Promote the Use of Public Transport
4. Transportation and Socio-Economic Planning
5. Adoption of Zero-Emission Vehicles
6. Adoption of Environmentally Friendly Fuels
7. Vehicle Inspection and Maintenance Programme
8. Integrated Multimodal Passenger Transport System
9. Noise Abatement Measures
10. Air Pollution Mitigative Measures
11. Road Safety Measures
12. Environmentally Sound Road Construction and Maintenance Practices
13. Key Issues for Road Transportation of Dangerous Goods
14. Environmental Impact Assessment (EIA) System
15. Effective Financing Mechanism
16. Environmental Awareness Programme
17. Enhancing Institutional Roles.

5.1 Implementation Potential of Traffic Management Measures

5.1.1 Area traffic control

Practically all area traffic control measures can be claimed to contribute to smoother traffic flow, thereby reducing fuel consumption, vehicle emissions and traffic noise. While the major cities in Group 2 and 3 countries should benefit from a well planned and efficiently operated ATC system, one cannot expect to rely on such a system alone to solve major traffic congestion problems experienced in these cities. ATC would not be able to relieve traffic congestion during peak hours when most roads are loaded beyond their capacities.

The experience of several cities in implementing ATC is worth mentioning. The early positive results of the 1982 ATC scheme in Bangkok became irrelevant very soon due to rapid increase in the traffic volume. In Kuala Lumpur and in Manila, the implementation of computer controlled ATC systems are only partially successful and are yet to be exploited to the full advantage (ST 14/2/95). On the other hand, due to the stringent nation-wide control on the growth of vehicle population, and various supporting policies from different government agencies, the positive effects of ATC are still evident today in the Central Business District of Singapore.

The application of ATC in Beijing has great significance because the city has many urban traffic control problems that are commonly found in many cities in the Group 2, 3 and 4 countries. In 1990, there were about 450,000 motor vehicles and 7.5 million bicycles in Beijing, increasing at the annual rate of 16 percent and 10 percent respectively. The system was fully operational in 1988 and covered 40 traffic intersections. The distinct feature of traffic in Beijing is the extremely high level of bicycle usage. A flow rate as high as 10,000 bicycles per hour has been recorded. It was crucial for the ATC system to include the bicycle traffic in its operation. Special features in the ATC system included bicycle exclusion boxes at intersections and the design of special bicycle detector loop. A performance survey indicated that the ATC system resulted in a reduction in delay between 15 and 41 percent depending on the time of day. The number of stops was reduced by 25 percent. The best journey time improvements of 16 percent were achieved during the morning peak hour. It also has beneficial impact on traffic safety. In 1986, there were 18 traffic accident fatalities in the controlled area. In 1988, with much increased traffic volume, the comparable figure was 10.

As the experience of ATC application in Beijing has shown, adjustments to an ATC system must be designed to meet the operating requirements special to each city. This is particularly true in many Group 2 and 3 countries where there exist non-motorized transport and paratransit unique to the cities Just as high bicycle traffic volumes are found on Beijing streets, there are the tuk-tuks in Bangkok, the jeepneys in Manila, and tricycles, handcarts and oxcarts in many of the Indian sub-continental cities. Given the different unique traffic conditions in the Asia Pacific cities, it is important that city engineers incorporate the necessary adjustments into an ATC system to account for the special needs. Ad hoc and undiscriminating import of techniques and strategies from industrialised countries of Europe and North America have not been successful.

The experience in Bangkok, Kuala Lumpur and Manila have highlighted the need for manpower training. Efficient operations of an ATC demands qualified staff with a good understanding of the system operations. It is crucial for city engineers to gain sufficient knowledge and experience to operate and maintain the system if lasting positive impacts of an ATC are to be achieved.

5.1.2 Traffic restraint measures

Traffic restraint measures, in spite of their very intentions of reducing traffic congestion, has invariably been unpopular among motorists, with no exception in the case of Singapore. The number plate based scheme in Manila and the rotating ban in Seoul both had drawn sharp criticism from the press and the motorists. All such measures are also met with strong objections from the business sector within the CBD that are worst hit by the restrictive access to CBD. In Singapore, a study found that the small retailers with annual turn over of around S$1 million were affected most by the Whole-Day ALS (ST 10/5/94). It reported that during the first 3 months after the implementation of the Whole-Day ALS, both shopper traffic and sales turnover at the retailer outlets within the CBD declined by more than 20 percent. These experiences clearly indicate that the city government and relevant authority must be prepared to handle negative response from the motorists and the business sector affected, especially during the initial phase of implementation.

The implementation of the various restricted access schemes in Jakarta, Manila and Seoul and Singapore has shown that relatively low-cost manual enforcement by policemen can be effective in achieving the desired results. Implementation costs are not an issue for adopting such restricted access schemes in the cities of Groups 2, 3 and 4 countries. The key factor to the successful implementation of such a police-manning operation is good planning plus strict enforcement. Good planning includes research and studies that are needed to establish that pre-requirements are met by a city before such measures are tried out. Such pre-requirements include the availability of a convenient and efficient alternative transport mode so that the major economic activities are not adversely affected, and that the associated benefits of such measures are adequately explained to the mass media and the general public to facilitate a smooth introduction of the measures.

In contrast, road use control by means of electronic road pricing, which is to be introduced in Singapore in 1998, is not viewed as a suitable technology to be used in Groups 2, 3 or 4 countries due to the high costs of instituting such advanced systems.

5.1.3 Measures to increase road capacity

While construction of new roads and widening of existing roads are required to meet the increased travel demand due to economic development, and have been used to alleviate traffic congestion, the focus of the present study is on measures which can be adopted to maximize the flow capacity of the existing road infrastructure without resorting to road widening or new road construction. The measures are practical as they often involve much less investment compared to road widening and construction, and they do not create additional destruction to the physical environment.

Reversible lanes for tidal flows appear to be an attractive measure for many big cities in Groups 2 and 3 countries. The extensive use of reversible lanes in Bangkok should serve as a good example for adoption of this measure in other cities in the region. Although Bangkok's experience has demonstrated that safety issues involved in the operation of reversible lanes operation are not a major factor there, such issues must be adequately addressed before the implementation of reversible lanes by other cities.

Effective parking management is another area that could benefit cities of Groups 2, 3 and 4 countries. Inadequate parking facilities are a common problem in face of the high rate of motorisation in most cities of Group 2 and 3 countries. This problem can be solved by learning from the useful practice of Singapore and some other cities in Group 1 countries where commercial developments are required to provide sufficient indoor parking facilities for their operations. In the meantime temporary parking space could be created to eliminate kerb-side parking. Attention must also be focused on the lack of enforcement on illegal use of road space for storage, commercial activities and working space.

Advanced technologies such as real-time traveller information systems, auto-drive vehicle highway systems have been developed to the state where they could produce real benefits to Groups 2, 3 and 4 countries. Nevertheless, some effective communication means relying on telephone system or other existing communication tools could be exploited to reduce delays caused non-recurrent incidents.

5.2 Implementation Potential of Traffic Demand Management Measures

Based on the current traffic situation in most cities of industrialised nations, it is clear that without some form of traffic demand restraint measures, most cities of the rapidly developing Asia Pacific countries would be very much troubled by urban traffic congestion in the future. One of the common questions often asked is whether Singapore's successful experience could be copied in other cities. The transferability of Singapore policies and management measures, unfortunately, strictly demands a favourable political culture and requires strong commitment from all related government authorities. Except for some cities in China, no other countries in the region have so far seriously considered copying Singapore's policies due to various concerns and constraints.

5.2.1 Road transport pricing measures

Fuel taxes, road taxes, highway tolls are among the most common modes of road transport pricing measures in use in Asia Pacific countries. These traditional means of road transport charges are also the main modes adopted in industrialised countries in the world today. It is expected these road transport pricing measures will continue to be used in most Asia Pacific countries in the foreseeable future. Singapore's planned implementation of congestion pricing and road use taxes, though conceptually sound, is difficult to be administered and is not likely to be easily adaptable for use in other Asia-Pacific countries.

5.2.2 Vehicle ownership restraint measures

A number of Asia Pacific countries, notably Malaysia and Singapore have applied restraint measures to ownership of cars through raising of vehicle import tax, vehicle registration fees and driving licence fees. Unfortunately, the experience of these countries and that of industrialised nations in other parts of the world have found these measures to be ineffective as far as car ownership control is concerned. It is unlikely that they would be effective for the same purpose for the Group 2, 3 and 4 countries which are experiencing high motorisation growth rates.

The only vehicle restraint measure that has guaranteed success is the Vehicle Quota System introduced in Singapore. Several cities in China have been reported to be planning to introduce certain schemes similar to the Singapore system. The costs of administering these schemes are low. However, due to expected opposition from motorists and would-be vehicle owners, and the political risk involved in introducing such a scheme, the likelihood of similar schemes being adopted in other Asia Pacific cities is rather low.

5.2.3 Decentralisation of commercial centres

Decentralisation of commercial centres is a sound strategy in urban land use development planning to ease the traffic congestion problems faced by the major cities of most Group 2 and 3 countries. For those cities where traffic congestion has not developed beyond control, this strategy would be an economical and effective way to avoid the costly experience of urban gridlock seen in Bangkok, Jakarta, Kuala Lumpur, Manila and New Delhi. For these latter cities, decentralisation of commercial centres would also be an applicable measure to curb the worsening trend. For example, the Thailand government has announced a 15-year plan to attract 2 to 3 million people away from Bangkok to new regional centres (Suraswadi 1997). These include the town of Saraburi in the north, Chachoengsao in the east and Nakhon Pathom in the west. While these towns are already connected to Bangkok by railways, there are plans to improve the connection by means higher speed quality commuter railways.

Another example is Kuala Lumpur where the Federal Government of Malaysia is moving ahead with the plan to develop an administration capital in a new city Putrajaya at about 20 km from the existing capital city. This new capital is scheduled to be completed in year 2005 at an estimated cost of RM 20 billion. Another new city called Cyberjaya, also to be situated at about the same distance from Kuala Lumpur, will be constructed at a cost of at least RM 10 billion as the centre of an ambitious development known as Multimedia Super-Corridor (Norsaidatul 1997). An express rail link will be established ply the three cities within 20 minutes.

The relocation of business and commercial services is a painful and costly correction process. A more desirable strategy is obviously a planned ahead decentralisation before the need arises. Both Hong Kong China and Singapore have valuable experience to offer in this regard. Singapore succeeded in carrying out urban renewal in its first 20-year Master Plan from 1972 to 1992, and developing Orchard Road into a new shopping and business district away from the original city centre. Its new master plan for the 21st century released in the late 1980s aims to develop four regional centres which are inter-linked and connected to the current Central Business District by MRT (Koh 1997). Hong Kong China's decentralised programme also began in the early 1970s. The initial programme comprised the development of three new towns at Sha Tin, Tsuen Wan and Tuen Mun for a combined population of 1.8 million, followed by the staged development of 6 more new towns for a planned total population of 3.6 million (Miller 1997). After about 25 years, the governments in both cities are still continuing with their respective decentralisation programmes.

The experience of Hong Kong China and Singapore emphasize that decentralisation is a continuous development process that requires the concerted efforts of different government authorities and the private sector, and that there should be a "balanced development" at any one stage giving adequate attention to transportation and social needs. A good transportation system is one of the most important factors that is needed to ensure the success of a decentralisation development. In Hong Kong China, areas with existing roads or a railway link have been developed first, and the road and rail link were upgraded as the development progressed. For instance, the Kowloon-Canton Railway was double tracked and electrified in early 1980s to permit development of new towns along the railway (Lo 1997). Cities in Group 2, 3 and 4 countries can benefit from planning expertise available in the cities of Group 1 countries in the region. The planning experience associated with the initial phase of decentralisation development is especially relevant to many fast developing cities in the region.

5.2.4 Measures to reduce work trips

Teleworking has not been proven anywhere on a large scale to be effective as a long-term measure to reduce work trips. It would be premature and impractical to introduce it for any city of Group 2, 3 and 4 countries. On the other hand, coordinated land-use development appears to be more within the means of most Groups 2, 3 and 4 countries. By consciously building housing estates near industry areas, or setting up labour intensive industry around high density residential regions have been found to be a practical planning strategy to eliminate the need for long work trips, thereby reducing the total travel distance made and overall traffic loading during the morning peak period.

5.3 Implementation Potential of Measures to Promote the Use of Public Transport System

5.3.1 Mass transit options

Mass transit system could be an alternative option. However, the large initial development investment and burdensome operation subsidies required present a dilemma for most developing countries. The construction of the 67 km long MRT system of Singapore began in 1983 and was fully operational in 1990. It cost S$5 billion (approximately US$3.6 billion) to build the entire system which has 19 km underground. The unit cost works out to be about S$75 million per km (approximately US$53.6 million per km). The 16 km Woodlands extension to the Singapore MRT system completed in 1996 cost about S$1 billion (approximately 0.7 billion). The unit cost of this 16 km above-ground extension is approximately S$63 million per km (approximately US$45 million per km). With this extension in operation, the overall daily passenger load in the entire MRT system has exceeded 1 million passenger trips. The Singapore government announced in March 1996 that another 20 km extension line, the so-called North-East Line that cuts through the CBD, would be built at a cost of S$5 billion (approximately US$3.6 billion) - amounting to a staggering S$250 million per km (approximately US$179 million per km). Also at about the same time, the Singapore government announced the plan to construct its first 8 km long LRT feeder service system within three years for a cost of about $300 million (approximately US$214 million). This works out to be about S$37.5 million per km (approximately US$26.8 million per km). The planned first phase construction of 14.5 km MRT line to be operational in the year 2001 is estimated at a cost of up to US$1.4 billion, or US$96 million per km (Abubakar 1995).

For medium-size cities where passenger load and financial considerations do not justify the development of costly intensive rail mass rapid transit system, light rail system (LRT) could offer a lower cost option. Eleven cities in the region already have LRT systems (Midgley 1994). Current technology is able to carry up to 50,000 passengers per hour per direction with four-car units operating at frequencies of one train per minute with a station dwell time of 20 seconds. The running of LRT trains can reach 60 km per hour. Midgley (1994) reported that the Manila LRT was carrying 16,500 passengers per hour per direction with two-car units operating at two and a half minute headways in 1986. The construction cost of the elevated LRT system was US$17.9 million per kilometre. With the worsening traffic congestion in Manila, another two LRT lines would be constructed with a project cost of more than US$550 million (ST 9/2/96).

In a study that analyzed how the MRT has been implemented in 21 developing cities and their impacts, Allport (1991) observed that MRT systems in developing cities were not financially viable. Such systems would only become economically justifiable when a city grows sufficiently in size and wealth, as in the case of Hong Kong China and Singapore. In view of its enormous investment, MRT should not be built until all other ways of solving the same problems have been studied. These include improvements of the managing of bus services, use of bus lanes and other bus preferential treatments, busways, improvements to road network, traffic control measures, and various types of traffic restraint schemes. To overcome the financial dilemma of building rail based mass transit system, Japan has been able to share the cost burden among the beneficiaries. Relying on private sector financing is another option. This include joint venture schemes with equity participation from the private sectors as has been done in Hong Kong China and Japan, and Build-Operate-Transfer (BOT) schemes as has been tried out in China, Indonesia, Hong Kong China, Malaysia, Thailand and Viet Nam.

In comparing the costs and benefits of different mass transit options, Gardner (1995) concluded that no other options come close to busway in cost-effectiveness or flexibility. The environmental impact of busways though higher than LRT or MRT, is highly acceptable compared to the alternative of mass use of private cars. Busways are an effective solution as an efficient means of public transport in urban corridors with demand of between 10,000 and 30,000 passengers per hour per direction (Smith 1993). Table 5.1 and Fig. 5.1 give the operating characteristics of the various modes of mass transit. In view of the limited use of this mode of mass transit in Asia-Pacific countries, there appears to be a need for publicizing their advantages and promote their use in medium size cities in all the four groups of countries in the region. For cities which have grown sufficiently in size, rail based mass transit systems may be considered, giving merits to their environmentally friendly operational characteristics to partially offset the difficulty with economic justifications of the systems.

Table 5.1 Approximate estimated commercial speed for selected systems

	Bus in CBD mixed traffic	Busway transit	Tram	LRT	Metro
Commercial Speed km/h	10	18-26	12-16	19-29	29-36

Source: G. Gardner (1995). Choosing an appropriate mass transit system. *New World Transport '95*, pp. 137-141.

5.3.2 Efficient management of bus service

Public bus systems are the backbone of practically every city in the ESCAP region. Efficient management of the public bus service is of paramount importance not only in providing a time-saving transport system for the urban dwellers, but also in offering an environmentally solution to the indiscriminate mass use of private cars. The transformation of the bus services in Singapore, from poorly coordinated unreliable services provided by 11 bus companies in the 1960s to the highly efficient modern bus fleets of the 1990s, and the success stories in Hong Kong China and Seoul present excellent examples of the difference that modern management can make.

As there exists a plentiful of experience in the region in effective management of bus fleets, this is an area where regional cooperation is most likely to bring positive results. On-site workshops or training courses could be organised to facilitate transfer of experience and acquisition of the necessary management skills and operational expertise. Organisations such as United Nations ESCAP can play the critical role of initiating such regional cooperation programmes.

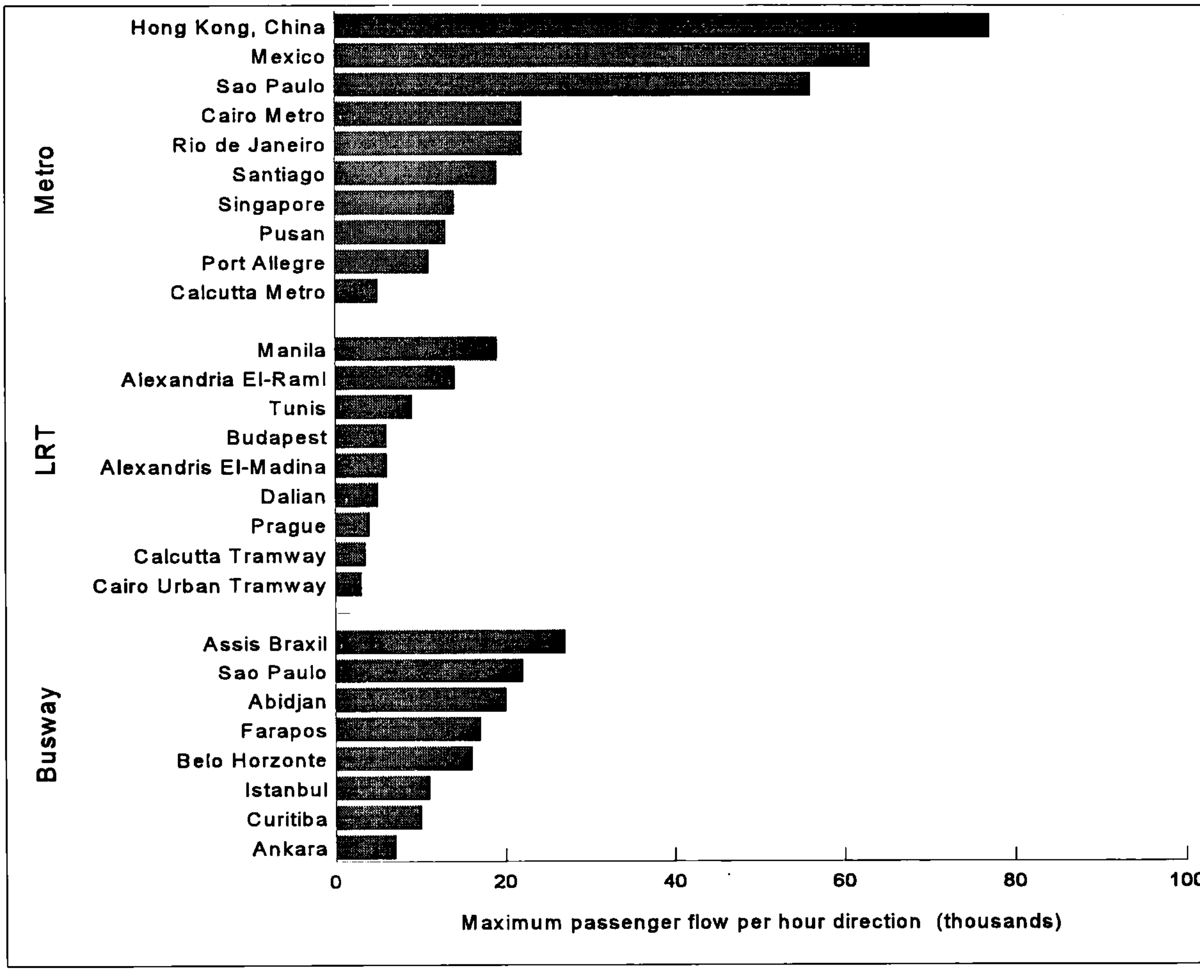


Fig. 5.1: Mass transit passenger flows in selected cities

Source: G. Gardner (1995). Choosing an appropriate mass transit system. *New World Transport `95*, pp. 137-141.

5.3.3 Management of paratransit

As it is economically unsound to purchase enough number of buses to meet the demand during the daily peak periods, paratransit has an important role to play in an urban public transit system, regardless of the economic grouping of the country. Comparison of the paratransit in the countries of different economic groupings in the region, however, has revealed large differences in the modes of paratransit operations. In Groups 3 and 4 countries, non-motorized transport (NMT) are widely used to provide the needed mobility. Unfortunately their capacity is rather low, and they tend to cause obstruction to motorised traffic in the urban area. For example, in Dhaka, NMT occupied 73% of road space to carry 56% of passenger trips, while buses occupied 4.4% of road space to carry 28% of passenger trips (ESCAP 1997e). In the cities of Group 2 countries, small capacity motorized paratransit are often found to compete with scheduled buses on busy streets. Based on the passenger load carried, they are inefficient road users both in terms of energy and occupied road space.

While there is the need ultimately to replace the low capacity inefficient passenger carriers by high capacity buses which are more efficient users of energy and road space, the current forms of non-motorized and low capacity motorized paratransit in the cities of Groups 2, 3 and 4 countries cannot be phased out in the short term due to economic and social constraints. They offer low cost solutions to the travel needs of a sizeable portion of urban commuters. This point is illustrated by Table 5.2 which estimates the number of additional buses required if half the cyclists in three major cities of China were to switch to buses (Wang 1990).

Table 5.2 Predicted increase in buses required if half the number of cyclists in 1985 used buses instead of bicycles

	Beijing	Tianjin	Shanghai
Current bus number	3,459	1,546	4,189
Additional buses needed	4,304	5,847	2,332
Ratio of increase to current fleet	1.24	3.78	0.56

Source: Z.H. Wang (1990). Bicycles in large cities in China. *Developing World Land Transport*. Edited by M.J. Heraty, Grosvenor Press International. pp. 130-134.

Socially, in the case of paratransit, the problem of re-employment of paratransit operators and drivers would have to be addressed too. For instance, in Dhaka, non-motorized transport operation employed 17% of the labour force and supported an estimated one million people (ESCAP 1997e - Dhaka NMT study). A participatory planning approach, involving NMT operators and other related private sectors, is desirable in the decision process concerning management policy of NMT paratransit.

The example in the preceding paragraph clearly indicates that an affordable high capacity form of public service has to be in place before the replacement plan can be introduced. Economic and social considerations require the replacement or upgrading to take place gradually in stages. For example, in the transition period, instead of competing for road space with regular bus services along busy main streets, the low capacity paratransit can offer useful feeder services as well as plying areas not served by regular bus services.

As NMT will continue to be a major form of paratransit in many of the cities in Group 3 and 4 countries, road design and traffic management should incorporate provisions for NMT operations so as to reduce traffic conflict and congestion, and to improve overall traffic flow condition and safety. In China, roads designed for mixed traffic of motorized and non-motorized vehicles are to have gradients not exceeding 3%. In its urban planning regulations issued in 1980s, urban primary and secondary roads are required to have dividers separating motorized and non-motorized traffic (ESCAP 1997e). In many cities of Group 3 and 4 countries, there is also a need to increase road use discipline and safety awareness of NMT operators through training and licensing.

5.4 Regional Implementation Potential of Transportation and Socio-economic Planning

Transportation network planning that is formulated in full integration with socio-economic development is the key to establishing an efficient and sustainable transportation system with little adverse environment impacts. A transportation plan that does not integrate well with socio-economic development, or reactive transportation infrastructure development to meet travel demand created by land use development are reasons for the traffic congestion problems faced by many Asia Pacific cities. The need to promote robust planning integrating transportation network with land use development is apparent in the case of Groups 2, 3 and 4 countries. Most of these countries do not have a formal planning process for transportation infrastructure to begin with at the national level or at the city level. The Group 1 countries of the region are in a position to offer their experience in planning to Groups 2, 3 and 4 countries. Regional cooperation programmes could be worked out between selected groups of countries to capitalise on the relevant experience of Group 1 countries.

In Groups 2, 3 and 4 countries, the lack of funds often means that they have to depend on foreign assistance for the construction of major transport infrastructure. Group 1 countries/territories such as Hong Kong China, Republic of Korea and Singapore have benefitted from external assistance programmes in the past in this regard. Similar programmes would be equally beneficial to growing cities in Group 2, 3 and 4 countries. Effort, however, needs to be made to ensure that the development projects should be planned and implemented to integrate well with the national transportation and socio-economic programmes.

There is also an emerging trend in Groups 2, 3 and 4 countries where more and more infrastructural development projects are funded, built and managed by the commercial sector. As different commercial groups are involved in different development projects, it is the responsibility of the relevant authorities to encourage and approve those commercially-funded development projects which are compatible with the overall transportation and socio-economic planning.

5.5 Regional Adoption Potential of Zero-Emission Vehicles

5.5.1 Electric vehicles

As zero-emission passenger cars are not expected to be marketed commercially in a large scale in the next 20 years or so, it is impractical for cities in Group 2, 3 and 4 countries to consider this option in the short to medium term planning. However, there exist possibilities of adopting the battery vehicle technology for motorcycles and other motorized paratransit. For example, it is encouraging that the Bangkok authority has embarked on an ambitious plan to replace more than 7,400 noisy, exhaust-spewing tuk-tuks with a quiet, non-polluting battery-powered version.

Considering the available technology currently and the general financial situation in the major cities of Group 2, 3 and 4 countries, the use of electric buses appear to have the greatest promise on improving urban air quality in the region. Of the different technology of electric vehicles described in Chapter 4, the trolley bus is undoubtedly an attractive choice for the region in view of its proven technology and widespread use worldwide, including many cities in China.

Although trolley buses are rarely found in the cities of Group 1 countries in the region, one must not overlook their advantage in providing a quiet, non-polluting, low vibration public transit service running on a relatively easy-to-maintain electric motor with an overall energy efficiency of about 90 percent. Wealthy countries like Switzerland are having electric buses in their major cities because of their environmentally attractive mode of operation. In Seattle in 1980-82 during the structure renewal of the trolley bus system, the local residents were outraged by the noise, smoke and smell as well as the vibration caused by the diesel buses that were used to replace the trolley buses Leembruggen (1990).

It is interesting to note that trolley bus service was terminated in the Chinese city of Guangzhou in 1995 as these buses were cited as one of the factors that caused traffic congestion due to their relatively frequent wire-related operational stoppages of the buses along busy streets. Traffic generated pollution, however, has led the city authority to re-introduce trolley buses again in 1997. This decision was taken to combat air pollution problem in the city after an technical improvement to make the trolley buses operationally more acceptable. This was possible following a research effort which had successfully incorporated a mechanical improvement into the trolley buses allowing them to continue to move for a distance, after electricity cut-off, and stop at a convenient location to allow re-connection of wire.

Given the positive experience with trolley buses in both industrialised and developing countries, there are good reasons for the cities of Group 2,3 and 4 countries in the region to seriously explore ways to introduce trolley buses in their public transit system. In view of the emerging battery technology which is expected to achieve practical means of electrical energy storage and generation in the 21st century, thereby making electric buses a viable commercial operation, the effort to switch to trolley buses and the investment committed would not be wasted.

5.5.2 Non-motorized vehicles

Non-motorized vehicles can have a positive role to play in Asia-Pacific countries of the various groups. In Group 1 and 2 countries, their use for short urban trips could help to counter the reliance on motor vehicles and solve the ground level pollution problem in the city centres. Walking and cycling should be encouraged in cities of Group 1 and 2 countries for short urban trips. Storage facilities for bicycles and safe NMV lane and network could be provided to promote the use of NMVs as a complimentary transport mode in providing access to mass transit stations and as the major transport mode for short-distance trips within neighbourhoods or CBD. In the affluent society of Group 1 and 2 countries where the urban dwellers are becoming more and more health conscious, the promotion of walking and cycling could gain added momentum by emphasizing the benefits of associated physical exercise.

In Group 3 and 4 countries where even buses are inaccessible to the poor, non-motorized vehicles can be an effective mode of transport to them for crucial mobility. Unfortunately, in the cities of Group 3 and 4 countries where NMV has generally not considered to be a positive factor in urban transport planning because it is seen as a "backward" mode of transport that would not enhance overall economic development. However, the experience in Bangkok, Bombay, Calcutta, Kuala Lumpur and Manila should provide sufficient evidence that the economic price to pay for traffic congestion and environmental damages could be even more destructive. Through proper planning, effective use of NMVs already in existence in many Asia-Pacific cities can be planned to provide a check on the uncontrolled trend of motorisation, and adverse environmental impacts of motor vehicle traffic. The phasing out of non-motorized paratransit needs to be handled in step with the economic development, giving adequate consideration to the mobility needs of the poor. Inconsiderate and drastic policies can lead to social problems and unrest. For example, attempts to ban bicycle trickshaws in Dhaka, Bangladesh led to the fall of the ruling party's municipal government (Hook 1995). Studies are needed in this aspect to identify ways and means by which the existing NMVs can be put to their best use, and highlight the positive roles that NMVs can play in the modernisation of the cities.

As a result, many city authorities have acted to place restrictions on NMT operations, although others have recognized the social, economic and environmental benefits of NMT and have adopted special provisions for NMT.

5.6 Regional Adoption Potential of Environmentally Friendly Fuels

The current undesirable state of air pollution caused by vehicle emissions in the cities of Group 2, 3 and 4 countries can be improved relatively quickly at an affordable cost by the use of suitable environmentally friendly fuels. Considering the current situations in these countries, the two most promising short to medium term strategies would be (i) to promote the use of unleaded fuel and phase out leaded fuel, and (ii) to encourage diesel-driven trucks and buses to switch to CNG engines.

5.6.1 Unleaded petrol

Many cities in the Group 2, 3 and 4 countries are now witnessing the adverse impacts of traffic generated pollution on human health. Bangkok and Beijing have both announced recently of plans to introduce restriction on the use of leaded fuel to new cars. Experience in a number of countries has shown that the phasing out of leaded fuel is a process that may take many years. Besides the need to cater for the large number of existing vehicles running on leaded fuel, consideration must also be given to the costs involved in the production of unleaded fuel. Subsidy and incentives from the authority are likely to be necessary to facilitate and expedite the switch to unleaded fuel. In Singapore, the government gradually reduced the lead content in petrol from 0.84 g/l to 0.15 g/l during the period from 1980 to 1987, and eventually introduced unleaded fuel in 1991 with favourable differential fuel taxation, followed by the imposition of the requirement of catalytic convertor for all new vehicles in 1992. The impact on vehicle emission pollution is significant as shown in Fig. 5.2 (LTA 1996).

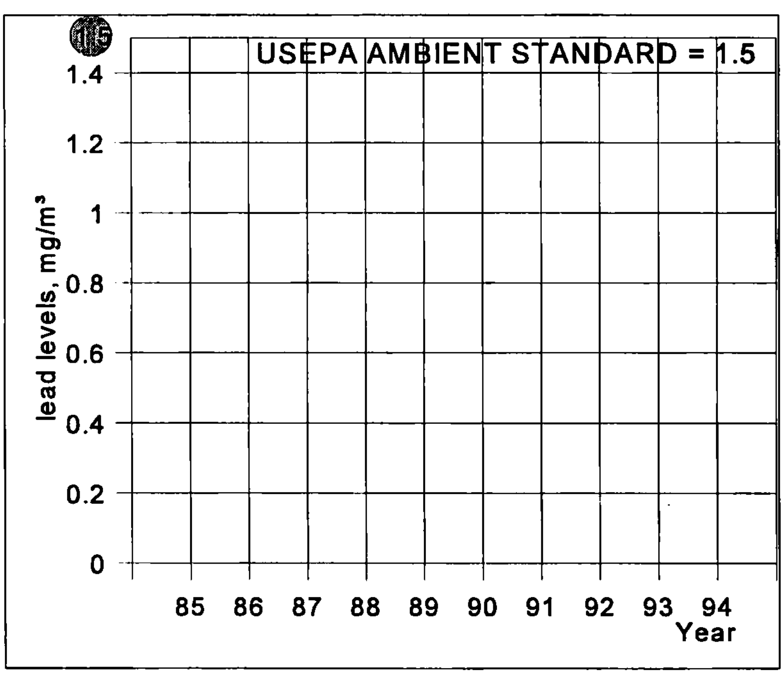


Fig. 5.2: Roadside lead levels in Singapore

Source: LTA (1996). A world class land transport system - a white paper. Land Transport Authority, Singapore

5.6.2 Compressed natural gas (CNG)

It has been shown in Section 4.6.3 that operation-wise, city buses and trucks are most suitable for conversion to use compressed natural gas (CNG). Statistics have shown that most of these buses and trucks in the ESCAP region are diesel-driven vehicles. Tables 5.3 and 5.4 (ESCAP 1994c) shows the share of diesel vehicles by vehicle class and the diesel vehicle fuel consumption characteristics in Pakistan. These statistics are representative of the general situation in Group 2, 3 and 4 countries in the ESCAP region. Being vehicles having the highest annual travel distances and fuel consumption, the benefits in pollution reduction will be the greatest by converting these vehicles which are 100 percent diesel-driven.

Due to their more regular operational characteristics and less diverse ownership, urban buses appear to be the most desirable target market to start with for a CNG conversion programme because only a few centrally located fuelling stations are needed. The potential beneficial effects are considerable. In the case of Pakistan, an ESCAP (1993) study indicated that if 15% of all urban buses (or 4,200 city buses) were to be operating on 100% CNG and with a three-way catalytic converter, the following annual reductions in exhaust pipe emissions could be achieved: 265 tons of NO_x, 55 tins of unburned HC, 69 tons of CO, 18 tons of SO^2, 18 tons of CO^2 and 328 tons of particulates. It highlighted that there would be a considerable reduction of visible particulate emissions (black soot) by up to 96%. It also identified the following two economic and ecological benefits of CNG driven urban buses: (a) The conversion of one diesel bus to CNG would save about 145 barrels of petroleum annually at average operating conditions; (b) Engine noise would be reduced by up to 5 dBA which corresponds to a 50 percent reduction of noise emission.

Table 5.3 Share of diesel vehicles by vehicle class

Vehicle class	Class definition	Percent of vehicles using diesel
Motorcycle	Motorcycles and scooters	0
Motor rickshaw	3-wheel passenger vehicles	0
Motor car	Cars, taxis, jeeps and all other light vehicles	5
Wagons/minibus	Wagons and vehicles with seating capacity of less than 20 passengers	15
Van/pick-up	Goods vehicles up to one tonne capacity	10
Tractor	Agricultural tractors	80
Bus	Seating capacity of more than 20 passengers	100
Truck	Goods carried with or without trailers over one tonne capacity	100

Source: ESCAP (1994). *Compressed Natural Gas (CNG) Technologies for Road Transport: Proc. Seminar-cum-Study Tour* (ST/ESCAP/1460). United Nations, New York.

Table 5.4 Diesel vehicle fuel consumption characteristics

Vehicle class	Specific fuel consumption litres/km litres/hour*	Average duty km/year hours*/year	Average unit fuel consumption litres/year
Motor car	0.10	15,000	1,500
Wagon	0.11	35,000	3,850
Van/pick-up	0.11	35,000	3,850
Tractor	5.90	1,300	7,670
Bus	0.33	70,000	23,100
Truck	0.33	70,00	23,100

* Figures for agricultural tractors are provided on the basis of hours instead of kilometres.

Source: ESCAP (1994). *Compressed Natural Gas (CNG) Technologies for Road Transport: Proc. Seminar-cum-Study Tour* (ST/ESCAP/1460). United Nations, New York.

It is important to note that to fully realize the potential benefits of CNG conversion of diesel-driven city buses, the programme must be profitable to the bus operators. In addition, CNG station operators and gas distribution companies must also benefit from it. The 1993 ESCAP study has recommended the following policy guidelines for creating these favourable conditions:

(a) Price of CNG has to be considerably lower than that of diesel in order to compensate for the cost of CNG cylinders and conversion investment.

(b) Taxes on CNG have to be comparative to those on diesel. As CNG is used to replace diesel, there is no loss of national tax revenue by having comparative taxes. On the other hand, it is possible to increase the taxes on diesel to discourage its use while subsidising CNG conversion at the same time.

(c) CNG conversion programme has to be supported by direct government assistance. Such assistance is required in facilitating the setting up of the CNG conversion facilities and CNG stations, and providing incentive package for the required investment during the initial phase of the programme.

(d) Conversion of diesel buses to CNG should preferably be confined to vehicles up to the age of three years. This is because the buses must be in good technical condition for an efficient conversion, and that old buses may not have sufficient remaining years of service for full recovery of the conversion cost.

(e) As a first step, conversion should be carried out in dual fuel technology. Optimum benefits are obtainable with new vehicles equipped with ex-factory CNG engines. For existing diesel-driven buses, however, full conversion to CNG engines require considerable skills. It is more practical to employ dual fuel technology with electronically controlled gas supply and pilot injection of diesel.

(f) A CNG conversion programme has to be accompanied by a technical training programming. Suitably qualified local technical personnel should be trained to ensure that the CNG conversion and maintenance programme become self-sustained.

(g) Country specific CNG demonstration projects should be initiated and supported by the government. The government should take the lead in launching the programme with demonstration projects to create awareness and to demonstrate the technical and operational feasibility of the technology.

5.7 Regional Implementation Potential of Vehicle Inspection and Maintenance Programme

An effective vehicle inspection programme can be achieved by adopting appropriate test procedures, periodic evaluation and review, and maintaining a high inspection standards through qualified inspectors. Good vehicle maintenance can be attained by adhering to proper repair procedures and training of vehicle mechanics. In Group 3 and 4 countries where the average age of vehicles is high and the standard of vehicle maintenance is relatively poor, the implementation of inspection and maintenance programmes that gradually tighten the control emission levels can achieve significant improvement in air quality.

Locally manufactured or modified vehicles are found in many ESCAP countries. They include the jeepneys in Philippines, tuk tuks in Thailand, and various forms of non-motorised vehicles in Group 3 and 4 countries. Many of these vehicles may not be designed with adequate safety elements to protect occupants or pedestrians. They also tend to be less satisfactorily maintained, thereby adding to safety and emission problems. Poorly repaired crashed vehicles also present a source potential safety and environmental hazards on the road. These problems can be mitigated through road worthiness tests.

It must be emphasized that to implement a successful vehicle inspection and maintenance programme, commitment by the relevant authorities is a must. Although this programme is expected to generate additional revenue in the long run for the government, there is a high initial investment in setting up inspection centres and the need to train skilled technical personnel. A logical first step is to initiate the programme in the cities where traffic generated pollution is most severe and only a relatively few number of centrally located inspection centres are required.

Ineffective enforcement of vehicle inspection has been identified as a major obstacle to achieving the desired objectives of raising the general roadworthiness of vehicles and reducing traffic generated air pollution. There is the risk of not being able to recover the investment costs if an effective enforcement cannot be put in place. This is expected to be a critical issue in many Group 2, 3 and 4 countries in the region. Another likely problem in these countries is the general lack of good quality and competent mechanics in the motor industry to support the programme. Government incentives and firm enforcement are necessary to overcome these problems.

5.8 Regional Implementation Potential of Integrated Multimodal Passenger Transport System

The potential of multimodal passenger transport, coordination between land and water or air transport in particular, have not been fully exploited in the region. A positive example is found in Bangkok where some commuters have been using water transport to avoid the gridlock in the city. Unfortunately, the water transport has created additional pollution to the river, and unbearable noise to residents along the river bank. Recently, in Manila, a private company has secured a 25-year concessional franchise to operate a ferry service along the Pasig River, the main waterway of the city (ST 16/10/97). The service was highly successful as it takes only 35 minutes to reach downtown Manila compared with a car trip which will take at least two hours. The service runs from 6 am to 7 pm with 50- and 100-seater ferries. The operator has planned to increase the number of ferries from 9 to 26 in three months' time. As water transport requires considerably less infrastructural investment compared with land transport, coastal cities and cities bordering inland rivers in Group 2, 3 and 4 countries should actively explore the potential of utilising ferries as a commuter transport.

There are many examples of successful integrated multimodal passenger transport systems in Group 1 countries in the region. The public transport system in Singapore offers an excellent example of how an integrated multimodal land public transport system could constantly upgrade its service and effectively respond to changes in land use development. A Public Transport Council was set up by the Singapore government in 1987 as a national watchdog body for public transport services, including all buses, taxis and MRT. With the approval of the Public Transport Council, the two main bus operators in Singapore and the MRT agreed on moves to form a fully integrated public transport network to allow easy interchange between services and to make the best use of each mode of transport. Steps that have been taken include the integrated ticketing system for both buses and MRT, and common ticket sales offices at MRT stations and bus termini. Passengers also enjoy transfer rebates for transfer between buses or between bus and MRT. with integration, there is less duplication of services and wasting of resources. The integration has also permitted smooth and rapid restructuring of the bus service routes as extensions of MRT lines took place.

In the case of Group 3 and 4 countries, there is an obvious need to consider the role of non-motorized transport (NMT) in an integrated multimodal passenger transport system. The transportation development experience in industrialised nations have shown that bicycles would continue to play an important role even in a modern city with the state-of-the-art transport technology. The message is clear that it would not be wise to have a long-term development plan to phase out indiscriminately all NMT. As explained in Sections 5.3.3 and 5.5.2, NMT in most Group 3 and 4 countries will continue to exist in the short and medium term, and it is crucial that all transport policies and development must address this important issue of how to incorporate NMT in the system. While the experience of Japan and other industrialised nations may offer some help in handling bicycle traffic, the experience in China in accommodating various modes of NMT would appear to be more relevant. A regional study on ways to incorporate NMT into an integrated multimodal passenger transport system should be a beneficial and rewarding undertaking.

5.9 Implementation Potential of Noise Abatement Measures

Enforcement of vehicle noise regulations is a major component of any traffic noise control programme. This is an area of major weakness in many Group 2, 3 and 4 countries. The staff of the enforcement unit or the traffic police force should be specially trained to perform effective spot checks at regular intervals, especially in built-up residential areas where the impacts of traffic noise are the greatest.

Since the most positive way of traffic noise control is to reduce the noise at its source, it would be wise to impose vehicle noise regulations on the vehicle manufactured or imported. Except for few countries which manufacture motor vehicles, most ESCAP member countries could put in place a "specific type approval test" for all new or imported vehicles to ensure that the required noise and other standards and regulations are met. This test would also cover vehicles that are locally built or assembled.

Finally, as any traffic noise problem is going to be costly to eliminate, there is a need to stress the importance of incorporating noise consideration into the road planning process at the very early stage. This is, unfortunately, rarely practiced in the countries (including Group 1 countries) in the region. An effective way to avoid such mistakes in the planning stage is to institute Environment Impact Assessment as part of the planning process in all road transport related projects.

Various policy instruments to implement different noise abatement measures should include: emission standards for individual sources generally laid down in legislation, emission standards based on noise quality criteria, land use planning, infrastructure measures, economic instruments, operational procedures, research and development, and education and information actions.

5.9.1 Emission standards

These are generally laid down by governments and consist of emission limit values applicable to individual sources and included in type approval procedures to ensure that new vehicles are, at the time of manufacture, complying with the noise limits.

5.9.2 Emission standards

Emission standards are based on noise quality criteria or guideline values for noise exposure to be applied to specific locations and are generally built into planning procedures.

5.9.3 Planning measures

Land use planning procedures are one of the means of putting emission regulations into practice, and are a key tool for noise abatement to ensure separation of dwellings and other noise-sensitive buildings from noise sources. Over the long term, land use planning is one of the most efficient ways of reducing noise as it can be used to prevent new problems from occurring. In particular, noise abatement through land use planning can include: restricting the use of land that is already subject to high levels of noise, restricting the siting of new noise generators such as traffic routes or industrial installations in order to protect existing developments and encouraging noise generating activities to be clustered together in order to preserve other low noise areas. Noise is one of the considerations to be dealt with in environmental statements for road transport developments requiring an environmental impact assessment.

5.9.4 Infrastructure measures

There are essentially two broad categories of infrastructure measures to abate noise: those that limit the transmission of noise such as noise protection walls, tunnels, noise attenuation dams, passive protection of buildings through insulation, and those that contribute to the reduction of noise at the source through, for example, the design of road surfaces.

5.9.5 Economic instruments

The types of economic measures that are and could be used in noise abatement policy include taxes and charges on noise emissions, economic incentives to encourage noise reductions and the development of low noise vehicles, and the payment of compensation to people affected by noise.

5.9.6 Operations procedures

Among the widely used measures are speed limits on sensitive road sections, and noise preferential routes, as well as restrictions on the use of.noisy vehicles in sensitive areas and during sensitive times.

5.9.7 Research and development

Research and development works into the effects of environmental noise, the methods of noise abatement, low-noise technologies, and the development of special low-noise vehicles are vital supporting instruments and often initiate improvements in the state of art of noise reduction. Financial support to pilot projects is useful in showing the advantages of technical and planning measures to reduce the noise exposure of citizens.

5.9.8 Education and information

Education and information activities are important in promoting acceptance of and compliance with noise regulations and to encourage changes in behaviour. They can also be used in their own right to encourage noise abatement and to increase awareness amongst decision makers and the general public.

5.10 Regional Implementation Potential of Air Pollution Mitigative Measures

5.10.1 Vehicular emission levels

Reduction of vehicular emission levels by 50 percent from uncontrolled levels in new vehicles is possible through limited engine modifications such as leaner air-fuel ratio, timing optimization, and by a further 30 to 40 percent by the use of three-way catalysts and electronic engine control systems. In light duty vehicles, diesel engines emit much fewer pollutants than gasoline engines. Heavy duty diesel vehicles emit more NO_x and particulates but much fewer hydrocarbons and CO than similar vehicles with uncontrolled gasoline engines. Various technologies are also available to reduce emissions from diesel engines through engine design changes, improved fuel injection systems, turbocharging and charge air cooling. Some of these technologies can be retrofitted to vehicles to reduce emissions.

The efforts to conserve petroleum products and the environmental concerns have led to improvements in the quality and range of available fuels. Vehicle emissions of internal combustion engines can be reduced in a cost-effective manner by 10 to 30 percent by modifying the characteristics of gasoline and diesel. The lead content of the gasoline consumed in many countries of the region has already been reduced beneficially, even if at the expense of increased benzene levels. Reduction of the sulphur content in gasoline is also feasible. In respect of diesel, reduction of sulphur content during the refining process and reduction of particulates is possible through the inclusion of additives.

Qualitative upgrading of lubricants reduces friction and yields the benefit of conserving fuels. Important breakthroughs have been made in the development of biodegradable, engine-specific lubricants which allow longer drain intervals, and recycling/reuse of lubricants. In two-stroke engines, the use of polyisobutylenes results in very significant smoke and particulate emission reduction.

5.10.2 Alternative fuels

Environmental concerns have also encouraged and accelerated the search for alternatives to traditional fuels. Significant progress has been made in respect of such alternatives as natural gas (NG) in compressed form (CNG) or liquefied form (LNG), as well as the use of various types of alcohols and liquid petroleum gas. Liquefied petroleum gas (LPG) is a cleaner fuel than petrol or diesel and is widely used as an automotive fuel in the United States of America, Canada, the Netherlands and several countries in the ESCAP region. The retrofitting of LPG kits to motor vehicles is relatively simple and cost attractive. The supply of LPG, however, is limited compared with gasoline and diesel and once its surplus is absorbed, its price may increase.

Natural gas in its compressed form (CNG) or liquefied form (LNG) has much better emission characteristics than LPG. It is a clean burning, non-toxic and comparatively cheap fuel which is available in larger volumes than oil in many parts of the world, including the ESCAP region. The main problem which has deterred its proliferation relates to the loss of space due to carriage of large gas cylinders and limited range due to capacity. Even so, CNG is being used as an automotive fuel in about 40 countries of the world. The total number of natural gas vehicles (NGVs) in the world is about one million, of which over 99 percent have gasoline-powered engines, fitted with conversion kits, operating in the bi-fuel mode. By comparison, LNG has not been used on a large-scale mainly because its cost varies considerably and liquefaction on a small scale is uneconomical.

Other possible fuel sources such as hydrogen, synthetic oil, biofuels, solar energy and gasified or liquefied coal are also being researched in an effort to identify alternatives which can be considered for commercial use in road transport. The use of electric vehicles represents another approach which can effectively reduce air and noise pollution. However, in spite of their advantages, electric vehicles are yet to be adopted on a large scale owing to higher capital cost than that of gasoline-powered cars, slow charging and the limited range of battery powered vehicles and the need for battery charging facilities.

5.10.3 Monitoring, regulation and enforcement

A prerequisite of any vehicle emission control strategy is the availability of adequate and reliable data on the following: ambient air quality; characteristics of transport systems and various types and makes of vehicles in use or expected to enter the market, and the impact they will have; cost of air pollution reduction programmes and legal and institutional requirements for implementing air pollution control programmes and measures.

Considerable international experience exists on the implementation of vehicle emission control strategies that could be adopted by developing ESCAP countries where such strategies respond directly to national requirements. Some potential strategies could include:

(a) Setting and monitoring emission standards with compliance initially on a voluntary basis;

(b) Monitoring and enforcing standards, with inspection being undertaken at facilities operated by the Government or authorized agencies from the public or private sector.

The implementation of vehicle emission controls involves significant economic and social costs in addition to an extra administrative and financial burden on Government resources. Inevitably, therefore, the costs of transport (vehicles, fuels and maintenance) may increase. Some of the costs incurred will have to be borne by the Government.

5.10.4 Possible policy instruments

The possible policy instruments suitable for the implementation of mitigative measures for air pollution from road transport can be classified into four different types: (i) economic instruments (registration fees, fuel taxes, emission fees); (ii) vehicle emission standards and/or technical requirements; (iii) other administrative requirements or prescriptions; (iv) information. To implement the action programme to control air pollution from road transport, it is necessary to employ one or more of the policy instruments. The relation between selected policy instruments, action measures and goals are shown in the Fig. 5.3 (Claus et al 1993).

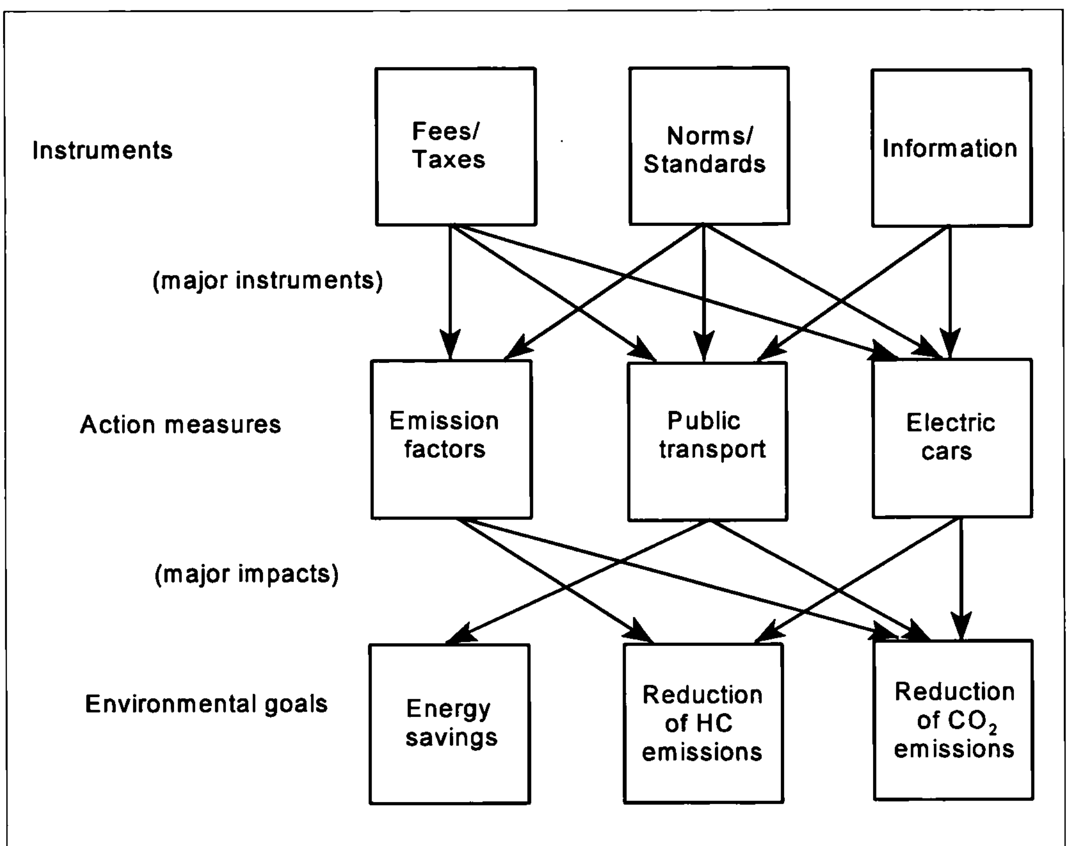


Fig. 5.3: Relation between selected policy instruments, action measures and goals

Source: Claus et. al (1993). Transport planning and policy: the Danish experience, *UNEP Industry and Environment,* Vol. 26, No.1, pp. 11-14.

5.10.5 Action programmes

It is important to recognize that an approach which more systematically takes all relevant effects of road transport policy into consideration is necessary. Basically, there are three main channels for achieving the goal: (a) reduction of emissions from each transport mode through (i) technical improvements and (ii) increasing average load factors; (b) shifts towards transport modes with less environmental impacts and reduction of overall transport activities.

Reduction of adverse impacts of air pollution from road transport requires a whole rethinking of the road transport systems. The focus of attention must be switched from particular modes of transport to the wider question of how to get people and goods moving from one place to another most efficiently. Almost always, the answer is a mixture of transport options which needs coordination and planning to implement. This requires not only innovative transport technologies, but also innovative government policies.

Each national government of the ESCAP region may wish to consider the following as priority issues: (i) enforce strict emissions standards; (ii) encourage the development and use of less polluting new vehicles as well as ensure good maintenance of existing ones; (iii) give much greater targeted support to efficient new mass-transit systems; and (iv) look beyond conventional approaches, to a new generation of integrated policies and technology solutions. There exist many novel solutions for the control of air pollution from road transport but the implementation of policy instruments and action programmes is very important. Also due considerations should be given to involve private sector as a source of financing, management skills and new technologies for controlling air pollution from road transport.

5.11 Regional Implementation Potential of Road Safety Measures

In the Asia-Pacific region, the death toll due to unsafe roads now exceeds 235,000 persons per year. This could rise to 450,000 persons per year within 10 years if present trends continue. Annual costs of road accidents in developing countries of the region already exceed US$ 20 billions per year (more than is loaned to these countries annually by the World Bank and the Asian Development Bank combined). There is no doubt these huge recurring annual losses inhibit the social and economic development of the region. Future increases in mobility and road traffic (currently 15-17 percent annually in many of the countries in the region) during the next 10- 15 years will cause further problems and result in millions of deaths and even more millions people being injured or crippled unless urgent action is taken to improve road safety (ESCAP 1995d).

Road safety was one of the priority areas included in the regional action programme for Phase II (1992-1996) of the ESCAP Transport and Communications Decade for Asia and the Pacific (ESCAP 1997d). As road infrastructure expands and road transport develops, national governments as well as concerned international agencies are becoming increasingly concerned with the improvement of road safety, thereby reducing human and material losses while maintaining the steady pace of development. The problem of road safety is multifarious. It includes: road planning and design; condition and road worthiness of vehicles, and their operation; behaviour and road safety awareness of road users; road safety education and awareness creation; accident information system and database, enforcement of traffic laws; driver training, and licensing; rescue and emergency medical services; and management of road safety in general.

5.11.1 Coordination and administration of road safety at national level

Road safety improvement is a multi-disciplinary task and does not occur by itself. Road accidents are a multi-sector social, health and economic problem which can only be tackled effectively if the respective country takes a leading role and responsibility for the improvement of road safety. One of the fundamental steps to be undertaken by a country is to create an organization dedicated to initiating and coordinating road safety activities. Realistic fatality and casualty reduction targets need to be established and adequate technical and financial resources applied to bring about the required improvements.

5.11.2 Road accident data systems

Accident data are essential since they provide the basis for decision making. Accident data bases need to be established but they should be decentralized and accessible to experts in all disciplines. These databases must enable the scale and characteristics of the problem to be analyzed and remedial measures to be devised at national and local level. Studies and research, including in-depth accident studies, must be supported as these are used to identify the issues and to develop solutions. It is also necessary to carefully evaluate completed actions and to explain accident trends. For this purpose, periodic surveys have to be carried out concerning the average speed, drinking and driving, seat-belt and helmet use, and many more.

5.11.3 Funding road safety initiatives and role of insurance

Investment in road safety is a highly cost effective activity. Sharp increases in funding in the countries of the Asia-Pacific region is justified to finance well-prioritized action plans based on cost benefit analyses. Each country must individually decide how to best finance its road safety policy at a level in accordance to its needs. An important objective should be to involve the insurance industry in funding some road safety activities and making them part of the decision making process. Focusing on accident prevention rather than repair is extremely cost effective both for the insurers and for all of society. Other private sector sources can also be involved. In some countries, the income resulting from fines is allocated, at least in part, to road safety activities. Funding assistance is now also available from the World Bank, and other aid agencies for road safety improvement.

5.11.4 Safe planning and design of roads

A number of countries which have adopted road safety targets expect that approximately half of casualty reductions will be achieved in the medium- and long-term through road infrastructure improvements. Some of these infrastructure improvements may be costly investments like new roads and expressways, but much will be achieved from targeted low-cost improvements at frequent accident occurring locations and from preventive activity such as safety audits and safety checking to create safer road networks. It is important that these low cost treatments are prioritized on the basis of cost-benefit analysis to optimize the road safety returns.

5.11.5 Safety improvement of hazardous locations

Considering the increasing urbanization of the region and the growing number of fatalities and injuries which now occur in cities and towns of Asia-Pacific region, it is necessary to reconcile the conflicts between traffic functions and the living functions in urban areas. The basic need is to establish a hierarchical classification of the road network based on road functions (e.g. flow, distributor, access and residential) and it is necessary to ensure that each classified road fulfils only its allocated role or function and no others, and to treat it accordingly. More attention must be paid to the needs of pedestrians, cyclists and other non motorized vehicles. There are now well established "traffic calming" and speed reduction techniques which slow down the speed of vehicles and sharply decrease the numbers and severity of accidents. One objective must be to build "low-cost 30 km/hr zones" in residential and similar areas to establish safer road networks for vulnerable road users.

5.11.6 Road safety education for children

Road safety education should begin at pre-school age and should continue through compulsory schooling. Aspects taught and materials and methods used will vary with the age of children being taught. Teaching should be undertaken by teachers with support, advice, materials, training and occasional visits from external specialists such as traffic police or road safety officers as well as from NRSC if one exists and guidelines for teachers and teaching materials must be developed by road safety specialists working with school curriculum developers so that road safety can be integrated into the school curriculum in many subjects. The focus should be on teaching children "survival skills" relevant to their needs at each stage of their development.

5.11.7 Driver training and testing

Driver training and testing should focus first and foremost on road safety. Education, training and re-training has to be supervised and regulated by the Government, even if private organizations are in-charge of the actual education and training of potential drivers. The introduction of a staged licensing process and of special rules for new drivers should be considered. Education programmes should be developed for special target groups. Public service vehicles and heavier vehicles should only be driven by those meeting age and driving experience criteria.

5.11.8 Road safety publicity and campaigns

A change in social attitude towards road accidents is key to bringing about significant improvements in the field of road safety and effective road safety publicity is an important tool to achieve this. Widespread and well-targeted information campaigns need to be undertaken regularly using modem means and especially TV as part of a comprehensive strategy related to changing road user behaviour. A first necessary step is the raising of public awareness. The use of realistic and even frightening posters and television spots showing accidents and accident victims should be seriously considered as it has produced remarkable results in reducing accidents in many countries. Information campaigns should be included when enacting new regulations and the introduction of police controls. Campaigns should be evaluated to ensure effectiveness. Target groups, messages and themes of publicity must be based on analyses of accident data if they are to be effective.

5.11.9 Vehicle safety standards

Vehicle control standards and procedures in the developing countries of the Asia-Pacific region compare unfavourably with those of developed countries. There is an urgent need to move towards harmonization with international standards and procedures for vehicle type approval and safety inspections of vehicles in operation. The activities must be regulated and standards set by the Government irrespective of whether such inspections are carried out in practice by the government agency or the private (licensed) sector. These activities should be self-funding but financial assistance and technical cooperation may be required in some circumstances.

National legislation should be provided for the application of international standards for domestic transport of dangerous goods. Because of the ageing vehicle fleet, more frequent and intense inspections of older vehicles should be adopted.

5.11.10 Traffic legislation

Traffic legislation in many developing ESCAP countries is outdated and often inappropriate to meet the needs of modern traffic conditions. Traffic acts should be updated to provide a modern legislative framework enabling the responsible ministry to take action as needed in each area. However, details of penalties, etc. should be included within ministerial regulations rather than in the Act itself to allow easier modification as and when needed in future. Traffic legislation should include provision for safety specific elements e.g. seat belts, drink driving, motorcycle helmets, speed zones and a penalty points system in addition to normal aspects relating to roads, vehicles and drivers. Efforts should be made to harmonize legislation between neighbouring countries and within subregions of the Asia-Pacific region.

5.11.11 Traffic police and law enforcement

A specialized national traffic police force is an important asset. The system of controls and penalties is an important factor in accident prevention as it is a prerequisite for some policies to be effective. The number of police personnel should be based on aspects such as traffic levels, road accidents, etc. They should be provided with modern equipment which can greatly increase enforcement efficiency and give a positive image of traffic police strength. An enforcement strategy should be defined which can be effective within the system of penalties in that country. Specialist training should be provided to develop a trained cadre with enhanced working conditions and incentives based on performance.

5.11.12 Emergency assistance to road accident victims

Timely and effective assistance to road accident victims is important to reduce deaths and permanent disabilities. In addition, it should not be forgotten that a large proportion of road accident victims are young and healthy people. Initiatives to organize and coordinate the rescue system framework should be undertaken by the Government even if some of the services provided are by nongovernment organizations and private service enterprises. The needs and potential low cost solutions such as "scoop and run" should be examined in developing countries instead of automatically adopting western models. Focus should be on extrication, maintenance of airway and breathing, control of bleeding and protection of spine while transferring quickly to a hospital or medical centre.

5.11.13 Road safety research

Road safety research provides the framework for effective policy decisions to be made and for cost effective investment in road safety. Research should be of an applied nature and results must be documented and disseminated in a useful and practical way so they can be used by practitioners to persuade policy makers to take action. There is considerable scope for drawing on international research but local research must also be undertaken at national level on the specific problems and needs of each country. A good national accident database must be available/accessible for researchers to carry out effective research works.

5.12 Regional Implementation Potential of Environmentally Sound Road Construction and Maintenance Practices

5.12.1 Environmentally sound road construction practice

Road transport plays a key role in Group 3 and 4 countries as a catalyst to their economic and social development. In particular, rural road development is crucial for providing access to health, education and agriculture extension and distribution services. Many Group 3 and 4 countries do have a comprehensive process of road planning. Road development has, however, strongly followed a piece-meal approach where project specific road construction is the norm under foreign assistance or to meet the needs of ad hoc development activities. This has resulted in poorly coordinated developments and undesirable route alignment and road network layout that causes traffic congestion, destruction of eco-environment and wasteful usage of natural resources.

In developing countries, construction cost consideration often governs engineering route alignment design for expressways or major highways. While displacement of people may have received some attention due to political consideration in some cases, other eco-environmental aspects are rarely factored in the entire planning process. As a rule, very little thought has been given to damage caused to natural habitat, disfiguration of natural land contours, and destruction to area drainage pattern. There is therefore a need to increase the awareness of transportation engineers and planners in these aspect. This can be achieved only with institutional support by incorporating environmental impact assessment into the transportation planning process and the evaluation of construction projects. For example, the conventional method of cost-benefit analysis should take the externalities of environmental impacts into consideration.

In general, standards for road design and construction in the region typically adopt those practised in industrialized nations with little or no modifications to suit the local conditions. It is interesting to note that different countries in the region, through historical and political connections, tend to look to different developed nations for road technology. Even though many of the technical problems faced by the countries are similar in nature, there have been practically no effective forums or workshops that promote exchange of experience and practice. An initiative by a regional organisation like ESCAP would be ideal in bridging the interaction gap to promote better road technology and environmental protection practice in the region.

5.12.2 Environmentally sound road maintenance management

The need for maintenance management is not clear and obvious when the roads are in good condition. It is common in developing countries that road maintenance funds are diverted for other uses and the needed maintenance is not carried out in time. This allows the roads to deteriorate to a point where much more expensive repair, rehabilitation and reconstruction intervention become unavoidable. This situation is not uncommon in Group 2, 3 and 4 countries in the ESCAP region. Experts have cautioned that the road building boom in Asia's developing countries is creating an infrastructure that threatens to crumble and collapse in the next decade or so if adequate maintenance is not carried out. Many road authorities are insulated from the effects and economic consequences of inadequate road maintenance. A major issue at hand is therefore to increase the awareness of decision makers of the importance to maintain a stable and adequate flow of road maintenance funds. This can be achieved through organising training workshops, regional seminars and conferences, a role which organisations such as ESCAP can help to promote.

An ESCAP/Work Bank seminar (ESCAP 1997a) has identified the following areas of focus for effective management and financing of road maintenance: (a) Increasing the awareness of the importance and economic implications for road maintenance; (b) Adequate and sustainable financing for road maintenance; and (c) Establishing consistent institutional structures for efficient and effective management of roads.

Under the assistance programmes and effort of international funding organisations, there are encouraging signs of increasing policy recognition of road maintenance in the ESCAP region. Examples include Pakistan's Maintenance Backlog Reduction Programme with World Bank support that expressly addresses maintenance; the programmes for rural roads in Nepal under German Assistance Programme (GTZ) and Swiss Agency for Development and Cooperation (SDC) where arrangement for maintenance work is secured well in advance before construction period is over; and the highway development programme in the Philippines medium term development plan that gives priority to maintenance rather than new construction (Rahmatullah 1996).

Increasing awareness of road maintenance needs

The relevant authorities in the developing countries should realise the benefits of properly maintained roads. Besides protecting the large sum of investment already committed in building the road infrastructure, good roads contribute to reliable and speedy transport of people and goods at reduced fuel and vehicle operating costs. A well maintained road reduces road safety hazards and stimulate social and economic activities. It also contribute to the preservation of road building materials and natural resources.

Practically all Group 2, 3 and 4 countries in the ESCAP region are relying on the traditional government tax mechanisms to generate revenue for road maintenance and traffic operations. As a result, most users are unaware of the direct connection between road expenditures and the quality of service provided by the road network, and the benefits of having efficient road maintenance agencies. The public road administrations and respective ministries need not face any real consequences of not maintaining road networks in good condition. Increased awareness of the public would create a positive environment for privatising road maintenance operations.

An effective way of creating an awareness among policy makers and road users of the need for maintenance is to raise revenues on fee-for-services basis and finance road maintenance with road related charges. The so-called weight-distance tax that is related to the relative road damaging effects of different vehicle classes has been implemented in some industrialised countries. In the ESCAP region, Singapore has announced a plan to implement a road damage charge, in additional to other charges for road use. In India, special funds for road expenditures have been created by levy on agriculture produce in certain states, making maintenance of roads responsibility of private operators for certain stretches (Rahmatullah 1996).

Financing of road maintenance

In most ESCAP member countries today, road policy is still formulated based on the understanding that roads are public goods which should be subsidized or provided free of charge by the government. Road maintenance is financed through government budget. This system of financing has been found inadequate and erratic in many developing countries. A concept that is developing nowadays is the commercialisation of roads by financing road maintenance on a fee-for-service basis, as described in the preceding paragraph. In the ESCAP region, the BOT (built, operate and transfer) and BOO (build, operate and own) concepts are gaining ground rapidly in Group 2 and 3 countries for toll road development. Most of these toll road projects, such as those in Malaysia, Philippines and China, operate as private sector concessions. There are also plans in several countries to contract out road work as well as long-term road maintenance.

Institutional roles for efficient road maintenance management

Efficient and effective institutional and budgetary process is particularly important for road maintenance. In most Group 2, 3 and 4 countries, weak institutional management leads to high operational costs, poor quality work and lack of innovation. One way to overcome this problem is to establish functionally and financially autonomous boards with active involvement of road users and private sector. For example, Road Boards have been set up in several countries, notably Ghana, Japan, New Zealand, Republic of Tanzania, South Africa and Zambia to advise the government or manage the road network, with active participation of road users and the private sector (Heggie 1996).

There has been little privatisation in the ESCAP region in respect of road maintenance management. Involvement of the road users in the maintenance management of roads is practically non-existent. A shift toward autonomous board and road users participation requires changes in terms of legislation, administrative and organization structure. Specifically, the following institutional requirements are important (Rahmatullah 1996): (i) clear definition and fixing of responsibility for government road agencies; (ii) delegation of responsibility, taking decision-making closer to the place of activity; (iii) defining the appropriate roles of the government agencies and the private sector, based on their respective comparative advantage, in the delivery of road maintenance services; (iv) institutionalizing public participation in road management and financing.

5.13 Regional Implementation Potential of Key Issues for Road Transportation of Dangerous Goods

With regard to the present situation covering transport of dangerous goods by roads in the Asia-Pacific region due to geographic, economic and social conditions in each country, the level of development in the countries differs. Some common key issues are legislation, rules and regulations, coordination and cooperation; enforcement; training and education; and information systems, contingency and emergency responded plans (1996c).

5.13.1 Legislations, rules and regulations

In most countries of the Asia-Pacific region, legislations, rules and regulations for transport of dangerous goods are inadequate and do not harmonize with international recommendations. The basic Acts in various countries are built upon different models and are not in conformity with each other. The reason is that some countries are using the same Act, for example, traffic safety in general, as the basis for dangerous goods regulations while, other countries have focused on handling of chemicals in general as a base for such regulations. None of the countries have established a system of legislation, rules and regulations which concerns only the activity of transport of dangerous goods. Systems with legislations, rules and regulations including detailed technical requirements are to a great extent undeveloped. Regulations concentrating on classification of dangerous goods, packaging, labelling, mixed packing, mixed loading, transport documents and written instructions to the emergency service are not dealt with. Where some of these details exist, the implementation of requirements has yet to be finalized.

In areas related to and affecting the transport of dangerous goods, e.g. infrastructure, some ESCAP countries are frying putting in a lot of effort and work intensively in planning road transport and traffic systems in general. Road networks are being developed to provide for the increasing need for transport services.

It needs to be verified that the Acts are suitable as the basis for dangerous goods regulations. Legislation may need to be complemented with coverage of specific issues or the countries might find it a good opportunity to consider the possibility of creating new legislations only for the activity related to the road transport of dangerous goods.

Related legislations, rules and regulations focusing on social planning, infrastructure, routing, conformity assessment, safety for workers, information systems, risk analyses, contingency plans and emergency response should also be over viewed.

The level of safety which the ESCAP countries find necessary, possible and desirable should be defined. This safety level will be the basis for the requirements. The countries should seek adjustment to the safety levels used in international regulations and recommendations, by issuing suitable regulations taking due consideration of relevant local and regional conditions.

When issuing legislations, rules and regulations, due consideration must be given to the existing international recommendations and agreements developed for transport of dangerous goods by roads. The UN recommendations on the transport of dangerous goods are *inter alia* used as the basis for regulations in most parts of the world. All these requirements, including the international requirements for sea and air transport of dangerous goods, are harmonized and built upon the UN Recommendations.

The advantages from harmonization with neighbouring countries, in the development of technical provisions for the safe carriage of dangerous goods by roads are obvious. Corresponding safety levels, through the same basic provisions, would facilitate trade in more than one way. The ease by which dangerous goods can be transported crossboundary, when complying with corresponding regulations, would be cost effective and would facilitate free trade between the nations.

5.13.2 Coordination and cooperation

Coordination and cooperation between the responsible ministries and authorities in the different countries in the region within the area of transport of dangerous goods is limited. There is also a lack of coordination between the countries in the region even though there is general agreement that this would be beneficial.

Coordination and cooperation are important cornerstones in the work to be undertaken in the area of transport of dangerous goods. They are the keys to a properly functioning system. Above all, they guarantee consistent safety levels for all modes of transport and can help in harmonizing interface problems. In other parts of the world, coordination has reached an acceptable level, only recently, although there is still a lot of work to be done.

It is important that each country of the ESCAP region identifies which ministry or ministries should have the legislative responsibility for the transport of dangerous goods. The designated ministries or authorities should establish channels for coordination, domestically as well as regionally and internationally. Within countries, this includes industry, transport organizations, enforcement authorities, emergency services as well as research institutes and testing institutes dealing with dangerous materials and transport technology.

In addition to coordination and cooperation, the countries in the region should find a way to cooperate with each other in relation to standards and other issues related to the transport of dangerous goods. This is important as it will ensure that safety levels correspond and that harmonized requirements facilitate trade between countries. ASEAN has adopted a declaration which will lead to a free trade area in the South-East Asia region within 15 years and this will require a harmonized transport system for dangerous goods as well as for general cargo. The countries in the region should consider the establishment of a focal point for exchange of knowledge and information and inspire countries to act as an instigator for the harmonization of common safety levels and dangerous goods requirements.

5.13.3 Enforcement

The systems for enforcement of the rules and regulation regarding the road transport of dangerous goods in the countries of the region are insufficient. Authorities issue special permits before a dangerous goods transport can be accomplished. Some countries request certain conditions to be fulfilled before and during transport, as a prerequisite for permits to be issued. The scope of such prerequisites varies between the countries. A permit can be issued for one single transport but more commonly, it is issued for a period of time with the possibility of an extension.

Effective enforcement is needed as an assurance that stipulated safety levels are maintained and that users fulfill the requirements for the safe transport of dangerous goods. The countries should develop and establish systems for enforcement of the rules and regulations regarding transport of dangerous goods. In order to establish well functioning systems, there is a need for technical regulations to be clear and understandable. Authorities responsible for the enforcement have to be clearly identified and the personnel performing the checks should be well trained and have expert knowledge.

Effective enforcement procedures could lead to a reduction or even the disappearance of permits as a tool in governing transport of dangerous goods. The combination of a well-developed system of rules and regulations for the transport of dangerous goods and satisfactory enforcement by checks and procedures should guarantee satisfactory adherence to safety levels and compliance with the requirements on the transport of dangerous goods.

Countries of the region should consider discontinuing their use of permits. In general, the number of such transport movements and the volumes of dangerous goods to be transported will presumably increase as a result of rapid growth in the region. The countries should fully adopt the classification criteria for dangerous goods set out in the United Nations recommendations.

This will undoubtedly lead to an increase in the number of transport units carrying dangerous goods as well as an increase in volumes. Without a change in the system the consequences will be that the activity of issue of permits for transport of dangerous goods alone will require an enormous bureaucracy. Today's resources will probably not be sufficient, procedures will be ineffective and the transport sector will find it difficult to transport dangerous goods in a cost-effective way.

5.13.4 Education and training

In most of the countries of the region, the legislation does not detail the requirement for educating and training personnel involved in transport of dangerous goods by road. However, some sort of training is provided by the chemical and petroleum industry and by some transport companies in some countries. These organizations impart the training to their own personnel at their own initiative in order to comply with their internal safety standards.

It is an urgent requirement for ESCAP countries to establish a system for training of personnel involved in the handling of dangerous goods. Target groups include drivers, consignors, consignees as well as personnel workings in depots who need to have knowledge about dangerous goods transport requirements. Education of personnel responsible for carrying out the actual training will be necessary. The basic parameters concerning the training system, i.e., organization, content and length of the training, certification and validity of certificates should be included in the legislation/regulations. Comprehensive regulations regarding training of personnel handling dangerous goods already exist in other parts of the world and the countries in this region would benefit from adopting those regulations or parts of the regulations suitable for the region.

Educating the governmental officials and other personnel within ministries and authorities responsible for the development of rules and regulations, enforcement, emergency planning and response and other activities in the field should be given priority. Competence in the public institutions with the responsibility for matters concerning transport of dangerous goods is a key to the safe transport of dangerous goods by road.

5.13.5 Information, risk analyses, contingency plans and emergency response

Some countries of the region have begun to consider issues related to the road transport of dangerous goods, such as establishment of information systems, risk analyses and contingency plans and emergency response actions. However, comprehensive work still remains to be done. The chemical and petroleum industries are actively involved, but they have focused on handling of chemicals in general and not transportation in particular and existing plans have been developed with industrial areas in mind. Functioning information systems and plans also exist in some countries in the region.

There is a need to establish or strengthen information systems to cover all relevant information on properties of dangerous goods, including classification, labelling and handling requirements. Relevant transport requirements, in the form of brief edited versions should be made available to transport providers, emergency services personnel and enforcement officers. Existing systems in use in other parts of the world could easily be adapted to the conditions prevailing in the ESCAP region. National centres where information about dangerous goods in general, emergency services, the industry, research findings, details of location of sophisticated equipment to be used when responding to severe accidents etc. should be developed. Such centres would be important tools in ensuring safer movement of dangerous goods.

The use of risk analyses as an instrument to minimize the risk for accidents and severe consequences should be encouraged. It is important to use well-developed models for risk analyses in order to achieve comparable values when calculating a specific situation using different assumptions. It is noticed, however, that this is not easy as regards the movement of dangerous goods where the environment and the surroundings change continuously.

Contingency plans, emergency planning and emergency response capabilities related to the road transport of dangerous goods are matters to be discussed and developed within the countries by responsible ministries or authorities together with the fire brigade, the industry and other relevant expertise. Opportunities could be explored for cooperation, on a regular basis, between experts within neighbouring countries as well as the subregion. Such cooperation could facilitate joint activities such as exercises in responding to accidents and provide the opportunity for common action plans, coordinate resources and eventually pooling of equipment for major disaster responses.

5.14 Regional Implementation Potential of Environmental Impact Assessment (EIA) System in Road Transport Projects

The EIA system has a great potential for implementation in road transport projects in the region. Therefore, the incorporation of the EIA process should be made mandatory for all road transport projects for immediate implementation in the ESCAP member countries where they are non-existent or scarcely followed. The EIA process should include a compulsory sectoral land use planning and design input as a technical part of the whole project.

For group 1 and 2 countries, where some form of EIA practices exist and scarcely followed, an improved guideline needs to developed and implemented. For group 3 and 4 countries where the EIA practices are virtually non-existent, a regulatory EIA guidelines need to be developed and implemented for road projects. When EIA is implemented, there should be a follow-up procedure by continuous monitoring.

In many of the developing countries of the ESCAP region, the application of EIA techniques is still at a rudimentary or evolutionary stage. The EIA methodologies developed and applied in other countries can, therefore, provide useful guidance. However, the immediate and wholesale adoption of the EIA standard of other countries, prior to thorough evaluation of their achievability and a quantification of their potential cost implications, would be considered premature yet.

5.14.1 Improvement of environmental assessments

In order to ensure the best integration of environmental factors into road transport project planning and decision making, the following recommendations are made.

a. Use of environmental impact assessment into an integrated design procedure be made mandatory for all road transport projects.

b. EIA process should include a compulsory sectoral landscape and cultural/natural heritage planning and design input as a technical part of the whole road transport project.

c. For an efficient EIA, it is important to adopt a methodology where the analysis of the existing environmental conditions is forward looking and is related to the environmental impacts generated due to new road transport project.

d. Agency coordination and public involvement are important issues. These should lead to the gathering of information and informing of agencies and the public well in time before critical decisions and approvals have to be made on project proposals. Countries reporting early and continued contact with outside agencies and the public consider that the benefits to be gained outweigh the extra effort that may be required. The process of gathering often critical information from agencies who have expertise or legislated responsibilities can be crucial to getting decisions made throughout the road transport development process.

e. Staff and managers of the road transport agencies should be appropriately trained so that they can deal with making difficult decisions and present a professional image to counterpart agencies and the public. Countries should strive to develop and improve road transport related educational opportunities whenever possible. Internal training efforts should be emphasised, but external training should not be overlooked. Opportunities such as cooperative training agreements with universities, environmental agencies, and private consulting firms should be considered.

f. Adverse impacts caused by the construction and operation phases of a road transport project should be fully covered in the EIA process.

g. Monitoring and follow-up should be considered as important components of EIA. These are necessary to ensure that the commitments made by road transport administration and by contractors are properly translated into specific provisions for action. These monitoring and follow-up activities must be defined by the EIA study and the benefits of monitoring and follow-up be recognised.

h. Communication and media professionals should teach their staff how to present environmental impact assessments. Technical staff need to be trained in quality report writing and model preparation so that the emphasis of the presentation is on the quality of the scheme and not on any bureaucratic process.

5.14.2 Research and development (R & D) activities

R & D activities are very important for different aspects of EIA. In this respect the following recommendations are made:

a. Road transport administrations should undertake case studies to examine the scope for developing the methods for identifying and assessing the strategic and regional effects of particular road transport projects or case studies. These case studies should consider the varying time scales of different environmental impacts.

b. Harmonisation of the principles of calculation and measurement methods, particularly for noise, vibration, air and water pollution impacts should be carried out by both regional and international experts, preferably within the structures of standardisation given by ISO. This harmonisation should include the calculation of the emissions of "greenhouse gases" such as CO_2 and the energy consumption needs of traffic and of road building and maintenance.

c. R & D on monetary and non-monetary valuation should be conducted. It will then be a question of national policy, how these different approaches are used in the decision making process. A prime concern is to clarify at every stage what assumptions the approach contains, in order to avoid confusing the public as well as the decision makers.

d. A system of landscape-ecological classification in each country, common to all project assessments, needs to be developed based on international interdisciplinary cooperation. A prerequisite for shared use of landscape-ecological information is that the information is sufficiently stable and not too adapted to specific users. The formation of traffic and geographical data bases will be a necessary precondition for successful strategic assessment. There is also a need to extend these efforts at the regional and international levels, which themselves will involve agreement on the way data is collected and presented.

e. Road transport administrations should realize the need for setting up a regular programme of monitoring of their assessment techniques to ensure that the assessment methodology remains valid over time or is updated as necessary. The effectiveness of different types of mitigation measures should also be monitored both in short-term and in longer-term. In the longer term, follow-up involves acquiring a better knowledge of the known impacts and identifying some unexpected effects in order to gradually improve forecasting methods. Particular importance should be attached to the environmental consequences of socioeconomic effects and of cumulative impact.

f. Information on the processes of community severance and fragmentation of landscape and nature is still lacking. Basic and applied R & D is also needed regarding the vulnerability of people and wildlife to the road transport infrastructure. Detailed knowledge of the fragmentation process is essential to balanced decision making. Current R & D into the appraisal of community severance should be extended.

g. Public perceptions of road traffic nuisance are not sufficiently understood. R & D activities could show that: (i) ratings of the nuisance of a noise at a fixed level depends significantly on the previous change in traffic level, (ii) lorries are a particular cause of traffic nuisance, and (iii) perceptions of traffic vary during the day and night. For these themes and other themes related to traffic nuisance, the conventional methods which analyse separately the different impacts of noise, air pollution, vibration and visual intrusion, do not provide a complete understanding and further R & D is necessary to investigate the perception of roads and traffic within a variety of countries..

h. Road transport agencies are required to include and effectively use a range of measures - in addition to the traditional infrastructure and traffic management techniques - with the aim of achieving the environmental goals of the road transport sector and to cooperate in contributing to sustainable development.

5.14.3 Strategic environmental impact assessment (SEIA)

In order to identify efficient measures and consider environmental impacts in strategic planning when considering cumulative effects, it is necessary to apply a systems approach and an intermodal approach. This demands Environmental Assessment (EIA) of road transport planning at a strategic level . The most important aspects assessed must be related to those impacts that are relevant to general policies and the goals formulated in order to facilitate the achievement of sustainable development, i.e. those policies and goals that are concerned with total road traffic emissions, greenhouse effects and national land use policies (OECD 1994c).

a. When strategic environmental impact assessment (SEIA) used, it should be seen as a step towards harmonising the planning procedures adopted by various services responsible. It should help in the coordination and the avoidance of duplication between sector planning and impact assessment. Appropriate methods for public involvement should also be considered and developed for this planning level.

b. An integrated process of road transport planning and environmental impact assessment should be applied in order to deal with the major issues at the appropriate level of planning and to determine whether, for a specific road transport project in a given environment, a full scale EIA, or a simplified EIA is needed. If plans and programmes proceeding the road project have been subject to a strategic environmental assessment, that assessment will in itself define the criteria and thresholds of EIA application at the road transport project level.

5.14.4 Environmental impact assessment at project level

At the project level in the preliminary stage, environmental impact assessment must be viewed as an integral part of a wider road project planning process, beginning with the early identification of project alternatives and the potentially significant environmental impacts associated with them, and continuing through the project development to include an external review of the assessment document and the involvement of the public. The following are the recommendations for environmental impact assessment at different levels:

a. At the project level in the design stage, the assessment should show that alternative corridors for a proposed road transport project were identified based on environmental studies as well as on other prerequisites. At this stage, EIA must also include the prediction of impacts and their comparison. Scoping of the project should try to identify all impacts that could be significant.

b. At the final design stage, the EIA results are incorporated into a report of the complete project design study which should describe the impacts of the proposed measures and the mitigating measures. At this stage, the impacts which could be mitigated need the greatest emphasis, for example, noise, vibrations, local air pollution, visual effects, and severance.

c. At the national level, countries of the region should introduce appropriate EIA techniques as pre-requisites for future, road transport development environment audits for operational projects; and adopt measures to remove the inadequacies in road transport infrastructure and improve its maintenance.

d. At the regional level, institutions and regional/international agencies should undertake surveys of the state of preparedness for and/or adoption of EIA techniques and audits and prepare brochures, handbooks and update guidelines which could include case-studies and examples of standards being applied in the region to assist the countries in improving their professional capabilities.

5.15 Regional Implementation Potential of Effective Financing Mechanisms

A common problem faced by many Group 3 and 4 countries, as well as some Group 2 countries, has been the lack of financial resources to fund the required transport infrastructural development. This includes projects to carry out the desired upgrading or improvement of transport facilities, and to implement environmentally friendly measures and policies. This section describes a number of financing mechanisms with implementation potential in the region.

5.15.1 Private financing and public/private partnership (PPP)

A number of strategies can be adopted to encourage private financing and public/private partnership in the ESCAP region. An active strategy is the establishment of state transportation development corporations. Being independent agencies, these corporations can serve to identify, encourage and assist environmentally sound transportation projects to be undertaken with private financing. They can function as a bridge between the public and private sectors (Beimborn et al. 1986). however, it must be cautioned that a properly defined charter must be made to ensure they do not develop into a competitor to private development. The government may take on an active role to identify potential projects, market them and seek financing. It could also actively source for proposals from the private sector and prioritize the proposals for implementation.

5.15.2 Toll roads and private financing

Toll roads and expressways have been used in many Asia-Pacific cities as differentially priced alternatives for the motorist to avoid congested city streets or local rural roads. A number of Asia-Pacific countries have sought to encourage investment from the private sector or foreign investors to improve their country's road infrastructure. A World Bank study concluded that private financing is needed to ease the burden on government finances, and more importantly it will encourage better risk sharing, accountability, monitoring, and management in infrastructure provision (WB 1994a and 1994b). A recent survey by the International Bridge Tunnel and Turnpike Association, as presented in Fig. 5.4, indicated that more than US$122 billion worth of toll facilities are planned world-wide, including US$27 billion in Asia (Yates 1995).

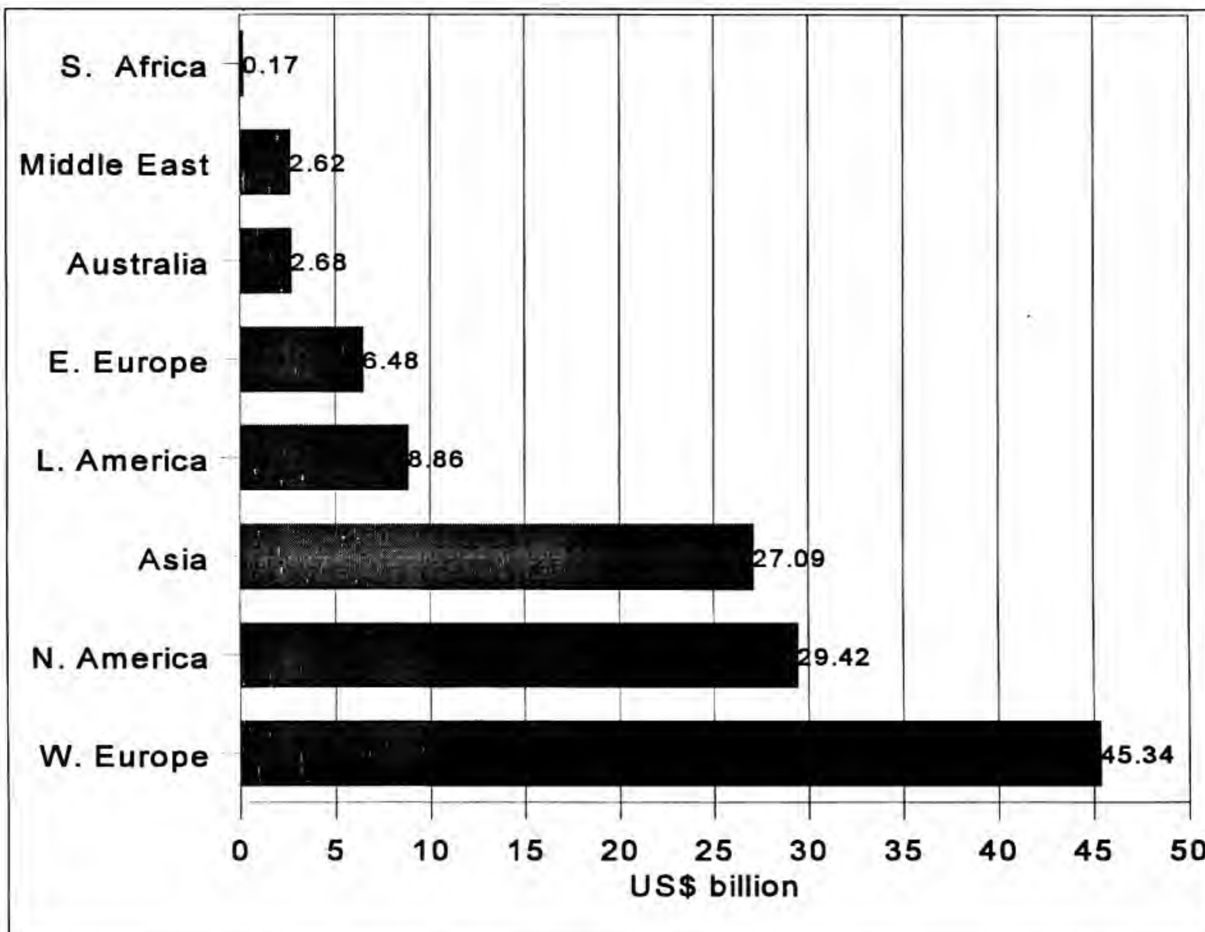


Fig. 5.4: Proposed word-wide toll facility projects, as of March 1994

Source: C.M. Yates (1995). Toll road in Argentina. *New World Transport '95*, pp. 83-87.

The approach of BOT (build, operate and transfer) has been adopted in many Group 2 and 3 countries, but with mixed results. Table 5.5 shows some of the BOT projects in the region. In Thailand, although the government has expected US$65 billion funding from the private sector for transport infrastructure development for the period 1992-1996, only one project has been operational and even this project is constantly troubled by controversies and dispute due to the following reasons (Allport 1995): (a) government has not provided leadership and commitment; (b) government has required projects to be financially viable, but providing only limited concessions in tax breaks and land provision; and (c) government has been unwilling to share the risk. In the Philippines, the political and economic performance has not been attractive to the private sector although the government encourages it. There was an attempt to construct a new LRT as a BOT project but failed because the government was not prepared to fund the public sector investment required.

Table 5.5 BOT transport infrastructure projects in Asia

	Urban highways	Urban rail	Inter urban highways	Total
Operational	6	1	3	9
Construction	5	2	4	10
Pre-construction	6	6	3	15
Planning	Many	Several	Many	Very many

Source: R.J. Allport (1990). *Transport and Development in Asia.* World Bank, Washington DC.

Malaysia has been highly successful in implementing BOT projects. The concept of privatisation became a Malaysian national policy in 1983. To expedite the achievement of privatisation, a Privatisation Master Plan was formulated in 1991 to provide guidelines in the implementation of the privatisation programme. Todate, a total of 85 projects have been successfully privatised out of which 12 were road construction projects (Muhammad 1995). One fine example is the North-South Highway which is one of the major highway projects worldwide. Other projects include the Penang Bridge which is operational, the second Malaysia-Singapore link, expressways around Kuala Lumpur, and two LRT projects in Kuala Lumpur. The main ingredients of Malaysia's success are (Allport 1990, 1995):

- A strong, stable government with commitment and sense of purpose;
- Preparedness to share risk and give guarantees;
- Preparedness to be flexible to create financial viability;
- Strong economic performance;
- Development of local capital markets; and
- Development of a strong, entrepreneurial private sector.

Another successful example is the Bangkok Expressway Company Ltd which owns 27 km expressway and holds a 30 year concession for another 40 km expressway since 1990. In 1995, with a toll charge of 30 Baht (about US$1.20 in 1995) per passenger car, it collected a revenue of 134 million US dollars giving a net surplus of 20 million US dollars.

5.15.3 Public/private cooperation and joint ventures

Joint financing of transport infrastructure projects is not new in the Asia-Pacific region. For instance, in Malaysia and Singapore access roads to and local roads within residential housing estates by private developers are constructed by the developers under government development control, and handed over to the road authority upon completion for subsequent maintenance.

It is common practice in many countries such as Japan and Singapore where vehicle inspection is carried out by private organisations to standards and specifications established by the relevant authority. In this way, it is not necessary for the government to invest in equipment, testing stations and staff.

It is important that the government must be proactive in identifying possible projects for joint venture development. To achieve a higher quality transportation system, a better environment and to enhance public investment, a land use plan may be developed to encourage private development. This should be done to assure that there is adequate control of safety, traffic flow, function and aesthetic. Furthermore, the state could accept or recognize contributions from the private sector in the form of land, services or monetary contributions. The state can exert control over private projects and can move a project ahead on the priority list if the developer is ready to make positive contribution favourable to environmental protection and sustainable development. It is interesting to note joint ventures between private companies from Group 1 countries and the public sector of Group 2, 3 and 4 countries are becoming more and more common in the region. Successful examples are found in the automobile manufacturing industry, such as the joint venture between Malaysian government and a Japanese manufacturer, and a similar cooperation in Indonesia with a Korean car manufacturer. In China, Singapore companies have started joint venture companies with the Chinese authorities to operate taxi services in number of cities. These joint ventures help to overcome the financing problem in Group 2, 3 and 4 countries, and facilitate the adoption of better management skills and more environment-friendly technology.

5.15.4 Innovative approaches to user charges

Private financing projects such as privately operated toll roads are viable only for high traffic volume corridors which account for 5 to 10 percent of main roads and about 2 percent of all roads (Heggie 1996). To maintain a sustainable and stable flow of fund, innovative user-based charges are necessary. The need for innovative financial techniques is not always self-evident. An important element in implementation of user-based charges is to create an awareness among policy makers and road users. Besides the forms of user charges mentioned in Section 4.16.3, there exist a wide range of possible strategies that Group 2, 3 and 4 countries can innovate to suit the local condition. In India, for instance, special funds for road expenditures have been created by levy on agricultural produce in certain states (Rahmatullah 1996).

To most major cities in Group 2, 3 and 4 countries which are suffering from traffic gridlock, some form of congestion pricing could offer the much needed relief. When properly implemented to support other demand management programmes, urban congestion levels are expected to reduce, thereby relieving other traffic associated environmental problems such as air pollution, noise and energy consumption. As congestion pricing pricing programmes are expected to generate substantial revenues, incentives can be awarded to users to encourage the use of environmentally friendly public transit. Singapore recently extended road pricing control to three of its expressway during the morning peak hours. As part of its publicity drive and to educate the general public of the net societal benefit of such a scheme, an one-off rebate of S$50 from the annual road tax was offered.

In a 1994 study of the feasibility of congestion pricing, the Transportation Research Board of USA concluded that it would result in a net benefit to the society (TRB 1994). While some motorists would lose out, all income groups as a whole would benefit from less environmental pollution and an appropriate distribution of revenues. The study warned that the institutional issues are complex, though not unresolvable. Van Hattum and Zimmerman (1996) recommended the following guidelines in introducing a congestion pricing programme:

(a) Determine the goals
(b) Contrast and compare congestion relief strategies
(c) Focus on revenue uses and equity impacts
(d) Make outreach to key opinion groups a priority
(e) Develop a reliable technology plan
(f) Use an incremental approach
(g) Carefully design a marketing and media strategy.

5.16 Regional Implementation Potential of Environmental Awareness Programmes

5.16.1 Environmental awareness of policy-makers

The entire transportation planning in developing countries inevitably involves opinion and input from politicians, ministry administrators, town/estate planners, and engineers. With few exceptions, politicians and ministry administrators are not familiar with the technical matters related to transport, and they do not have adequate awareness in the adverse environmental impacts of road transport policies. To make the matter worse, the educational programmes in tertiary institutes are not putting enough emphasis on the need for environmental protection in the training of transportation professionals. As a result, the level of environmental awareness among the transportation professionals in the regional as a whole has to be raised. It appears that while effort is made to educate the politicians, administrators and the general public on the need for environmental awareness, the transportation professionals themselves must first be educated and convinced that it is part of their responsibility to promote environmentally friendly schemes and measures.

5.16.2 Public awareness

As far as public opinion is concerned in most Asia-Pacific countries, road building and other road capacity enhancement measures are seen as the most positive strategy to reduce traffic congestion problem. For example, in a survey conducted by the Automobile Association of Hong Kong China in 1995 (Straits Times Singapore, 11 February 1995), 90% of the respondents considered road building to be the single most important way of resolving traffic ills. This is a typical example of the perception of the general public on transportation matters. Even in Group 1 countries in the region, with possible exception in Australia, Japan and New Zealand the authorities would find it difficult to justify a transport policy on environmental ground alone.

The most effective approach of raising public awareness in the region is probably a long term strategy of raising the general educational level in the region and promote environmental protection through school and university curricula. The current curricula in schools and tertiary institutions do not prepare students well in terms of environmental awareness with respect to transportation issues. Education in schools tends to be more intensive and effective compared to other methods in conveying the concept of environmental protection. It has great potential in stimulating positive attitudes towards environment protection. Information programmes such as publicity campaigns and theme exhibitions are useful in highlighting new policies and strategies in environmental protection. Since such programmes must compete with other types of information, it must be able to attract attention easily in order to create impacts.

5.16.3 Regional cooperation programmes

While individual countries in the region is encouraged to embark on its own public campaign and educational programmes to increase public awareness of environmental issues in road transport, there is much to do in the region to increase the awareness of senior government officers involved in road transport planning and decision making. Organisations like OECD have been actively involved in promoting such activities through regular fora, workshops, seminars and conferences in industrialised countries. In comparison, there is a general of such regular activities in the Asia-Pacific region. Regional organisations such as ESCAP could take the lead in initiating a series of seminars or a regular regional conference (say once every two or three years) with special focus on Road Transport and Environmental Protection.

5.16.4 Participation of citizens and non-governmental organisations

On the whole, the level of participation of citizens and non-governmental organisations is very low in the Asia Pacific countries. Except for a few Group 1 countries, such participation is practically non-existence in the region. This is probably due to the comparatively low level of environment awareness in the policy makers and the general public alike. The situation is generally worse in the poorest countries in Group 3 and 4. Efforts in poverty eradication and improving of education level are required before one could expect active participation of citizens and non-government organisations in the region, Group 3 and 4 countries in particular.

Figure 5.5 illustrates an example of how NGOs could contribute in guarding against environmental destruction by road construction. The Nature Society (Singapore) constantly provides its comments and feedback to the Road Planning Authority, Urban Redevelopment Authority (URA), and the Ministry of Environment. In the case shown in Figure 5.5, a proposed road route has encroached into a Nature Reserve Area designated in the Singapore Green Plan by the Ministry of Environment. It was pointed out by the Nature Society that the proposed route would destroy the area which was an important site for mangroves and migrating wading birds and resident waterfowl.

The idea of citizen participation in vehicle emission control has been carried out in some developed countries (Straits Times Singapore, 10 April 1996). Under this scheme, citizens would report sightings of smoky vehicles and the vehicles would be hauled in for checks and action taken if they were found to be in violation of emission rules.

A network known as Sustainable Transport Action Network for Asia and the Pacific (SUSTRAN 1995), consisting of interested NGO representatives, academics, government officials, transport and urban planners has been formed in 1995 with its secretariat based in Kuala Lumpur. It aims to provide (a) information about sustainable transport plans and policies from throughout the Asia Pacific region to local interested groups, (b) a "Current-Awareness" service through the international distribution of a quarterly newsletter, (c) a "Citizen Action Guide" on steps to take for local groups to influence local, regional and national transport policy, (d) a series of "Fact Sheets" on principles and practices of sustainable transportation, (e) an "Expertise Service of NGO Experts" in the field of sustainable transportation world-wide, and (f) direct advocacy, lobbying and monitoring of bilateral donor organisations and multi-lateral funding organisations involved in transport sector activity in the region. While not all input and feedback from the NGOs are incorporated into the policies formulated by the relevant authorities, it is important that such effort should be continued to highlight the need for environmental consideration in transportation planning and decision making, and to increase environmental awareness of government officials and the general public.

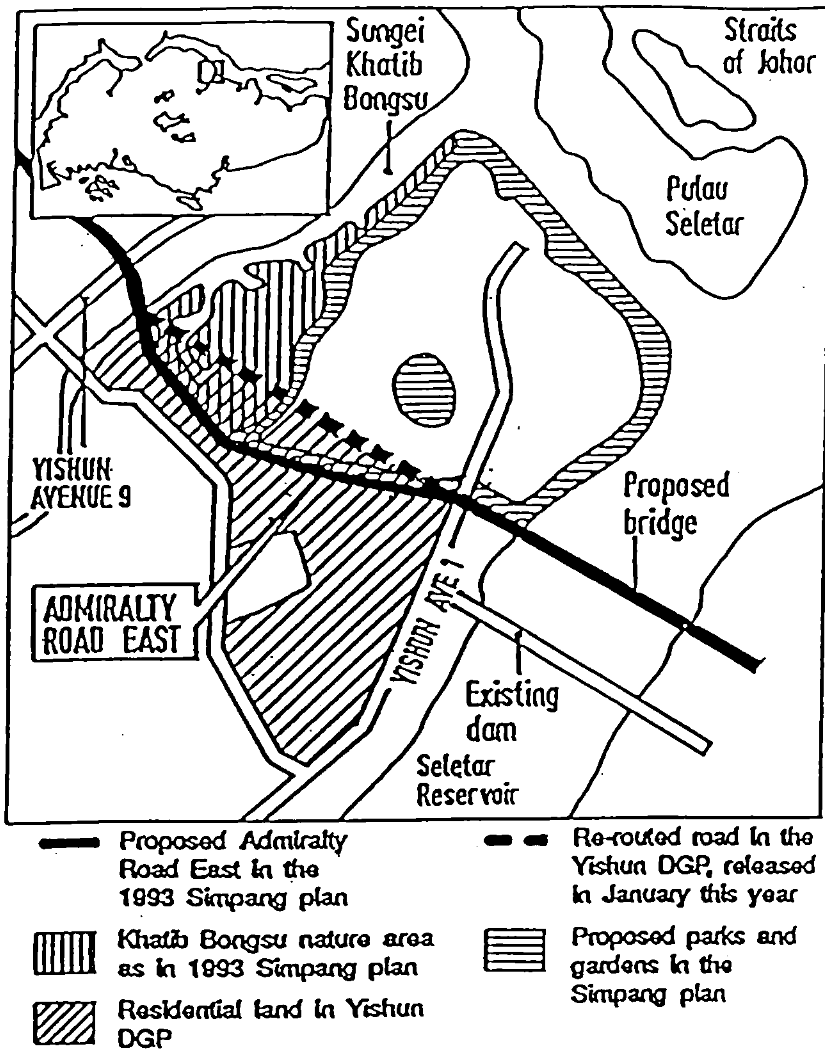


Fig. 5.5: Encroachment of road route

Source: Straits Times Singapore, 19 March 1996.

5.17 Enhancing Institutional Roles

In the discussions in all the preceding sections presented in this chapter, the need for institution commitment and proactive institutional roles has been repeatedly highlighted. Unfortunately, as compared with technical and operational management issues, this appears to be the most difficulty to achieve as it requires considerable re-organisation of the governmental structure.

A regional assessment of the institutional situation in the transport sector cannot be made easily because the structure of road administration in the ESCAP region does not lend itself to any generalization. In general, there has been relatively little involvement of the private sector and the road users in infrastructure financing, management of road network and traffic operations. There is a need to change the traditional institutional role of providing and managing transportation infrastructure and services. Changes in this direction call for some amendments in the existing legislation, administrative and organisation structure as well as redefining government's role in the economy. Such changes are not possible without a strong political commitment.

Experience in Bangladesh has shown that timely and effective transport infrastructure intervention can have profound positive socio-economic effect on rural population, and that sound institutional framework is a prerequisite for administering such interventions. Ahmed et al (1997) reported that prior to 1984, Bangladesh suffered from the following situations commonly found in Group 2 and 3 countries: (i) absence of cohesive rural transport infrastructure development strategy; (ii) incoherent rural transport infrastructure development; (iii) lack of clear focal point for coordination at the central government level; (iv) too much decision making at the central government level; (v) unsustainable arrangement for long-term management and maintenance of road network; and (vi) no systematic approach for the development of transport services in rural areas. Several institutional reforms have since taken place and the following lessons learned were reported: (i) a single purpose rural road agency is more effective than a road agency with multiple purpose; (ii) a strong local government is prerequisite for effective rural transport infrastructure management; (iii) NGOs can play a vital role where the public sector has limitations in administering interventions; and (iv) institutional constraints should be removed to enhance community participation in rural infrastructure development.

The Bangladesh example has highlighted the fact that weak institutional arrangement has been a major factor responsible for the inefficient management of transportation infrastructure and services in most Group 2, 3 and 4 countries. It leads to high unit cost, poor quality work and lack of innovation. Incentives for staff to produce good service are generally absent, so are transparency and accountability of transport planning and management procedure. The situation is further aggravated by low salaries in the public sector of these countries. As a result, the traditional practice of financing transportation infrastructural development and management from general budget has been inadequate and erratic. One way to correct this weakness is to separate planning and management from policy and regulation, and transfer them to an autonomous agency operating on commercial lines with sound management procedure and accountability. The emphasis is to improve responsiveness and to provide quality service to road users' satisfaction.

5.18 Summary

This chapter has identified areas of recommended priority actions and road transport-related environmental protection measures that are considered to have good potential of bringing about positive and significant impacts on the physical, social and human environment in the ESCAP region. For each of the measures identified, critical issues in the context of the ESCAP region, Group 2, 3 and 4 countries specifically, are highlighted together with methods or relevant regional experience to tackle these issues.

It should be emphasized that to effectively reduce the overall adverse environmental impacts created by road transport, it is necessary to embark on a total approach addressing the problem in the various aspects, applying the different measures described in this chapter in a coordinated manner.

6 SUMMARY AND CONCLUSIONS

6.1 Current Situation of Road Transport and Environmental Protection in ESCAP Member Countries

The ESCAP region as a whole has been leading the world in economic growth for more than a decade. The region-wide economic upsurge has brought about significant changes in practically every country in the region. This has led to very rapid rates of urbanization and motorization in some countries, and there are intensive infrastructural development activities across the region to meet the needs of industrialisation and economic growth. However, the road transport development activities have created a host of serious adverse environmental impacts and consequences in the region.

Most of the adverse environmental impacts are found in the urban areas of high population concentration. These are the areas that deserve special attention because of their significant shares of economic contributions to the countries, and the large number of people affected by the adverse impacts. Any remedial measure that proves to be effective would generate considerable economic benefits, and improve the living environment of a large proportion of the urban population. On the other hand, the road transport needs and environmental protection in the rural areas must not be neglected. Properly planned road network development and its efficient management provides the needed mobility for activities in rural areas to eradicate poverty and promote rational use of natural resources.

The road transport and environmental protection needs by different countries in the region have been studied by grouping the countries into four groups. Countries with per capita income higher than US$5,000 are classified into Group 1, those between US$750 and US$5,000 as Group 2, those between US$200 and US$750 as Group 3, and those below US$200 as Group 4. Group 1 countries are way ahead of the other countries in both road transport infrastructure development and environmental protection. Most Group 2 and 3 countries suffer from past under-investment in road transport development and negligence in environmental protection. The major cities in these countries are most affected by inadequate road transport infrastructure facilities, lack of financial resources and consequent adverse environmental impacts. Many of the cities have been plagued with these problems for many years with no immediate solutions in sight in the near future. The road transport and environmental situation in most major cities of some Group 4 countries is not much better either. In these countries, there are the added problems of poverty and severe lack of mass transport facilities. The poorly developed rural road network presents another major issue in the large hinterland of most Group 3 and 4 countries.

6.2 Environmental Issues and Remedial Measures in Road Transport

This study has identified the major weaknesses of road transport and areas of environmental concern in the four groups of countries in the ESCAP region. Road transport generated environmental problems were discussed taking with account whether they are vehicle related, road related, user related or policy related.

The main adverse environmental impacts of road transport which are causing concern in the region are: (a) urban traffic congestion and pollution caused by vehicle emissions, (b) poor management of road network resulting in wastage of investments and natural resources, (c) inefficient use of transport energy, (d) inefficient management of transport operations causing inconvenience and suffering of commuters and the general public, (e) poorly planned road infrastructure development causing damage to natural environment, and (f) lack of funds to finance the need of road transport operations and infrastructure development.

The following corrective and preventive measures that have been used or experimented in different parts of the world for priority actions were described in the report:

(A) Measures to combat problems associated with urban traffic congestion

- Traffic management systems
- Traffic demand management
- Promoting use of public transport system
- Integrated multimodal passenger transport system
- Comprehensive transportation and socio-economic planning

(B) Measures to combat traffic-generated pollution problems

- Adoption of zero emission vehicles
- Use of environmentally friendly fuels
- Regular and effective vehicle inspection and maintenance programme
- Noise abatement measures
- Air pollution abatement measures

(C) Measures to relieve inconvenience and suffering of human beings

- Measures to enhance road safety
- Safe transportation of hazardous goods
- Participation of citizens and non-governmental organisations
- Incorporation of EIA in transportation planning and project evaluation

(D) Measures to reduce wasteful use of natural and human resources

- Raising environmental awareness of policy makers, road users and the general public
- Efficient road construction and maintenance
- Effective financing mechanisms and participation of private sector
- Strengthening of institutional roles

However, once the environmental issues and remedial measures in road transport have been identified, it is important to select those of particular concerns to the ESCAP developing countries.

6.3 Implementation Potential of Environmental Protection Measures in ESCAP Region

In this process, the following **major issues**, most adequately reflecting the conditions in the ESCAP developing countries (Group 4 in particular) were identified to be addressed:(a) rapid motorisation and urbanisation leading to severe traffic congestion and traffic-generated environmental pollution in urban areas; (b) absence of a comprehensive and integrated approach in many developing countries to promote a balanced land use and transportation development; (c) shortage of funds in many ESCAP member developing countries to finance road transport infrastructure development and operations; (d) weak institutional role and lack of government commitment in the planning and implementation of environmentally sound road transport policies; and (e) generally low level of environmental awareness of road users as well as decision makers in the road transport industry of the region.

To address these major issues is the task for regional policy-makers/experts fora to debate and provide respective guidance as well as to invite the governments' commitment as a foundation to the whole process of the alleviation of negative impact of road transport on the environment.

6.4 Concluding Remarks

While road transport related environmental situations in ESCAP member countries in general defer from country to country there are a number of common issues and general remedial approaches which can be identified. Basically common problem areas could be grouped into two area-type categories namely: urban and rural.

Traffic congestion and other environmental problems caused by urbanization and motorization have to be tackled by proper road transport demand management, integrated land use and transport planning, and effective use of public transport and multimodal passenger transport systems.

In the rural areas, the lack of mobility due to poor road infrastructure and inefficient management of existing road network requires re-organization of the road authority structure, innovative financing, and a management system with well-defined responsibility and accountability. Similarly in the financing of road infrastructure development both in the urban and rural areas, new improved financing schemes have to be explored, including the participation of private sector.

It is important to stress however that in both cases for most of the remedial schemes and measures to work, a strong government commitment and proactive institutional roles are the pre-requisite. In view of the weak government intervention mechanisms in place in the region as a whole, special effort must be made to improve this situation. In addition, this problem is aggravated by low overall level of environmental awareness in the ESCAP region, inclusive of road transport policy makers, road users and the general public.

The importance of increasing general environmental awareness cannot be over-emphasized and should, therefore, be particularly stressed. A high level of environmental awareness is really needed to serve as a driving force to push for a strong government related commitments and active institutional roles. A possible effective way to correct these weaknesses is apparently by means of special regional and subregional programmes.

Regional cooperation in the field of the protection of the environment from adverse impact of road transport is not yet as strong in the region as in the case of the road infrastructure development where a number of activities have been undertaken and completed under the ESCAP Asian Land Transport Infrastructure Development (ALTID) project.

The development and strengthening of the cooperation, including Technical Cooperation among Developing Countries (TCDC) in the field of the environmental protection in road section would expectedly assist developing countries of the region in improving environmental situation related to road transport.

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