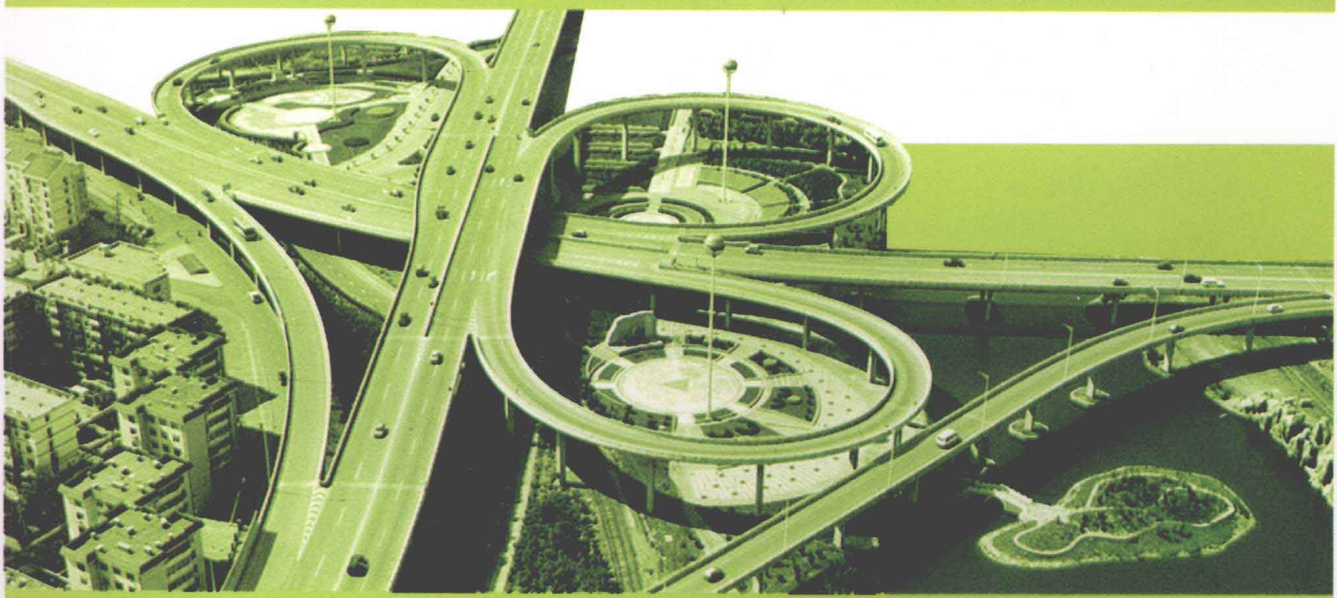
普通高校交通运输类专业系列教材

可持续发展的交通运输

SUSTAINABLE TRANSPORTATION

主编 周红梅



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Sustainable Transportation
可持续发展的交通运输

主　编　周红梅
副主编　罗美清

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·武汉·

内 容 简 介

本书参考了国内外大量外文资料和书籍，反映了当代交通运输可持续发展的成果。全书共分8章，围绕可持续发展交通运输的研究内容，以道路运输的可持续发展为重点，结合当代中国可持续发展交通的现状，依次介绍了：可持续发展交通运输的内涵及发展；铁路运输的发展趋势和前景；汽车运输的发展趋势和前景展望；汽车运输与空气污染；可持续发展交通运输的燃料；公交优先战略；中国巴士快速公交的发展；中国可持续发展交通战略。

本书可作为高等院校交通工程专业、交通运输规划与管理专业本科生教材以及其他专业本科生选修的公共选修课教材，也可作为交通运输管理部门、交通工程从业人员的参考书籍。

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前　言

由于世界各国普遍认识到经济增长与生态环境之间的相互依赖性以及全球经济系统对社会生态系统产生的压力，可持续发展不仅成为发展中国家，同时也成为发达国家形成共识的长期发展战略。交通运输体系涉及广泛，对可持续发展起到关键性影响。面对日益严重的资源短缺和环境恶化问题，可持续发展的交通运输是政府发展战略的必然趋势。

本书是为了满足高等院校交通运输类专业教学的需要，根据该专业培养目标而编写的。交通运输的可持续发展主要研究内容包括：交通运输可持续发展的基本内涵，交通运输可持续发展与经济、环境和社会可持续发展的关系，交通运输可持续发展的影响因素，推进交通运输可持续发展的战略和措施等。不同运输方式对可持续发展的影响不尽相同，本书重点分析了公路、铁路运输的发展趋势，对可持续发展的影响及实现可持续发展的若干策略。

本书参考了国内外大量外文资料和书籍，力求反映当代交通运输可持续发展成果，适应并满足可持续发展的要求。全书共分 8 章，围绕可持续发展交通运输的研究内容，以道路运输的可持续发展为重点，结合当代中国可持续发展交通的现状，依次介绍了：可持续发展交通运输的内涵及发展；铁路运输的发展趋势和前景；汽车运输的发展趋势和前景；汽车运输与空气污染；可持续发展交通运输的燃料；公交优先战略；中国巴士快速公交的发展；中国可持续发展交通战略。

本书可作为高等院校交通工程专业、交通运输规划与管理专业本科生教材，也可作为其他专业本科生选修的公共选修课教材，还可作为交通运输管理部门、交通工程从业人员的参考书籍。

本书由武汉理工大学周红梅主编并负责编写，东南大学陈学武教授（博士生导师）担任主审。武汉理工大学罗美清、王海燕老师，研究生司徒莉英、王博、张曙光参加了编写工作。分工为周红梅、王海燕第 1 章，罗美清第 2 章，周红梅第 3 章，司徒莉英第 4、5 章，王博第 6、8 章，张曙光第 7 章；罗美清参与了全书的校对工作。在本书的编写过程中，得到了武汉理工大学交通学院副院长王丽铮教授、交通工程系主任朱顺应教授以及交通学院教学办的积极帮助，武汉理工大学教务处和武汉理工大学出版社给予了大力支持，在此一并表示诚挚的感谢。

由于编者水平有限，外文资料较多，加之时间仓促，书中难免存在一些错误和遗漏，敬请广大读者提出宝贵意见。

编　者

2008 年 1 月

CONTENTS

1 Introduction to Sustainable Transportation ..... (1)

1.1 Background of Sustainable Transportation ..... (1)
1.2 Introduction to Transportation Modes ..... (2)
1.3 Sustainability and Sustainable Transportation ..... (6)
1.4 Notions of Sustainable Transportation ..... (8)
1.5 Main Challenges of Sustainable Transportation ..... (9)
1.6 Summary ..... (11)

2 Trends and Outlook in Rail Transportation ..... (17)

2.1 Introduction ..... (17)
2.2 Environmental Sustainability of Rail Transportation ..... (18)
2.3 Rail + Property Development ..... (26)
2.4 The Application and Trends of Rail Transportation ..... (29)
2.5 Summary ..... (32)

3 Trends and Outlook in Motor Vehicle Transportation ..... (35)

3.1 Introduction ..... (35)
3.2 Key Influences on Past and Recent U. S. Trends ..... (36)
3.3 Long-term U. S. Outlook ..... (48)
3.4 Motor Vehicle Trends Worldwide ..... (52)
3.5 Summary ..... (57)

4 Air Pollution and Motor Vehicle Transportation ..... (62)

4.1 Air Pollutants and Health ..... (62)
4.2 Air Pollutions and Motor Vehicles ..... (63)
4.3 Government Policy ..... (69)
4.4 Automobile Emissions Standards ..... (72)

5 Sustainable Automobile Fuels ..... (87)

5.1 Automobile Fuel Impacts on the Environment ..... (87)
5.2 Fuel Crisis ..... (88)
5.3 Alternative Fuels for Automobile ..... (91)
5.4 Application of Alternative Fuels ..... (95)

5.5 Automotive Fuel Quality ..... (96)

6 Public Transport Priority ..... (109)

6.1 Introduction ..... (109)
6.2 Strategy Objectives and Measures ..... (111)
6.3 Effects of Public Transport Priority ..... (116)
6.4 Public Transport Priority in China ..... (120)

7 Bus Rapid Transit Development in China ..... (133)

7.1 The Definition of BRT ..... (133)
7.2 Background of the Development of BRT in China ..... (134)
7.3 Objectives of BRT Design ..... (138)
7.4 Status Quo of BRT in China ..... (140)
7.5 BRT Outlook ..... (147)

8 Strategies for China's Sustainable Transportation ..... (162)

8.1 Introduction ..... (162)
8.2 Strategy Objectives and Strategy Measures ..... (174)
8.3 Policy Recommendations ..... (178)

people and goods can have significant environmental consequences, which can in turn have social and economic repercussions. Sustainable transportation calls for ensuring that the environment is considered along with economic and social considerations in transportation decision-making.

In recent years, efforts have been made to identify, understand, and control many of the economic, environmental and social effects of the transportation system in many countries. Some, such as emissions of lead and carbon monoxide from motor vehicles and leakage of ozone-destroying compounds from vehicle air-conditioning systems, have been reduced significantly. In other cases, steps have been taken to lessen or contain environmental influences, for example by controlling sedimentation and contamination of streams near road construction sites and adopting protective measures to reduce the loss of endangered species living near transport corridors. The treatment of environmental disturbances, however, has often been inconsistent and haphazard and some have gone virtually unnoticed and untreated for years.

1.2 Introduction to Transportation Modes

The field of transport has several aspects: loosely they can be divided into a triad of infrastructure, vehicles, and operations. Infrastructure includes the transport networks (roads, railways, airways, waterways, canals, pipelines, etc.) that are used, as well as the nodes or terminals (such as airports, railway stations, bus stations and seaports). The vehicles generally ride on the networks, such as automobiles, bicycles, buses, trains, and aircrafts. The operations deal with the way the vehicles are operated on the network and the procedures set for this purpose including the legal environment (Laws, Codes, Regulations, etc.) Policies, such as how to finance the system (for example, the use of tolls or gasoline taxes) may be considered part of the operations.

Broadly speaking, the design of networks are the domain of civil engineering and urban planning, the design of vehicles of mechanical engineering and specialized subfields such as nautical engineering and aerospace engineering, and the operations are usually specialized, though might appropriately belong to operations research or systems engineering.

Modes are combinations of networks, vehicles, and operations, and composed of road transport, rail transport, water transport , air transport and pipeline transport.

1.2.1 Road Transport Mode

Road transport is the transport of passengers and goods from one place to another with the vehicles along roads. It has higher transport cost in contrast with rail and water transport modes. Road infrastructures are large consumers of space with the lowest level

of physical constraints among transport modes. However, physiographical constraints are significant in road construction with substantial additional costs to overcome features such as rivers or rugged terrain. Road transport has an average operational flexibility as vehicles can serve several purposes but are rarely able to move outside roads. Road transport systems have high maintenance costs, both for the vehicles and infrastructures. Yet, with containerization, road transport has become a crucial link in freight distribution.

Road transport, however, possesses significant advantages over other modes:

The capital cost of vehicles is relatively small. This produces several key characteristics of road transport. Low vehicle costs make it comparatively easy for new users to gain entry, which helps ensure that the trucking industry, for example, is highly competitive. Low capital costs also ensure that innovations and new technologies can diffuse quickly through the industry.

Another advantage of road transport is the high relative speed of vehicles, the major constraint being government-imposed speed limits.

One of its most important attributes is the flexibility of route choice, once a network of roads is provided. Road transport has the unique opportunity of providing door-to-door service for both passengers and freight.

These multiple advantages have made cars and trucks the modes of choice for a great number of trip purposes, and have led to the market dominance of cars and trucks for short distance trips.

1.2.2 Rail Transport Mode

Rail transport is the transport of passengers and goods from one place to another along railways or railroads.

Rail transport is typically used for long-distance shipping. Less expensive than air transport, it offers about the same delivery speed as trucks over long distances and exceeds transport speeds via marine waterways. In fact, deregulation and the introduction of freight cars with larger carrying capacities has enabled rail carriers to make inroads in several areas previously dominated by motor carriers. But access to the network remains a problem for many businesses.

Rail transport, like roads, has an important relationship with space, since it is the transport mode the most constrained by the physiography. These constraints are mainly technical and involve issues such as:

Space consumption. Rail transport has a low level of space consumption along lines, but its terminals are important consumers of space, especially in urban areas. This increases operation costs substantially.

Gradient and turns. Rail transport can support a gradient of up to 4% (e. g. 40 meters per kilometer), but freight trains rarely tolerate more than 1%. This implies that an

operational freight rail line requires 50 kilometers to climb 500 meters. For turns, the minimal curvature radius is 100 meters, but radiuses of 1 km for a speed of 150 km/hr and 4 km for a speed of 300 km/hr are needed.

Vehicles. Rail transport is very flexible in terms of vehicles and there is a wide variety of them filling different purposes. The locomotion technology ranges from steam, to diesel and electric. The recent trend has been a specialization of freight wagons, such as hopper wagons (grain, potash and fertilizers), triple hopper wagons (sand, gravel, sulfur and coal), flat wagons (wood, agricultural equipment, manufactured goods, and containers), tanker wagons (petrochemical products), box wagons (livestock, paper, and manufactured goods), car wagons and passengers wagons.

Gauge. The standard gauge of 1.435 meters has been adopted in many parts of the world. But other gauges have been adopted in other areas. This makes integration of rail services very difficult, since both freight and passengers are required to change from one railway system to the other. As attempts are being made to extend rail services across continents and regions, this is an important obstacle. The potential of the Eurasian land bridge is limited in part by these gauge differences.

Other factors that inhibit the movement of trains between different countries include signaling and electrification standards. These are particular problems for the European Union where the lack of "interoperability" of the rail systems between the member states is a factor limiting the wider use of the rail mode.

The emergence of high-speed rail networks and increasing rail speed had significant impacts on passengers transport. For instance, China high-speed railway from Beijing to Tianjin has an operational speed of about 300 km/h, it takes only half an hour. High-speed passenger trains require special lines, but can also use the existing lines at a lower speed. In many cases it permitted a separation between rail passenger traffic rolling at high speed and freight traffic using the conventional rail network. The efficiency of both the passengers and freight rail network is thus improved significantly. Since high-speed trains require some time to accelerate and decelerate, the average distance between stations has increased significantly, by-passing several centers of less importance. Over average distances, they have proved to be able to compete effectively with air transport.

1.2.3 Water Transport Mode

Water transport is the least expensive and slowest mode of freight transport. It is generally used to transport heavy, large quantity and low-value products over long distances when speed is not an issue. It includes maritime transport and short sea shipping. The main advantage of water transport is that it can move products all over the world. But they have worse accessibility, because they are necessarily limited to coastal area or major inland waterways-piggybacking is possible using either trucks or rail cars.

Maritime transport. Because of large transport volume and low cost, maritime transport is the most effective mode to move large quantities of cargo over long distances. Their typical cargoes include container, oil products, ore and so on. In China, more than 90 percent international trade is carried out by maritime transport. More than any other mode, maritime transport is linked to heavy industries, such as steel and petrochemical facilities.

Short sea shipping refers to the movement of freight along coasts and inland waterways. Short sea shipping includes the movements of wet and dry bulk cargoes, containers and passengers around the coast and the term is also often used to include inland barges. Typical cargoes include grain, fertilizers, steel, coal, salt, stone, scrap and minerals (all in bulk), oil products (such as diesel oil, kerosene, aviation spirit-all in bulk), containers and passengers (yes, even ferries are technically short sea ships).

In contrast with other transport modes, short sea shipping is considered as an energy saving mode, and developed largely in many countries. In Europe, short sea shipping is at the forefront of the European Union's transport policy. It currently accounts for roughly 40% of all freight moved in Europe. In the US, short sea shipping has yet to be utilized to the extent it is in Europe, but there is some development in the area. New York's Port Inland Distribution Network (PIDN).

The main advantages promoted for short sea shipping are alleviation of congestion, decrease of air pollution, and overall cost savings to the shipper and a government. Shipping goods by ship (one 4000 dwt vessel is equivalent to between 100 and 200 trucks) is far more efficient and cost-effective than road transport (though the goods, if bound inland, then have to deliver by truck) and is much less prone to theft and damage.

1.2.4 Air Transport Mode

Air transport is the movement of passengers and cargo by aircraft such as airplanes and helicopters. It has become the primary means of common-carrier traveling.

Air transport offers the advantage of speed and can be used for long-distance transport. However, air is also the most expensive means of transport, so it is generally used only for smaller items of relatively high value—such as electronic equipment—and items for which the speed of arrival is important—such as perishable goods. Another disadvantage associated with air transport is its lack of accessibility; since a plane cannot ordinarily be pulled up to a loading dock, it is necessary to bring products to and from the airport by truck.

According to "Transport and Distribution", air cargo remains a comparatively small segment of total freight transport volume when measured by tonnage. But with the increase of manufacturers adopting "just in time" delivery systems, as well as the increasing number of high-tech industries adopting the "build-to-order" strategy, accessing to air transport is expected to become increasingly important.

1.2.5 Pipeline Transport Mode

Pipelines are almost everywhere designed for a specific purpose only, to carry one commodity from a location to another, such as oil and gas, they can also be used to deliver certain products (chemicals, slurry coal, etc.).

Pipelines are an extremely important and extensive mode of land transport, although very rarely appreciated or recognized by the general public, mainly because they are buried underground (or under the sea as in the case of gas pipelines from North Africa to Europe). In the US, for example, there are 409,000 miles of pipelines that carry 17% of all ton/miles of freight.

Pipeline routes tend to link isolated areas of production with major centers of refining and manufacture in the case of oil, or major populated areas, as in the case of natural gas.

Pipeline operating costs are very low, pipelines represent a very important mode for the transport of liquid and gaseous products. One major disadvantage of pipelines is the inherent inflexibility of the mode. Once built (usually at great expense), expansion of demand is not easily adjusted to. There are specific limits to the carrying capacity. Conversely a lessening of supply or demand will produce a lowering of revenues that may affect the viability of the system. A further limit arises out of geographical shifts in production or consumption, in which a pipeline having been built from a location to another may not be able to easily adjust to changes.

1.3 Sustainability and Sustainable Transportation

1.3.1 Definition of Sustainability

The terms "sustainable development" and "sustainability" have come to encompass a wide variety of environmental, economic, and social concerns (Figure 1.1). The phrases "sustainable societies" and "sustainable development" had their origin in the mid-1970s, when concern over the environment and an expanding world population began to grow in many industrialized nations (Hitchcock 1991). An often-cited definition of sustainable development is the following, adopted in 1987 by the United Nations World Commission on Environment and Development (WCED) (Bundled Commission) (WCED 1987, 43): "A sustainable condition for this planet is one in which there is stability for both social and physical systems, achieved through meeting the needs of the present without compromising the ability of future generations to meet their own needs."

1.3.2 Sustainability and Sustainable Transportation

The antecedents to contemporary concerns over sustainable development extend back

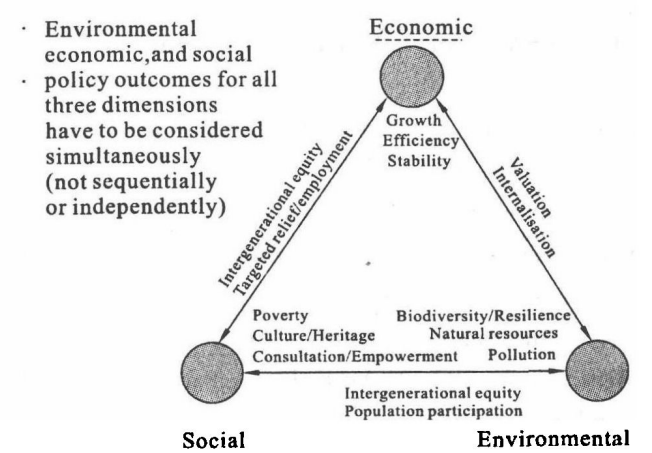

Figure 1.1 Three Dimensions of Sustainable Development

more than 200 years to the theories of Thomas R. Malthus and more recently to concerns raised in the 1960s over "limits to growth" (see Reading Materials). Although the earlier concerns focused mainly on the overuse and depletion of tangible resources and materials such as agricultural land, fuel, and minerals, much of the current debate over sustainable development centers on the mistreatment of more ubiquitous but intangible natural resources, such as global climates, the protective ozone shield, and the life support provided by well-functioning ecosystems and a diversity of plants and animals. Often the benefits provided by these resources transcend geographic and generational boundaries; hence their misuse is difficult to regulate by either market mechanisms or government intervention. Yet, if these irreplaceable resources are permanently degraded, the harm to future generations could be significant.

As notions of sustainable development have evolved and been applied in recent years, they have become associated with a wide array of issues and public policy concerns. Although these applications have often been related in their fundamental emphasis on ensuring a habitable planet, some have focused more on ecological and natural resource needs for achieving this goal, whereas others have stressed the social and economic dimensions of this goal. In the transportation field, a number of conferences, papers, and reports have addressed these issues as part of broad conceptions of "sustainable transportation", "sustainable communities", and "sustainable cities" (Replogle 1991; Roseland 1992; Whitelegg 1993; OECD 1995; Sperling and Shaheen 1995; World Bank 1996; President's Council on Sustainable Development 1996a, 1996b). Numerous subject matters have been covered in these activities, such as the role of transportation in ensuring future availability of petroleum and other energy supplies, curbing urban air pollution and traffic congestion, providing access to jobs and services for the low-income and elderly population, and creating more inviting and prosperous central cities.

1.3.3 Transportation—A Strategic Key to Development

Transportation is central to development—without physical access to jobs, health, education and other amenities, quality of life suffers; without physical access to resources and markets, growth stagnates and poverty reduction cannot be sustained. However, inappropriately designed transport strategies and programs can result in networks and services that aggravate the conditions of the poor, harm the environment, ignore the changing needs of users and exceed the capacity of public finances.

Studies by the World Bank (1996) show that transport generates growth by facilitating trade, both nationally and internationally, and by increasing access to health and education facilities as well as local and national amenities. At the macroeconomic level, cross-country studies have confirmed that investment in transport raises growth by increasing the social return to private investment without"crowding out" other productive investment' and that inadequate transport infrastructure is an important constraint on aggregate agricultural productivity. At the microeconomic level, transport improvements directly lower agricultural input prices and hence production costs, increase access to markets and hence diversification of outputs, and indirectly facilitate the development of the non-agricultural rural economy. In urban areas, the quality of transportation infrastructure and public transport service affects the location decisions made by firms and individuals, the scale and form of urban agglomerations, the efficiency of the labor market and the costs at which labor is obtained. At the project level, OED reports show the performance of the Bank's lending in the transport sector is above average, both at appraisal and at completion.

1.4 Notions of Sustainable Transportation

A sustainable transportation system is one that is safe, efficient and environmentally friendly. Sustainable transportation is about integrating economic, social and environmental considerations into decisions affecting transportation activity. Economically, we need a transportation system that is efficient and competitive. Socially, our transportation system must be safe and accessible. In addition, we need a transportation system that respects the natural environment. It is not always easy to balance these three considerations—sometimes there are trade-offs but there are also win-win-win opportunities.

According to the report *Sustainable Transport: Priorities for Policy Reform* (World Bank, 1996), the definition of sustainable transportation consists of three dimensions, economic, environmental, and social sustainability.

1.4.1 Economic and Financial Sustainability

The primary economic and financial sustainability is to make transport more cost-ef-

fective and continuously responsive to changing demands. The strategy to achieve this involves creating competition in those parts of the sector where a commercial market can operate without significant adverse spillover and distributional consequences, and enhancing user participation in those parts where it cannot. Competition must be facilitated by regulatory reform to enable private firms to enter and exit from the market freely. Where social or environmental consequences are important, as for infrastructure with significant economies of scale, competition "for the market" through tendered franchises may be more appropriate than free competition "in the market". The commercialization of remaining public sector firms can also contribute significantly to economic and financial sustainability. In all these cases, markets will not work properly unless users are charged the full cost to society of their use of transport infrastructure.

1.4.2 Environmental Sustainability

Transport has significant effects on the environment that should be explicitly addressed in project and program design. Reducing life and health-threatening effects should be the highest priority. Making better use of readily available and cost-effective technology is necessary, but not in itself sufficient. More strategic action is also required in the form of better directed land-use planning and stricter demand management including the use of pollution and congestion charges to correct the relative prices of private and public transport.

The objective is to ensure that environmental issues are addressed as an integral part of transport strategy formulation and project design, and that actions are selected that have a high ratio of benefit to cost or are cost-effective.

1.4.3 Social Sustainability

Transport strategies and programs can be designed to provide the poor with better physical access to employment, education and health services. For the urban poor, adequate public transport, including the services of the informal sector and non-motorized transport is essential. For the rural poor, the provision and maintenance of rural access facilities can be improved by extending community participation in decision-making and project implementation. Effective arrangements are also necessary to address occupational and spatial dislocation and any distributionally unacceptable consequences of the further commercialization of transport.

1.5 Main Challenges of Sustainable Transportation

1.5.1 Challenges to Economic and Financial Sustainability

Economic and financial sustainability, which involves making the best use of available

resources and maintaining physical assets, is the basis on which environmental and social sustainability can be founded. Excessive government intervention has undermined this basic economic sustainability by undermining incentives to efficiency and flexibility.

The first challenge to be faced in overcoming this is the creation and maintenance of a competitive market based transport sector. This can be achieved either by liberalizing entry to transport can be subject to competition or by contracting out activities suitable for private supply and through competition for concessions to finance, construct and operate.

The second challenge is the introduction of economically efficient charges in general and for the use of road infrastructure in particular. Where direct charging is not applied, as for roads in most countries, the level and structure of taxation, particularly fuel taxation, is critical. European levels of fuel taxation are a better benchmark than U. S. levels when the full social costs of transport are taken into account.

1.5.2 Challenges to Environmental Sustainability

Transport assists income growth but can also reduce social welfare by creating local air, noise and visual pollution, contributing to global warming, and acting as an instrument through which natural habitat and biodiversity can be undermined. These adverse effects often go unchecked because they are the unrecognized public side effects of private activity.

The first challenge is to understand the mechanisms through which environmental and ecological impacts emerge, the values which society places on them, and the range of potential remedial actions, so that manageable issues of high priority, such as road safety and some air pollution problems (for example, lead from gasoline), can be addressed immediately.

The second challenge is to find ways of integrating the less critical but widely dispersed environmental concerns within economic incentive structures. Direct congestion and pollution charges are the preferred mechanism, but require further development. In their absence, policies on public transport fares and on road user charges must be complementary, urban structure and transport planning must be integrated, and physical demand management must also be used to compensate for pricing deficiencies. The appraisal of rail and non-motorized transport should involve a rigorous assessment of their potential environmental advantage.

1.5.3 Challenges to Social Sustainability

The wealth increasing effect of transport should reduce poverty. But it does not always do so both because improvements may concentrate benefits on richer classes (particularly where expanded provision for the private automobile is concerned) and because the processes of transport improvement (for example, deregulation) may sometimes adversely affect the poor.

The first challenge is thus to design general transport policies focused on the poor. This involves providing adequate transport for journeys to work, eliminating impediments to non-motorized transport, mobilizing the potential of the informal sector, and eliminating gender biases in transport planning and provision. Poor rural areas may best be helped by emphasizing accessibility rather than high service quality in infrastructure provision, and by enhancing local participation in supply and labor based infrastructure construction and maintenance.

The second challenge is the mitigation of unwanted social effects of economic reforms in the sector. This will involve managing problems created through spatial or occupational dislocation through efficient and fair implementation of local programs of resettlement and re-employment.

1.6 Summary

The definition of sustainable transportation consists of three dimensions, economic, environmental, and social sustainability.

The primary economic and financial sustainability is to make transport more cost-effective and continuously responsive to changing demands. The economic sustainability is to ensure that environmental issues are addressed as an integral part of transport strategy formulation and project design, and that actions are selected that have a high ratio of benefit to cost or are cost-effective. Transport strategies and programs can be designed to provide the poor with better physical access to employment, education and health services.

To realize transport sustainability, we have to overcome some challenges. To economic and financial Sustainability, the first challenge to be faced in overcoming this is the creation and maintenance of a competitive market based transport sector. The second challenge is the introduction of economically efficient charges in general and for the use of road infrastructure in particular.

To environmental sustainability, the first challenge is to understand the mechanisms through which environmental and ecological impacts emerge, the values which society places on them, and the range of potential remedial actions, so that manageable issues of high priority can be addressed immediately. The second challenge is to find ways of integrating the less critical but widely dispersed environmental concerns within economic incentive structures.

Whereas to social sustainability, the first challenge is to design general transport policies focused on the poor. The second challenge is the mitigation of unwanted social effects of economic reforms in the sector.

New Words and Expressions

sustainability *n.* 可持续发展

sustainable transportation	可持续发展的交通运输
economic and financial sustainability	经济和财务的可持续发展
lead	*n.* 铅
carbon monoxide	一氧化碳
ozone	*n.* 臭氧
sedimentation	*n.* 沉淀，沉积
contamination	*n.* 污染
tangible resource	实物资源，有形资源
cross-country	横越全国的
cost-effective	*a.* 符合成本效益的
trade-off	*n.* 权衡利弊，效益悖反
restriction on entry	进入壁垒
subcontractor	*n.* 分包商
unregulated	*a.* 不受管制的
cartelization	*n.* 组成卡特尔，组成企业联盟
unremunerative	*a.* 无报酬的，无利可获的
road franchising	线路特许经营
toll road	*n.* 收费公路
maritime transport	海上运输
inland waterway transport	内河运输
non-motorized transport	非机动车交通
congestion and pollution charges	拥塞和污染收费

Exercises

1. Describe the background of endorsing the concept of sustainable development.
2. Explain the definition of sustainable transportation.
3. Describe the characteristics of the five transportation modes.
4. List the three dimensions of sustainable development.
5. What's the key issue in sustainable transportation?
6. List the main challenges of sustainable transportation.

Reading Material

Malthus, Limits to Growth, and Sustainable Development

The concern over sustainable development is not new, but has roots that extend back at least to the eighteenth-century economist and philosopher Thomas R. Malthus. Theorizing that temporary improvements in human living standards would trigger population sur-