Urban Transport and the Environment
An International Perspective

Urban Transport and the Environment
An International Perspective

World Conference on Transport Research Society
And
Institute for Transport Policy Studies

United Kingdom – North America – Japan
India – Malaysia – China

Emerald Group Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2004

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-0-08-047029-0

Awarded in recognition of Emerald's production department's adherence to quality systems and processes when preparing scholarly journals for print

INVESTOR IN PEOPLE

FOREWORD

At the present time, emissions of greenhouse gases from transport are continuing to rise in almost all countries, at a rate much higher than those from industrial or domestic use. If this trend continues, transport will certainly be the largest sector influencing the global atmospheric environment in the 21st century.

Even now in many of the developed countries, car ownership and use are continuing to rise. On the other hand, although engine technology has recently been much improved, the usage level of low emission cars is still much lower than that needed to clear up environmental problems. For this reason, the reduction of local atmospheric pollution caused by transport in urban areas has also not been as successful as it should have been.

In developing countries, along with the increase in income, there is a rapid shift from walking and cycling to motorised transport. Since many of the motorized vehicles are aged or poorly maintained, deterioration of the environment especially in urban areas has been getting worse. Especially in rapidly growing countries, where motorisation is occurring at a very swift pace while the automobile maintenance system is not developing at the corresponding rate, local environmental pollution is very serious. Moreover, the potential impact of this local traffic on the global environment as a whole is becoming critical.

Although various countermeasures have been taken both in developed and developing countries, their effects have tended to be limited because of lack of systematic implementation. It is also a sad fact that the valuable experiences of one country are not sufficiently reflected in the policy measures taken by other countries. In order to adequately address the environmental problems arising from transport, it is imperative to gather the policy experiences from each country into a knowledge-base which can be shared by all.

This book focuses particularly on urban transport, since this is a serious local issue with a significant influence on the global environment. It attempts firstly to understand the current conditions of urban transport and the environment. Then it tries to give a picture of what sort of measures can be taken to improve the situation and what their effects on the environment would be. For this purpose, the relationships of the various objectives, measures and effects are first presented systematically. Since these objectives, measures and effects may differ from country to country and from city to city, experiences in different cities in the world, collected through international cooperative research, are presented. By compiling them into a future perspective for transport and the environment, the book aims to identify future issues and suggest policy directions to contribute to more integrated measures for cities around the world in order to improve the local and global environment.

For understanding the environmental problems of urban transport and finding suitable countermeasures, it is important to have adequate knowledge not only of transport planning and engineering but also of the mechanisms of environmental impacts and of the effectiveness of measures. This book is designed for researchers, practitioners and students who work in either the transport or the environment field and are interested in an integrated understanding

of both. In addition, we hope that for those attempting to take a cross-speciality approach to the development of policy measures, it will serve as a reference to promote further international collaborative research and cooperative work.

A Special Interest Group on Transport and the Environment was established at the 9th Seoul Conference of the World Conference on Transport Research Society (WCTRS) held in July 2001, together with another related Special Interest Group on Transport Policy Instruments. A major trigger for this initiative was the growing seriousness of the urban transport impact on the environment and an awareness of the importance of international collaboration for dealing with it.

The WCTRS is an international forum bringing together researchers and practitioners in transport, which has extended beyond established disciplines such as engineering and economics, and modes of transport like railways, roads, shipping and aviation, to include experts in a variety of fields including logistics, land use, and financing. Concerning the problems of transport and the environment in cities, it was considered essential to carry out research by bringing together experts from representative cities around the world. It was decided that researchers with a deep interest in the environment would be selected from among the members of WCTRS, and an international research programme under the title of "Comparative Study on Urban Transport and the Environment (CUTE)" would be undertaken. It was only the wealth of human resources within the WCTRS, and the long-standing relations of trust among individual members, that made it possible for the authors to realise this challenging systematic work "Urban Transport and the Environment".

The research was started on the initiative of Hideo Nakamura of the ITPS (Institute for Transport Policy Studies, Tokyo) as a joint research project with the WCTRS. The overall progress of the research and the details of its structure were ensured by Hideo Nakamura, Yoshitsugu Hayashi, Anthony D. May and Kazuaki Miyamoto, and the research was conducted through the cooperation of Werner Rothengatter, Genevieve Giuliano, Daniel Sperling, Alain Bonnafous, Dominique Mignot and Wolfgang Schade, requiring six major meetings and innumerable e-mail communications. Some of these members also served as lead authors for individual chapters.

In addition to the lead authors, chapter sections were contributed by the researchers listed below. As it was our purpose not only to understand the general mechanisms of the transport environment problems but also to share experiences of various practices that have been adopted in different cities of the world, we requested other researchers who had expert knowledge of practice in these cities to join our project as writers.

The secretariat for this research, provided by the ITPS, bore the responsible for maintaining steady progress in the research and writing. We gratefully acknowledge the support of the Japanese Ministry of Land, Infrastructure and Transport and of the Nippon Foundation. In addition, we especially thank former Vice Minister Jiro Hanyu in person, for his invaluable advice from the first proposal of the CUTE project up to final publication.

March 2004

Representing the editors,

Hideo Nakamura, Director, Institute for Transport Policy Studies, Tokyo
Professor, Musashi Institute of Technology
Former President, World Conference on Transport Research Society (WCTRS)

Yoshitsugu Hayashi, Professor, Graduate School of Environmental Studies, Nagoya University
Chair, Special Interest Group on Transport and the Environment, WCTRS

Anthony D. May, Professor and Director, Institute for Transport Studies, University of Leeds
Chair, Special Interest Group on Transport Policy Instruments, WCTRS

COMPARATIVE STUDY ON URBAN TRANSPORT AND THE ENVIRONMENT (CUTE)

2001-2004

Members of CUTE Project

Yoshitsugu HAYASHI *(Nagoya University) [Project Chair]*
Alain BONNAFOUS *(L'université Lumière Lyon)*
Genevieve GIULIANO *(University of Southern California, Los Angeles)*
Shinya HANAOKA *(Asian Institute of Technology, Bangkok)*
Hirokazu KATO *(Nagoya University)*
Anthony D. MAY *(University of Leeds)*
Dominique MIGNOT *(L'université Lumière Lyon)*
Kazuaki MIYAMOTO *(Tohoku University, Sendai)*
Hideo NAKAMURA *(Institute for Transport Policy Studies, Tokyo)*
Werner ROTHENGATTER *(University of Karlsruhe)*
Wolfgang SCHADE *(University of Karlsruhe)*
Daniel SPERLING *(University of California, Davis)*
Masaharu YAGISHITA *(Nagoya University)*

Secretariat

Mikiharu ARIMURA *(Institute for Transport Policy Studies, Tokyo)*
Yuichiro KANEKO *(Institute for Transport Policy Studies, Tokyo)*
Masanobu KII *(Institute for Transport Policy Studies, Tokyo)*
Akira OKADA *(Institute for Transport Policy Studies, Tokyo)*

LIST OF AUTHORS

Lead Authors

Hideo NAKAMURA *(Chapter 1)*
Genevieve GIULIANO *(Chapter 2)*
Daniel SPERLING *(Chapter 3)*
Anthony D. MAY *(Chapter 4)*
Kazuaki MIYAMOTO *(Chapter 5)*
Werner ROTHENGATTER *(Chapter 6)*

Authors

Surya Raj ACHARYA *(Institute for Transport Policy Studies, Tokyo) [5.19, Box 7]*
Mohammed Abdul AZIZ *(National University of Singapore) [5.22]*
Mikiharu ARIMURA *(Institute for Transport Policy Studies, Tokyo) [1, Box 9]*
Jean-Michel CUSSET *(Laboratoire d'Économie des Transports, Lyon) [5.10, 5.18]*
Tien Fang FWA *(National University of Singapore) [5.22]*
Haluk GERÇEK *(Technical University of Istanbul) [5.4, Box 3]*
Genevieve GIULIANO *(University of Southern California, Los Angeles) [2.1, 2.2.3, 2.3.1–2.3.2, 2.4, 2.6]*
Shinya HANAOKA *(Asian Institute of Technology, Bangkok) [3.1–3.3, 3.5.1, Box 8]*
Yoshitsugu HAYASHI *(Nagoya University) [Introduction, 6.1, 6.2, 6.5]*
Burkhard E. HORN *(International University, Niigata) [2.3.3]*
Balazs HORVATTH *(TRANSMAN Ltd., Budapest) [5.3]*
Ali S. HUZAYYIN *(Cairo University) [5.8, Box 19]*
Bruce JAMES *(City of Nottingham) [5.6]*
Hirokazu KATO *(Nagoya University) [2.4.1, 4.9, 5.14, 6.2, 6.5, Box 2, Box 21]*
Masanobu KII *(Institute for Transport Policy Studies, Tokyo) [2.3.3, Box 6]*
Yoshikuni KOBAYASHI *(Institute for Transport Policy Studies, Tokyo) [1, 2.2.1, 3.4]*
Hanh Dam LE *(University of Southern California, Los Angeles) [5.9]*
Sungwon LEE *(Korea Transport Institute, Seoul) [5.21]*
Francisco J. MARTINEZ *(University of Chile, Santiago) [5.13]*
Anthony D. MAY *(University of Leeds) [4.1–4.4, 4.6–4.8, Box 12–18]*
Dominique MIGNOT *(L'université Lumière Lyon) [2.2.2, 2.3.3, 5.5]*
Kazuaki MIYAMOTO *(Tohoku University, Sendai) [2.4.1, 4.3.3, 5.1]*
Janos MONIGL *(TRANSMAN Ltd., Budapest) [5.3]*
Antonio N. MUSSO *(University of Rome "La Sapienza") [5.7, Box 10]*
Fumihiko NAKAMURA *(Yokohama National University) [5.11]*
Hideo NAKAMURA *(Institute for Transport Policy Studies, Tokyo) [Introduction, 1, 3.4]*
Jean-Pierre NICOLAS *(L'université Lumière Lyon) [5.5]*
Akira OKADA *(Institute for Transport Policy Studies, Tokyo) [2.3.2, 3.1, 3.2.2, 3.5.1]*
Makoto OKAZAKI *(Tottori University of Environmental Studies) [3.2.1, 3.3.2, 4.5]*

Omar OSMAN *(Cairo University) [5.8, Box 19]*
Antonio PÁEZ *(McMaster University, Hamilton) [5.12, Box 19]*
Rodrigo QUIJADA *(Ciudad Viva, Santiago) [5.13]*
Werner ROTHENGATTER *(University of Karlsruhe) [6.3, 6.5.1]*
Wolfgang SCHADE *(University of Karlsruhe) [3.6, 5.2, Box 1, Box 11, Box 20]*
Daniel SPERLING *(University of California, Davis) [2.5, 3.2.1, 3.5.2–3.5.4, 4.5, 6.4, Box 5, Box 23]*
Yordphol TANABORIBOON *(Asian Institute of Technology, Bangkok) [5.16, Box 4]*
Michael A.P. TAYLOR *(University of South Australia, Adelaide) [5.15]*
Varameth VICHIENSAN *(Tohoku University, Sendai) [4.3.3]*
Karl N. VERGEL *(University of the Philippines, Manila) [5.20, Box 22]*
Masaharu YAGISHITA *(Nagoya University) [3.2, 3.3]*
Zhongzhen YANG *(Dalian University of Technology) [5.17]*
Rocco ZITO *(University of South Australia, Adelaide) [5.15]*

LIST OF FIGURES

I.1	Chapter structure of this book	5
I.2	Means of transport covered in the Comparative study on Urban Transport and the Environment (CUTE)	6
I.3	Environmental problems covered in CUTE	7
I.4	Objectives and alternative strategies for transport and land use policy	8
1.1.1	Change in number of trips and shares by different transport modes	13
1.1.2	Change in vehicle ownership in developed countries from 1926 to 1960	16
1.2.1	Average air pollution of high income and middle / low income countries (1995)	26
1.3.1	Proportional volumes of CO_2 emitted by various countries of the world	31
2.2.1	Personal vehicles and per capita GDP, 1998	41
2.2.2	Rate of motorization vs income level, 54 countries, 1990–1996	42
2.2.3	Vehicle ownership, U.S. by year and 1998 selected world regions	43
2.2.4	Projections of motorisation, 1980-2020	44
2.2.5	Automobiles per 1000 persons, 1991-2000	46
2.2.6	Trucks per 1000 persons, 1991-2000	46
2.2.7	Stock of trucks (thousand), base 100, 1995-2001	49
2.2.8	Trends in public transport bus fleet, 1970 - 2000	50
2.3.1	Trends in annual VKT, selected U.S. metro areas. 1960–1990	57
2.3.2	Trends in annual VKT, selected European metro areas, 1960–1990	57
2.3.3	Trends in annual VKT, selected Asian metro areas, 1960–1990	57
2.3.4	Average mode shares	61
2.3.5	Mode shares, North America metro areas	62
2.3.6	Mode shares, metro areas in Germany, France, UK	63
2.3.7	Mode shares, other EU metro areas	63
2.3.8	Mode shares, Asian metro areas	64
2.3.9	Average mode shares of countries by income group	64
2.3.10	Mode shares, selected developing countries	68
2.3.11	Growth in freight tonnage by mode, U.S., 1960–1998, ton-mile billions	70
2.3.12	Growth in freight tonnage by mode, EU 15 countries, 1970–2000, ton-kilometre billions	71
2.3.13	Trends in population, employment and measures of transport, Los Angeles region, 1981–1997	72
2.3.14	Transport distance per ton in Tokyo	74
2.3.15	Number of truck companies in Japan	74
2.3.16	Increase and decrease of commodities transport volume, 1995–2000, in Japan	75
2.3.17	Changes in capacity ton-kms and transport ton-kms of the freight vehicle	75

	fleet in Tokyo	
2.4.1	Average annual private sector job growth	79
2.4.2	City and suburban population growth, selected European cities	79
2.4.3	Change in resident population, Sendai metro area, Japan, 1992–2002	84
2.4.4	Expansion of densely inhabited district area in Iida city, Japan, 1970–1990	84
2.4.5	Expansions of Bangkok during past decades	85
2.5.1	Illustrating the relationship between mode choice and income	95
3.1.1	Inventory of atmospheric gas in the U.S. (Year of 2000)	102
3.1.2	Energy intensity and population density in cities	103
3.1.3	Energy use per passenger of each mode in representative cities	103
3.2.1	Impacts of air-fuel ratio on engine performance and characteristics of exhaust gas	105
3.2.2	Share of freight vehicles by registered year 2002	112
3.2.3	Passenger vehicle emission regulation in Asian countries	113
3.3.1	Emission – velocity (speed) curve of carbon monoxide	119
3.3.2	Trends in emission inventory of major air pollutants in U.S.	122
3.3.3	Emission inventory of major air pollutants in Europe	123
3.3.4	Transition in emission of major air pollutants in Europe (1990=100)	123
3.3.5	Emission inventory of automobile sector sources in Japan (2000)	124
3.3.6	State of car transport during winter (Sapporo)	125
3.3.7	Reduction in the amount of falling dust generated during winter in Sapporo and the corresponding reduction in spike tyre usage (1988–1995)	126
3.3.8	Conceptual figure of mutual relationship among air pollutants and spatial distribution in urban areas	128
3.3.9	Distance attenuation of NO, NO_2 from edge of the road	130
3.3.10	Distribution of air pollution monitoring stations in the U.S. (SLAMS and NAMS)	131
3.3.11	Trends in average pollution concentrations in Japan of NO, NO_2 and PM10	135
3.4.1	Urban population density, and concentrations of SPM, SO_2, and NO_2	138
3.4.2	Annual emissions of transport related pollutants	142
3.4.3	An electric scooters' recharging station	143
3.5.1	Changes in CO_2 emission levels in the major developed countries	149
3.6.1	Children's prize winning pictures to illustrate noise	164
3.6.2	Survey on experienced transport noise pollution in West Germany	168
3.6.3	Distribution of outdoor noise levels from roads during the day affecting the Swiss	169
3.6.4	Development of noise annoyance in the Netherlands (1980-2000)	170
3.6.5	European noise emission standards for road transport vehicles	183
4.3.1	Land use transport interaction	206
4.4.1	Causal loop diagram: the impacts of changes in road capacity	212
4.4.2	Causal loop diagram: the impacts of changes in road and rail capacity	213

4.7.1	Percentage of European cities having full, joint and no responsibility for different policy instruments	237
4.7.2	Percentage of European cities having differing levels of dependence on other authorities	238
4.7.3	Percentage of European cities for whom finance is a major or minor constraint on different policy instruments	238
4.7.4	Percentage of cities for whom political barriers are a major or minor constraint on different policy instruments	239
4.8.1	The optimisation process	243
4.9.1	Causal loop diagram (1): reduce car use	246
4.9.2	Causal loop diagram (2): improve alternative modes	247
4.9.3	Causal loop diagram (3): improve road network	248
4.9.4	Causal loop diagram (4): improve vehicles and fuels	249
4.9.5	Example of application of causal loop diagram in Nagoya (1998)	250
4.9.6	Example of application of causal loop diagram in Jakarta (1998)	251
5.1.1	Distribution of case study cities	256
5.2.1	Comparison of the development of population in West and East Berlin	259
5.2.2	Potsdamer Platz in 1961 and in 2003 after it became the new city center of Berlin	259
5.2.3	Modal-split in the two parts of Berlin before reunification in 1989	263
5.2.4	Modal-split of motorized passenger trips for total Berlin after reunification	263
5.2.5	Car ownership in West and East Berlin compared with Hamburg and West Germany	264
5.2.6	Development of migration flows between Berlin and its Hinterland	265
5.2.7	Age structure of migration balance between Berlin and its Hinterland	265
5.2.8	Average concentrations in Berlin 1990 – 2000	267
5.2.9	NO_x concentrations at three locations in Berlin	268
5.2.10	CO_2 emissions in Berlin	269
5.3.1	Development of car fleet and public transport (1990=100)	275
5.3.2	Air pollution in Budapest (1980-2000) - yearly average emission	276
5.4.1	Major roads in Istanbul	282
5.4.2	The Bosphorus railway tunnel crossing project	283
5.5.1	Population densities within Greater Lyon	286
5.5.2	Distances covered by mode according to the place of residence	287
5.5.3	Average annual concentrations of different pollutants in the Lyon agglomeration	289
5.5.4	Emission rates in m^2 per zone, linked to Lyons inhabitant mobility	289
5.5.5	The Greater Lyons public transport system 2003-2006	292
5.6.1	Integrated transport framework	294
5.9.1	SCAG region and population density in 2000 census	310

5.9.2	Distribution of population and employment by county	311
5.9.3	Commuting patterns in metropolitan Los Angeles	312
5.9.4	Highway use and performance	314
5.9.5	Commuter rail, urban rail and rapid bus system in the SCAG region	315
5.9.6	Improved air quality in the SCAG region	316
5.9.7	Evolution of California auto controls: pollutants emitted by a new vehicle	318
5.9.8	Emissions trends from on-road motor vehicles in SCAB	318
5.9.9	Technology-driven mobile source emissions control	320
5.9.10	Particulate mater (PM10)	321
5.10.1	Transmilenio	324
5.11.1	The development axis in Curitiba	327
5.11.2	Speedy bus and specially designed tube-bus stop	329
5.12.1	Modal share by mode	334
5.13.1	Number of motorized trips and mode splits in week-day for 1991 and 2001	336
5.13.2	Total emissions per year	337
5.13.3	Responsibility for emissions, year 2000	337
5.13.4	Responsibility for transport emissions, by vehicle type, year 2000	338
5.13.5	Contingences declared, 1990-2001	339
5.13.6	PM10 concentration ($\mu g/m^3$) during the July/3-6/2000 episode and effectiveness of the "emergency traffic network" (RVE)	341
5.13.7	Opinions about the trend of air quality	342
5.14.1	Nagoya –area and public transport network–	343
5.14.2	100m width street in central Nagoya	344
5.14.3	Relationship between population density and passenger car ownership in principal Japanese cities in 1995	346
5.14.4	Changes in the number of passengers carried by various modes of transport in Nagoya metropolitan area	347
5.14.5	Changes in the vehicle-km and ton travelled by freight vehicles in Aichi Prefecture	347
5.14.6	Changes in concentration of various air pollutants in the city of Nagoya (Annual average of all monitoring stations)	348
5.14.7	Bus system introduced in Nagoya	355
5.14.8	Average fuel economy for new passenger cars in Japan	356
5.14.9	Route-no.23, where air pollution is very serious	358
5.16.1	Trends of new vehicles registered in Bangkok as compared with the base year 1997	365
5.17.1	Car ownership in the main city by year	371
5.17.2	Surveyed pollutants at 5 monitoring stations in the Dalian city	372
5.18.1	Hanoi public transport in the modal split 1975-2002	375
5.18.2	Road traffic in Hanoi	375

5.19.1	Map of Kathmandu valley	379
5.19.2	Vehicle population trend in Kathmandu valley	381
5.20.1	Jeepneys used for public transport in metro Manila	384
5.20.2	Vehicle registration by fuel type in metro Manila, 1980-2001	385
5.20.3	Smoke-belching bus being subjected to roadside inspection	387
5.22.1	Percentage composition of vehicles in Singapore in 1999	395
6.3.1	Diesel vehicles (cars and LDVs) as a percentage of all newly licensed vehicles up to 5 tons in Western Europe	419
6.3.2	Forecast for the concentration of soot and particulate matter along an arterial road in Berlin	421
6.4.1	Greenhouse gas emissions due to transport: results from scenario analyses (ratio of forecasted emissions in 2020 to actual emissions in 2000)	435
6.5.1	ODA in the transport sector in Japan	440
6.5.2	An implementation of CDM to a railway construction project	442
6.5.3	FEST system coordinating GEF and CDM	445

LIST OF TABLES

1.2.1	Variation in vehicle ownership in different groups of countries, classed by income	25
1.2.2	Estimates for transport-related energy consumption	25
1.3.1	Conferences of parties to the framework convention on climate change	30
1.3.2	Evolution in volume of world CO_2 emissions	32
1.3.3	CO_2 emission and energy production (1995)	33
1.3.4	Energy consumption by sectors (1985 and 1995)	33
1.3.5	Forecasts of energy consumption and CO_2 emissions	34
2.2.1	Trends in world motor vehicle fleet	40
2.2.2	Vehicle ownership by UN world region, 1998	41
2.2.3	Vehicle ownership, rate of increase, income elasticity, by World Bank income category, 1988-1998	42
2.2.4	Country level vehicle ownership forecast, by World Bank income category	44
2.2.5	Median age of passenger car fleet (years), by country, year	47
2.2.6	New passenger car average engine cubic capacity (cm^3) by country by year, selected European countries	47
2.2.7	Trends in U.S. goods movement vehicle fleet, registered vehicles (millions)	49
2.2.8	Trends in U.S. public transport vehicle fleet	49
2.2.9	Trends in European public transport vehicle fleet	50

2.2.10	Explanatory factors for differences in car use, selected countries	54
2.2.11	Surface transport infrastructure per capita	54
2.3.1	Mode shares trends, all person trips, selected urban areas	58
2.3.2	Car ownership, U.S. and Great Britain, 1995, share of persons	59
2.3.3	Average daily person trips, travel distance, travel time, U.S. and Great Britain	59
2.3.4	Mode shares, U.S. and Great Britain	60
2.3.5	Paratransit services in developing countries	66
2.3.6	Freight transport in a German metropolitan area	72
2.3.7	Dominant environmental measures in logistics sector	76
2.4.1	Population growth for U.S. metro areas with 1 million or more population, central and suburban counties	79
2.4.2	City and suburban population shares, France, 1975-1999	81
2.4.3	City and suburban employment shares, France, 1975-1999	81
2.4.4	Employment change by type and local authority district, 1984-91-96, in Full-Tire Equivalent, percent	82
2.4.5	Commute flows in U.S. metropolitan areas, 1980 and 1990	88
2.4.6	Journey to work mode choice, 1995, by job location, U.S.	88
2.4.7	Journey to work mode choice, 1995, by job location, Greater London	88
3.2.1	Passenger vehicle emission control in Europe	110
3.2.2	Passenger vehicle emission control in the U.S.	111
3.2.3	Passenger vehicle emission control in Japan	111
3.3.1	Classification of air pollutants by EEA	114
3.3.2	List of mobile source air toxics (MSATs)	116
3.3.3	Environmental standards of WHO, Japan, U.S. and Europe	118
3.3.4	Emission levels of pollutants of vehicle types	120
3.3.5	Reduction rate of major air pollutants in Europe from 1990 to 1999	124
3.3.6	NO_x emission levels in Japanese metropolitan areas	124
3.3.7	Monitoring methods of major air pollutants in Japan	130
3.3.8	Status of air pollution monitoring stations in European countries	133
3.3.9	Number of monitoring stations for each air pollutant in Japan (as of 2000)	134
3.4.1	Pollutant emission levels per unit area (ton/ha) and their correlation	139
3.4.2	Density, modal share, and atmospheric pollution from private vehicles	140
3.4.3	Correlation coefficient between the level of pollutant emissions and index	144
3.5.1	CO_2 emission level in major developed countries (2000)	148
3.5.2	CO_2 emissions and vehicles per capita for selected countries (1998)	153
3.5.3	Greenhouse gas emissions from vehicles and transport modes in developing countries	153
3.5.4	Policy and investment choices to reduce vehicle use and greenhouse gas emissions	157

3.6.1	Exposure to transport noise in Germany as share of affected population	169
3.6.2	Comparison of percentages of people reporting annoyance because of transport noise in surveys	170
3.6.3	Estimates of shares of Italian population affected by different noise levels in 1997	171
3.6.4	Measurement of noise levels at 1000 dwellings in the UK in 1990	171
3.6.5	Number of U.S. citizens exposed to transport noise from different modes	172
3.6.6	Examples of noise levels in developing countries from the WHO report (1999)	172
3.6.7	Noise immission standards of the German 16th BimSchV	174
3.6.8	Zoning system for noise protection in Switzerland	176
3.6.9	Environmental standards for road transport noise in Switzerland according to LSV87	176
3.6.10	Dutch noise immission standards according to Noise Abatement Act 1979	177
3.6.11	Japanese noise immission standards according to Environment Agency notification No 64	179
3.6.12	Noise immission standards for different countries for residential zones and road transport	181
4.2.1	Contribution of strategies to objectives	200
4.3.1	Classification of policy instruments and their contribution to transport and environmental strategies	203
4.5.1	Emission reduction technologies for petrol engines	224
4.5.2	Emission reduction technologies for diesel engines	224
4.5.3	Technologies for vehicles using alternative energies	225
4.5.4	Recent fuel cell powered vehicles	229
4.5.5	Performance comparison of vehicle technology	232
4.6.1	Contributions of different types of instrument to strategies	234
4.6.2	Contribution of policy instruments to objectives in city centres	235
4.6.3	Contribution of policy instruments to objectives in inner suburbs	235
4.6.4	Contribution of policy instruments to objectives in outer suburbs	236
4.6.5	Contribution of policy instruments to objectives in smaller urban areas	236
4.8.1	An integration matrix, illustrating the ways in which policy instruments may contribute to the performance of others	242
5.2.1	Distribution of daily traffic volume on the main road network of Berlin	260
5.2.2	Key data of public transport in Berlin for 1999	262
5.4.1	Population and motorisation in Istanbul (1980-2000)	283
5.4.2	Modal split of daily motorised trips	283
5.4.3	Emissions caused by road traffic in Istanbul	284
5.5.1	Distribution of population and employment in the Lyon urban area in 1999	287

5.5.2	Modal distribution for commuting, by urban area and by origin – destination	287
5.5.3	Perception of pollution and living conditions for the French	290
5.6.1	Travel mode shares for Nottingham	293
5.6.2	Air pollution exceedences in Nottingham	294
5.7.1	Rome's public transport statistics (year 2000)	297
5.7.2	Rome municipality area private vehicles fleet size (year 2000)	298
5.7.3	Rome municipality area vehicles, according to the fuel used (2001)	298
5.7.4	Emissions in the Rome municipality area	299
5.7.5	Motorized two wheels fleet size (year 2000)	299
5.7.6	Overall emissions generated by all the motorised modes in the "Tridente" area from 8.00 to 9.00 am, during a working day (year 2001)	299
5.7.7	Average specific CO_2 emissions of the Italian car fleet size	302
5.8.1	Air pollution indicators at 15 survey locations, autumn 2001	304
5.9.1	Primary travel mode for work trips in the SCAG region	313
5.13.1	Key government measures to reduce air pollution	340
5.13.2	Measures included in "contingences scheme" as of September 28th, 2002	340
5.14.1	Transport policies for a better environment in Nagoya	350
5.15.1	Modal splits for passenger trips in Adelaide	359
5.15.2	Representative air pollutant concentrations in an inner suburb of Adelaide	361
5.16.1	Ambient air quality in general area and at the roadside in Bangkok	367
5.16.2	Annual emissions of Air contaminants in Bangkok, 1997	368
5.17.1	Surveyed modal split in the main city	371
5.17.2	Comparison of equivalent noise level along roads in 1995 and 2000	372
5.18.1	Bicycle and motorbike ownership trends	375
5.19.1	Concentration range of major pollutants at different test sites in Kathmandu	380
5.19.2	Monthly average concentration of PM10 at the permanent monitoring stations	380
5.20.1	Registration by vehicle type in metro Manila, 2001	384
5.20.2	Transport demand by mode in metro Manila, 1996	385
5.20.3	Greenhouse gas emissions (1994)	388
5.21.1	Air pollutants emission trend by automobiles	391
5.21.2	Energy consumption trend by sector in Korea	391
5.21.3	CO_2 emission trend by sector in Korea	391
5.22.1	Demographic trends, population prediction, households, elderly and employment	394
5.22.2	Trends in car ownership and travel	395
5.22.3	Comparison of the atmospheric mean concentration of BC, CO and NO at different sites in Singapore	399

5.22.4	Average traffic noise levels at 4 locations among three different classes of roads in Singapore	400
6.1.1	Major political occurrences concerning transport environment policies	406
6.2.1	Facts and first results of the London area pricing	410
6.3.1	Share of particle emissions due to exhaust and non-exhaust processes	420
6.3.2	Differentiation in use-of-infrastructure charges on heavy goods vehicles on German motorways in cents per vehicle km	425

LIST OF BOXES

1	Success and failures of the "Karlsruher modell" for public transport	64
2	Environmental measures for the logistics sector – lessons in Japan	75
3	Migration to the city, illegal housing and transport system	82
4	Old Venice of the east is now one of the most traffic congested cities	84
5	The two-wheeler mystery	93
6	Age of freight vehicles and emission control regulations in Japan	112
7	Air pollution in Kathmandu valley takes its toll on tourism industry	116
8	Emission factors for petrol engine and diesel engine vehicles in Tokyo	120
9	Atmospheric pollution caused by the use of spike tyres in Japan	125
10	Electric scooters in Rome	143
11	Noise protection policy in Germany	185
12	Potential objectives of urban transport policy	196
13	Key elements of an urban transport strategy	198
14	The structured approach in KonSULT	208
15	Infrastructure policy instruments in KonSULT	209
16	Regulatory policy instruments in KonSULT	213
17	Information provision and enlightenment instruments in KonSULT	218
18	Pricing instruments in KonSULT	221
19	Use of alternative fuels in Greater Cairo and Mexico City	232
20	Ten years of citizens fight against unacceptable noise and air pollution at the Brückenstrasse	240
21	The air pollution lawsuits in the southern part of Nagoya	357
22	Non-governmental activities for clean air in Manila	433
23	Four case studies	435

FRONTPAGE PHOTOGRAPHS

Intro Traffic congestion in Bangkok by Shinya Hanaoka.

Intro Traffic congestion in Chicago by Express Highway Research Foundation of Japan.

Chap1 Congested highway in Tokyo by Metropolitan expressway public corporation.

Chap1 Buses at Portland by Yuichiro Kaneko.

Chap2 Subway in Nagoya by Hirokazu Kato.

Chap2 Buses at Curitiba by Fumihiko Nakamura.

Chap3 Smoking-belching bus in Manila by the Partnership for Clean Air.

Chap3 High occupancy vehicle lane in Los Angeles by Express Highway Research Foundation of Japan.

Chap4 Bicycle lane in Gauteng by the Institute of Behavioral Sciences.

Chap4 Electric road pricing gantry in Singapore by Tomonori Nagase.

Chap5 Light Rail Transit in Lyon by Shinya Hanaoka.

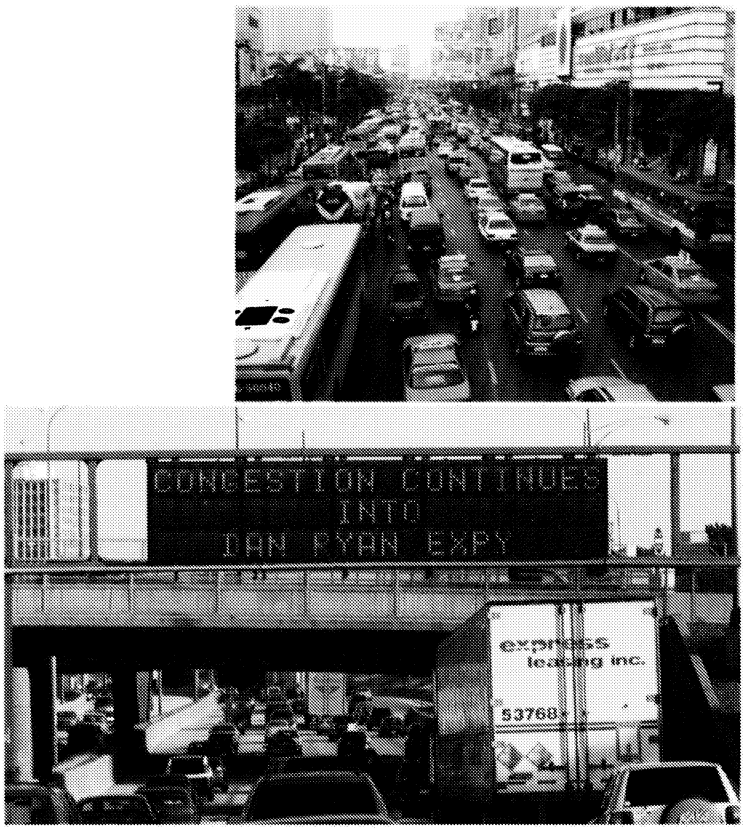
Chap5 General road in Hanoi by Atsushi Fukuda.

Chap6 Road sign in London by ALMEC Corporation.

Chap6 Transit mall in Karlsruhe by Naohiko Hibino.

INTRODUCTION

AUTHORS ***Yoshitsugu Hayashi***
Hideo Nakamura



INTRODUCTION

I.1 The Present State of Transport-related Environmental Problems

In developed countries, there are notable examples of countermeasures to lighten the burden that traffic imposes on the environment. In Freiburg, Germany, a rail link allows direct access from the city centre tram mall to the residential suburbs on the one hand and the main line rail station on the other, which has led to a significant shift to public transport. In Japan the "green" car tax system has encouraged purchase of vehicles with low rates of emission and fuel consumption. In the UK, the concept of Integrated Transport has established itself as a mainstay of transport policy. In the Netherlands, too, the national transport policy is remarkable in that it is concerned with location regulations which take into consideration the available transport systems in the area and actually seeks for slower transport modes in towns.

In developing and newly industrialised countries, also, there are numerous creditable examples to be found. For example, the raising of the taxation rate on leaded petrol in Thailand led successfully in just a few years to a national changeover to unleaded fuel. Or there is the case of Cairo, in Egypt, where the attractive, recently introduced underground system, together with the well utilised traditional suburban tramways, has allowed rail to maintain a 20% share of public transport for the past twenty years, a figure that would be notably high in a developed country, let alone a developing one.

However, it can hardly be said that good practices like these are being readily transferred from one country to another. There may well be these individual success stories, both in the developed and developing worlds, yet in the end there is no denying the overall picture which is that attempts to use transfer of policies as a means for dealing with transport-related environmental problems are generally feeble, and individual policy initiatives are not systematically organised.

One of the barriers is that the relationships between transport and the environment are extremely complicated. To give one example, the advances in engine technology development achieved by automobile manufacturers in developed countries since the latter half of the 1990s have been truly remarkable from an environmental point of view. In Japan, as a result of the introduction of a "green" car tax preference, there has been a very rapid shift among consumers to cars with lower fuel consumption, and this in turn spurs competition in technology development among the manufacturers, leading to a positive chain reaction. This example shows how it is possible to control the load imposed on the environment by traffic once the mechanisms linking the multiple parties have been properly grasped and effective policies have been discerned. However, in developing countries, there is a widespread demand among consumers for poor quality second-hand cars and engines at extremely low prices. It is extremely difficult to control this unless there are policy measures that encompass the complex mechanisms operating between demand and supply. Unless the chain mechanisms linking the

multiple parties can be grasped in this way, and effective policies discerned, it will be extremely difficult to control the load imposed by traffic on the environment.

Research to date, however, has concentrated on advances in discrete areas of analysis such as car ownership, travel behaviour models, traffic management, energy consumption, life cycle assessment, pollution diffusion, environment tax schemes, urban planning regulation and the like. Comprehensive analyses of environmental influences taking transport as their focus have rarely been attempted. Moreover, transport-related environmental problems clearly differ regionally between Europe, America, Japan, the newly industrialised and the developing nations, in terms of problems, public awareness and the assignment of priorities. Analyses and surveys being conducted are almost invariably concerned with particular regions or countries, and are therefore of little help for a wider understanding of transport environment issues or for projects of international collaboration. One of the important recent exceptions has been the EST (Environmentally Sustainable Transport) project proposed by the OECD to bring to light examples of "best practice" in the area of sustainable transport systems. Now we are at the stage of being able to prepare concrete methods to transfer these models of success to other countries and cities.

The deterioration in the global environment has led to the creation of an international framework of measures, including the establishment of Global Environmental Facilities (GEF) by the World Bank, the proposal and approval of the Kyoto Protocol, and concrete plans for implementing the Kyoto mechanisms in such applications as Clean Development Mechanisms (CDMs). Various projects, including for example afforestation and the re-equipment of electricity generating facilities, have been suggested, and concrete means of implementation are under consideration. But in the transport sector, the sad reality is that virtually no ideas have been put forward.

I.2 The Approaches Required and the Contents of this Book

As will already be apparent from the above remarks, solutions to traffic-related environmental problems depend on the following requirements:

a) understanding these problems within a more comprehensive and general framework
b) the establishment and provision of policy instruments and of a knowledge-base regarding their effects
c) support for policy choices aimed at the improvement of local environments
d) actual case studies of policy applications in representative cities together with "pathology histories" illustrating negative effects
e) institutions and policies that facilitate international collaboration for environmental improvements on a world scale.

Local environmental problems and the effects of the remedial measures exhibit peculiarities specific to the country and region affected as well as to the time of occurrence. It is therefore valuable to know the experiences of other cities and to understand the underpinning explanatory mechanisms. At the same time, in solving environmental problems on the world scale, it is imperative to be able to devise and enact countermeasures jointly, on the basis of a shared international understanding.

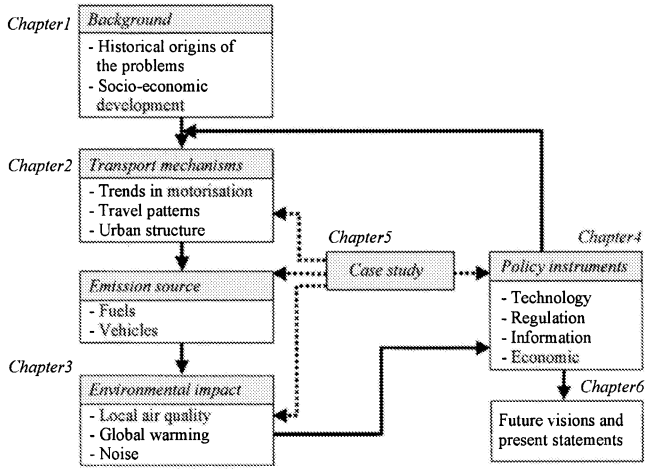


Figure I.1 Chapter structure of this book

For these reasons, this book will not confine itself to the introduction of individual policy examples. Rather, it will follow the structure set out in Figure I.1 below. First, chapter 1, dealing with the environmental problems stemming from urban transport, will trace the path of development that has led from the earliest powered transport to the present day, providing an overall outline of the subject, working from the developed to the developing countries, and from local pollution occurrences to global environmental issues. Following on from this, in chapter 2, we shall be analysing the means and mechanisms by which transport comes to act upon its environment, in particular from the point of view of the various factors that have an effect on transport demand and traffic flow. Chapter 3 then addresses the mechanisms that lead to the generation of exhaust gas emissions, a root cause of traffic pollution, and assesses the impact which they have on the local and global environments. A classification of policy approaches is next undertaken in chapter 4, from the various angles of technology, regulation, information and awareness, and economic measures, applied to such strategy areas as transport demand, traffic flow and sources of emissions. There is also some discussion in this chapter of knowledge bases from which appropriate instruments can be selected. Actual examples of these policies being put into practice and of the benefits accruing from them are presented in chapter 5, for cities such as Nagoya, Los Angeles and Berlin in the developed countries, and

Bangkok, Cairo and Santiago in the developing ones. Finally, chapter 6 offers some future visions and present position statements concerning the prospects for sustainable urban transport.

I.3 The Treatment of "Urban Transport and the Environment" in this Book

As the terms "urban transport" and "environment" are both open to an extremely wide interpretation, it is impossible for this book to describe all of the problems involved in these two areas. For example, air and sea transport also result in toxic gas emissions into the atmosphere, while in certain areas the vibrations caused by rail traffic are a serious environmental hazard. Another concern is that while global environment problems may have grave future effects for the population of the whole planet, actual interest in such matters is very scant in developing countries. However, we as authors neither have the expertise to deal with the entire range of these problems, nor the necessary page space at our disposal were we tempted to try.

We therefore propose to restrict the coverage of this book to the following matters.

Means of transport

The subject treated will be the transport of passengers and goods in cities. The private modes studied will include walking, cycling and individually owned automobiles; the public modes will take in all kinds of motorised transport from railways and trams through automated guideway transit and buses to paratransit. (Figure I.2).

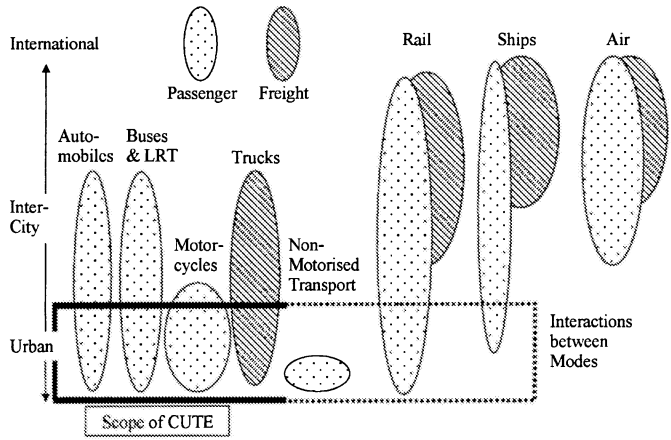


Figure I.2 Means of transport covered in the Comparative study on Urban Transport and the Environment (CUTE)

Environmental problems

Here we shall deal with problems of atmospheric pollution from urban road traffic attributable to causes such as emissions of carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter (PM), and noise pollution due to both rail and road transport, and also with wider-scale local environmental problems such as acid rain, due mainly to exhaust gas emissions from road traffic, and finally the global environment problem arising from the so-called "greenhouse gases" (Figure I.3).

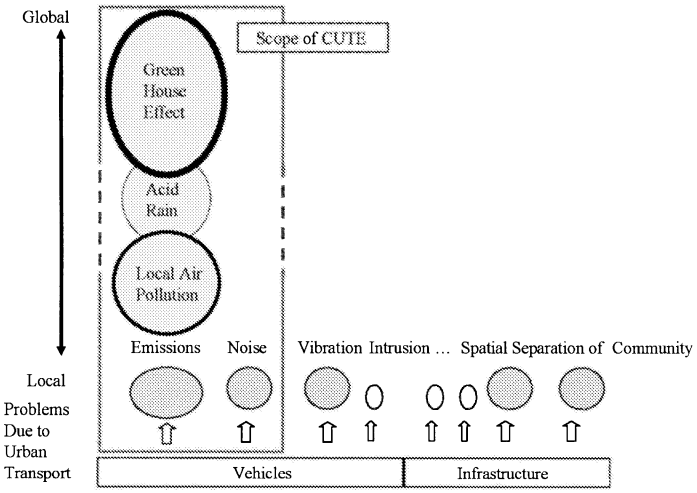


Figure I.3 Environmental problems covered in CUTE

Time span

The time span covered extends from the present to the relatively near future (about 15 or 20 years ahead). Regarding both transport and environmental problems, it is often the case that things that previously went wrong in the developed countries are now occurring again in the developing ones. In some cases it is the results of what happened earlier in the developed world that have led to the present serious situations in the developing world; situations which in turn are now set to aggravate future problems in the same areas. For example, it is not uncommon to find the environmentally harmful automobiles once driven in the developed countries being put to a second use in the developing ones now. Accordingly, our account will have to pay attention to these regional lags in the stages of development, and to the differences in the environmental problems found from one region to another.

Policy objectives

The primary policy objectives as far as this book is concerned are the amelioration of local atmospheric and noise pollution, and the prevention of global warming. At the same time,

however, we need to appreciate the fact that transport exists, and is used, in order to serve other objectives. These objectives may vary somewhat depending on the country or city in question, but most typically they are efficiency, fairness, liveability, equity, safety and economic growth, all of which are valued not only for the present generation but also for future ones. In certain cases, purposes like these may conflict with the kind of environmental improvement objectives we are concerned with in this book, or may be an obstacle to the implementation of an effective environmental strategy. To take one example, a restriction in the use of cars, while desirable from the environmental point of view, might bring an inconvenience in day-to-day living and a loss in production efficiency from the point of view of the people whose mobility is hampered by it. It could also possibly have a detrimental effect on the whole urban economy. On the other hand, it is also possible that the pursuit of these objectives might serve as a reinforcing motive for the policies we are envisaging. For example, effective pricing for the use of a road can result in a double benefits of improved efficiency, convenience and safety on the one hand and environmental improvement on the other. Similarly, an improvement in fuel efficiency leads to a more effective use of resources.

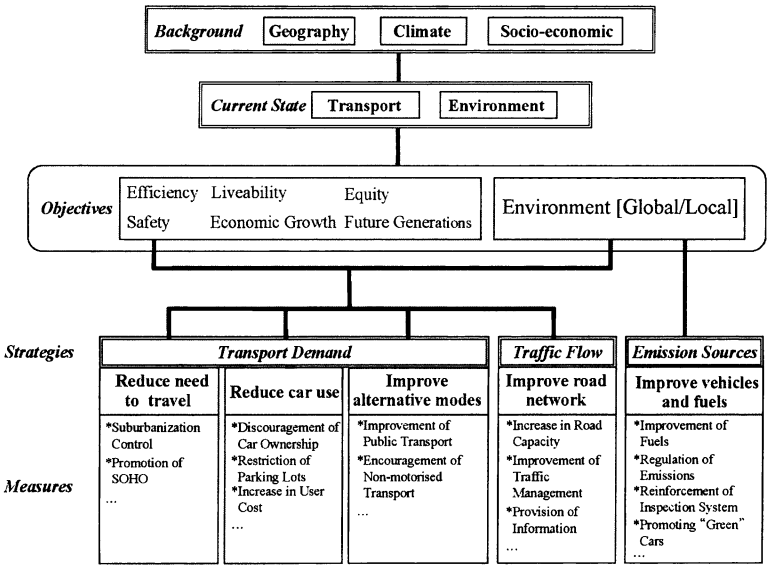


Figure I.4 Objectives and alternative strategies for transport and land use policy

Strategies for the attainment of policy objectives

To meet these objectives, a strategy is needed for the choice of an appropriate direction in policy, taking into consideration geographical features, climate and the socio-economic conditions of the region, as shown in Figure I.4. The principal strategies are likely to be reducing the needs to travel; reducing car use; providing improved alternative to the car,

improving the operation of the road network; and improving vehicles and fuels. The promotion of these alternative strategies requires individual measures of the kinds exemplified in the figure.

Policy instruments

The measures for promoting the above mentioned strategies depend for their implementation on a range of technology, regulation, information and public awareness, and economic instruments. In this book, accordingly, the various policy measures will be classified on the two axes of "strategy," indicating the direction of the intended effect, and "type of instrument." It is on the matrix thus generated that all the individual policies will be categorised. By way of example, Table 4.3.1 in chapter 4 presents a diverse selection of policy examples fitted in place on this matrix.