Transit-oriented Development versus Car-oriented Sprawl: The Story of Tokyo and Adelaide

Ali Soltani[1] Noriko Kono[2]
[1] PhD Candidate, University of South Australia, Adelaide, SA, Australia
[2] Researcher, Institute for Global Environmental Strategies (IGES), Urban Environmental Management Project, Kanagawa, Japan

1 Introduction

The increasing urban sprawl and its subsequent concerns highlighted the importance of planning paradigm to promote sustainability of communities through land use-transportation solutions. Two case metropolitans: Adelaide and Tokyo locate in Asia-Pacific area and both from developed countries are selected for the study of interactions between urban structure and transport issues. Tokyo is well known as one of largest and densest cities and one of the best public transit serviced cities in the world. On contrast, Adelaide is known as one of the low density cities and one of the most car dependent cities. From an analytical standpoint, metropolitan Adelaide represents an acceptable representation of an “Australian city”, in the widespread car use/ownership occurred well in recent century. There are also noticeable differences in transportation structure, planning, supply and pricing as well as cultural issues. However, despite some limitations such as the difficulties involved in obtaining data in comparable spatial units which preclude such comparisons across the two cities, this work will provide a starting point for systematic comparative analysis of travel trends resulted from urban form issues.

This paper specifically looks for three main questions. (a) In which ways, urban form differs between Adelaide and Tokyo metropolitan areas? (b) What are the influences of urban form on transport issues included travel behaviour and greenhouse gas emissions? (c) What are the policy implications for overcoming car dependency concerns in Adelaide?

This paper is organised in three sections: section one introduces the spatial structure of two case areas; section two compares two case areas in terms of transport issues and in the last section the potential implications of snapshot comparisons for metropolitan Adelaide are discussed.

2 General image of two case studies

Though there are different ways to introduce metropolitan areas, in this study a general image of them are presented. The Adelaide metropolitan area includes CBD and outside suburbs and is consistent with 2001 Journey to Work (JTW) Survey boundaries. The Tokyo metropolitan area includes central Tokyo city as the 23-ward area in Tokyo Prefecture plus to the areas outside the central city which is consistent with the Tokyo metropolitan region as defined for the Tokyo Metropolitan Regional Person Trip Survey (TMRPTS98) included Tokyo, Kanagawa, Saitama, Chiba Prefectures, and the southern portion of Ibaraki Prefecture (Figure 1). The Adelaide metropolitan area is 5.1 times smaller than Tokyo’s area. The Tokyo’s population is 30.8 times bigger than the Adelaide’s one. The number of workers in Tokyo metropolitan is 45.5 times bigger than Adelaide’s working population showing Tokyo’s considerable job accessibility for people living outside of the area.

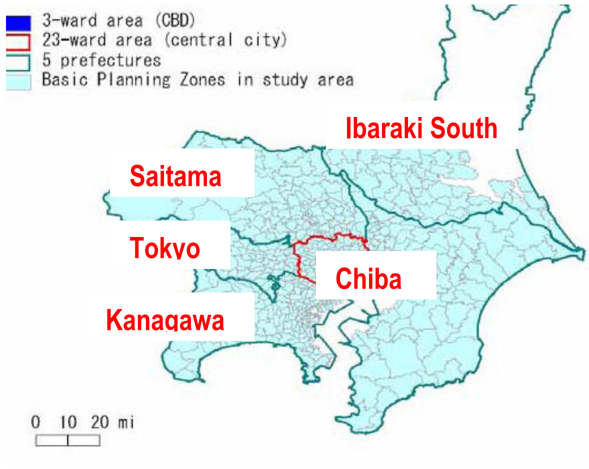

Figure 1: Tokyo metropolitan area.

3 Differences in spatial development pattern

The typical Japanese urban development is characterised by metropolitanisation, conurbation, emergence of new industrial cities (towns) and sate conurbation, emergence of new industrial cities (towns) and satellite cities like cities around large metropolitan cities, and stagnation of small and me around large metropolitan cities, and stagnation of small and medium cities.

Environmental problems have become a serious issue in the fast growing urban areas of Korea. The most critical problems are related to the rapid expansion of built-up areas and the explosive growth in car dependence.

While metropolitan Tokyo is an establishment of *Transit-Oriented Development (TOD)* system at regional level, it is going to be changed to the concentrated decentralised city model. This model, advocated by Lynch (1981) suggests that cities could be built from a series, or galaxy of separate medium-sized communities, surrounded by large amounts of open space and connected major roads. He argued further that the city should be located as part of a distinct regional area, with clear boundaries based on ecological and social capacities. Concentrated decentralisation has been advocated on environmental grounds, because of its potential to reduce energy use, in particular by encouraging greater use of public transit and allowing the viable development of combined heat and power systems (Haughton and Hunter 1994). Current Japanese plans for the Tokyo Capital Region are most reminiscent of this model, as the city attempts to create a multi-nodal pattern both within the central city and throughout the urban region. A *"New City Planning Vision for Tokyo"* clarifies basic policies regarding the implementation of urban planning in the future was established in 2001 (Tokyo Metropolitan Government 2001). The scheme called *'Circular (Ring) Megalopolis Structure'* has been planned for the target year of 2025 with the aim of reduction in air pollution; increase in speed of vehicular traffic; reduction of rail commuters to Tokyo 23 wards; strengthen radial axes and decrease of load in city centre; and reduction in through traffic (Figure 2). The suburban development of Tokyo metropolitan has been following the *TOD* model. According to this idealised urban form theory, intense and comprehensive development around transit stations is a solution to locate people close to transportation services to minimise their dependence to private transportation. In fact, through a good coordination between transport projects and land development, financial benefits have been achieved through the mechanism of value capture (Morichi 2005). This strategy was presented by the *Tokyo Corporation* could generate financial resources for capital investment. However, shortages of vacant land in the urban areas, traffic congestion and environmental degradation have raised new challenges.

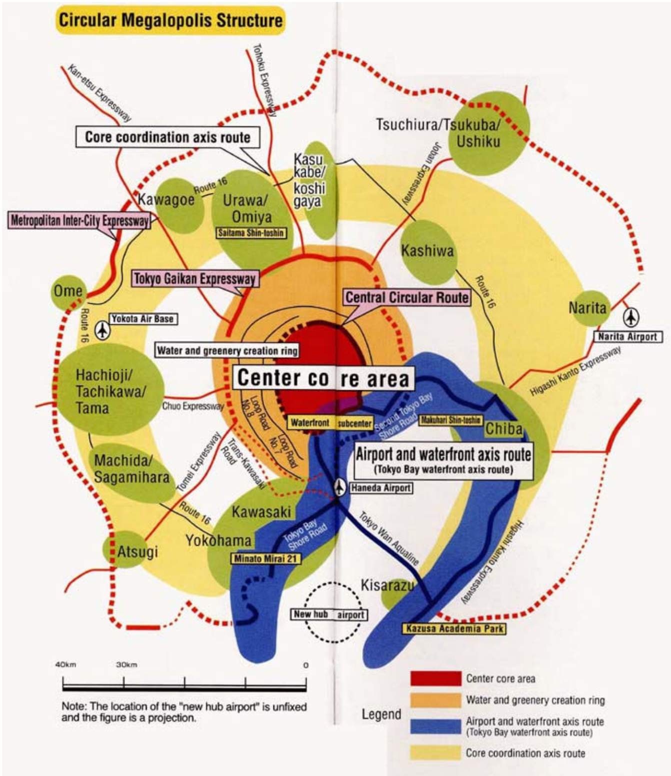

Fig. 2: Circular Structure of Tokyo (Source: Tokyo Metropolitan Government)

Due to mono-centric structure of Tokyo, all private and public sector jobs are located at the city centre, and residential areas are in the suburban area. The average one-way commuting time is over one hour. The dominant mode for commuting is the urban railway. But due to large number of commuters to the city centre especially during peak hours, there is severe congestion inside train cars and also on the railway tracks (due to higher frequency of train). Important terminals in the city centres are also over-crowded. In addition, higher frequency of trains is disrupting the road traffic since many suburban rail lines cross the roads at grade. To address these problems, TMG adopted a strategy to decentralise the concentration by creating sub-urban centres and encouraging business and government offices to relocate there. This strategy now is expected to change the mono-centric structure of Tokyo into polycentric. Japanese government is taking various measures under this strategy.

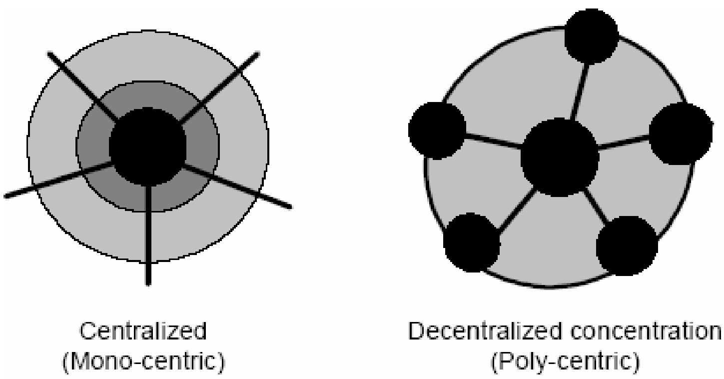

Fig. 3: Tokyo's mono-centric form is being changed to poly-centric

The metropolitan Adelaide, based on the *Garden City* model, on the other hand, has faced increasing sprawl (Figure 4). The extension of residential development and its associated service industries into the eastern mountain area raises serious issues of increased pollution in the water catchments area as well as environmental/air pollution. An urban growth boundary has recently been defined to limit this urban expansion and encourage higher density residential development at locations closer to CBD. This plan would benefit Adelaide environmentally as reductions in vehicle emissions and reduced pressure on agricultural land and water resources at the urban fringe.

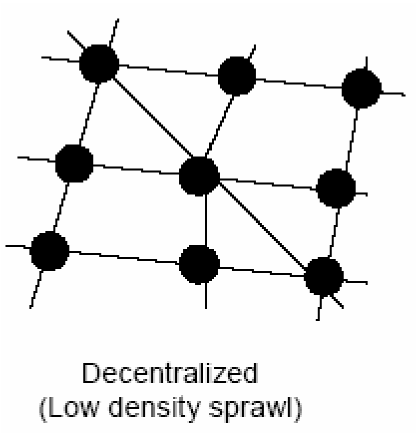

Fig. 4: Adelaide's decentralised form

4 Travel effects of urban structure; debate on previous studies

A heated debated ensued in the early 1990s over analysis by Newman and Kenworthy on the correlation between densities and gasoline consumption for a sample of international cities (Kenworthy and Laube et al. 1999).

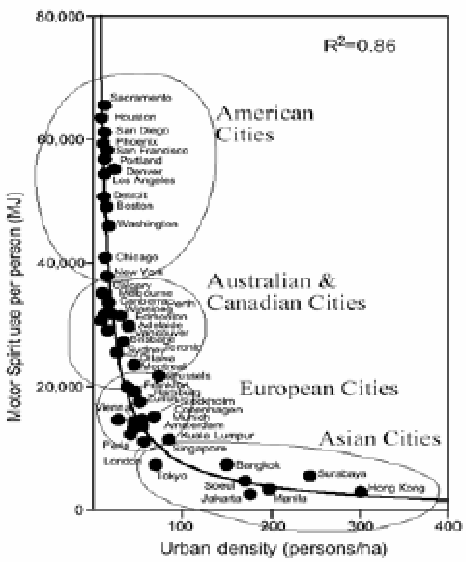

Fig. 5: Private motor vehicle fuel use vs. urban density for 46 international cities (Kenworthy and Laube et al. 1999)

Spatial features of particular areas have a strong influence on travel patterns, and the spatial policy can address transport problems effectively (Newman and Kenworthy 1999); (Banister 1992); (Cervero 1996). Higher employment density is related to higher usage of public transport (Frank and Pivo 1994). Cervero (1991) points out that walking and cycling are more popular in highly mixed land use areas. Ewing (1996) reports that building residential housing in employment areas to achieve a spatial balance between jobs and housing can decrease commuting cost. Physical planning may exert its strongest influence on non-work travel (Handy 1992).

On the other hand, some argue that spatial features are not so important, and the transport problem can be solved by the market itself (Gordon and Richardson 1989); (Giuliano and Small 1993). Some researchers are sceptical about densification since they do not believe that it is feasible or acceptable (Breheny 1992). Urban form issues are very difficult to compare between cities because of huge differences between the cities of Asia, Africa, Europe and US (Williams, http:// www.urbancity.org). Marcotullio (2001) recognises the limits of the compact city model for Asian cities, which are already the densest or most 'compact' in the world, and, which continue to suffer from extreme environmental conditions.

The important thing to be considered here is that more empirical study is needed which gives more insight with the relationship between land use and transport, and particularly the travel implications of different land use policies under the urban form issues. Furthermore, most existing studies have been done in European and North American countries, and there has been relatively little research undertaken in developing countries. Given the spectacular growth in prospect in countless cities throughout the Asia-Pacific region, more empirical studies from them are necessary and urgent.

5 Tokyo versus Adelaide

5.1 Travel patterns

While Tokyo density is five times bigger than Adelaide, but car use (km) per capita is 3.5 times less than Adelaide. Urban density is a good initial indicator of a transit-friendly urban form. Therefore, density can be used in determining a city's viability of public transport and the level of car use. Higher densities along with more mixture of land uses shorten the length of travel activities and make walking and cycling possible for more trips. An effective public transport system works better with such an area. Table 1 and Table 2 show the differences in transport-related issues between tow case study metropolitan areas.

The figures in these tables show that vehicle ownership and use is although a function of wealth and income, but it relates also to urban form characteristics. Adelaide's car dependency is considerably higher than Tokyo.

One reason is that driving and maintenance of cars in Adelaide are cheaper, easier to park and less congested. For instance, the cost of owning a car is higher in Tokyo: fuel taxes double those of the Australia account for almost half of the price of gas; car tax levies and vehicle inspection fees. A main factor in car dependence is how well the car is catered for in basic infrastructure. The length of road per person and the amount of parking in the CBD are indicatives of this factor. The role of transport in producing CO_2 had been considerable. Transport was the first sector of CO_2 production about 37% in Tokyo and 30% in Adelaide. In Adelaide, car driver was the most predominate for the 20-74 year age groups, whereas in Tokyo, it was for the 30-64 year age groups. While in Tokyo, the age group between 10 and 40 years old, tended to ride a bike, the age period for biking in Adelaide was shorter: between 10 and 20 years old. During the period of 1988-1998, in Tokyo, there was a decrease in car use, but in Adelaide, the use of public bus; car passenger and walking decreased.

Table 1: Vehicle ownership; car cost, road and parking spaces; commuting time and share of transport in air pollution in Adelaide and Tokyo

	Vehicle ownership (per 1000 persons)	Households with Zero Vehicles (percent)	Car Keeping Cost (Aus$)	Length of Road (meter per person)	No. of parking spaces per 1000 jobs	Avg. Commuting time (min)	CO_2 Share of Transport (percent)
Tokyo	280	43	2700	1.9	67	37	37
Adelaide	460	11	1400	8.7	327	23	30

Table 2: VKT; transit share; driving and biking age and changes in travel pattern in Adelaide and Tokyo

	VKT (per person)	Transit share of total km travelled	Major Car Drivers (age group)	Major Bike Riders (age group)	Travel Pattern Change between 1988and 1998
Tokyo	2800	64	30-64 years old	10-40 years old	Decrease in car using
Adelaide	7100	6	20-74 years old	10-20 years old	Decrease in public transport/walking/cycling

(Source: MAHTS99, ABS2001, TMRPTS98)

The spatial variations in job accessibility in Tokyo are somewhat unique. Generally, central-city areas, particularly around the CBDs, have high public transit accessibility. The high accessibility zones for public transit users are also found in outer suburbs such as Hakone, Liokamachi, and Kamogawa. For auto commuters, high accessibility areas are extensive, and many suburban zones, particularly inner-suburban zones, have high access measures. It is interesting that nine zones within the central city of Tokyo have job-access measures that are greater for public transit users than for auto users (Kawabata and Shen 2004).

In Adelaide, the areas with the highest levels of accessibility possess the following characteristics: close proximity to the Adelaide CBD; transport provisions; and residents with higher socio-economic status levels (Primerano 2004). Areas that have lower levels of accessibility are areas furthest away from the Adelaide CBD such as Gawler, Willunga, and Noarlunga.

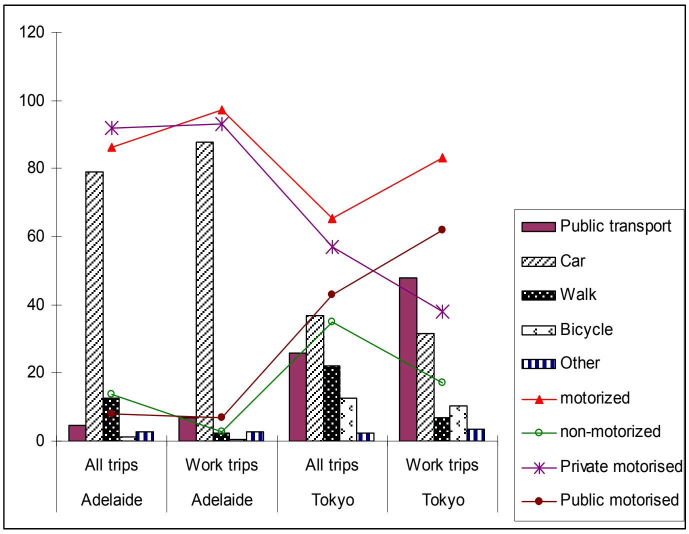

Fig. 6: Modes of travel in Adelaide and Tokyo (Source: MAHTS99, TMRPTS98)

Travel patterns differ between two areas: private car is the dominant mode of travel for both work and non-work trips such as education; shopping; social and recreation trips in Adelaide. In Tokyo, while using private vehicle is the main mode, but the majority of commuting is taken by train. Also, non-motorised modes have a considerable part in share market. In fact, travel pattern in Adelaide is mostly dominated by car using, however, in Tokyo, there is a combination of different modes of travel.

Figure 6 shows the mode share of travel for work and non-work travel in Adelaide and Tokyo. Adelaide with its low density and dispersed development pattern has only 3% of workers walking or bicycling, while Tokyo is relatively high with 17%. For all daily trips (including work and non-work trips) the figures are higher: Adelaide 14% and Tokyo 35%.

The low share of non-motorised transport in Adelaide is partly resulted from the lack of appropriate infrastructure and spaces for walking/bicycling. The majority of Adelaide citizens have bicycles and use them occasionally for recreation but have a little interest to use them for transport. For those who would like to make active choices, street design can limit their options. Key functions and activities are often located far from people's homes. The single use and large-area zoning usually found in suburban landscapes further limits residents' ability to bicycle for daily transportation. Cul-de-sacs, curvilinear streets, and limited access between neighbouring communities create circuitous routes for bicyclists. The challenges facing bicyclists in Adelaide are due to street design such as road network permeability and connectivity; urban furnishing and building facades; safety and security and access to local services. In the absence of segregated bicycle lines, bicyclists use the kerb-side lane. This makes a barrier for buses to use the kerb-side lane. The relatively small investment in cycle lanes could increase the road space for motorised traffic. Bicycle lanes also result in better space utilisation. For example, a 3.5 m lane has a carrying capacity of 1'800 cars per hour, but 5'400 bikes per hour (Replogle 1991).

On the other hand, in Tokyo, as the number of bicycles increase, the parking sites and bicycle facilities are expanded. From the early 1970s many municipalities began to build large and high-tech bicycle parking sites as an antidote to "bike pollution"-which were masses of bikes gathered next to train stations and in urban centres (Wittink 2003). The use of bicycle had increased 4.9 times from 1968 to 1998 (Ministry of Transport 2005). Nowadays, lots of outdoor bicycle parking spaces throughout the city are established. At main train stations, also indoor parking facilities are provided. Outdoor parking is mostly free of charge and indoor spaces are for a nominal fee. The setbacks of commercial buildings provide a bicycle shed places for parking where is guarded by on street eyes.

Figure 7: Bicycling in Tokyo

To encourage non-motorised travel now, TMG is attempting to improve and expand plazas in front of railway stations and roads around the stations. The 3-D crossing facility has been created to improve the safety and convenience of pedestrians. Roads in Tokyo are targeting to not only facilitate traffic, but also accommodate various public facilities and provide places for people's interaction (TMG 2001). Creation of attractive and road space; widening sidewalks and securing them; and provide more bike parking are of Tokyo 2000 Vision plan.

5.2 Change in Travel Pattern over time

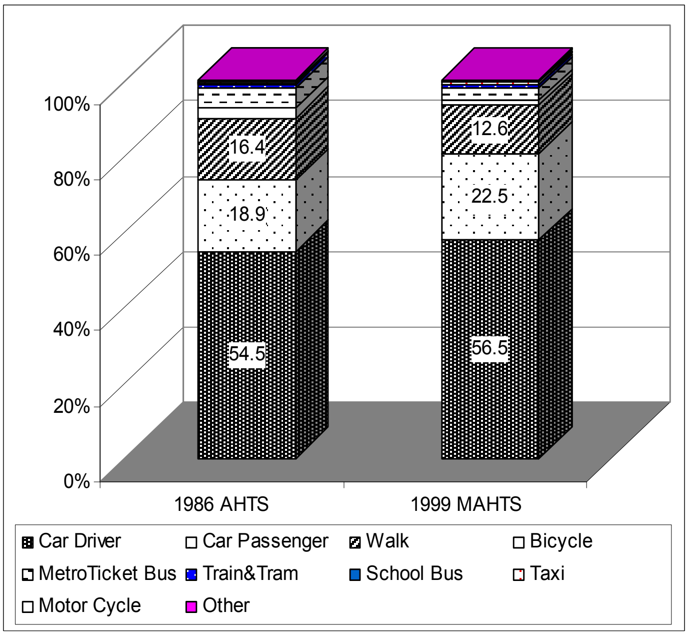

Figure 8: Change in modal choice for Adelaide

There have been several significant changes in modal trip choices since 1986, as illustrated in Figure 9. These include:

- Levels of car usage shows a marginal overall increase in generation rates;
- Walking has also significantly declined, by in the order of 35% since 1986;
- Bicycle usage has declined by nearly 50%;
- Usage of regular Metro Ticket bus service rates has declined by approximately 50% since 1986;
- A reduction in train usage rates by some 40%.

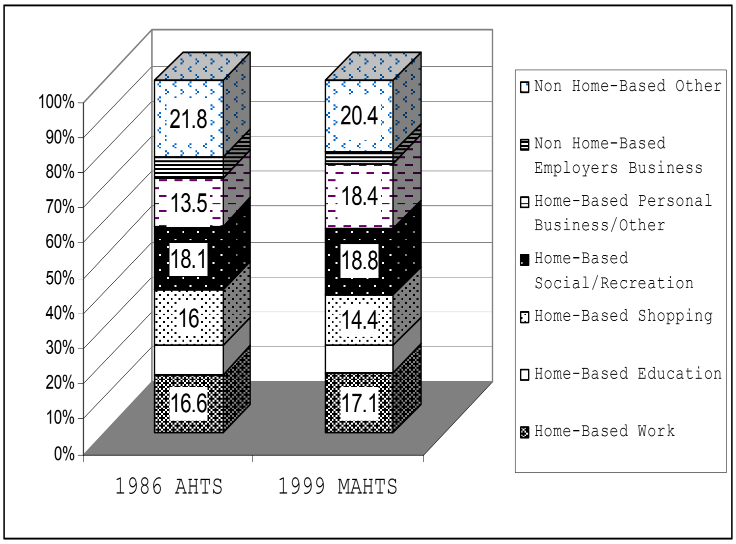

Figure 9: Change in trip purpose for Adelaide.

The comparison of the average rates by trip purpose from 1986 to 1999 in Figure 9 indicates:

- A slight increase in home-based (HB) work trips;
- A slight increase from 1986 to 1999 for discretionary trip making- for shopping, social/recreational, personal business and other home-based trips;

- Relative to 1986, the main reduction has occurred in HB shopping and non home-based (NHB) Other.

Change in travel pattern in Tokyo

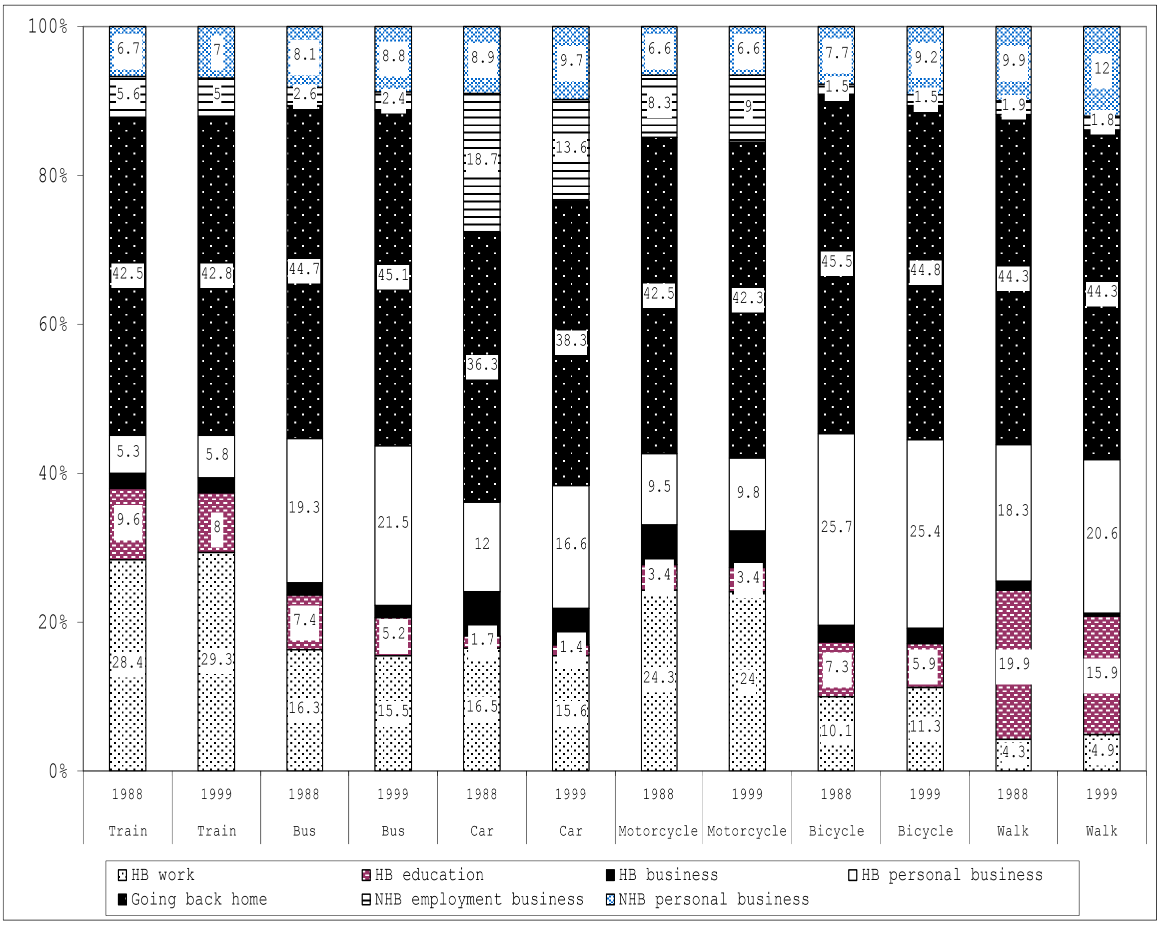

Figure 10: Change in travel pattern by mode and purpose for Tokyo (Source: TMRPTS98)

The comparison of trips taken between 1988 and 1998 by mode and purpose depicted in Figure 10 shows:

- Increase in HB work trips taken by train; walk; bicycle and decrease in work trips taken by car and bus;
- General reduction in education trips by various modes: walking and train were most favourite modes;
- Increase in car use; walk; bus and train for HB personal business;
- Decrease in train and bicycle for returning to home and increase in car and bus use;
- Not significant change in modes for the purpose of NHB employment business except decrease in car use;
- Slight increase in all modes for other personal business trips.

5.3 Emissions

One of the most important environmental issues related to the transport and land-use policies is the reduction of energy consumption and use policies is the reduction of energy consumption and especially CO_2 emission in transport field which actually accounts for emission in transport field which actually accounts for twenty per cent of total CO_2 mission in Japan. And about 90% of the emission in Japan the emission is caused by the fuel consumption of automobile traffic emission. Fuel types were electricity and oil in producing CO_2. The majority of these oil and electricity are used by transport, residential and commercial sectors. The estimation of CO_2 emissions by sector and fuel type suggests that CO_2 emissions in Tokyo have increased more than two times in last three decades (1970-1998) with 2.5% annual average growth rate. During the same time, the annual average growth rate of energy was 6.87% (Dhakal et al. 2003).

Figure 8 illustrates the share of different sectors in producing CO_2 in Tokyo. The role of transport in producing CO_2 had been considerable. Transport was the first sector of CO_2 production about 37% (22'000 thousand tons) of the main CO_2 during 1980-1998. It had a greater increase between 1970 and 1980. While the share of commercial sector had increased during 1970-98; the share of industry had decreased at the same period. The share of residential sector had remained stable from 1980 to 1998 around 125 of total CO_2 production, although it had a large increase between 1970 and 1980.

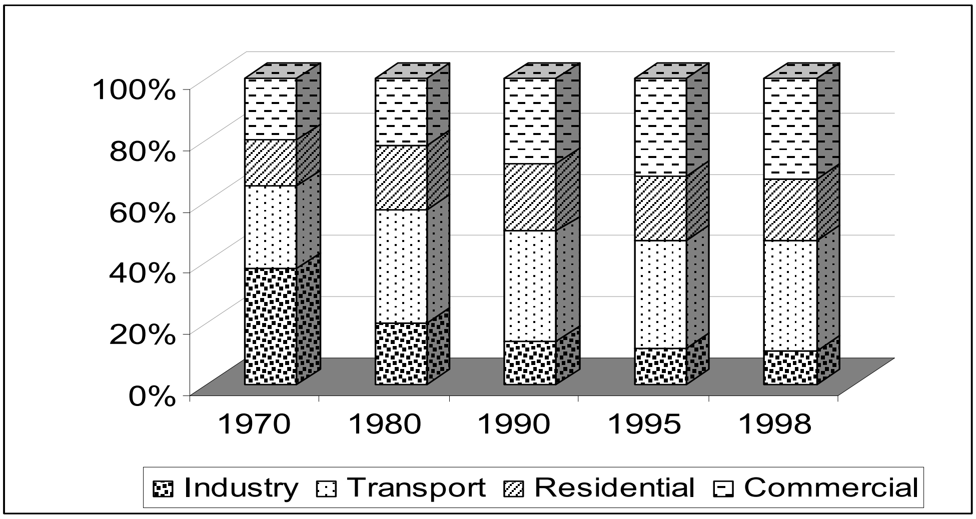

Figure 11: Sources of CO_2 production in Tokyo
(Source: Dhakal et al. 2003)

Dhakal et al. 2003 showed that showed that passenger vehicle population was responsible for most of the increase in CO_2 emission from transport sector. Vehicle utilization effect contributed significantly in increasing CO_2 emissions. Shares of car with 2000 cc or more has increased from 6% in 1990 to 27.5% in 1997. In Figure 12 is shown the share of CO_2 produced from various vehicles in Tokyo. Cars were responsible for the majority of CO_2 production in transport sector with an increasing trend from 1990 to 1994. Usual freight had also a main role in producing CO_2; while other means such as taxi; train; bus and small freight were less contributed.

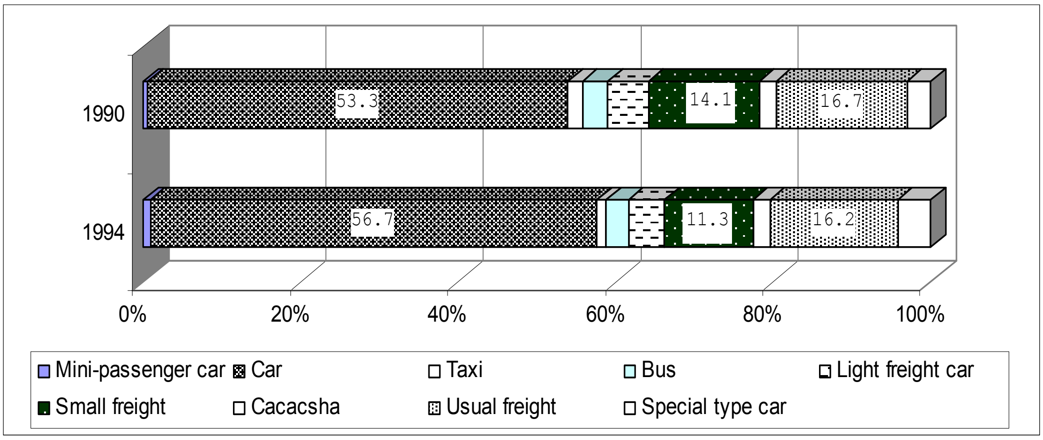

Figure 12: the share of different vehicle types in CO_2 produced in Tokyo.

The reliance on motor vehicles is still significant and the increasing number of driver's licence holders as well as increasing the number of motor vehicles confirms that the overall access to private vehicle is increasing in Tokyo. The government has tried to improve the efficiency of city transport system by the introduction of Transport Demand Management (TDM). The measures include:

- increasing the number of services and reducing costs of public transport;
- increasing the speed of traffic flow to reduce the production of emissions;
- introducing environmental-friendly vehicles;
- improving the efficiency of the distribution of goods within the city; and
- introduction of motor vehicle green tax as balance between heavy taxation and discount tax as the rule of PPP (Polluter Pays Principal).

Such TDM policies have been implemented in other countries such as South Korea; Germany and in France.

Transport energy is a major cause of environmental pollution adding to the greenhouse effect with about 30% of total South Australian CO_2 emissions resulting from petroleum fuel use. About 88 per cent of these emissions came from road transport, including cars, trucks and buses (Figure 13).

Greenhouse gas emissions from the transport sector are growing substantially, rising by 27 per cent between 1990 and 2002 (SA Government 2003). Latest projections indicate that emissions from the transport sector will rise by 42 per cent between 1990 and 2010. Transport SA (2005) claims that an increase of 5% in patronage on the Adelaide Metro system (bus and train) would reduce the greenhouse gas emissions by 7,800 tonnes per annum.

A short comparison between producing CO_2 in Adelaide and Tokyo indicates that: Transport has higher portion compared to other sectors in producing CO_2 in Tokyo than Adelaide. Cars are contributed so more in producing emissions in Adelaide. In both metropolitans, the participation of transport in producing CO_2 is increasing significantly.

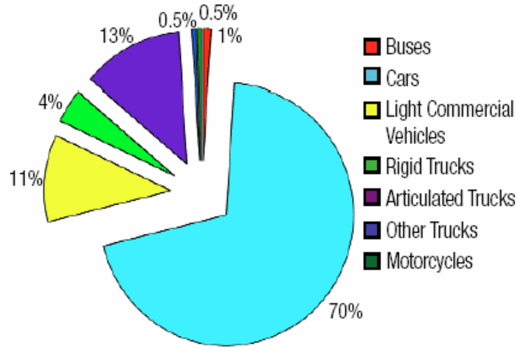

Figure 12: South Australian greenhouse gas emissions from transport 1997-98 (Source: Government SA)

6 Implications of the international comparison

The snapshot comparisons provided would be useful for policy making for Adelaide. Through the comparison with Tokyo situation, the implications can be summarised as below:

6.1 Establishing public transit and TOD built form network

Adelaide's low density and dispersed development make it costly for public transport. In addition, the low level of service in terms of frequency makes people less willing to catch the existing public transport. Also, since a big part of work and shopping trips ends in the CBD area, the lengths of trips are too long to be taken by slow public bus. Thus, the challenge would be partly addressed by decentralisation from CBD and make regional nodes supporting basic necessities throughout the metropolitan area (TOD pattern). The CBD can serve as an attractive core to create infill development there, thereby contributing to the containment of sprawl. Station-area TOD, like that done in Tokyo is also an opportunity. The federal and state governments should think about providing a high quality, fixed guide way transit system and station infrastructure. In fact, an effective rail-based public transport system would appear to be a priority for Adelaide if it is to ever compete with cars. Mass transit strategies such as rail network may look financially demanding for the time being but worth pursuing in the long term. The construction of such efficient infrastructure is possible with the joint sharing of cost between public and private sectors. Access to national loan or grant funding to facilitate a TOD and a supportive, high quality transit system would be a key point for developers.

6.2 Limiting private car use especially in the CBD through TDM programs

The relatively low cost of driving private vehicle in Adelaide motivates people to take their own vehicles. In the absence of an efficient public transport system and due to the limitations associated with non-motorised transport the trend will not stop. In addition, the presence of car manufactures and related business encourage car using. Adelaide needs to establish some policy constraints on motor vehicles. This would be as physical or economic planning disincentives against cars. Tokyo has faced congestion and emissions in city centre but some limitations such as the high cost of driving private vehicle (road pricing policy; limitation on parking) motivate people to use fewer vehicles thus making the city more energy efficient. Tokyo Metropolitan Government (TMG) has attempted to decrease the traffic. Some suggestions are: constructing ring roads and bypass to disperse traffic; re-establishing parking zones; green taxing and smoothing flow of vehicular traffic. The Tokyo government has tried to improve the efficiency of city transport system by the introduction of Transport Demand Management (TDM) such as encouraging environmental-friendly vehicles and introducing motor vehicle green tax as balance between heavy taxation and discount tax as the rule of PPP (Polluter Pays Principal).

6.3 Encouraging and facilitating non-motorised modes of transport

Much of the low level of walking/cycling in Adelaide appears to be resulted from the segregated distribution of services in urban fabric. Also the lack of pedestrian/cyclists friendly environment makes walking/cycling less pleasant. Arterial and collectors are associated with the risk of confliction with cars in the absence of bike lanes. Poor lighting in addition to increasing car traffic give less sense of safety and security especially at evenings and dark time. The extended large lots of blocks in recently developed suburbs as well as building orientations create an unattractive environment for pedestrians and bicyclists. On the other hand, in Tokyo, as the number of bicycles increase, the parking sites and bicycle facilities are expanded. Nowadays, lots of outdoor bicycle parking spaces throughout the city are established. Local municipalities began to build large and high-tech bicycle parking sites as an antidote to "bike pollution"-which were masses of bikes gathered next to train stations and in urban centres. Outdoor parking is mostly free of charge and indoor spaces are for a nominal fee. In conclusion, if priority were to be given to improving pedestrian/cyclists environments, people would be more interested to use them for short trips. Also, zoning regulations should be revised to make fine grained mixed land uses rather than develop single family large houses. Tokyo strongly demonstrates this point.

7 Conclusions

Despite some limitations such as the difficulties involved in obtaining data in comparable spatial units which preclude such comparisons across the two cities, this work will provide a starting point for systematic comparative analysis of travel trends resulted from urban form issues. The international comparison presents similarities and differences between two metropolitans in terms of urban form and transport issues.

Urban form differs between Adelaide and Tokyo. While Adelaide metropolitan exhibits sprawling and car-oriented development pattern, Tokyo has a mono-centric form because of its highly centralised activity centres serving by high-quality public transport. Suburban development in Tokyo region follows Transit-oriented development idea. In addition to environmental benefits, through a good coordination between transport projects and land development, financial benefits also have been achieved through the mechanism of value capture. This strategy presented by *Tokyo Corporation* could generate financial resources for capital investment.

8 Acknowledgment

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