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A FRAMEWORK FOR BENCHMARKING ENVIRONMENTAL SUSTAINABILITY OF TRANSPORT IN ASIAN MEGA-CITIES

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Abstract: An increase in environmental load from the transport sector is of particular concern in Asian mega-cities due to the anticipated increase of automobile traffic. This paper aims to propose a framework for an inter-city comparison of Asian mega-cities in order to evaluate their states of urban spatial structure, transport and environmental situation. Motorization, as the dominant factor of increases in environmental load from the transport sector, has the characteristics of irreversibility and synergism with urban sprawl. To deal with such issues, five topics are introduced: 1) induced vehicle traffic due to road improvement, 2) the relationship between vehicle-related taxation and road budget, 3) the relationship between public transport improvement and motorization, 4) the impact of urban planning and land use management, and 5) public consensus for enforcing policy measures for Environmentally Sustainable Transport (EST). Finally, the paper describes the necessity of benchmarking based on the given five topics for inter-city comparison and relative evaluation.

Key Words: Environmentally sustainable transport (EST), Motorization acceleration, Urban sprawl, Benchmarking

1. INTRODUCTION

To control transport-related carbon dioxide (CO_2) emission that has been rapidly growing worldwide is one of the most significant issues to reduce greenhouse gases (GHGs). Needless to say, a dominant cause of increase in transport-related CO_2 emission is the progression of motorization (Altshiler, et al, 1984). The methodologies to tackle it can be divided mainly into two ways. One is the technological approach by improving vehicles and fuels. The other is the control of transport demand itself. While the former is effective for solving air pollution problem, it has limitation for achieving CO_2 emission reduction. Hence, the necessity not to implement one independently of the other, but to combine both ways, has been widely recognized.

In mega-cities of Asian developing countries, air pollution from the transport sector has been a serious problem, and further deterioration is of great concern due to 1) the rapid increase of the number of automobiles with economic growth, 2) the proliferation of transport demand and suburbanization caused by an over-concentration of people in the primary metropolis, 3) delay of transport infrastructure improvements, and 4) delay of technological improvement to vehicles and fuel. Harmful results, such as traffic accidents and congestion, are also serious matters to be concerned. Such a transport system can be regarded as the factor which undermines urban sustainability. Thus, feasibility of sustainable cities depends on improvement of such transport systems. This paper aims to propose a framework of a methodology which examines environmental sustainability of transport system in Asian mega-cities.

2. ENVIRONMENTAL SUSTAINABILITY OF URBAN TRANSPORT SYSTEM AND MOTORIZATION

In order to examine environmental sustainability of urban transport systems, the definition of sustainability must be clarified in the first place. A general definition of sustainability is to satisfy the needs of the current generation without damaging the ability to meet the needs of the next generation. In other words, it means the state where livelihood and socio-economy of the next generation are not deteriorated by the excessive environmental loads resulting from such current human activities as wasteful use of land and energy resources.

How can motorization be evaluated from such the viewpoint? An automobile is a convenient instrument which dramatically improves human mobility. With ownership and use of automobiles, accessibility to wider areas is provided and stable logistics is assured, thereby leading to an increase of available areas. As a consequence, the degree of spatial freedom for inhabitation and production is improved. Since mobility is also a basic means of communication, motorization enables various meetings and creates business chances. Because of an increase of social costs by environmental loads, traffic congestion and infrastructure investment, the necessity to avoid those costs by controlling motorization is often claimed (Uzawa, 1974). However, the fact that motorization has developed in almost all the countries or cities can be interpreted as the result of recognizing higher social benefits than social costs by motorization. This interpretation is proved by Japanese experience. In Japan, an increase in automobile ownership and usage has not eased despite excessive burdens for automobile owners and users resulting from the mechanism to internalize the social costs, such as vehicle-related taxes as specific revenue sources for road construction, and automobile insurances as provisions for traffic accident costs. It is commonly known in cost-benefit-analyses of road construction that benefits from time savings largely exceed those from environmental loads, even though there remains an issue on how to convert them into monetary terms (Kato, et al, 1996).

It is, however, still unwise to conclude that motorization is thoroughly affirmed, because the effects of motorization are perceived not in a long-term perspective, but in a short-term perspective.

The term ‘motorization’ does not only mean dissemination of automobiles but also indicates the significant change of society and individual life style by the popularization of automobiles. This can be classified as following four stages.

1) Dissemination of automobiles: Increase of automobile ownership,
2) Motorization of transport activity: Increase of automobile usage in transport,
3) Motorization of lifestyle: Shift to automobile dependent lifestyle, and
4) Motorization of urban spatial structure: Shift to urban spatial structure supposing use of automobiles.

Of the four stages, 3) and 4) are of particular importance. As mentioned earlier, automobiles remarkably enhance mobility of individuals. Once lifestyle is changed for automobile reliance (e.g. commuting, shopping, choice of business partners, etc), it is very difficult to change the lifestyle afterwards regardless of various measures to control automobiles. More specifically, motorization has the characteristic of irreversibility by its nature. More over, in the motorization of urban spatial structure, a high mobility of automobiles induces sprawling phenomenon in low density areas as population increases with economic development. Since this phenomenon leads to a decline of public transportation usage and creates the cycle in which the necessity of automobiles is enhanced, reversing it can be seen as an almost impossible task. The process through which dissemination of automobiles first generates a synergy effect with urban sprawl and then arrives at a lifestyle and urban spatial structure depending on automobiles is named 'motorization acceleration' in this paper.

Because of its irreversibility, the more motorization develops, the less the effects of policies for controlling automobiles become. To put it another way, the more the implementation of such policies is delayed, the larger the negative effects of motorization is and the lower is future transport convenience, thus damaging urban sustainability.

Figure 1 shows the transitive relationship between per capita gross regional product (GRP) and cars per 1,000 inhabitants in Tokyo, Nagoya, Bangkok, and Beijing. As can be seen from the figure, any of these cities undergo a transition proportionally with a similar path at the stage of GRP from 3,000 to 4,000 US$. It can be concluded that automobiles are luxury goods until that stage, and thus have no relationship between urban spatial structure and the transport system.

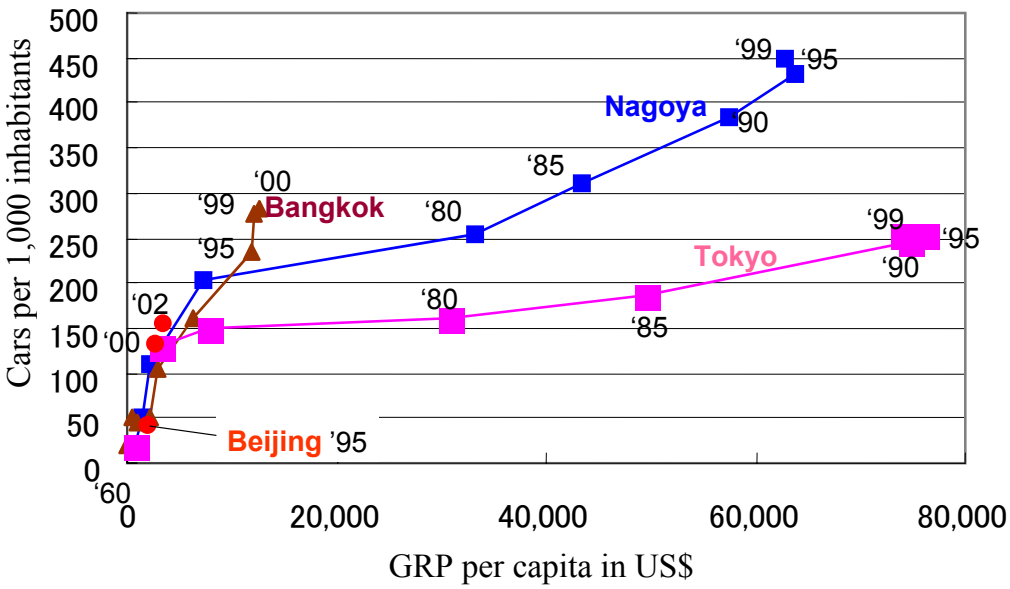

Figure 1. Relationship between per capita GRP and Cars per 1000 Inhabitants

After that stage, both Tokyo and Nagoya show a moderate upward trend, but the degree of inclination of Nagoya is greater than that of Tokyo. It results from different urban spatial structures and transport systems at the stage when automobiles were popularized. The difference can be explained by a lower city population density and a less advanced railway transport system in suburban areas in Nagoya, compared with those in Tokyo. Although the development of subways and suburban railways has been continuously implemented in Nagoya, the upward construction does not proceed so easily and the business after opening of subways and suburban railways tends to be unprofitable due to less densely developed suburban areas.

In Bangkok, this trend went up to a still higher level in the past ten years, without becoming smaller. Despite its economic growth level, automobiles have spread excessively. Since the 1970's, Bangkok has conducted road-oriented transport policies in which large-scale road projects, such as ring road developments, have been carried out. As a result, Bangkok was called the worst traffic congestion city in the beginning of the 1990's. In order to tackle this issue, the development of railways was emphasized. An example of this is the BTS Skytrain which was in service from 1999. However, the "road map" for moving away from automobile-dependent urban spatial structure has not been found at all.

In mega-cities of Asian developing countries, including Bangkok, para-transit occupies the important position as a mobility pattern in the metropolitan area. Since people's needs to door-to-door transport modes are strong, the conversion from bicycles to motorbikes and further to automobiles according to income levels is comparatively easy to happen. Because it is difficult to reduce an increasing rate of ownership ratio of automobiles, it has to be suggested to carry out a railway-oriented transport system at a high service level and to complete the regulation and taxation system for controlling suburbanization.

This viewpoint is important not only for the urban areas with developed motorization like Bangkok but also for the areas with still developing motorization like Beijing. In other words, it can be predicted that urban sustainability will be aggravated by serious traffic congestion and global and local environmental loads triggered by an increase of vehicles with economic growth unless a railway-oriented transport system is promptly developed.

3. BENCHMARK SYSTEM FOR EVALUATING EFFECTS OF TRANSPORT SYSTEM ON URBAN SUSTAINABILITY

In order to quantitatively evaluate the change of urban sustainability accompanied by the synergism of motorization with urban sprawl, this paper introduces the methodology of benchmarking. The factors that contribute to the progress of motorization and environmental degradation are first arranged into the five categories to be focused, i.e. 1) induced traffic due to road improvement, 2) the relationship between vehicle-related taxation and road budget, 3) the relationship between public transport improvement and motorization, 4) impact of urban planning and land use management and 5) public consensus for enforcing policy measures for Environmentally Sustainable Transport (EST). The five categories are then to be attempted to carry out inter-city comparison and relative evaluation in the benchmarking process proposed.

3.1 Induced Traffic Due To Road Improvement

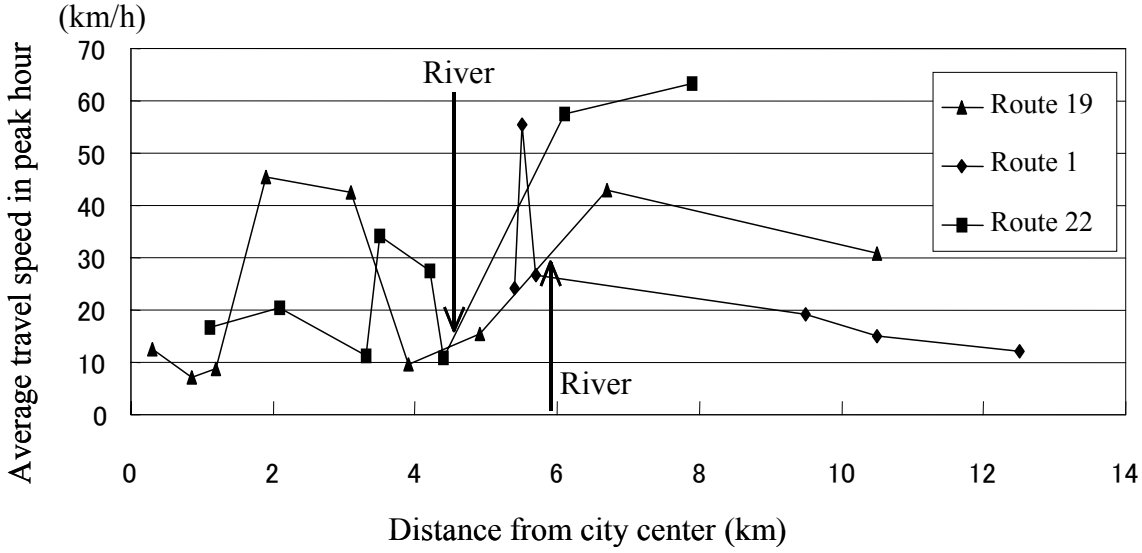

Figure 2. Average Vehicle Travel Speed in Peak Hour on Main Corridors in Nagoya

Road improvement is a policy that mitigates traffic congestion as well as environmental loads since fuel consumption and environmental load emission factor are decreased by enhancing travel speed. This effect is, however, effective only in a short-term viewpoint. In the longer term, more convenience of vehicles enhanced by road improvement generates additional transport demand and again leads to traffic congestion. Furthermore, it also must be noted that many of public transportation users will shift to automobiles triggered by road improvement in a city where road and public transport coexist. This results in traffic congestion and declining frequency and service level of public transport. The situation is called "The Downs-Thomson Paradox" (Sugiyama, et al, 2002). In recent years, as seriously discussed in the European Conference of Ministers of Transport (ECMT), induced traffic due to road improvement has been one of the most important interests in transport policies. It is also necessary to analyze how much motorization will be pushed up, and how much the traffic condition will be cooled down, after enough time has passed from the road improvement.

One of the approaches verifying this effect in a real metropolis is to examine the possibility to control traffic inflow by creating a bottleneck in the road network. In other words, the phenomenon can be assessed where the traffic flow into central areas is controlled by the topographically created bottlenecks in the sections a little apart from the central areas. Figure 2 shows the relationship between the distance from city center and average travel speed in peak hours by corridors in the Nagoya radial trunk roads. The part shown by the arrow indicates position of the Shonai River which is the bottleneck of road networks, flowing from the northeast to west through Nagoya. Travel speed near the Shonai River by corridor drops and, more important, recovers to the equivalent level as that in the center and suburban areas. On this basis, it can be considered that automobile convenience has been kept to a high level in the central area of Nagoya because of the topographical control of automobile access from suburban areas by such bottlenecks. However, in order to efficiently benefit from such control, it is necessary to develop railway-oriented transport network in parallel as an alternative means of transport from the suburban to central areas.

3.2 Relationship between Vehicle-Related Taxation and Road Budget

Regardless of economic development level, many countries have collected taxes at the stage of automobile registration, acquisition, possession and use (fuel consumption). In recent years, the introduction of carbon tax, which plays a role of vehicle usage tax, is moving ahead in some of the European Union member nations. Although vehicle-related taxation is effective to restrain car ownership and use, it is necessary to examine the balance of the tax rates in each stage because its effects differ in the collection stage (Hayashi, et al, 1999).

The principal reason why many countries have introduced vehicle-related taxes is to secure tax revenue. Vehicle-related taxes are positioned as luxury taxes in developing countries. Meanwhile, they are appropriated for development, operation and maintenance of road and public transport, or for some special tax revenue, in many developed countries. Since motorization has a characteristic of irreversibility, imposition of taxes does not discourage automobile ownership and use. Furthermore, vehicle-related tax revenue does not fluctuate in line with business cycles. For these reasons, vehicle-related taxes can be applied as highly convenient revenue sources by nature.

More controversial is the use of vehicle-related taxes. Some countries like Japan have implemented the financial framework in which vehicle-related taxes are used for road development and maintenance. This framework is based on a beneficially-pay principle. Under this framework, the more vehicles are used, the more roads are developed, leading to induced traffic, and furthermore, to reproduction of motorization. Because it is very difficult to supply roads in accordance with traffic demand from a financial viewpoint in developing countries, serious traffic congestion and local environmental issues are often found despite their car ownership level. It can be seen that it is effective to apply vehicle-related taxes as the revenue sources exclusively used for road development in the short-term. However, it should be noted that this financial framework results in the expanded reproduction of motorization in the long-term.

Some European countries such as Germany have a system in which vehicle-related taxes are appropriated for public transport improvement, and the system plays a role to assure mobility with public transport and reduces automobile ownership and use. Thus, it can be seen that to examine the relationship between vehicle-related taxation and road budget is crucial to comprehend the effects of transport systems on urban sustainability.

3.3 Relationship between Public Transport Improvement and Motorization

In response to the irreversibility of motorization, it is effective to develop a public transport system at the stage where motorization is not so progressive. In this sense, Japan has a successful experience. Until the 1960s, well-developed railway and bus networks played a significant role in supporting the increase in public transport in metropolitan areas. In particular, the following characteristics are praised as being uniquely Japanese; 1) development of railways linking between inner and suburban areas by private railway companies, 2) absorption of development profit and passenger securing by additionally operating related businesses, such as real estate, distribution and leisure business, and 3) mutual direct line between subways and suburban railways. These characteristics remain valid today to secure a self-sustaining system of public transport companies. Such a business

scheme for introducing public transport can be of relevance to developing countries where motorization and urban area expansion is still at the initial stage.

3.4 Impact of Urban Planning and Land Use System

Because urban development is accompanied by an increase in population and economic activities, suburbanization enabling such an increase can not be avoided. However, by use of adequate regulations of land-use, phenomena such as sprawl and ribbon development in the process of suburbanization can be averted. Also, it relates with public transport service level at the same time. The encouragement of Transit Oriented Development (TOD) and the location regulation according to the transport facility service status, such as the ABC policy in the Netherlands, are effective to restrain the progression of motorization in the long-term. Meanwhile, in developing countries and Japan, there is much dissatisfaction on the urban planning system, which is not effective to control motorization.

Moreover, it is necessary to examine land regulation and taxation systems that support the urban planning system. Japan, for example, has a land system in which the factors to disturb urban planning are included. These include the strong land ownership right, considerably subdivided land ownership, and less advanced land registration system. In line with the land systems, comparative examination on land-related taxation is also needed because of its location induction effect.

3.5 Public Consensus for Enforcing Policy Measures for EST

Underlying causes of motorization of lifestyle and urban spatial structure are consciousness and habitude of individuals and societies. Generally, in developing countries, holding vehicles is a series of pride, while public transport and para-transit have negative images. This consciousness, as a result, enhances development of motorization. Also, the consciousnesses with regard to environmental issues and social cost burdens accompanied with vehicle usage are not in a uniform state. Since this aspect directly affects the policy proposals and implementation, the approach to directly involve citizens plays a critical role in enhancing their feasibilities.

In addition, it is necessary to examine the process of the consensus building that includes political and public administration system in order to coordinate stakeholders when transport and environment policies are implemented.

4. CONCLUSION

This paper examines a methodology for evaluating the sustainability of urban transport systems in Asian mega-cities, considering economic development stages, urban scales, and the speed of urbanization and motorization processes. Overall structure of the methodology can be summarized as shown in Figure 3. The figure illustrates the mechanism with regard to motorization and environmental degradation in which the items are monitored and indicators are positioned. 1) Induced traffic due to road improvement and 2) Relationship between vehicle-related taxation and road budget are intended to comprehend the mechanism of motorization acceleration from a macroscopic viewpoint. 3) Relationship between public

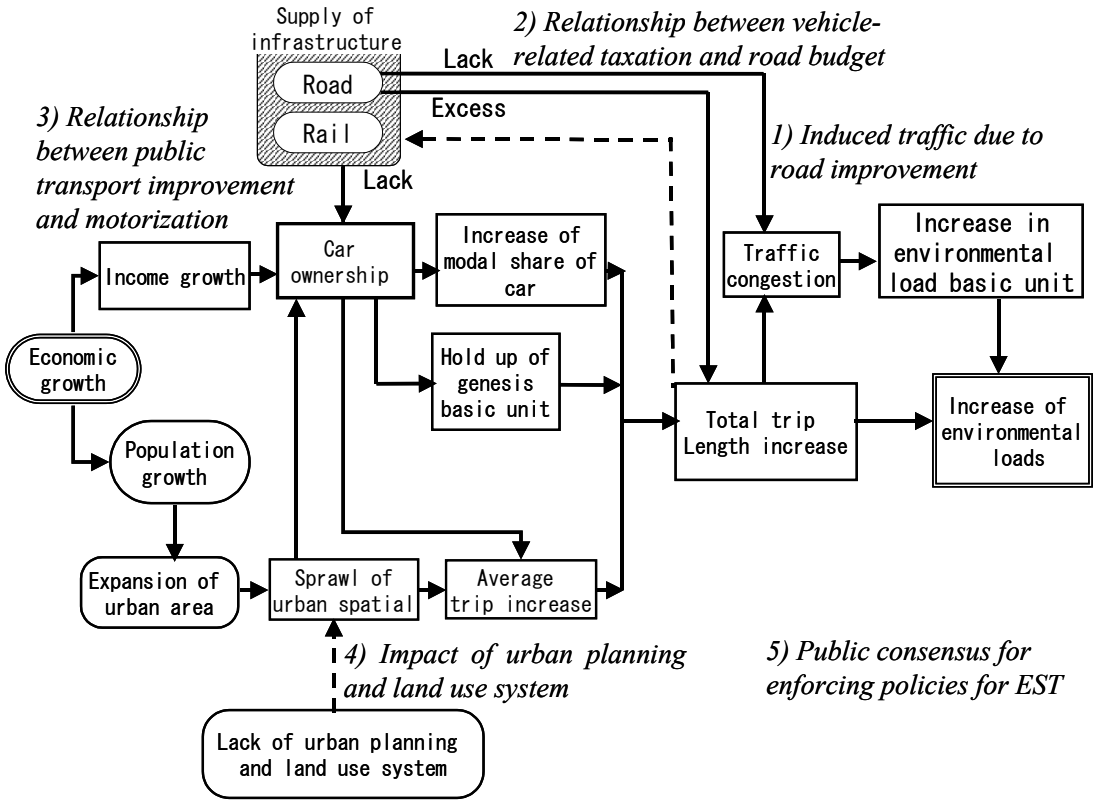

Figure 3. Motorization Mechanism and Benchmarking of Urban Environmental Sustainability

transport improvement and motorization and 4) Impact of urban planning and land use system are attempted to consider transport-related policies in accordance with the development stages of motorization. 5) Public consensus for enforcing policy measures for EST is set out to examine the feasibility of policy implementation from political and social viewpoints.

In the future, observable benchmarking indicators are concretely to be introduced on a basis of the proposed framework in order to reduce transport-related environmental loads in the long-term in Japan and Asian developing countries. Also transport systems management and travel demand management techniques, which have wide varieties, have not been chosen as a benchmarked item in this paper, but they should be examined in the future. Later, this study will examine the "road map" to realize sustainable urban development.

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