# 5 TRANSPORT DEMAND FORECAST

## 5.1 Future Socio-economic Framework

### 5.1.1 Methodology

The future socio-economic framework of the study was set for 2010 as the target year with 2005 as the medium-term year and 2000 as the base year. First, the basic indicators of population and GDP are fixed. Then, employment, number of pupils and students, and household income are forecasted based on these indicators.

All indicators are spatially distributed into the level of traffic zones except for GDP, which is forecasted only for the city and the Study Area. Employment and number of pupils and students are forecasted both at residence and at work/school places.

In setting the future framework, the target figures for 2010 in the Chengdu City Development Plan (the 10th 5-Year Plan) and the Integrated Master Plan for the Central Area of Chengdu City are used as the basis. However, since the 10th 5-Year Plan has not been released yet, the GDP forecast was determined through discussions with the counterpart team and with considerations based on the recent economic trend and the forecast by related development projects.

### 5.1.2 Population

There are three categories of population considered; namely: registered, temporary and floating population. Due to the limitation of the data related to floating population, future population for this study is forecasted only for registered and temporary population.

**(1) Future Population Planned in the Integrated Master Plan for the Central Area of Chengdu City**

In the Integrated Master Plan for the Central Area of Chengdu City, the future population from 2000 to 2020 is set as shown in Table 5.1.1. In the plan, the central area is defined as the area within the planned Outer Ring Road. This study covers the same area as the Integrated Master Plan with the inclusion of the southern part of Gaoxin district, which juts out to the south beyond the Outer Ring Road.

**Table 5.1.1 Population Forecast of the Integrated Master Plan for the Central Districts of Chengdu City**

('000)

| | | 2000 | 2005 | 2010 | 2020 |
|---|---|---|---|---|---|
| Central Area | Urban Population | 2,300 | 2,550 | 2,700 | 3,100 |
| | - Registered | 2,050 | 2,290 | 2,420 | 2,780 |
| | - Temporary | 250 | 260 | 280 | 320 |
| | Rural population | 500 | 440 | 400 | 320 |
| | Sub-total | 2,800 | 2,990 | 3,100 | 3,420 |
| Gaoxin District (outside central area) | Urban population | | | 60 | 120 |
| Total | | | | 3,160 | 3,540 |

Source: Integrated Master Plan for the Central Districts of Chengdu City. Rural population was estimated in this study.

The present population in the Study Area is 3.09 million composed of 2.62 million registered and 0.47 million temporary population. Although it is difficult to divide them into urban and rural population, 2.55 million (the sum of urban registered population and rural population in 2000) is almost equal to the registered population of the Study Area in 2000. However, the temporary population of 0.47 million assumed in this study is significantly larger than 0.25 million set in the Integrated Master Plan. According to the Institute of Planning and Design, the temporary population for infrastructure development is defined as the people who stay for more than one month while what in the Study includes people who stay over three days but less than one month. In the Integrated Master Plan, the future population in 2010 is placed at 2.82 million of registered population and 0.28 million temporary population.

### (2) Future Population in the Study Area

Assuming that the growth of registered population can be controlled to some extent, the future population assumed in the Integrated Master Plan was adopted also in this Study. However, for the temporary population, the figure at 0.47 million in 2000 was employed as the basis for forecast because its growth control is difficult and this Study aims to formulate a transport plan on the safer side. However, the growth rate of temporary population will decrease considering the development of planned satellite cities (Longquan, Huayang, Dawan, Guihu, Liucheng, Pitong, Dongsheng) located outside the Study Area which receive a number of increasing temporary population. The growth rate of temporary population in the Study Area was estimated to be 5.05% between 1999 and 2000, based on the changes in the number temporary population in the Central Districts. Hence, it was assumed that annual growth rate of temporary population will be 3.5% for 2000-2005 and 2% for 2005-2010.

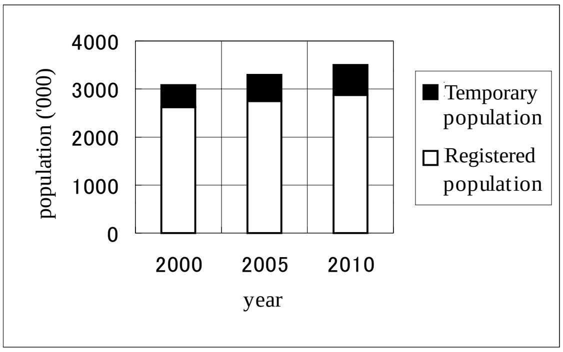
Future population in the Study Area will be 3.29 million in 2005 and 3.5 million in 2010 with annual growth rates of 1.25-1.26% as shown in Table 5.1.2 and Figure 5.1.1. The percentage of temporary population will slightly increase to 17.0% in 2005 and 17.6% in 2010. As compared to the figures in the Integrated Master Plan shown in Table 5.1.1, registered population of 2.88 million composed of 2.48 million urban and 0.4 million of rural population is the same. However, future temporary population of 0.62 million is 0.34 million larger than the one in the Integrated Master Plan.

**Table 5.1.2 Forecast of Population in the Study Area**

| | Population ('000) | | | Average Annual Growth Rate (% p.a.) | |
|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2000-05 | 2005-10 |
| Registered population<br>- Urban Area<br>- Rural Area | 2,620 | 2,730 | 2,880<br>2,480<br>400 | 0.83 | 1.08 |
| Temporary population | 470 | 560 | 620 | 3.57 | 2.06 |
| Total | 3,090 | 3,290 | 3,500 | 1.26 | 1.25 |
| % share of temporary population | 15.2 | 17.0 | 17.6 | | |

Source: Study Team

**Figure 5.1.1 Future Population in the Study Area**




In addition, the 2010 population will be 3.75 million which is the sum of 2.98 million of registered and 0.77 million of temporary population if the current trend of natural increase and migration of registered population, which are about 5,000 and 30,000 per year, respectively, and the growth rate of temporary population (5%) will not change. Therefore, it is understood that promoting the development of satellite cities and control of population inflow to the central area are the conditions for the future population set in this Study.

### (3) Population by Area

The distribution of future population by area should be determined based on the direction shown in the Integrated Master Plan. These directions are that the central area within 1st Ring Road should be developed as the CBD by decreasing population to 0.7 million in 2010 and the areas between 1st and 2nd Ring Roads and between 2nd and 3rd Ring Roads should be developed to be the residential area with urban functions. New residential area and work places, on the other hand, should be developed in the outer area between 3rd and Outer Ring Roads. In this study, the following methodology was taken in determining population distribution by area based on the released land use plan for 2010:

- The smallest unit area is the traffic zone.
- In order to fit the future population in the area within 1st Ring Road with the target of the Integrated Master Plan, the population density in the habitable area (mixed-use zone for residential and commercial and zone for commercial and public facilities in the land use plan) within the Inner Ring Road is reduced to 70% of the present figure (75% for mixed-use only).
- In the zones between the Inner and 1st Ring Roads, population density is reduced to 75% for the old urban area and 80% for the rest.
- In the zones between 1st and 2nd Ring Roads and between 2nd and 3rd Ring Roads, the population density for old urban area is reduced to 90%, and for the new urban area planned densities are applied considering the present densities

and the ideal residential development. There are some zones that are considered rural in Chenghua District.

- In the zones outside the 3rd Ring Road, the population is distributed considering the new urban area where planned density is applied for an ideal residential development and rural area where the agricultural land exists.

The results of distribution of population by area is shown in Table 5.1.3. The reason why the future population in the area within 1st Ring Road is 0.71 million is that some zones extend to outside of the 1st Ring Road. If those zones are divided by the 1st Ring Road, the future population of the area within the 1st Ring Road will be exactly 0.7 million.

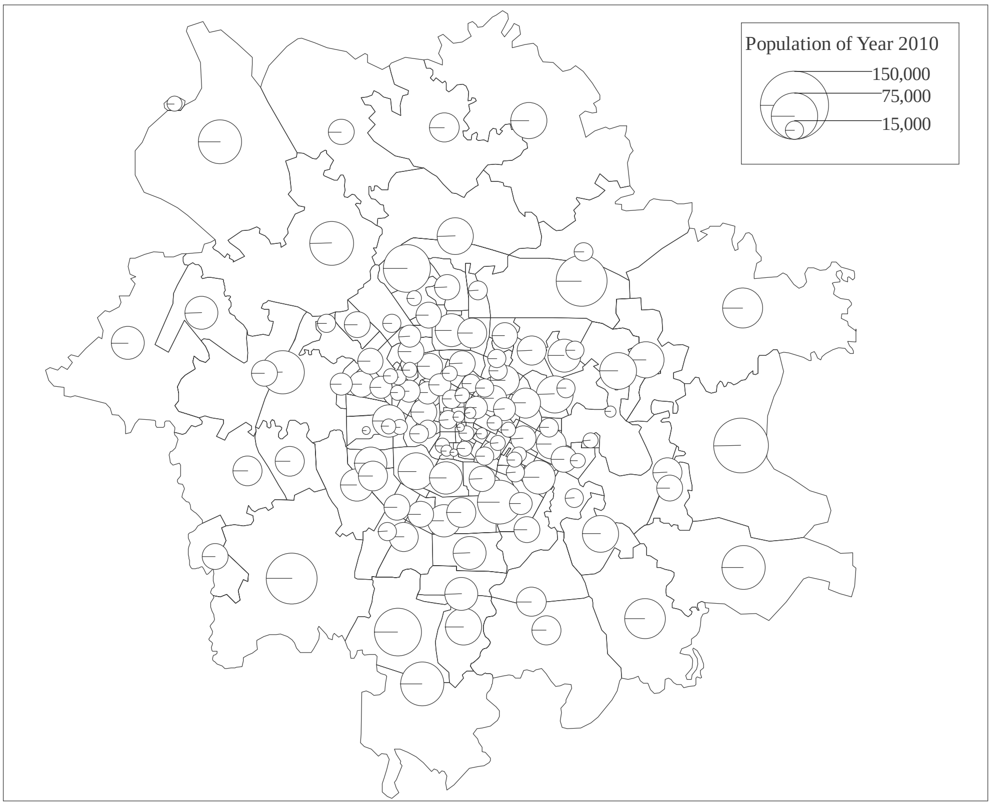
**Table 5.1.3 Future Population by Area**

| Area | Population | | | | 2010/2000 |
|---|---|---|---|---|---|
| | 2000 | 2010 | | | |
| | Total | Urban | Rural | Total | |
| Within Inner Ring Road | 485,100 | 345,100 | 0 | 345,100 | 0.71 |
| Between Inner and 1st Ring Roads | 472,400 | 364,900 | 0 | 364,900 | 0.77 |
| Central Area Total | 957,500 | 710,000 | 0 | 710,000 | 0.74 |
| Between 1st and 2nd Ring Roads | 763,300 | 771,000 | 0 | 771,000 | 1.01 |
| Between 2nd and 3rd Ring Roads | 664,100 | 917,400 | 13,700 | 931,100 | 1.40 |
| Inner Ring Area Total | 1,427,400 | 1,688,400 | 13,700 | 1,702,100 | 1.19 |
| Outer Ring Area (outside 3rd Ring Road) | 705,000 | 701,600 | 386,300 | 1,087,900 | 1.54 |
| Study Area Total | 3,089,900 | 3,100,000 | 400,000 | 3,500,000 | 1.13 |

Source: Study Team

As gleaned from the above table, the future population in the area within the Inner Ring Road and area between the Inner and 1st Ring Roads will be reduced to 71% and 77%, respectively. As a result, the population of the central area will be reduced to 0.7 million or to about 74% of the present population. The population in the area between 1st and 2nd Ring Roads will remain almost the same. The population in the area between 2nd and 3rd Ring Roads will be 1.4 times more than the present, so that the inner area will accommodate 1.7 million population, i.e. 1.2 times the present population. In the area outside the 3rd Ring Road, residential areas with 1.1 million (or 1.5 times the present population) will emerge.

# Figure 5.1.2 Changes in Population Distribution by Traffic Zone

### 5.1.3 GDP

The GDP in Chengdu City is anticipated to increase with the effect of the Western Development in the future. However, the 10th 5-Year Development Plan that will indicate the target economic growth rates is still not available. Therefore, the prospects for the future are discussed based on the past trend. The values after 2000 are expressed in 1999 constant price.

#### (1) Chengdu City

In 1990's, the GDP growth rates of Chengdu City were a little lower for the primary sector and rather higher for the secondary and tertiary sectors as compared to the whole country. In 1999, the GDP growth rate of Chengdu City was recorded at 10.2% as compared to the 7.1% of the country (Table 5.1.4).

**Table 5.1.4 GDP Growth Rates of China and Chengdu City**

(Unit: % p.a.)

| | | 1991-1998 | 1999 |
|---|---|---|---|
| China | All sectors | 10.8 | 7.1 |
| | Primary sector | 4.1 | 2.8 |
| | Secondary sector | 14.8 | 8.1 |
| | Tertiary sector | 9.3 | 7.5 |
| Chengdu City | All sectors | 14.1 | 10.2 |
| | Primary sector | 3.8 | 3.4 |
| | Secondary sector | 17.1 | 10.3 |
| | Tertiary sector | 15.1 | 11.7 |

Sources: culled from various statistical yearbooks

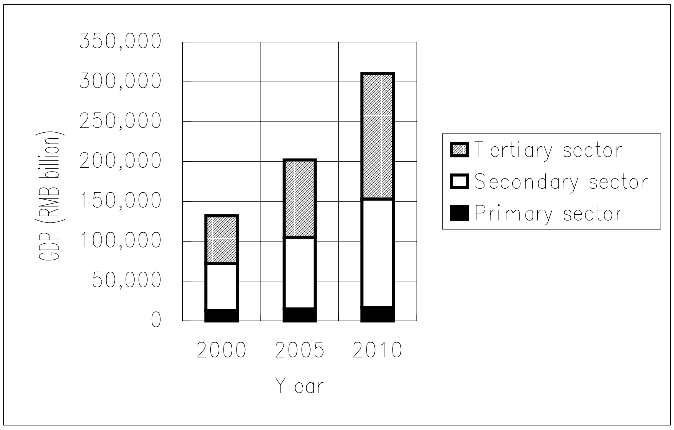
As of 2000, the GDP growth rate of the country will be more than 7.9% according to the projections made by the National Economy and Trade Committee. In this case, it is almost certain that the GDP growth rate of Chengdu City will be over 10%. For the future, however, it is difficult to maintain the high growth rate of the 1990's. Thus, future growth rates were set at 10% for 2000 and 9% for years after 2000. In the ADB project for Cheng-Nan Expressway, the growth rates were assumed at 9% for 2000 and 8.7% for 2000-2010. Total GDP was distributed by sector based on the actual data in 1999. Results of the forecasted GDP are shown in Table 5.1.5 and Figure 5.1.3.

**Table 5.1.5 GDP Forecast for Chengdu City, 2000-2010**

| | | 1999 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| GDP at 1999 price (RMB mill.) | All sectors | 119,003 | 130,903 | 201,411 | 309,896 |
| | Primary sector | 12,374 | 12,770 | 14,804 | 16,996 |
| | Secondary sector | 53,239 | 58,610 | 89,637 | 136,033 |
| | Tertiary sector | 53,390 | 59,523 | 96,969 | 156,866 |
| Average annual growth rate (% p.a.) | All sectors | - | 10 | 9 | 9 |
| | Primary sector | - | 3.2 | 3.0 | 2.8 |
| | Secondary sector | - | 10.1 | 8.9 | 8.7 |
| | Tertiary sector | - | 11.5 | 10.3 | 10.1 |
| Average population ('000) | | 10,002.8 | 10,068.5 | 10,368.5 | 10,633.5 |
| Per Capita GDP (RMB) | | 11,897 | 13,001 | 19,425 | 29,143 |

Source: Study Team

**Figure 5.1.3 GDP Forecast for Chengdu City**




**(2) Study Area**

As for the Study Area, the total GDP was forecasted based on the historical data available for the Central Districts, after analyzing the future situation of the Central Districts and the future growth rates by sector. Recently, the share of GDP in the central districts has been decreasing gradually. Moreover, it shows that areas outside of the central districts will be more progressive. As such, the GDP share of the central districts to the city will decrease from 45.5% in 2000 to 44.0% in 2010. As described in the previous section, development of satellite cities will be promoted and work places are spatially distributed. Therefore, the share of the central districts to the city was set at 44% considering that it will significantly decrease further. By sector, the decreasing trend of value-added of the primary sector was considered. The sum of GDP of the primary, secondary and tertiary sectors should be equal to the total.

The results of the GDP forecast are presented in Table 5.1.6. The growth rates for 2000-2005 by sector are –9.0% in primary sector, 8.1% in secondary sector and 9.4% in tertiary sector, and for 2005-2010 -7.0%, 7.9% and 9.3%, respectively.

**Table 5.1.6 GDP Forecast for the Central Districts, 2000-2010**

| | | 1999 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| GDP of Chengdu City (RMB mill.) | All sectors | 119,003 | 130,903 | 201,411 | 309,896 |
| | Primary sector | 12,374 | 12,770 | 14,804 | 16,996 |
| | Secondary sector | 53,239 | 58,610 | 89,637 | 136,033 |
| | Tertiary sector | 53,390 | 59,523 | 96,969 | 156,866 |
| GDP of central districts (RMB mill.) | All sectors | 54,483 | 59,561 | 90,232 | 136,354 |
| | Primary sector | 877 | 781 | 487 | 339 |
| | Secondary sector | 24,129 | 26,275 | 38,719 | 56,561 |
| | Tertiary sector | 29,477 | 32,506 | 51,026 | 79,454 |
| % share of central districts to the city (%) | All sectors | 45.8 | 45.5 | 44.8 | 44.0 |
| | Primary sector | 7.1 | 6.1 | 3.3 | 2.0 |
| | Secondary sector | 45.3 | 44.8 | 43.2 | 41.6 |
| | Tertiary sector | 55.2 | 54.6 | 52.6 | 50.7 |
| Average annual growth Rate (% p.a.) | All sectors | | 9.3 | 8.7 | 8.6 |
| | Primary sector | | -11.0 | -9.0 | -7.0 |
| | Secondary sector | | 8.9 | 8.1 | 7.9 |
| | Tertiary sector | | 10.3 | 9.4 | 9.3 |

Source: Study Team

As for the Study Area, labor productivity by sector was first forecasted for the Central Districts based on the GDP by sector and the employment at workplace by sector obtained from the results of the person trip survey. The GDP by sector for the adjoining five townships in the Study Area was obtained by multiplying employment at work place by sector and labor productivity by sector. The forecasted average growth rates by sector for the Central Districts are applied also for the Study Area.

The results of the GDP forecast for the Study Area are shown in Table 5.1.7.

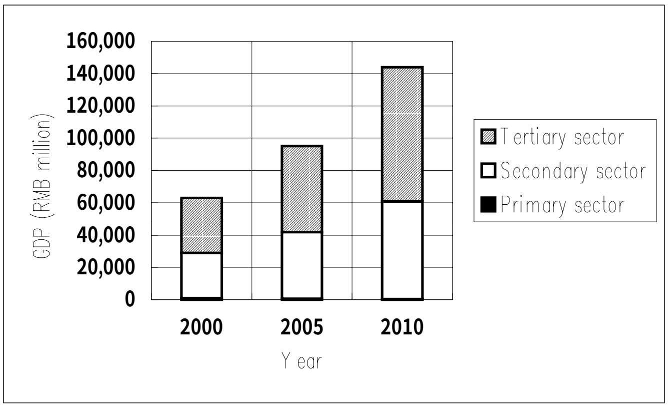
**Table 5.1.7 GDP Forecast for the Study Area, 2000-2010**

| | | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| GDP (RMB mill.) | All sector | 62,487 | 94,536 | 142,975 |
| | Primary sector | 903 | 564 | 392 |
| | Secondary sector | 27,868 | 41,137 | 60,165 |
| | Tertiary sector | 33,716 | 52,835 | 82,418 |
| % share of the Study Area to the city (%) | All sector | 47.7 | 46.9 | 46.1 |
| | Primary sector | 7.1 | 3.8 | 2.3 |
| | Secondary sector | 47.5 | 45.9 | 44.2 |
| | Tertiary sector | 56.6 | 54.5 | 52.5 |
| Average annual growth rate (% p.a.) | All sector | | 8.6 | 8.6 |
| | Primary sector | | -9.0 | -7.0 |
| | Secondary sector | | 8.1 | 7.9 |
| | Tertiary sector | | 9.4 | 9.3 |
| Average population (mill.) | | 3.09 | 3.29 | 3.50 |
| Per Capita GDP(RMB) | | 20,222 | 28,734 | 40,850 |

Source: Study Team

As shown in the table above, the share of GDP in the Study Area for the city will decrease from 47.7% in 2000 to 46.1% in 2010. Per Capita GDP of 2010 will increase from RMB 20,200 in 2000 to RMB 40,850 in 2010, about twice higher..

**Figure 5.1.4 GDP Forecast for the Study Area**



### 5.1.4 Employment

Employment in the Study Area is forecasted for both at residence place and at work place by sector.

#### (1) Study Area

##### a) Employment at Work Place by Sector

The sectoral employment "at work place" is calculated based on the increase of GDP and labor productivity by sector.

The sectoral labor productivity in Chengdu City has been basically increasing as shown in Table 5.1.8. Inasmuch as the trend is not consistent, the average annual growth rates were posted at 6.4% in the primary sector, 16.6% in the secondary sector and 5.3% in the tertiary sector during the period 1995-1999. Its relationship with the GDP growth rates can be indicated in terms of the elastic value. For example, the elastic value of 1.82 of the primary sector shows that labor productivity increased at 1.82% with the increase in GDP. If sector's elastic value is 1.00, it shows that this sector achieve the growth in GDP with only increased labor productivity and without changes in the labor force. Similar to the primary sector, the secondary sector also recorded an elastic value of 1.40. Employment in the primary and secondary sectors is decreasing. However, these sectors have realized GDP growth mainly through the conversion to high value-added products.

The tertiary sector, on the other hand, posted an elastic value of 0.46, which is lower than 1.00. This shows that growth in the sector was attributed more to the increase in employment rather than increase in labor productivity.

**Table 5.1.8 Changes in Increase Rate of Labor Productivity by Sector in Chengdu City, 1995-1999**

| | | 1995-96 | 1996-97 | 1997-98 | 1998-99 | 1995-99 |
|---|---|---|---|---|---|---|
| Annual Increase Rate of Productivity (%) | Primary sector | 8.3 | 4.8 | 3.5 | 9.2 | 6.4 |
| | Secondary sector | 15.1 | 14.1 | 18.8 | 18.7 | 16.6 |
| | Tertiary sector | 1.7 | 6.9 | 10.1 | 2.9 | 5.3 |
| Annual growth rate of GDP (% p.a.) | Primary sector | 4.4 | 3.2 | 3.1 | 3.4 | 3.5 |
| | Secondary sector | 13.0 | 13.5 | 10.8 | 10.3 | 11.9 |
| | Tertiary sector | 12.2 | 11.7 | 11.0 | 11.7 | 11.6 |
| Elasticity | Primary sector | 1.89 | 1.49 | 1.14 | 2.69 | 1.82 |
| | Secondary sector | 1.16 | 1.05 | 1.74 | 1.81 | 1.40 |
| | Tertiary sector | 0.14 | 0.59 | 0.91 | 0.24 | 0.46 |

Source: culled from various statistical yearbooks

Based on the situation above, the future increase in the sectors' labor productivity is assumed as follows:

- In order to realize the future GDP growth by sector, increase in labor productivity in accordance with the past trend is necessary.
- The future increase of labor productivity by sector in Chengdu City can be applied for the Study Area.

The future increase of labor productivity by sector is shown in Table 5.1.9.

**Table 5.1.9 Future Increase of Labor Productivity by Sector**

| | | 2000-05 | 2005-10 |
|---|---|---|---|
| Annual increase rate of GDP in Chengdu City (%) | Primary sector | 3.0 | 2.8 |
| | Secondary sector | 8.9 | 8.7 |
| | Tertiary sector | 10.3 | 10.1 |
| Elasticity | Primary sector | 1.82 | 1.82 |
| | Secondary sector | 1.40 | 1.40 |
| | Tertiary sector | 0.46 | 0.46 |
| Annual Increase rate of labor productivity (%) | Primary sector | 5.5 | 5.1 |
| | Secondary sector | 12.5 | 12.2 |
| | Tertiary sector | 4.7 | 4.6 |

Source: Study Team

Namely, the average annual growth rates of labor productivity are 5.5% for 2000-2005 and 5.1% for 2005-2010 in the primary sector, 12.5% and 12.2% in the secondary sector and 4.7% and 4.6% in the tertiary sector, respectively.

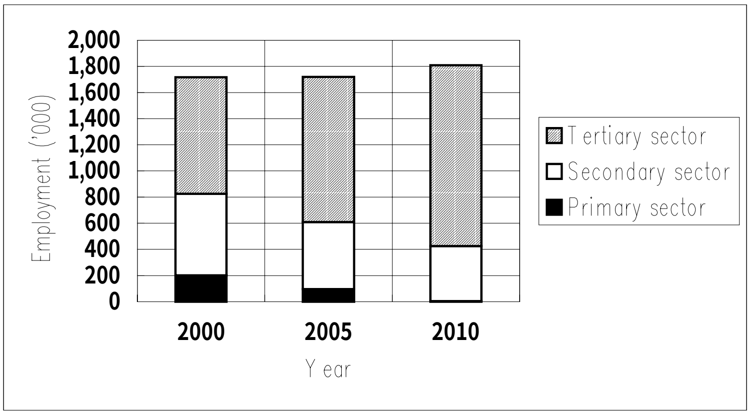
The future employment by sector is calculated by applying the above results and future GDP in the Study Area (Table 5.1.10). The employment of primary sector will decrease from 200 thousand in year 2000 to 50 thousand in 2010. The employment of the secondary sector will also decrease from 600 thousand to 400 thousand. The employment of the tertiary sector will increase from 900 thousand to 1.4 million (or 1.5 times that of the present).

**Table 5.1.10 Future Employment by Sector in the Study Area**

| | | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| GDP by sector (RMB mill.) | Primary sector | 903 | 564 | 392 |
| | Secondary sector | 27,868 | 41,137 | 60,165 |
| | Tertiary sector | 33,716 | 52,835 | 82,418 |
| | All sectors | 62,487 | 94,536 | 142,975 |
| Labor productivity by sector (RMB) | Primary sector | 4,479 | 5,854 | 7,507 |
| | Secondary sector | 44,603 | 80,376 | 142,920 |
| | Tertiary sector | 37,802 | 47,561 | 59,554 |
| | All sectors | 36,363 | 54,996 | 76,988 |
| Employment by sector ('000) | Primary sector | 201.6 | 96.3 | 52.2 |
| | Secondary sector | 624.8 | 511.8 | 421.0 |
| | Tertiary sector | 891.9 | 1,110.9 | 1,383.9 |
| | All sectors | 1,718.4 | 1,719.0 | 1,857.1 |

Source: Study Team

**Figure 5.1.5 Future Employment by Sector in the Study Area**



**b) Employment at Residence Place by Sector**

As for the employment at residence place, first the share of total employment to the population over 15 years old is determined. By sector, it is assumed that primary sector employment is the same as the one at work place, and the proportion of employment between at residence and at work places is the same in secondary and tertiary sectors. As of 2000, the composition of population in the Study Area by age group is 7.1% for less than 6 years old, 10.8% for 6 to 14 years old and 82% for over 15 years old. In the future, the trend of aging and less children will continue. Therefore, the composition of population by age group in 2010 is assumed to be 6.5% for under 6, 10.5% for 6-14 and 83% for over 15.

**Table 5.1.11 Future Population by Age Group, 2000 and 2010**

| Age Group | Less than 6 | 6-14 | Over 15 | Total |
|---|---|---|---|---|
| Population in 2000<br>(% share to the total) | 220,599<br>(7.1) | 335,069<br>(10.8) | 2,534,232<br>(82.0) | 3,089,900<br>(100.0) |
| Population in 2010<br>(% share to the total) | 227,500<br>(6.5) | 367,500<br>(10.5) | 2,905,000<br>(83.0) | 3,500,000<br>(100.0) |

Source: Person Trip Survey for the year 2000 and estimation of the Study Team for the year 2010

In 2000, population over 15 years old are 8.6% for student, 68.0% for employed and 23.4% for others. Students and employed persons share 76.6% of the total. It is expected that the share of non-workers and number of students increases because of the increase of shares of aged population and number of students who need higher education. Therefore, in 2010, it is assumed that the share of others will be 24.0% and the rest (i.e., students and employees) is 76.0%. The number of students forecasted is at 375.5 thousand and the total employment will be at 1,833.1 thousand, 12.9% and 63.1% of the population over 15 years old, respectively (Table 5.1.12).

**Table 5.1.12 Future Population (over 15 Years) by Employment Status, 2000 and 2010**

| Type | Students | Employees | Others | Total |
|---|---|---|---|---|
| Population in 2000<br>(% share to the total) | 216,576<br>(8.6) | 1,723,568<br>(68.0) | 594,088<br>(23.4) | 2,534,232<br>(100.0) |
| Population in 2010<br>(% share to the total) | 375,500<br>(12.9) | 1,833,100<br>(63.1) | 696,400<br>(24.0) | 2,905,000<br>(100.0) |

Source: Person Trip Survey for the year 2000 and estimation of the Study Team for the year 2010

Based on the methodology explained above, the employment by sector in 2010 is forecasted to be 52.2 thousand in the primary sector, 415.4 thousand in the secondary and 1,365.5 thousand in the tertiary sector. The employment at residence and work places is shown in Table 5.1.13. As shown, the employment at work place is less than that *at residence* in 2000. It shows that more workers travel outside of the Study Area at present. In order to achieve the target GDP, however, more workers should be absorbed in the Study Area.

**Table 5.1.13 Future Employment by Sector at Residence and Work Place in the Study Area, 2000 and 2010**

| Sector | 2000 | | 2010 | |
|---|---|---|---|---|
| | At residence | At work place | At residence | At work places |
| Primary sector | 202,079 | 201,636 | 52,200 | 52,200 |
| Secondary sector | 627,899 | 624,826 | 415,400 | 421,000 |
| Tertiary sector | 893,590 | 891,912 | 1,365,500 | 1,383,900 |
| All sectors | 1,723,568 | 1,718,374 | 1,833,100 | 1,857,100 |

Source: Study Team

### (2) Employment by Zone

#### a) Employment at Work Place by Sector

The future distribution of employment *at work place* by sector is forecasted using the methodology below:

- The employment in the primary sector is distributed to the area outside of 3rd Ring Road and part of the area between 2nd- and 3rd Ring Roads considering the future agricultural land and present distribution of employed population of the primary sector.
- The employment in the secondary sector is divided into two types. One is related to the distribution of the industrial land use and the other not related. The former are mainly manufacturing industry workers and the latter are partly workers in construction industry and management of manufacturing industry.
- The secondary sector workers who are not related to the distribution of the industrial land use can be considered as the secondary sector workers in the zones without any industrial land use in 1994 and 2000 (based on the land use map). These accounted for 14.2% of the total secondary industry employment in 2000. Assuming that this share will not change in the future, then the secondary sector employment which is not related to the industrial land use will be 59.7 thousand in 2010. These workers are distributed in proportion to the current employment of the secondary sector to the zones with no industrial land use in the 2010 land use plan.
- The remaining secondary sector workers (361.3 thousand) who are related directly to the industrial land use are given considering the distribution of industrial land use in the 2010 land use plan and the present density of secondary sector workers by zone.
- The employment in the tertiary sector is divided into two types. One that works in neighboring business and service enterprises catering the local residents and the other that works in the city-wide business and service enterprises.
- The density of tertiary sector workers as of 2000 in the zones mainly of the

residential land use without public facility (commercial/service land use) is 95 per 1000 population. Based on this, it is assumed that the future density of the tertiary workers of the former type is 100 per 1000 population and they are distributed based on the 2010 population by zone.

- The latter tertiary workers are distributed considering the existing accumulation, and the planned distributions of public land use and commercial-residential mixed land use of the 2010 land use plan.

The result of the forecast of employment at work place by zone is shown in Table 5.1.14.

**Table 5.1.14 Future Employment at Work Place by Area**

| Area | Employment at Work Place | | | | | | | | 2010/ 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | | | | 2010 | | | | |
| | Primary | Secondary | Tertiary | Total | Primary | Secondary | Tertiary | Total | |
| Inside Inner Ring Road | 2,001 | 39,351 | 209,233 | 250,585 | 0 | 9,900 | 249,400 | 259,300 | 1.03 |
| Between Inner- and 1st Ring Roads | 2,586 | 83,372 | 157,625 | 243,583 | 0 | 20,700 | 210,400 | 231,100 | 0.95 |
| Central Area Total | 4,587 | 122,723 | 366,858 | 494,168 | 0 | 30,600 | 459,800 | 490,400 | 0.99 |
| Between 1st- and 2nd Ring Roads | 7,918 | 139,096 | 211,796 | 358,810 | 0 | 63,000 | 275,900 | 338,900 | 0.94 |
| Between 2nd- and 3rd Ring Roads | 63,533 | 223,962 | 180,809 | 468,304 | 9,200 | 177,500 | 317,800 | 504,500 | 1.08 |
| Inner Area Total | 71,451 | 363,058 | 392,605 | 827,114 | 9,200 | 240,500 | 593,700 | 843,400 | 1.02 |
| Outer Area (outside 3rd Ring Road) | 125,598 | 139,045 | 132,449 | 397,092 | 43,000 | 149,900 | 330,400 | 523,300 | 1.32 |
| Study Area Total | 201,636 | 624,826 | 891,912 | 1,718,374 | 52,200 | 421,000 | 1,383,900 | 1,857,100 | 1.08 |

Source: Study Team

As shown in the table, the primary sector workers will be gone and the secondary sector workers will also be decreased greatly in the area within the Inner Ring Road. The secondary sector workers will increase only in the outer ring area where increase in industrial land is planned. The tertiary sector workers will increase in all areas. It will especially increase extensively in the outer ring area where large increase in population and development of the cores of commercial service such as sub-urban centers are expected.

As a result, employment will increase by 1.3 times its present level in the outer ring area but will remain virtually unchanged in the central area and inner ring area.

**b) Employment at Residence by Sector**

The distribution of employment at residence place by sector is estimated using the following methodology:

- First, the total number of students and employed persons aged 15 and over is determined for every zone and the number of employed is calculated by deducting the number of students which will be explained in the next section.
- The primary sector workers are distributed in the same area with the

employment at work place assuming there are no trips crossing the zone.

- As for the secondary and tertiary workers, they are distributed based on the existing proportion of the secondary to tertiary sectors of each zone as well as on the future distribution of the industrial lands commercial and public facilities lands.

The future employment by sector at residence place by ring area is shown in Table 5.1.15.

**Table 5.1.15 Future Employment at Residence by Area**

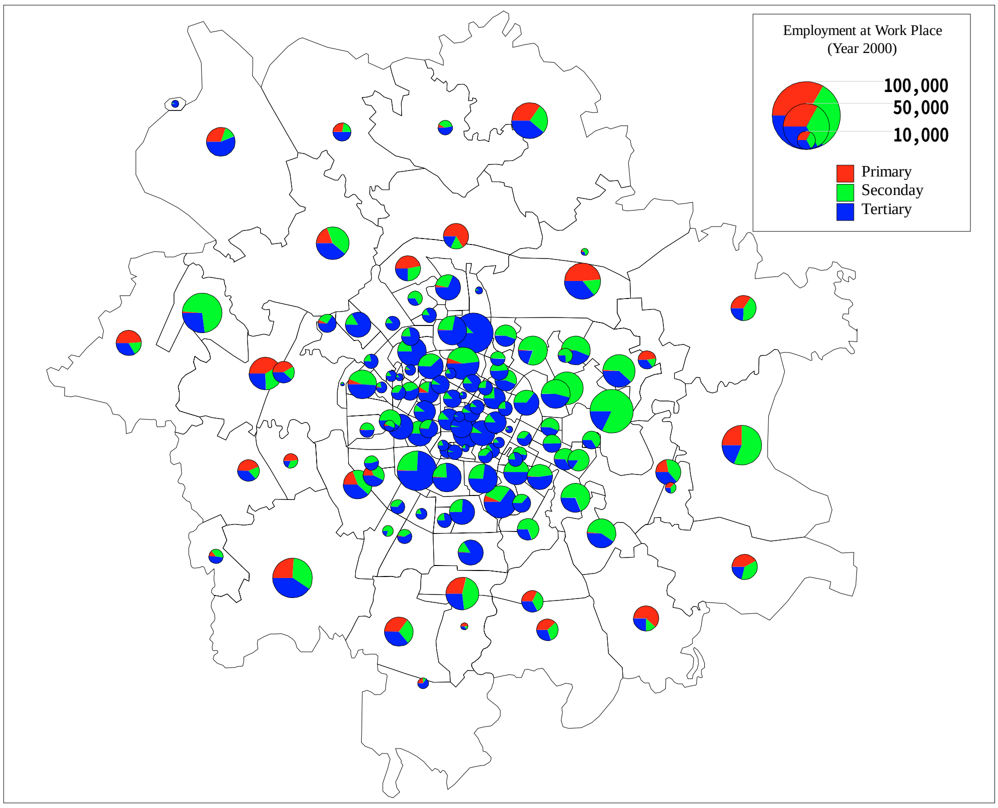
| Area | Employment at Residence | | | | | | | | 2010/ 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | | | | 2010 | | | | |
| | Primary | Secondary | Tertiary | Total | Primary | Secondary | Tertiary | Total | |
| Inside Inner Ring Road | 1,759 | 63,901 | 173,658 | 239,318 | 0 | 27,500 | 129,500 | 157,000 | 0.66 |
| Between Inner- and 1st Ring Roads | 2,997 | 92,778 | 159,821 | 255,596 | 0 | 44,500 | 143,300 | 187,800 | 0.73 |
| Central Area Total | 4,756 | 156,679 | 333,479 | 494,914 | 0 | 72,000 | 272,800 | 344,800 | 0.70 |
| Between 1st- and 2nd Ring Roads | 5,961 | 170,552 | 233,244 | 409,757 | 0 | 100,600 | 284,200 | 384,800 | 0.94 |
| Between 2nd- and 3rd Ring Roads | 69,975 | 163,420 | 173,509 | 406,904 | 9,200 | 119,900 | 381,400 | 510,500 | 1.25 |
| Inner Area Total | 75,936 | 333,972 | 406,753 | 816,661 | 9,200 | 220,500 | 665,600 | 895,300 | 1.10 |
| Outer Area (outside 3rd Ring Road) | 121,387 | 137,248 | 153,358 | 411,993 | 43,000 | 122,900 | 427,100 | 593,000 | 1.44 |
| Study Area Total | 202,079 | 627,899 | 893,590 | 1,723,568 | 52,200 | 415,400 | 1,365,500 | 1,833,100 | 1.06 |

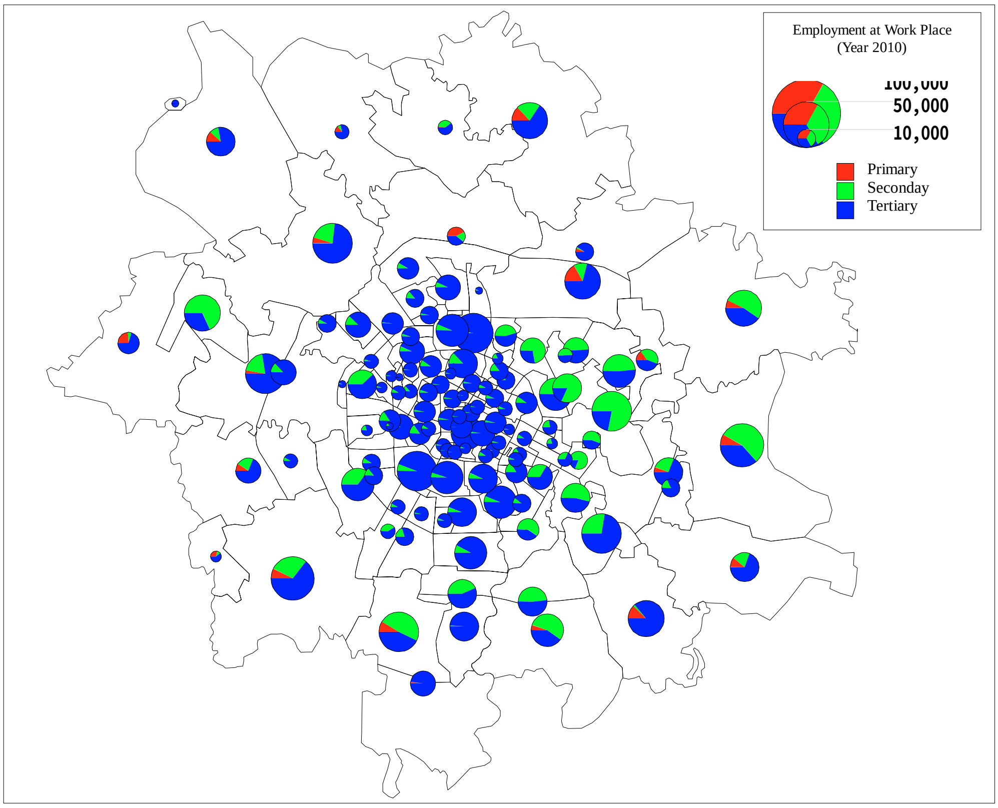
Source: Study Team

Reflecting the future decrease in population in the central area, employment at residence place will likewise post a decrease to 70% of the present. The situation in the Inner Ring Area will experience very little change. In the Outer Ring Area, employment will increase to more than 1.4 times its present level. A comparison of employment between at residence place and at work place reveals that the former will be larger in the Outer Ring Area while the latter will occur more in the Inner Ring Area. This only means that more work trips will be made from the Outer Ring Areas to the Inner Ring Areas.

By sector, there are no trips in the primary sector crossing the zone. In the secondary sector, the employment at residence is larger than that at work place in the areas within the Inner Ring Road and between the Inner and 1st Ring Roads and between 1st and 2nd Ring Roads. This means that the work trips from the inner ring areas to the outer ring areas will be larger. The tertiary sector will exhibit clearly the opposite characteristic as the secondary sector. Specifically, the future trip flows will be more from the center to the outer ring areas for the secondary sector workers while the trip flows of workers in the tertiary sector will be more from the outer to the center areas.

## Figure 5.1.6 Employment by Sector and by Traffic Zone



### 5.1.5 Number of Students and Pupils

The number of students and pupils is estimated based on the classification that pupils are in the elementary and middle school levels while students are in the high school and university levels, and both at residence basis and at school place basis.

#### (1) Study Area

##### a) Pupils (Elementary School and Junior High School)

According to the results of the person trip survey, the number of pupils at residence place is 335,069, of which 99.6% or 333,836 attend schools in the Study Area and the rest of 1,233 attend schools outside of the Study Area. Since almost 100% of the population aged 6-14 are enrolled in the school. This number can be assumed as the total population of the same age group. As it is explained in the previous section, the population ages 6-14 years is 367,500 in 2010. This number could be the future number of pupils at residence place assuming the rate of school admission at 100%. If it is assumed that the future share of pupils attending schools in the Study Area is still 99.6%, then the number of pupils at school place will be 366,100 (Table 5.1.16).

**Table 5.1.16 Forecast of Number of Pupils in the Study Area**

| | 2000 | 2010 | 2010/2000 |
|---|---|---|---|
| Number of pupils living in the Study Area | 335,069 | 367,500 | 1.1 |
| Number of pupils attending schools in the Study Area | 333,836 | 366,100 | 1.1 |
| Number of pupils attending schools outside of the Study Area | 1,233 | 1,400 | 1.1 |

##### b) Students (High School and University)

The number of students in the Study Area in 2000 is 216,576, of which 98% or 212,332 attend schools located in the Study Area while the rest of 4,244 attend schools outside of the Study Area. On the other hand, the number of students who are living outside the Study Area but attending schools in the Study Area is 1,409. This means that the number of students at residence place and at school place are 216,576and 213,741, respectively.

The density of students per thousand population is used as the index expressing the spread of higher education level. It is 31.8 in Chengdu City in 1999 and 70.1 in the Study Area in 2000. In Chengdu City, the number of students per thousand population has been increased from 25.0 in 1995 to 33.55 in 2000. It is estimated that it will reach 51.35 in 2010 (Table 5.1.17). If it is assumed that the number of students per thousand population in the Study Area increases at the same rate as that in Chengdu City, then it will increase from 70.1 in 2000 to 107.3 in 2010 as shown in Table 5.1.18.

**Table 5.1.17 Forecast of Student Density in Chengdu City [1/]**

| | Year | No. of students per 000 population (senior middle school and university) | Rate (2000=1.00) |
|---|---|---|---|
| Actual Data[2/] | 1995 | 25.0 | |
| | 1996 | 26.2 | |
| | 1997 | 28.7 | |
| | 1998 | 29.7 | |
| | 1999 | 31.8 | |
| Forecast | 2000 | 33.55 | 1.00 |
| | 2005 | 42.45 | 1.27 |
| | 2010 | 51.35 | 1.53 |

Note: 1/ Estimated by using the number of students in senior middle schools and universities
2/ Extracted from various statistics.

**Table 5.1.18 Forecast of Student Density in the Study Area**

| | 2000 | 2005 | 2010 |
|---|---|---|---|
| No. of students per 000 population (senior middle school and university) | 70.1 | 89.0 | 107.3 |
| Rate (2000 = 1.00) | 1.00 | 1.27 | 1.53 |

Source: Study Team

The future number of students at residence place in the Study Area is estimated at 375 thousand by applying the student density to the population of 3.5 million in 2010. Assuming that the future rate of students crossing the border of the Study Area to attend school is the same as the present, then the number of students at school place in the Study Area will be 370.5 thousand, of which 368.1 thousand students live in the Study Area and 2.4 thousand students live outside the Study Area but attend school in the Study Area (Table 5.1.19). The population for 2010 is forecasted to increase by only 1.13 times the year 2000 level but the number of students will increase by 1.7 times because of the tendency for higher education.

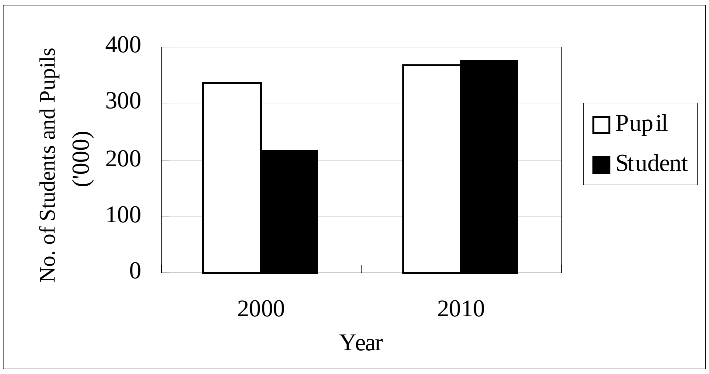
**Table 5.1.19 Forecast of Number of Students in the Study Area**

| Area of Residence | Area of School Place | | | | | | 2010/ 2000 |
|---|---|---|---|---|---|---|---|
| | 2000 | | | 2010 | | | |
| | Study Area | Outside Study Area | Total | Study Area | Outside Study Area | Total | |
| Study Area | 212,332 | 4,244 | 216,576 | 368,100 | 7,400 | 375,500 | 1.7 |
| Outside Study Area | 1,409 | | | 2,400 | | | |
| Total | 213,741 | | | 370,500 | | | 1.7 |

Source: Study Team

The future number of students at residence is shown in Figure 5.1.7 together with the students at school place. As shown in the figure, in 2010 the number of students will exceed the number of pupils.

**Figure 5.1.7 Future Number of Pupils and Students in the Study Area**




## (2) Number of Pupils and Students by Zone

### a) Pupils

The future number of pupils by zone is estimated based on the following methodology:

- First, the number of pupils at residence place is estimated by zone.
- The future proportion of pupils (population of 6-14 years old) is estimated considering the existing land use and future plan because the existing proportion of pupils by zone is irregular ranging from 0-27% to the total. Basically, higher proportion decreases while lower proportion remains the same as its existing level.
- The future number of pupils at residence place is estimated by applying the proportion thus determined to the future population by zone.
- Then, the future number of pupils at school place is estimated considering the Elementary and Junior High School Development Plan for Chengdu City and the current proportion of pupils at residence place to at school place.

The forecast results of the number of pupils are presented by area in Table 5.1.20.

**Table 5.1.20 Future Number of Pupils by Ring Area**

| Ring Area | 2000 | | 2010 | | 2010/2000 |
|---|---|---|---|---|---|
| | At residence | At school place | At residence | At school place | |
| Inside Inner Ring Road | 44,565 | 52,083 | 30,100 | 35,800 | 0.7 |
| Between Inner- and 1st- Ring Roads | 42,986 | 43,093 | 31,700 | 33,200 | 0.7 |
| Central Area Total | 87,551 | 95,176 | 61,800 | 69,000 | 0.7 |
| Between 1st- and 2nd Ring Roads | 62,664 | 58,904 | 62,000 | 60,200 | 1.0 |
| Between 2nd- and 3rd Ring Roads | 77,647 | 77,261 | 103,600 | 100,700 | 1.3 |
| Inner Area Total | 140,311 | 136,165 | 165,600 | 160,900 | 1.2 |
| Outer Area (outside 3rd Ring Road) | 107,207 | 102,495 | 140,100 | 136,200 | 1.3 |
| Study Area Total | 335,069 | 333,836 | 367,500 | 366,100 | 1.1 |

Source: Study Team

Note: increase rate from 2000 to 2010 is based on the one *at residence place.*

**b) Students**

The future number of students is estimated based on the following methodology:

- First, the number of students *at residence place* is estimated by zone.
- There are large differences in the existing proportion of students per thousand population by zone. They vary from 0 to 775.5 of Zone No. 56 where the Sichuan Industry College is located or 615.0 of Zone No. 57 where the Southwest Jiaotong University is located as all the students are living in a dormitory within the universities.
- Considering the future increase in the rate of admission to higher educational institutions, the future proportion of students per thousand population is estimated by zone. The zones where universities are located are kept at their existing proportions while the zones with lower proportions are modified to higher proportions.
- The future number of students at residence place is estimated by applying the above proportion to the future population by zone.
- Then, the future number of students is estimated considering the zone characteristics and the current proportion of students at residence place to at school place.

The forecast results of the number of students are presented by area in Table 5.1.21.

**Table 5.1.21 Future Number of Students by Area**

| Ring Area | 2000 | | 2010 | | 2010/2000 |
|---|---|---|---|---|---|
| | At residence | At school place | At residence | At school place | |
| Inside Inner Ring Road | 30,188 | 27,487 | 35,400 | 33,000 | 1.2 |
| Between Inner- and 1st- Ring Roads | 27,358 | 29,248 | 35,900 | 36,800 | 1.3 |
| Central Area Total | 57,546 | 56,735 | 71,300 | 69,800 | 1.2 |
| Between 1st- and 2nd Ring Roads | 57,693 | 62,973 | 88,300 | 104,800 | 1.5 |
| Between 2nd- and 3rd Ring Roads | 59,616 | 57,909 | 114,800 | 111,300 | 1.9 |
| Inner Area Total | 117,309 | 120,882 | 203,100 | 216,100 | 1.7 |
| Outer Area (outside 3rd Ring Road) | 41,721 | 36,124 | 101,100 | 84,600 | 2.4 |
| Study Area Total | 216,576 | 213,741 | 375,500 | 370,500 | 1.7 |

Source: Study Team
Note: increase rate from 2000 to 2010 is based on the one *at residence place.*

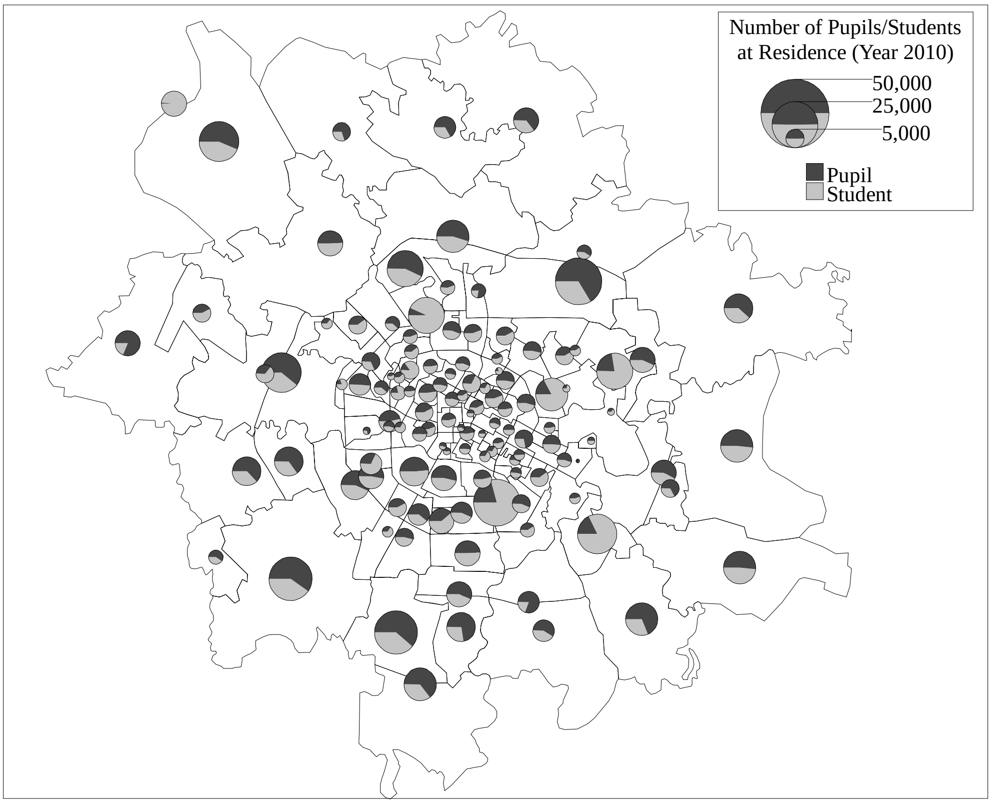
### 5.1.6 Household Income

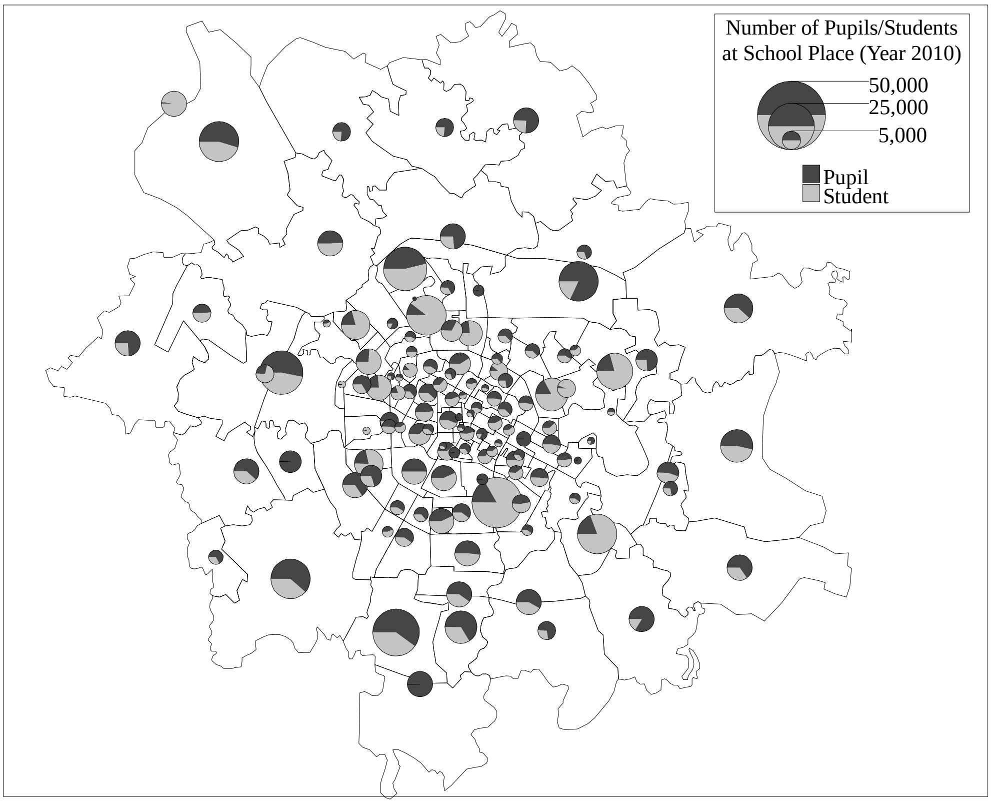
#### (1) Study Area

The number of households in the Study Area is 1.3 million at present. Average number of household members is 2.35. The distribution of monthly household income is shown in Table 5.1.22. One third of the total households belong to the income group of RMB 1,000-2,000, followed by 390 thousand households (29.7%) to the RMB 600-1,000 and 281 thousand households (21.4%) of less than RMB 600. Therefore, the share of households with monthly income of less than RMB 2,000 is 84.1%. The average monthly household income is RMB 1,334.

These household incomes are considered to be a part of GDP. The GDP in the Study Area is estimated at RMB 62.5 billion produced by the employment of 1,718 thousand at work place (refer to Chapter 5.1.3 and 5.1.4). Assuming that labor productivity remains the same, the total production income created by 1,724 thousand workers living in the Study Area is estimated at RMB 62.7 billion based on the rate of employment between at residence place and at work place. Compare with the total yearly household income of RMB 21.0 billion; the resultant 33.5% of the total production income is distributed to the people as their income.

## Figure 5.1.8 Changes in Distribution of Pupils and Students by Traffic Zone



The number of households in 2010 will be 1.49 million assuming the average household size will not change from 2.35. The production income of the employment at residence of 1.83 million will be RMB 141.1 billion based on the RMB 143.0 billion GDP and 1.86 million of employment at work place. Assuming the income distribution rate of 33.5% will not change in the future, the total household income will be RMB 47.3 billion per year or RMB 3.9 billion per month, and average monthly household income will be RMB 2,650.

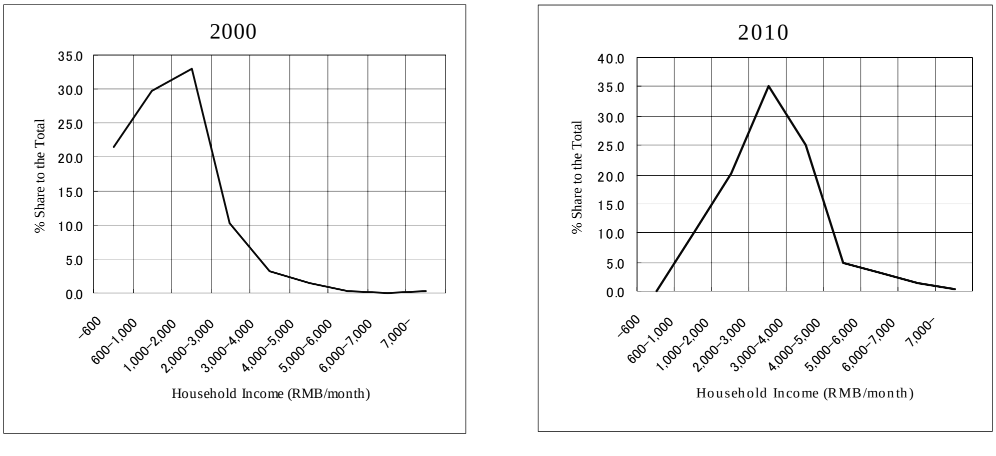
Given the average household income in the future at RMB2,650, its distribution pattern should be that the highest income group shifts to RMB 2,000-3,000 and the income group of RMB 1000-4000 shares more than 80% of the total as shown in Table 5.1.22 and Figure 5.1.8.

**Table 5.1.22 Future Number of Households by Income Level in the Study Area**

| Household Income (RMB/month) | 2000 | | 2010 | | 2010/2000 |
|---|---|---|---|---|---|
| | No. of households | % share to the total | No. of households | % share to the total | |
| less than 600 | 280,729 | 21.4 | | 0.0 | 0.0 |
| 600-1,000 | 390,393 | 29.7 | 148,900 | 10.0 | 0.4 |
| 1,000-2,000 | 433,078 | 33.0 | 297,900 | 20.0 | 0.7 |
| 2,000-3,000 | 134,601 | 10.3 | 521,300 | 35.0 | 3.9 |
| 3,000-4,000 | 44,285 | 3.4 | 372,400 | 25.0 | 8.4 |
| 4,000-5,000 | 18,491 | 1.4 | 74,500 | 5.0 | 4.0 |
| 5,000-6,000 | 5,530 | 0.4 | 44,700 | 3.0 | 8.1 |
| 6,000-7,000 | 1,477 | 0.1 | 22,300 | 1.5 | 15.1 |
| Over 7,000 | 4,353 | 0.3 | 7,400 | 0.5 | 1.7 |
| Total | 1,312,937 | 100.0 | 1,489,400 | 100.0 | 1.1 |
| Average | 1,334 | | 2,657 | | 2.0 |

Source: Study Team

**Figure 5.1.9 Changes in Distribution of Household Income in the Study Area**



### (2) Income by Zone

The present average household income distribution varies largely by zone from RMB 607 to RMB 2,439. For the future, the number of households by zone is estimated based on the future population at first. In order to increase the income to about twice that of the present, the distribution pattern should shift higher by one or two groups. For the newly developed zones, middle to high income groups are assigned. For the zones with already high average income, income distribution is assumed to shift to higher direction at a moderate rate.

The forecast results by area are shown in Table 5.1.23. Although average income largely varies by zone, it has less disparity when aggregated by area. The present average income is a little low in the area between 2nd- and 3rd Ring Roads but in the future it will reach the same level as the area between 1st- and 2nd Ring Roads because middle to higher income groups are located in the new residential areas. The average income in the area within Inner Ring Road and between Inner and the 1st Ring Roads will decrease relatively because it is not expected there to increase to the middle-higher income groups. The outer area with higher household incomes at present and will remain as such in future.

## Table 5.1.23 Future Number of Households by Income Group and by Area

| Income Levels (RMB/Month) | Inside Inner Ring Road | Between Inner- and 1st Ring Roads | Central Area Total | Between 1st- and 2nd Ring Roads | Between 2nd- and 3rd Ring Roads | Inner Area Total | Outer Area (outside 3rd Ring Road) | Study Area Total |
|---|---|---|---|---|---|---|---|---|
| **Year 2000** | | | | | | | | |
| less than 600 | 56,115 | 47,024 | 103,139 | 65,199 | 68,174 | 133,373 | 44,217 | 280,729 |
| 600-1,000 | 54,773 | 52,015 | 106,788 | 95,344 | 103,758 | 199,102 | 84,503 | 390,393 |
| 1,000-2,000 | 64,301 | 55,995 | 120,296 | 117,256 | 98,401 | 215,657 | 97,125 | 433,078 |
| 2,000-3,000 | 24,945 | 19,998 | 44,943 | 38,511 | 25,880 | 64,391 | 25,267 | 134,601 |
| 3,000-4,000 | 7,303 | 7,411 | 14,714 | 11,224 | 9,264 | 20,488 | 9,083 | 44,285 |
| 4,000-5,000 | 2,849 | 2,891 | 5,740 | 2,739 | 3,287 | 6,026 | 6,725 | 18,491 |
| 5,000-6,000 | 1,159 | 772 | 1,931 | 1,191 | 1,186 | 2,377 | 1,222 | 5,530 |
| 6,000-7,000 | 249 | 113 | 362 | 610 | 207 | 817 | 298 | 1,477 |
| Over 7,000 | 306 | 425 | 731 | 1,604 | 737 | 2,341 | 1,281 | 4,353 |
| Total | 212,000 | 186,644 | 398,644 | 333,678 | 310,894 | 644,572 | 269,721 | 1,312,937 |
| Average | 1,318 | 1,320 | 1,319 | 1,367 | 1,256 | 1,313 | 1,407 | 1,334 |
| **Year 2010** | | | | | | | | |
| less than 600 | | | | | | | | |
| 600-1,000 | 29,800 | 25,000 | 54,800 | 34,300 | 36,400 | 70,700 | 23,400 | 148,900 |
| 1,000-2,000 | 22,100 | 23,700 | 45,800 | 61,000 | 103,900 | 164,900 | 87,200 | 297,900 |
| 2,000-3,000 | 43,500 | 42,700 | 86,200 | 126,400 | 154,900 | 281,300 | 153,800 | 521,300 |
| 3,000-4,000 | 40,700 | 36,200 | 76,900 | 99,800 | 100,000 | 199,800 | 95,700 | 372,400 |
| 4,000-5,000 | 6,000 | 7,400 | 13,400 | 15,400 | 23,000 | 38,400 | 22,700 | 74,500 |
| 5,000-6,000 | 3,600 | 4,400 | 8,000 | 6,300 | 13,300 | 19,600 | 17,100 | 44,700 |
| 6,000-7,000 | 2,400 | 1,700 | 4,100 | 4,000 | 7,800 | 11,800 | 6,400 | 22,300 |
| Over 7,000 | 600 | 600 | 1,200 | 2,100 | 1,700 | 3,800 | 2,400 | 7,400 |
| Total | 148,700 | 141,700 | 290,400 | 349,300 | 441,000 | 790,300 | 408,700 | 1,489,400 |
| Average | 2,524 | 2,557 | 2,540 | 2,665 | 2,638 | 2,650 | 2,755 | 2,657 |
| **2010/2000** | | | | | | | | |
| less than 600 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 600-1,000 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 | 0.4 |
| 1,000-2,000 | 0.3 | 0.4 | 0.4 | 0.5 | 1.1 | 0.8 | 0.9 | 0.7 |
| 2,000-3,000 | 1.7 | 2.1 | 1.9 | 3.3 | 6.0 | 4.4 | 6.1 | 3.9 |
| 3,000-4,000 | 5.6 | 4.9 | 5.2 | 8.9 | 10.8 | 9.8 | 10.5 | 8.4 |
| 4,000-5,000 | 2.1 | 2.6 | 2.3 | 5.6 | 7.0 | 6.4 | 3.4 | 4.0 |
| 5,000-6,000 | 3.1 | 5.7 | 4.1 | 5.3 | 11.2 | 8.2 | 14.0 | 8.1 |
| 6,000-7,000 | 9.6 | 15.0 | 11.3 | 6.6 | 37.7 | 14.4 | 21.5 | 15.1 |
| Over 7,000 | 2.0 | 1.4 | 1.6 | 1.3 | 2.3 | 1.6 | 1.9 | 1.7 |
| Total | 0.7 | 0.8 | 0.7 | 1.0 | 1.4 | 1.2 | 1.5 | 1.1 |
| Average | 1.9 | 1.9 | 1.9 | 2.0 | 2.1 | 2.0 | 2.0 | 2.0 |

## 5.2 Outline of Future Transport Demand Forecast

### 5.2.1 The Purpose of Forecasting Transport Demand

The future traffic demand is forecasted in this section to basically determine the traffic characteristics or scenario of the future for the Study Area as an important requirement in the conduct of further analyses and assessments. The information offered will be used, among others, to clarify planning direction and priority by identifying problem areas and issues. It will also provide basis with which the performance of the proposed measures or projects can be evaluated. More specifically, the purpose of each forecasting step undertaken are as follows:

**(1) Calculating future OD matrix**

This step estimates the total number of person trips, which considers the future socio-economic framework and volume of trips traveling between traffic zones, in order to supply information for the planning of the new transport system.

**(2) Forecasting traffic volume on the planned network**

This step predicts volume of traffic on the network based on the planned transport system in Chengdu City, and points out problems and issues according to the balance between traffic volume calculated and transport capacity.

**(3) Forecasting traffic volume on a new transport system**

This step estimates the traffic volume on the basis of the new transport system reflecting the transport measures to solve the problems. It also evaluates the service level of the new transport network.

**(4) Evaluating the role of the public transport system in the new system.**

In the new transport system, this step provides necessary service level indicator for public transport network such as demand by bus route, headway by bus route, transfer at a bus terminal, etc.

### 5.2.2 Process of Forecasting Traffic Demand

In general, the process in forecasting traffic demand entails the following:

- Analyses are first done on the current situation of the urban structure and on the trip behaviors in the Study Area based on the person trip survey results;
- Models are then developed for determining future traffic demand. These models are basically divided into two groups: namely, the models for estimating future OD matrices, and the model for calculating the traffic volume on the transport network. The OD matrix is made by inputting the socio-economic indicators based on the social-economic framework discussed in the previous section of this chapter. The service level of the transportation, especially the service level of public transport, is also inputted. Then, this future OD matrix is assigned on a base transport network, which includes the existing network and the committed planned projects, so as to calculate the future traffic demand. This base network represents the “Do nothing” scenario or case. Results of this calculation will show the balance between supply

and demand as well as issues of the future base network.

Figure 5.2.1 illustrates the specific process followed in this study. They are as follows:

(a) Firstly, in terms of the person trip survey data and existing OD matrix, the models of traffic demand forecasting are built;

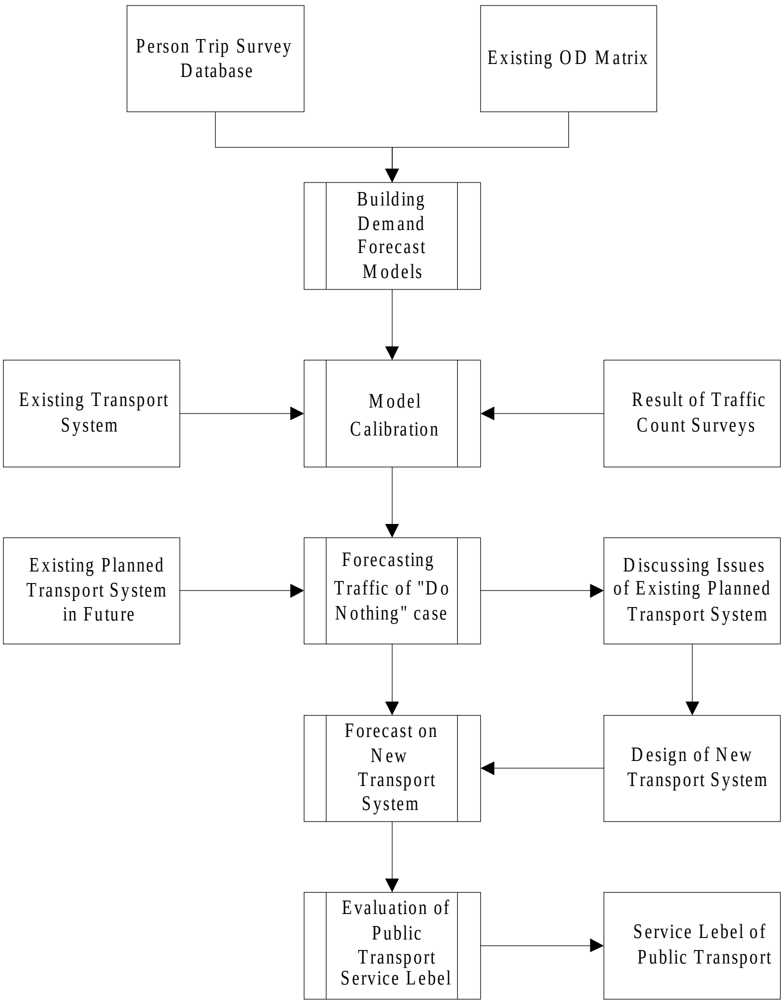
(b) Then, the next step estimates the existing traffic situation using the existing condition and examines the model's performance of calibration, that is, by comparing the survey result of traffic count survey under the current situation of traffic system (the network of roads, the network of public traffic system) with the traffic volume which is calculated according to the existing OD matrix;

(c) Thirdly, after gaining adequate result of the calibration, the future OD matrix is calculated by inputting the future socio-economic framework into the models;

(d) Fourthly, based on the above result, a new traffic system (fixed plans + proposed plan = master plan) is considered and the traffic volume on this master plan system is estimated. And this result is also applied to examine road facilities' capacity and referred to for discussing the necessity of public service for special use;

(e) The final step predicts public transport volume of the new transport system and determines traffic needs of different routes.

**Figure 5.2.1 Process of Future Traffic Demand Forecast**



### 5.2.3 Building Models for Forecasting

Basically, forecasting the traffic demand are calculated using the conventional four-step model; namely: trip generation and attraction model, distribution model, modal split model and assignment model. JICA STRADA is a synthetic model developed on the basis of this four-steps calculation method. It is used to develop the forecasting model in this study. The JICA STRADA is also used in the calculation of transferring of trains or bus routes (for example, the transferring passengers of public transport routes network, etc.). Our study also uses it to engage in the relevant calculation of public transport network.

According to when a modal choice model is done, this four-step calculation method can be divided into the following three representative models:

**Trip End Model:** Before calculating trip distribution (OD matrix), this model determines the modal share of the traffic of every traffic zone.

**Trip Interchange Model:** After calculating trip distribution (OD matrix), this model calculates the modal share of traffic between traffic zones.

**Route Choice Model:** When calculating trip distribution, this model estimates routes of different transport mode and decides modal choice at the same time on the route.

Considering the characteristics of mode choice at existing situation, the trip interchange model was decidedly applied in this study. Because, for instance, some families still use public transportation according to where they go, even though they have a car. Meanwhile, in order to realize the sharing of trip mode between traffic zones, the service level of transport routes is an important factor. In addition, because subway route no.1 will be introduced in Chengdu in 2010, the route choice model in the aspect of the sharing of public transport and subway is adopted.

#### (1) Trip Generation/Attraction Model

This model consists of trip production model, and trip generation and attraction model. The trip production model forecasts the total number of trips in the whole Study Area by using trip rate of specific personal attribute, which can be obtained through the analysis of the person trip data. The trip generation and attraction model is used to calculate trip generation and attraction by traffic zone, meanwhile, this model can be described by the comparison of the trip generation and attraction, and socio-economic indicators by traffic zone.

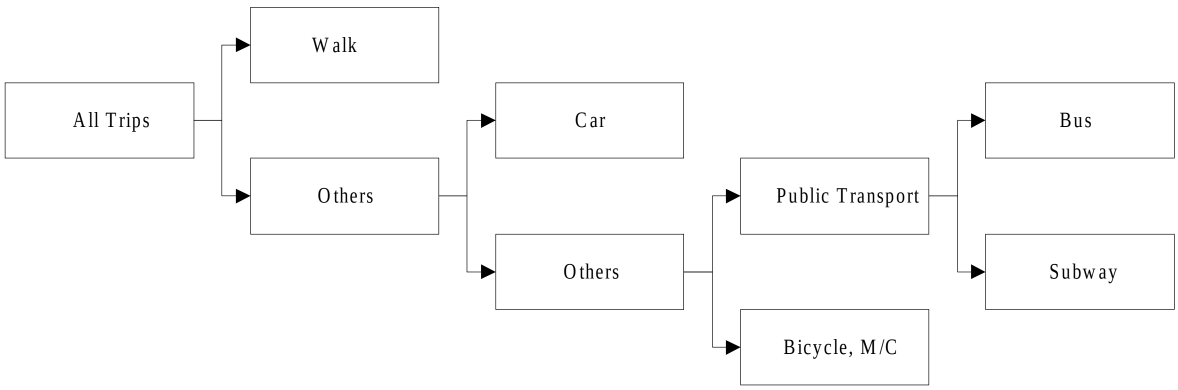
#### (2) Distribution Model

A distribution model is a model to calculate the trip distribution between traffic zones (OD matrix). The variables of the gravity model are trip generation and attraction, and the impedance between traffic zones, such as distance, time and generalized cost. The parameters can be calculated by analyzing the relationship between the volume of trip distribution and these variables.

### (3) Modal Split Model

A modal split model is shown in the following figure. First, all trips are divided into walk trips and other trips. Then the other trips are divided into passenger car trips and the other trips, which is shared by the public transport (buses, subways) and the other transport (bicycles, motorcycles). This transport-sharing model is a logit model, which calculates the sharing rate of public transportation according to the service level (travel time, travel cost, etc.). The calculation is done separately for car owner and non-car owner.

**Figure 5.2.2 Modal Split Structure**




### (4) Assignment Model

A traffic assignment model is a model, which assigns the OD matrix generated according to the modal split model (or distribution model) on the transport network, and calculates the traffic volume on each link in the network. Every link of roads in the transport network has the data reflecting their respective information about transport facilities and the data reflecting the service level of transportation system. The travel speed on every link varies because of the difference of traffic volume, based on which QV equation. Then, the shortest time between origin and destination zones is found, and the volume of trip distribution between specific zones is assigned on the shortest route. The assignment model of JICA STRADA includes one function to estimate transport demand for the public transport and railway system, considering the transferring of buses between routes or systems. It is mainly divided into the assignment model for evaluating the traffic volume of road transportation and the assignment model considering the public transport system, etc.

## 5.3 Future Traffic Demand

The forecast results are presented in this section. While the previous section explains the outline of the forecast models, this section describes each model and their results. Moreover, the following two cases are examined in the simulation of future demand forecast:

- Do-nothing Case: designates the future traffic condition with the existing network and only the committed transport projects by the city government are in place.
- Do-improvement Case: designates the future traffic condition when further improvements and development in transport infrastructure and system are implemented in addition to the Do-nothing Case.

### 5.3.1 The General Picture of Future Transport Needs

As mentioned in Chapter 5.2, the future transport demand is forecasted through four steps of trip generation and attraction, trip distribution, modal split and traffic assignment. However, trip characteristics will be changed by the car ownership. It is very obvious that the car ownership of Chengdu City will be getting higher. This is shown in the past trend of Chengdu City and other large cities in China. Therefore, demand forecast models are developed considering car ownership.

As shown in Figure 5.3.1, car ownership rates by zone are first estimated based on the future socio-economic framework. The trip production model calculates the total number of person trips. The number of trips generated and attracted by zone is estimated by trip generation/attraction model based on the future socio-economic framework. The numbers of trips by zone are then adjusted to coincide with the estimated trip production (total number of person trips) as the control total. By using this, the numbers of trips distributed are estimated by the trip distribution model. These are called the OD (origin-destination) matrices. In this study, the OD matrices are prepared by car ownership and by trip purpose. Trip purposes are classified into five; namely: to-work, to-school, private, business and to-home. By using modal split model, the number of trips by transport mode (OD matrices by mode) is estimated from the OD matrices by car ownership and by trip purpose. The transport modes are classified into four; namely: walking, car, public transport modes (bus and subway) and two-wheeled vehicles (bicycle and motorcycle). The modal split models are developed by car ownership.

Among the estimated OD matrices by mode, the OD matrix for public transport mode is assigned to public transport network and traffic volume by route is estimated. For this, the transit assignment model of JICA STRADA is used as the model for public transport. The traffic volume of public transport by route is converted to car traffic volume and loaded unto the road network as the initial traffic volume. Other OD matrices (car and two-wheeled vehicles) are assigned on this network. The incremental assignment model of JICA STRADA is used as the traffic assignment model.

**Figure 5.3.1 Models for Forecasting Traffic Demand**

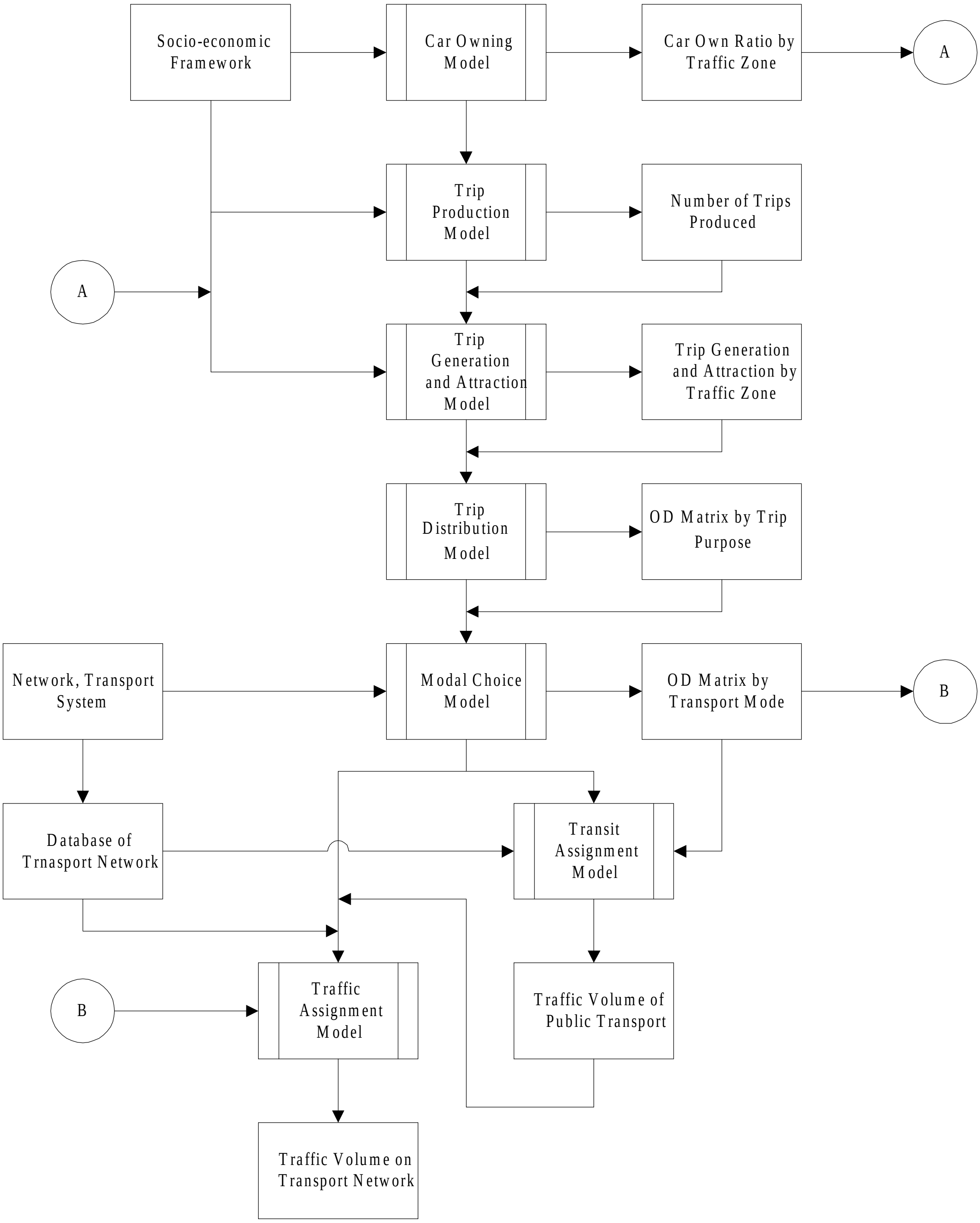
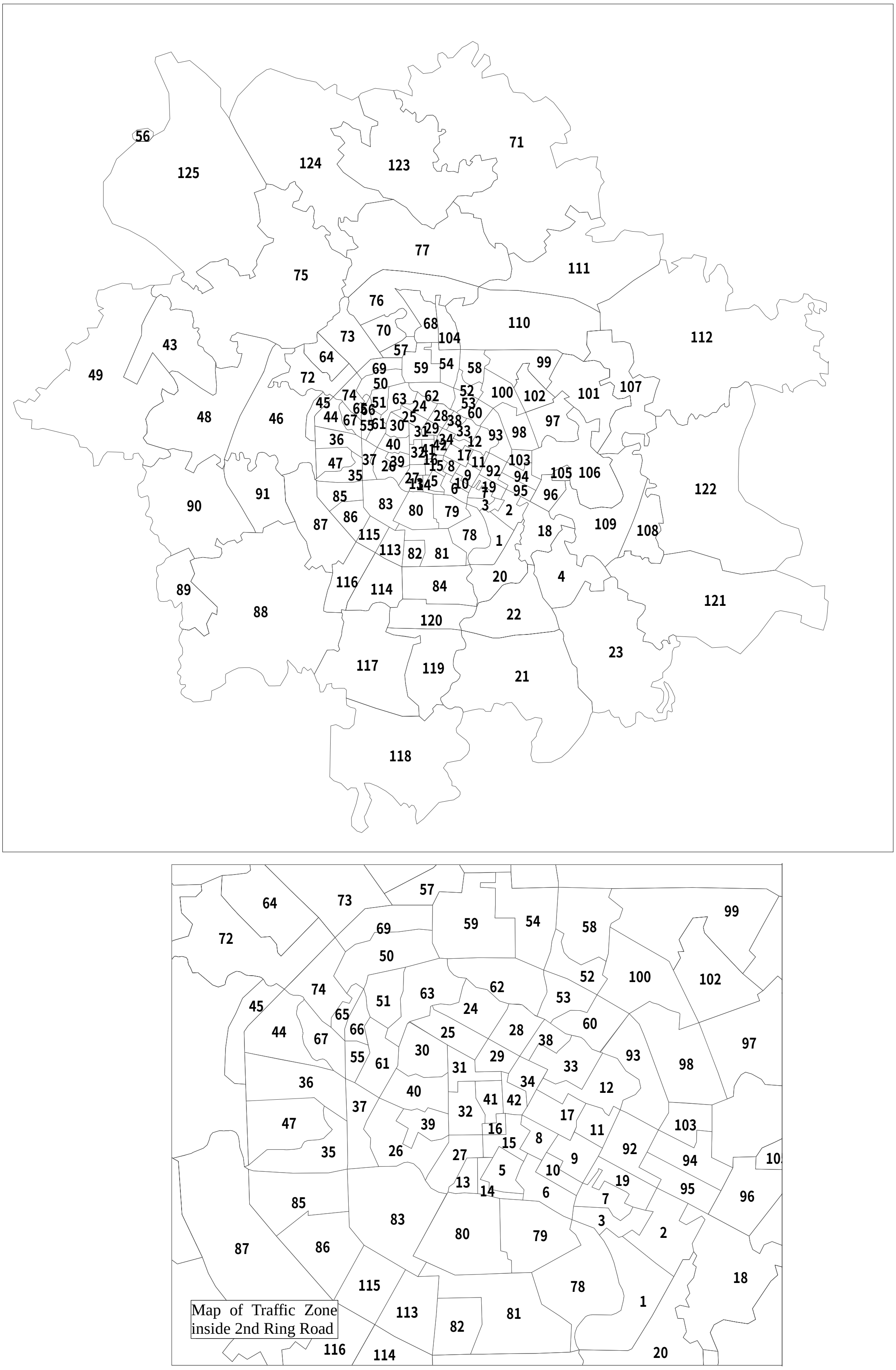


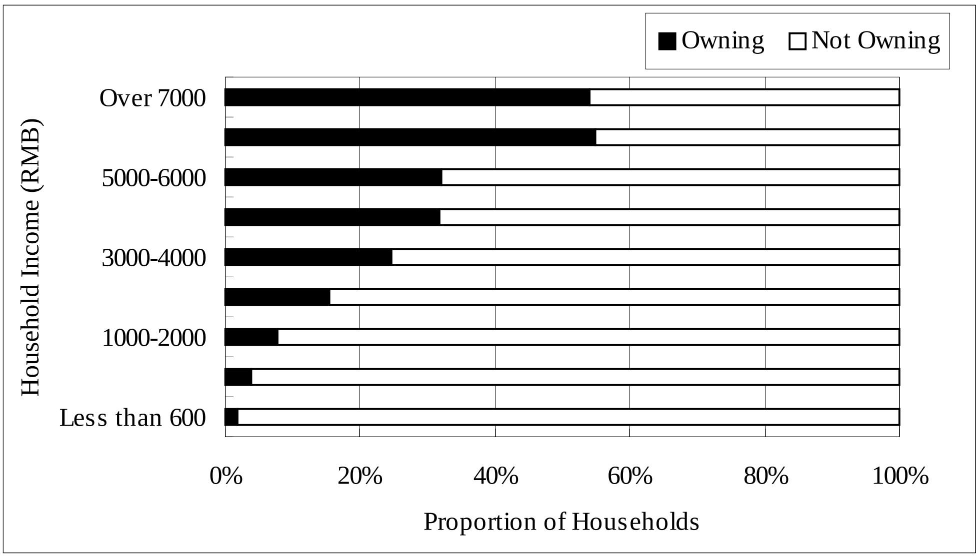
**Figure 5.3.2 Traffic Zones in the Study Area**



### 5.3.2 Car Ownership Rate

The figure below presents the household car ownership rate by income group obtained from the person trip survey. It reveals that the higher the income level, the higher car ownership rate becomes. This relationship is expressed in the following model, and high correlation was worked out.

**Figure 5.3.3 Car Ownership Rate by Income Group**

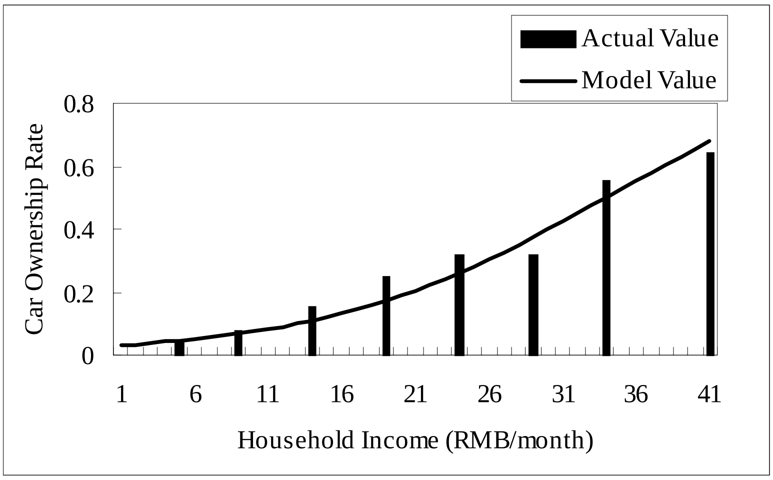



(Car Ownership Rate Model)

$$P = \frac{1}{1 + e^{-0.000524 \times I + 3.455}} \quad \text{(Correlation Coefficient: 0.95)}$$

P: Car Ownership Rate
I: Household Income (RMB)

**Figure 5.3.4 Car Ownership Rate Model**



### 5.3.3 Trip Production

#### (1) Trip Production Model

Trip production model is to estimate the future total number of person trips per day in the study area. There are three types of models as follows:

- Standard Unit Method
- Growth Rate Method
- Functional Model Method

In Chengdu City, the expansion of urban area is remarkable. It is estimated that citizens' mobility will grow considering the increase in car ownership and the completion of the planned subway. Considering the changes in the socio-economic structure and the transport environment, the standard unit method is adopted in the trip production estimation.

The trip rate by personal attributes such as age, occupation, car ownership is considered to be the standard unit for trip production. Among them, trip rate by car ownership and by household income is selected due to the following reason:

- Attribute has significant differences.
- Standard unit by attribute will not change in future.
- Structure will change in future.
- Future changes in structure are forecasted easily.

The following information were imputed in the trip production: (1) the trip rate of car owning household member is higher than that of non-owning, and (2) the higher the household income, the higher the trip rate becomes. Therefore, it is understood that the trip rate will increase correspondingly with the increase of income and the number of car owning households.

**Table 5.3.1 Trip Rate by Car Ownership and by Household Income**

| Household Income (RMB/month) | Non-Car Owning Households | Owning Households |
|---|---|---|
| Less than 600 | 2.56 | 2.82 |
| 600-1,000 | 2.69 | 3.06 |
| 1,000-2,000 | 2.79 | 2.87 |
| 2,000-3,000 | 2.85 | 2.96 |
| 3,000-4,000 | 2.90 | 2.86 |
| 4,000-5,000 | 2.86 | 3.08 |
| 5,000-6,000 | 3.24 | 2.83 |
| 6,000-7,000 | 2.88 | 2.91 |
| Over 7,000 | 3.39 | 3.33 |

#### (2) Forecast of Trip Production

The future car ownership rate is estimated by future household income. The future total number of person trips and mobility are estimated by multiplying trip rate and population by car ownership and by household income. These are shown in Table 5.3.2. The number of trips by trip purpose is presented in Table 5.3.3. The total number of person trips will increase 1.27 times from 7,923 thousand in 2000 to 10,091 thousand in 2010. Mobility will increase 1.12 times but it will be lower than the number of trips because the population will increase only 1.13 times.

**Table 5.3.2 Change in Mobility by Car Ownership**

| | 2000 | | | 2010 | | |
|---|---|---|---|---|---|---|
| | Non-Owning | Owning | Total | Non-Owning | Owning | Total |
| Population ('000) | 2,815 | 275 | 3,090 | 2,898 | 602 | 3,500 |
| No. of Trips ('000) | 7,174 | 750 | 7,923 | 8,284 | 1,807 | 10,091 |
| Trip Rate | 2.55 | 2.72 | 2.56 | - | 3.00 | 2.88 |
| Increase Rate of Mobility | - | - | - | - | - | 1.12 |

As mobility increases, the number of trips will increase in any trip purpose. The shares of private and business will expand.

**Table 5.3.3 Number of Trips by Trip Purpose**

| | 2000 | | 2010 | |
|---|---|---|---|---|
| Trip Purpose | ('000) | (%) | ('000) | (%) |
| To work | 1,401 | 17.7 | 1,769 | 17.5 |
| To school | 557 | 7.0 | 717 | 7.1 |
| Private | 1,663 | 21.0 | 2,189 | 21.7 |
| Business | 595 | 7.5 | 797 | 7.9 |
| To home | 3,708 | 46.8 | 4,619 | 45.8 |
| Total | 7,923 | 100.0 | 10,091 | 100.0 |

### 5.3.4 Trip Generation and Attraction

#### (1) Trip Generation/Attraction Model

This model is to estimate the number of trips generated and attracted to and from each zone by trip purpose. This has generally a close relationship with socio-economic indices such as population. There are three standard models normally used as trip generation/attraction model as follows:

- Standard Unit Method:

  By using the number of generated/attracted trips per population, land areas by type of use, etc., the number of trips generated and attracted in each zone is estimated by multiplying the above rate and the future value of the variables.

- Growth Rate Method:

  This method estimates trips generated/attracted by setting the future growth rates of trips that were obtained from the person trip survey.

- Functional Model Method:

  This method estimates trips generated/attracted by developing the multi-regression formula with explanatory variables of socio-economic indices such as population.

In this study, the functional model method i.e., multi-regression formula was adopted due to the following reasons: 1) plural number of explanatory variables can be considered, 2) the model with rational explanatory variables can be developed, and 3) handling of the model is easy. The parameters of the model are shown in Table 5.3.4.

**Table 5.3.4 The Parameters for the Generation/Attraction Model**

| | Purposes | Trip Generation | | Trip Attraction | |
|---|---|---|---|---|---|
| | | Model Formula | Correlation Coefficient | Model Formula | Correlation Coefficient |
| Car Owning | To work | $G=1.073\times W2+0.652\times W3+1001.9$ | 0.907 | $A=1.104\times E2+0.691\times E3$ | 0.959 |
| | To school | $G=1.35\times RP+0.214\times RS+323.1$ | 0.913 | $A=0.995\times SP+0.451\times SS+468.8$ | 0.885 |
| | Private | $G=0.323\times P+0.173\times ET+2486.4$ | 0.880 | $A=1.443\times E3+1627.7$ | 0.980 |
| | Business | $G=0.355\times E1+0.103\times E3+0.095\times P+556.2$ | 0.851 | $A=0.228\times E1+0.529\times E3$ | 0.912 |
| | To home | $G=1.042\times E2+2.629\times E3+2541.4$ | 0.952 | $A=0.980\times P+4442.5$ | 0.935 |
| Non Car Owning | To work | $G=1.279\times W2+0.464\times W3+74.9$ | 0.948 | $A=0.047\times E2+0.071\times E3$ | 0.693 |
| | To school | $G=1.307\times RP+0.247\times RS+17.8$ | 0.950 | $A=0.175\times SP+0.280\times SS$ | 0.740 |
| | Private | $G=0.436\times P+0.009\times ET+72.0$ | 0.926 | $A=0.131\times E1+0.107\times E3+175.8$ | 0.734 |
| | Business | $G=0.253\times P+0.002\times ET+15.5$ | 0.891 | $A=0.078\times E1+0.084\times E3$ | 0.778 |
| | To home | $G=0.071\times ST+0.162\times ET+132.9$ | 0.769 | $A=1.229\times P$ | 0.980 |

Where: G: Trips generated A: Trips attracted P: Population
RP: Number of pupils *at residence place* SP: Number of pupils *at school place*
RS: Number of students *at residence place* SS: Number of students *at school place*
ST: Number of pupils and student *at school place*
W1, W2, W3: Employment *at residence place* by sector
WT: Employment *at residence place*
E1, E2, E3: Employment *at work place* by sector
ET: Employment *at work place*

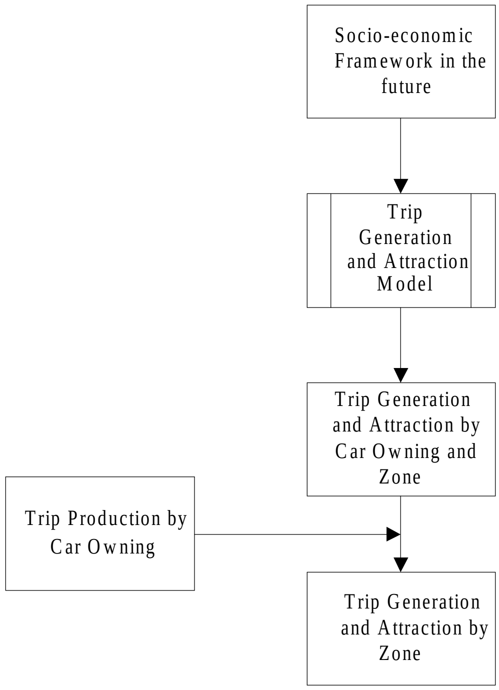
### (2) Forecast of Trip Generation and Attraction

The future number of generated/attracted trips by zone is estimated by applying the future socioeconomic indices into the models developed above. The results are adjusted by using the number of trips by car ownership and by household income as control total.

The future changes in the number of generated/attracted trips by zone are shown in Figures 5.3.6 and 5.3.7. As shown in those figures, its characteristics are explained as follows:

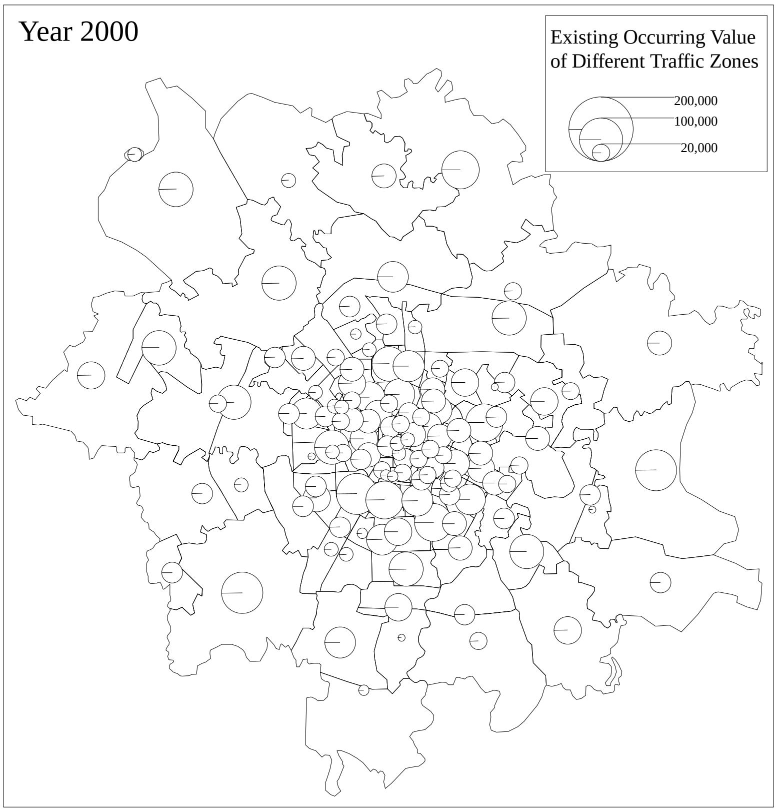
- The trip generation/attraction is concentrated in the area within the 2nd Ring Road at present but some zones in the area outside 2nd Ring Road will have relatively large number of trips in the future.
- The trip generation is concentrated in the area within 2nd Ring Road both at present and in the future. The concentration of generated trips will even be more visible in the future for the outside zones as these are larger than the ones in the center.

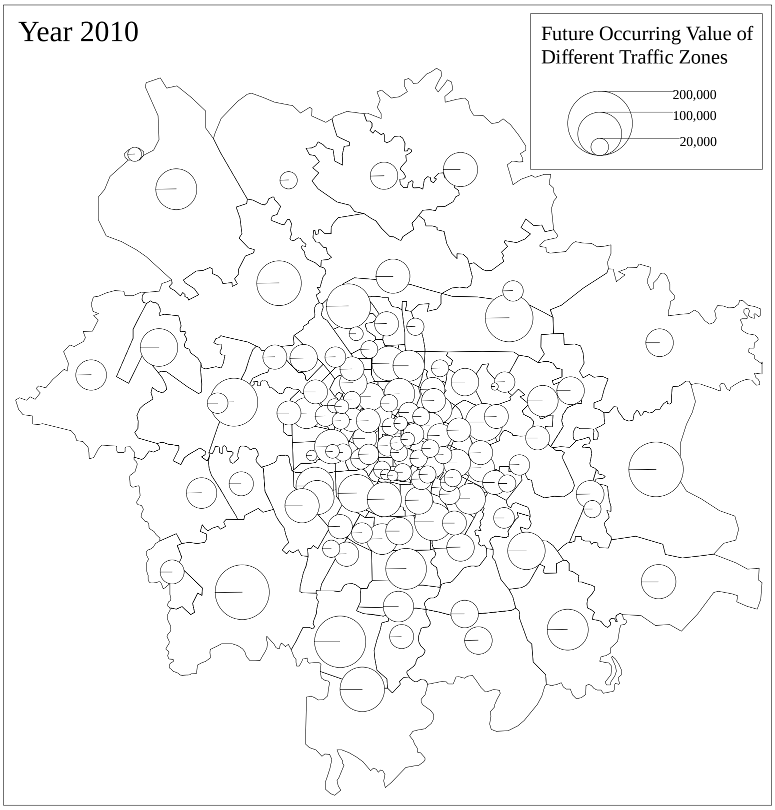
**Figure 5.3.5 Forecast of Trip Generation and Attraction**




- In the area outside of the 2nd Ring road, the zones that will have relatively large trip generations are, Zone No.110 (Qinglongchang), Zone No.122 (Longquanyi), Zone No.117 and 118 (Shiyangchang), Zone No.88 (Cuqiao), Zone No.46 (Supoqiao) and Zone No.75 (Tuqiao). The number of generated trips in those zones is more than 100 thousand.
- The zones with high growth rate in trip generation are Zone No.108 (Baohe), Zone No.117 and 118 (Shiyangchang) and other zones, which are newly developed.
- In the area outside the 2nd Ring road, the zones, which will have large trip attractions are Zone No.122 (Longquanyi), Zone No.23 (Gaodianzi), Zone No.88 (Cuqiao), and Zone No.48 (Supoqiao). At the areas within this ring road with large trip attractions are the neighborhood the Northern station in Zone No.54 (Xiaojiacun) and Zone No.59 (Yangliucun), Zone No.16 (Renmindonglu) and Zone No.83 (Jiangxijie).
- The zones with high growth rate in trip attraction are Zone No.111 (Qinglongchang), Zone No.108 (Baohe), Zone No.23 (Gaodianzi), Zone No.118 (Shiyangchang), and Zone No.119 (Sanwayao).

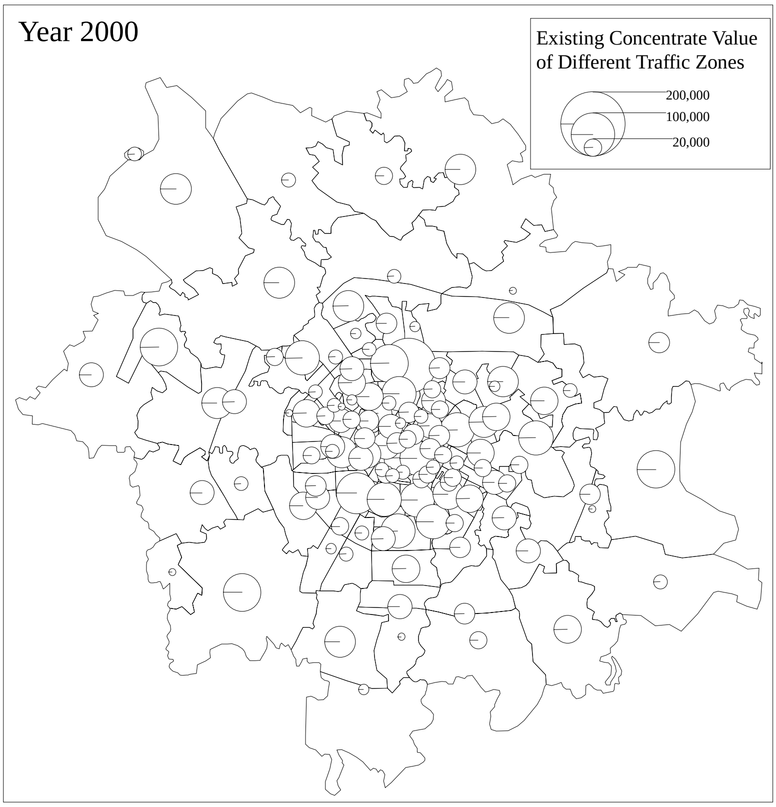
**Figure 5.3.6 Changes in Generated Trips by Traffic Zone**

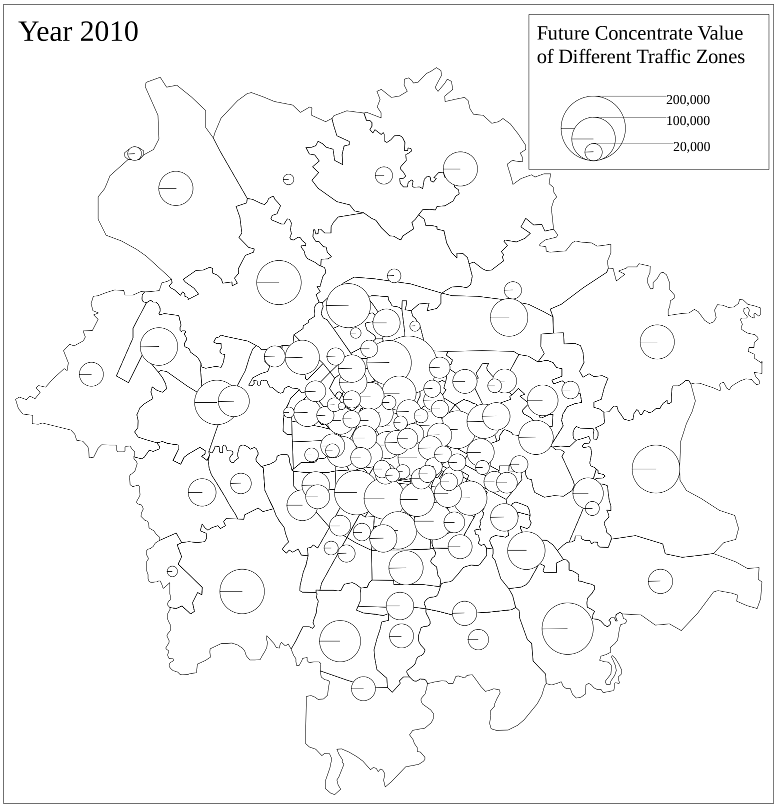



Note: excludes "To home" purpose trips

## Figure 5.3.7 Changes in Attracted Trips by Traffic Zone



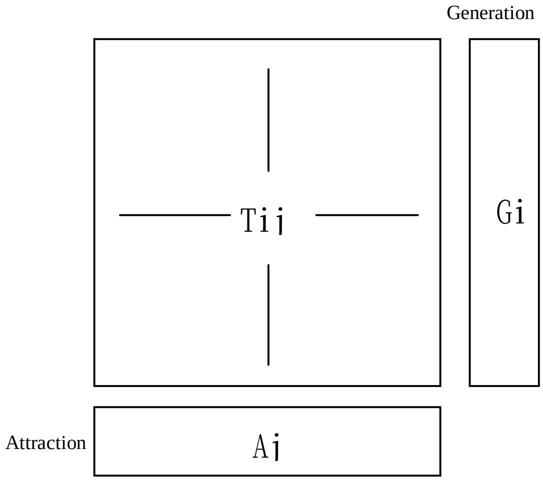

Note: excludes "To home" purpose trips

### 5.3.5 Trip Distribution

#### (1) Trip Distribution Model

This model is to estimate the number of distributed trips by OD pair, i.e., OD matrices, based on the trip generation and attraction by zone, which is described in the previous section. It is specifically to estimate the $T_{ij}$ from the sums of $G_i$ and $A_j$ (Figure 5.3.8).

**Figure 5.3.8 Output of Trip Distribution Model**




**<u>Number of Inter-zonal Distributed Trips</u>**

Generally there are three typical trip distribution models as follows:

- Present Pattern Method
- Gravity Model Method
- Probability Model Method

Among the above models, the present pattern method and gravity model method were examined. The present pattern method was selected for adoption due to the following reasons: 1) forecast is done for the target year of 2010, which does not have the duration differences, 2) it is assumed that trip distribution pattern will not change much in future because the urban structure of the study area will have no distinct discrepancy, 3) the structure is more simpler and handling is easier, and 4) gravity model tends to estimate a similar pattern of trips in every OD pair. The formula of the present pattern model is as follows:

$$T_{ij} = t_{ij} \times \left(\frac{G_i}{g_i} + \frac{A_j}{a}\right) \times \frac{1}{2}$$

Where: Tij: Future number of trips from i zone to j zone
tij: Present number of trips from i zone to j zone
Gi: Future number of trips generated from i zone
gi: Present number of trips generated from j zone
Aj: Future number of trips attracted to i zone
aj: Present number of trips attracted to j zone

### Number of Intra-zonal Trips

The formula with input data of trip generation/attraction and zone area was adopted for the model to estimate the number of intra-zonal trips.

$$T_{ii} = C \times G_i^{\alpha} \times A_i^{\beta} \times L_i^{\nu}$$

Where: Tij: Future number of intra-zonal trips
Gi: Future number of trips generated from i zone
Ai: Future number of trips attracted to i zone
Li: Area of zone I

**Table 5.3.5 Parameter of Intra-zonal Trip Model**

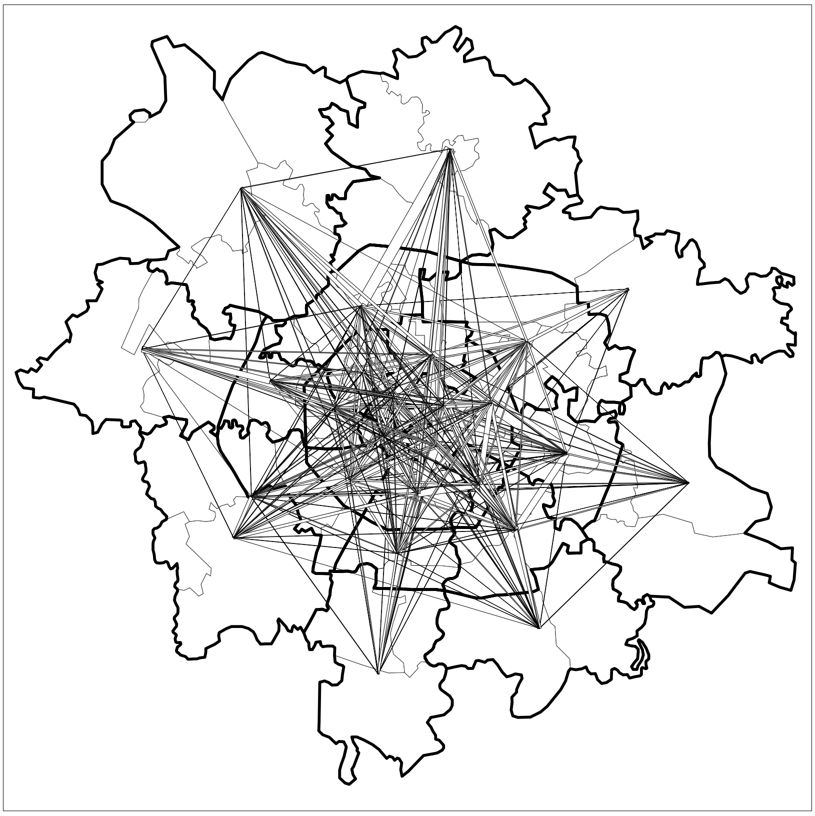
| | Purposes | Parameter | | | |
|---|---|---|---|---|---|
| | | α | β | ɣ | C |
| Car Owning | To work | 0.734 | 0.457 | 0.392 | 0.006 |
| | To school | 0.691 | 0.519 | 0.250 | 0.018 |
| | Private | 0.697 | 0.552 | 0.368 | 0.004 |
| | Business | 0.628 | 0.455 | 0.343 | 0.021 |
| | To home | 0.559 | 0.803 | 0.328 | 0.001 |
| Non Car Owning | To work | 0.454 | 0.531 | 0.196 | 0.153 |
| | To school | 0.495 | 0.487 | 0.154 | 0.259 |
| | Private | 0.587 | 0.234 | 0.256 | 0.306 |
| | Business | 0.503 | 0.453 | 0.194 | 0.144 |
| | To home | 0.337 | 0.635 | 0.233 | 0.014 |

### (2) Forecast of Trip Distribution

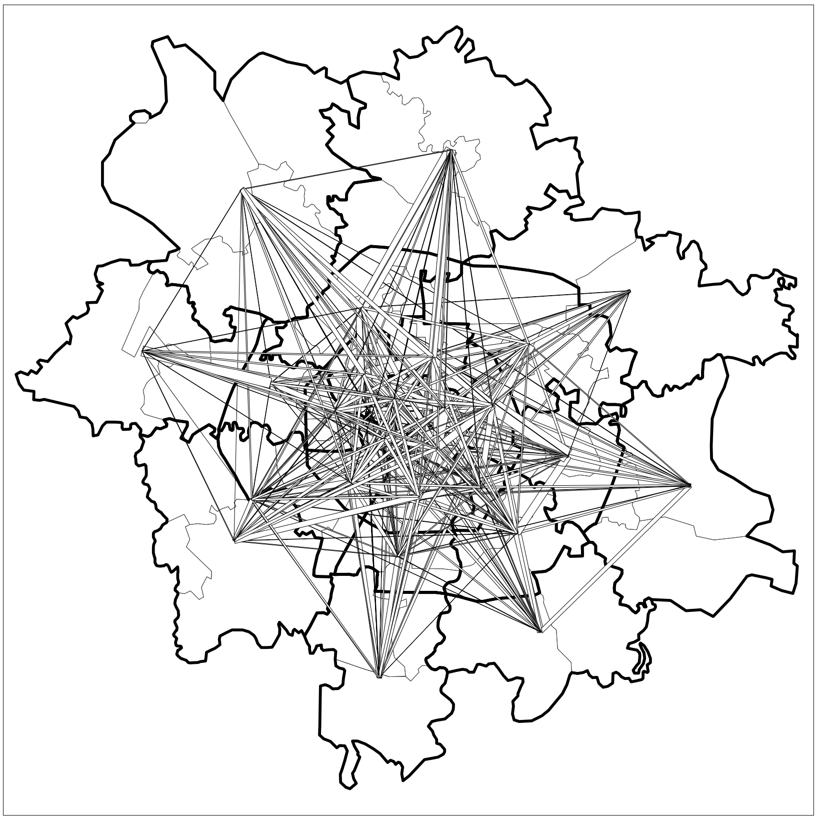
First, the intra-zonal trips by zone are estimated and by using present pattern method the OD matrices by car ownership and by trip purpose are estimated using the present OD matrices and trip generation/attraction by zone. The following Figure 5.3.9 shows the changes in trip distribution in middle-sized zone system defined in Chapter 4. The short distance trips are dominant at present but long distance trips between zones in the center and outer areas will increase, especially in the axes of north-south and east.

**Figure 5.3.9 Changes in the Desire Line (Medium-sized Zone)**

**2000**



**2010**



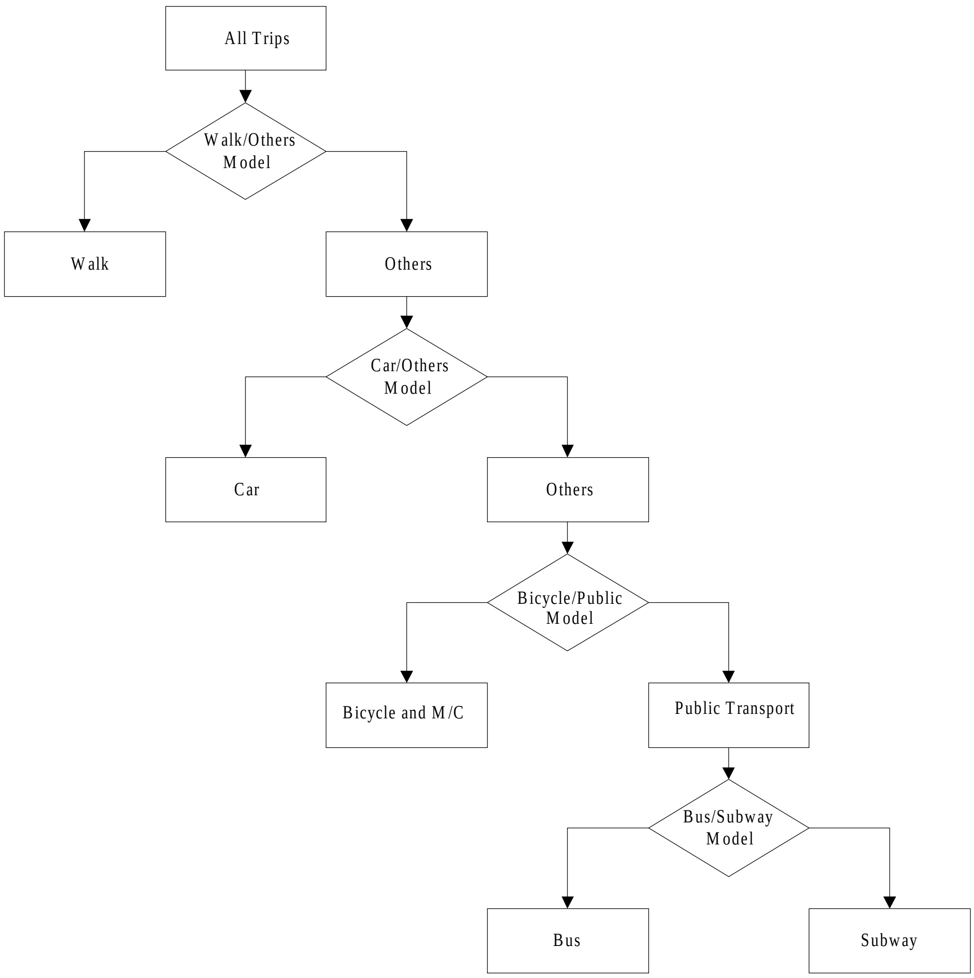
### 5.3.6 Modal Split Model

#### (1) Outline of Modal Split Model

By applying the trip distribution model, the OD matrices by trip purpose are estimated. It shows how many trips are made between zones by trip purpose. The next step is to estimate what kind of transport modes is used for making the trips in each distributed trips. For example, in transport planning, road infrastructure should be developed to meet the estimated car demand and public transport services should be supplied to meet estimated public transport demand. This study especially focuses on the development of the public transport system, so the results of the modal split model are important conditions that will influence planning.

In this study, the binary choice model is adopted as modal split model. This model has some steps and each step is to estimate the share between two modes. The selection of explanatory variables and structure of each steps are very essential. The model structure in this study is shown in Figure 5.3.10.

**Figure 5.3.10 Modal Split Structure and Modal Choice Models**



As it was illustrated in the figure above, the modal split model consists of the following four models:

1) **Walk Split Model:**

   This model determines the share of walk trips out of the total number of trips by OD pair.

2) **Cars Split Model:**

   This model determines the share of car trips out of the number of trips excluding walk by OD pair.

3) **Public Transport Split Model:**

   This model divides the share of trips between public transport and two-wheeled vehicles out of the number of trips excluding walk and car by OD pair.

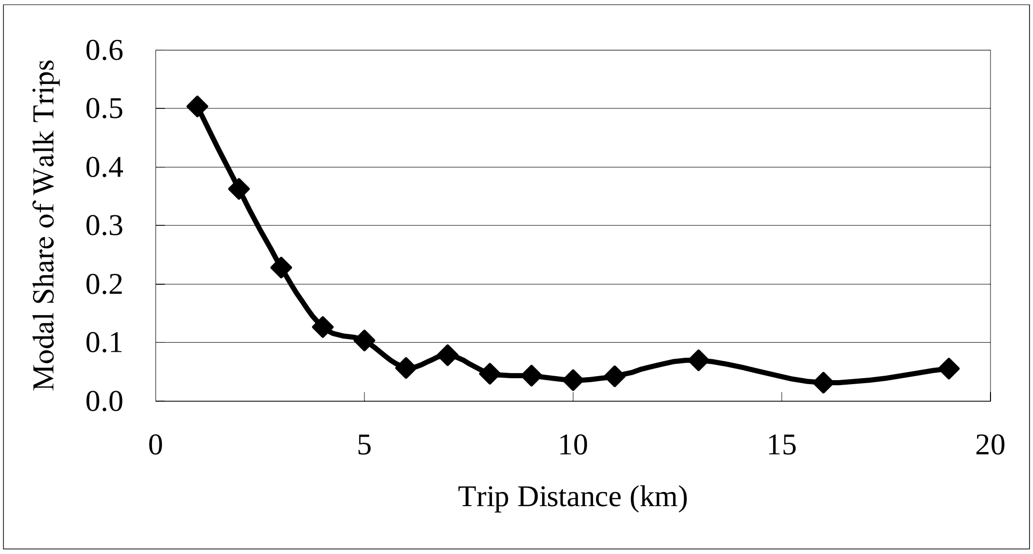
4) **Bus/Subway Split Model:**

   This model divides the share of trips between bus and subway out the number of trips excluding walk, car and two-wheeled vehicles.

### (2) Walking-Sharing Model

The share of walk trips by trip distance (walk trips/total trips) is shown in the figure below. Up to 5km, the share is decreasing progressively. After that, it is maintains a low share. There still exists the share of walk trips in the trip distance more than 10km because in the model, walk trips include the type of "other modes" in the category used in the person trip survey.

**Figure 5.3.11 Modal Share of Walk Trips by Trip Distance**




The following split curve was applied as it is most suitable for the actual distribution of modal share of walk trips shown in above figure.

$$P_{ij}^{W} = -0.0004 \times d_{ij}^{3} + 0.0143 \times d_{ij}^{2} - 0.1645 \times d_{ij} + 0.6274$$ (Correlation Coefficient: 0.982)

Where: $P_{ij}^{w}$ : Modal share of walk trips from zones i to zone j

$d_{ij}$ : Distance between zones i and j

**(3) Cars Split Model**

The car split model is to estimate the modal share of car trips by OD pair (car trips/(total trips – walk trips)). Two models were developed by car ownership, because it has a strong relation with the use of car. In order to represent the mechanism of modal shift from car to public transport, the differences of travel time between them are considered in the model as one of the explanatory variable. The travel time of car was calculated assuming 50% of the maximum speed of OQ curve in road network. As for public transport, specifically buses, it was assumed that bus takes the shortest route on the road network with travel speed of 15km/h. Based on these conditions, the model parameters were estimated. The formula used is as follows:

Non-Car Owning: $$P_{ij}^{C} = \frac{1}{(1 + e^{-2.6207 \times (t_{ij}^{B} - t_{ij}^{C}) + 1.9989})}$$ (Correlation Coefficient: 0.890)

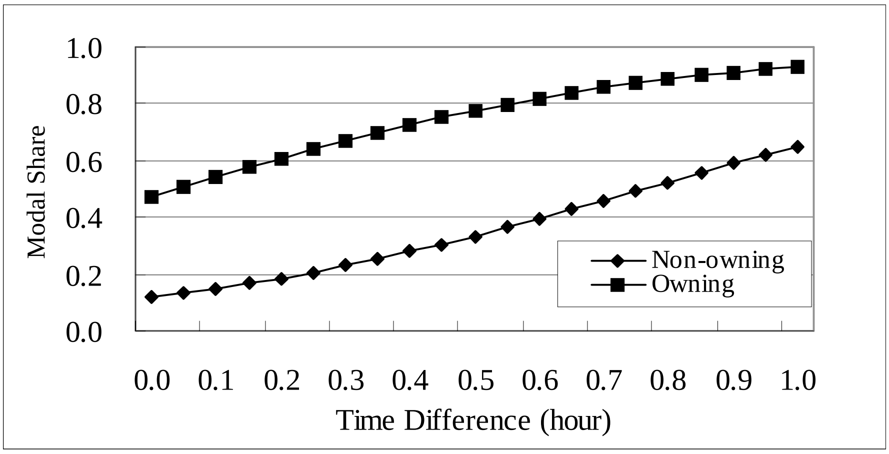
Car Owning: $$P_{ij}^{C} = \frac{1}{(1 + e^{-2.6886 \times (t_{ij}^{B} - t_{ij}^{C}) + 0.0989})}$$ (Correlation Coefficient: 0.779)

Where: $P_{ij}^{C}$ : Modal share of car trips from zones i to zone j

$t_{ij}^{B}$ : Travel time of public transport from zones i to zone j (hour)

$t_{ij}^{c}$ : Travel time of car from zones i to zone j (hour)

**Figure 5.3.12 Modal Share Curve of Car**



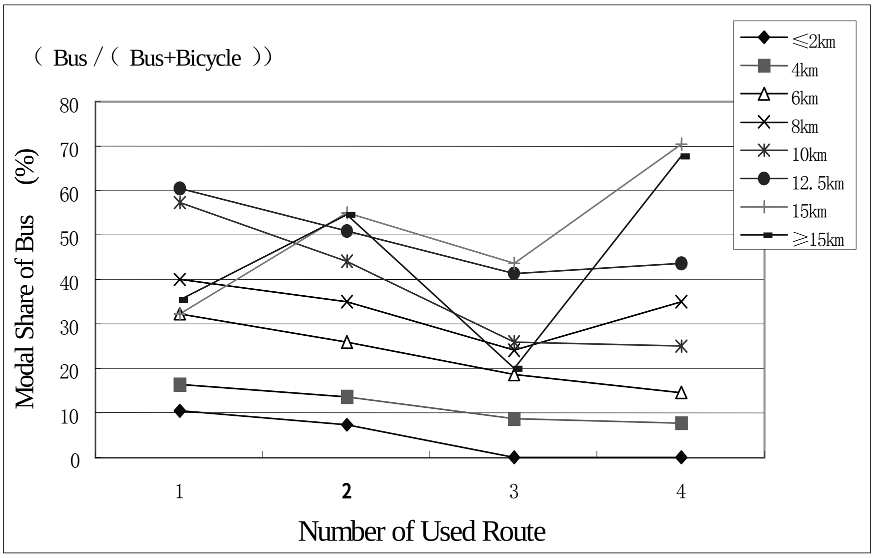

**(4) Public Transport Split Model**

This model is to estimate the share of public transport mode (public transport trips/(public transport trips + bicycle and motorcycle trips)). As the result of the analysis on the existing conditions, it is found that the factors considered in choice of bus are level of bus services such as: 1) travel time, 2) fare, 3) difficulty in route transfer, 4) waiting time, 5) accessibility to bus stop, and 6) comfort inside bus vehicle and so on. If these factors can be considered in the model as the explanatory variables, it will be easy to evaluate the situation when public transport system is improved. In order to take these factors in the model, the method described below was worked out in this study.

First, the present public transport network was prepared based on the existing bus routes. This network is composed of individual bus routes with attributes of service indices such as operating speed, service frequency (round trips per day), etc. By using this network and the transit assignment module of JICA STRADA, shortest route search can be done considering the impedances of bus fare and transfers.

The figure below shows the modal share of public transport by trip distance calculated by using public transport network and shortest routes. The vertical axis shows modal share of public transport and horizontal axis the number of routes taken using the shortest route. According to the results, for trips over 15km, the modal share of bus is higher as trip distance becomes longer. Moreover, as the number of required routes increase, the higher the modal share of bus. On the other hand, for trips less than 15km, the modal share of bus is unstable.

**Figure 5.3.13 Modal Share of Public Transport Mode by Trip Distance**




Therefore, in this study the public transport split model was developed based on the indices obtained from the public transport network. It was assumed that the travel speed of bicycle is 10km/h and for public transport 15km/h. The waiting time and fare of bus are fixed at 10 minutes and RMB 1 per route, respectively. In addition, the trips less than 15km were not used for estimation of model parameters.

$$p_{ij}^{B} = \frac{1}{1+e^{\left(-0.4020\times d_{ij}-7.3488\times\left(t_{ij}^{Y}-t_{ij}^{B}\right)+1.5546\times t^{W}-1.2023\times c_{ij}^{B}+2.4281\right)}}$$ (relevant coefficient: 0.879)

Where: B : Modal share of public transport from zone i to zone j

$d_{ij}$ : Shortest-time route distance on road network between from zone i to zone j (km)

$t_{ij}^{Y}$ : Travel time of bicycle from zone i to zone j (hour)

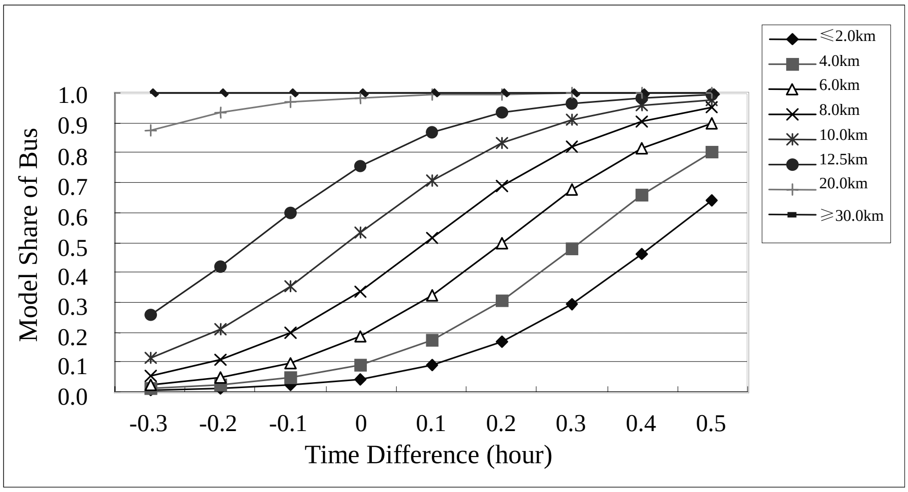
$t_{ij}^{B}$ : Travel time of public transport from zone i to zone j (hour)

$t^{w}$ : Waiting time of public transport (hour)

$c_{ij}^{B}$ : Fare of public transport (RMB)

Figure 5.3.14 shows the results of modal split curve.

**Figure 5.3.14 Modal Share Curve of Bus by Trip Distance**




The rate of the parameter of time differences (-7.3488) to the cost parameter (1.2023) is 6.1 RMB/hour. It is higher than that estimated in a different approach (4 RMB/hour). It means that the model developed by transport data considers more on the time factor.

### (5) Buses/Subways Split Model

The share between bus and subway is estimated by using transit assignment module based on the public transport network. The subway route is added to the prepared bus network. It is assumed that the capacity of subway is unlimited, travel speed is fixed at 30km/h and its fare is 1 RMB/ride. The resultant modal share is explained in Chapter 5.3.9.

### (6) Forecasting result of traffic volume by different means of transportation

Table 5.3.6 shows the results of future modal split (number of trips by mode). Two cases are examined here. Their conditions are as follows:

1) **Do-nothing Case:**

designates the future traffic condition with the present network and only the committed transport projects by the city government in place.

2) **Do-improvement Case:**

designates the future traffic condition when further improvements and development in transport infrastructure and system are implemented especially in the public transport system in addition to the Do-nothing Case. It is assumed that the travel speed of public transport is improved by 20% and all OD pairs are connected by bus route network with a maximum 1 time transfer.

The future modal share of walk trips are not so different in all cases compared to the present. In Do-nothing Case, modal share of car trips will rapidly grow sharing one fourth of the total. The modal share of bus trips will remain at its present share level even if the number of trips is increased. On the other hand, in Do-improvement Case, the modal share of bus trips will increase two folds from 14% to 27%, while the share of bicycle trips will decrease. The share of car trips is lower than that in Do-nothing but higher than the present level.

**Table 5.3.6 Future Transport Demand by Mode**

| Representative Transport Mode | 2000 | | 2010 | | | |
|---|---|---|---|---|---|---|
| | | | Do-nothing Case | | Do-improvement Case | |
| | No. of Trips ('000) | Proportion (%) | No. of Trips ('000) | Proportion (%) | No. of Trips ('000) | Proportion (%) |
| Walk | 967 | 19.6 | 1,247 | 20.2 | 1,247 | 20.2 |
| Car | 833 | 16.9 | 1,547 | 25.1 | 1,189 | 19.3 |
| Bicycle | 2,420 | 49.2 | 2,484 | 40.2 | 2,045 | 33.1 |
| Bus | 703 | 14.3 | 895 | 14.5 | 1,691 | 27.4 |
| Total | 4,923 | 100.0 | 6,173 | 100.0 | 6,173 | 100.0 |

Note: excluding intra-zonal trips

### 5.3.7 Traffic Assignment

#### (1) Methodology of Traffic Assignment

The procedure of traffic assignment is given in Figure 5.3.15. First, the public transport OD matrix is assigned on the public transport network by transit assignment module. The person trips in OD matrices are converted into the bus (subway) traffic volume in transit assignment module. The result is obtained in PCU (passenger car unit) by using carrying capacity of bus (average number of passengers per bus) and PCU value. The bicycle OD matrices is assigned on the bicycle network.

After this, the car OD matrix is assigned on the road network where the traffic volume of public transport and bicycle are already loaded. The incremental assignment method controlling the relationship with capacity and speed (QV curve) is used and as a result, the traffic volumes by vehicle type and by road link are calculated.

In fact, the bicycle OD matrix includes motorcycle trips. At present, it is ignored because motorcycle is regulated to enter the area within 2nd Ring Road and its traffic volume is limited. Bicycle and motorcycle should be divided in the traffic assignment because they use different lanes. Therefore, if the motorcycle is deregulated in the future, the prepared bicycle OD matrix should be divided and assigned on different networks of road and bicycle.

**Figure 5.3.15 Traffic Assignment Procedure**


## (2) Average Number of Passengers and PCU

The average number of passengers and PCU value should be defined by mode when the person trip OD matrices are assigned and converted in PCU volume. Table 5.3.7 shows the average number of passengers and PCU volume by mode according to the total vehicle-km at present. The PCU values used in the Chengdu City are adopted in this study. The PCU of bicycle is set at 0.25 and tricycle at 0.75.

### Table 5.3.7 Average Number of Passengers and PCU by Mode

| Representative Mode | Transport Mode | Average No. of Passengers[1/] | PCU | No. of Trips ('000) | Trip-km ('000km) | Vehicle-km ('000km) | Weighted Value | Average no. of passengers (Representative mode) | Weighted Value | Average PCU (Representative Mode) |
|---|---|---|---|---|---|---|---|---|---|---|
| Bicycle | Bicycle | 1.00 | 0.25 | 3,362.8 | 8,644.0 | 8,644.0 | 8,644.0 | | 2,161.0 | |
| | Tricycle | 1.53 | 0.75 | 106.9 | 236.9 | 155.2 | 236.9 | | 177.7 | |
| | Motorcycle (2-w) | 1.47 | 0.50 | 188.2 | 629.5 | 428.3 | 629.5 | | 314.7 | |
| | Motorcycle (3-w) | 1.80 | 0.50 | 17.3 | 47.1 | 26.1 | 47.1 | | 23.5 | |
| | Total | | | | | 9,253.6 | 9,557.5 | 1.03 | 2,677.0 | 0.28 |
| Car | Taxi | 1.10 | 1.00 | 371.7 | 1,840.4 | 1,673.1 | 1,840.4 | | 1,840.4 | |
| | Passenger Car | 2.07 | 1.00 | 323.0 | 1,622.8 | 785.5 | 1,622.8 | | 1,622.8 | |
| | Small Truck | 1.90 | 1.50 | 107.5 | 575.3 | 302.9 | 575.3 | | 862.9 | |
| | Large Truck | 1.96 | 2.50 | 45.7 | 268.3 | 136.7 | 268.3 | | 670.7 | |
| | Total | | | | | 2,898.2 | 4,306.8 | 1.49 | 4,996.9 | 1.16 |
| Bus | Standard Bus | 29.83 | 2.50 | 561.3 | 3,023.2 | 101.3 | 3,023.2 | | 7,558.1 | |
| | Mini Bus | 11.25 | 1.30 | 245.5 | 1,344.7 | 119.5 | 1,344.7 | | 1,748.1 | |
| | Total | | | | | 220.9 | 4,367.9 | 19.78 | 9,306.2 | 2.13 |

Note:1/ including drivers

### (3) Forecast of Assigned Traffic Volume

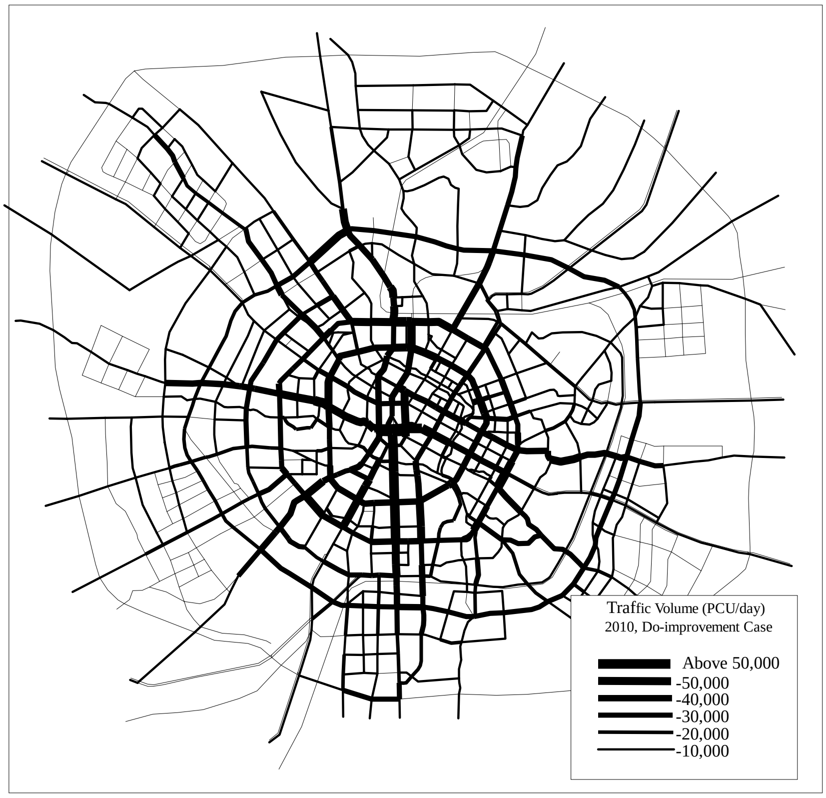
The results of traffic assignment by case are presented in the table below. In Do-nothing Case, the average travel speed of car and bus increases only slightly due to the increase of traffic volume. In Do-improvement Case, the travel speed of bus will be much higher than the present level.

### Table 5.3.8 Summary of Traffic Assignment Result by Scenario

| Vehicle Type | Indices | Unit | 2000 | 2010 | |
|---|---|---|---|---|---|
| | | | | Do-nothing Case | Do-improvement Case |
| Car | Total Travel Distance | 1,000 PCU×km | 4,405.3 | 9,463.9 | 6,332.3 |
| | Total Travel Time | 1,000 PCU×h | 108.1 | 171.9 | 108.9 |
| | Average speed | km/h | 40.8 | 55.1 | 58.1 |
| Bus | Total Travel Distance | 1,000 PCU×km | 259.7 | 443.9 | 805.9 |
| | Total Travel Time | 1,000 PCU×h | 21.6 | 35.8 | 47.6 |
| | Average speed | km/h | 12.0 | 12.4 | 16.9 |
| Total | Total Travel Distance | 1,000 PCU×km | 4,665.0 | 9,907.7 | 7,138.2 |
| | Total Travel Time | 1,000 PCU×h | 129.7 | 207.7 | 156.5 |
| | Average speed | km/h | 36.0 | 47.7 | 45.6 |
| | Capacity | 1,000 PCU×km | 10,765.9 | 25,462.9 | 28,948.0 |
| | Volume/capacity ratio | | 0.43 | 0.39 | 0.25 |

**Figure 5.3.16 Future Assigned Traffic Volume (Do-nothing Case)**


**Figure 5.3.17 Future Assigned Traffic Volume (Do-improvement Case)**

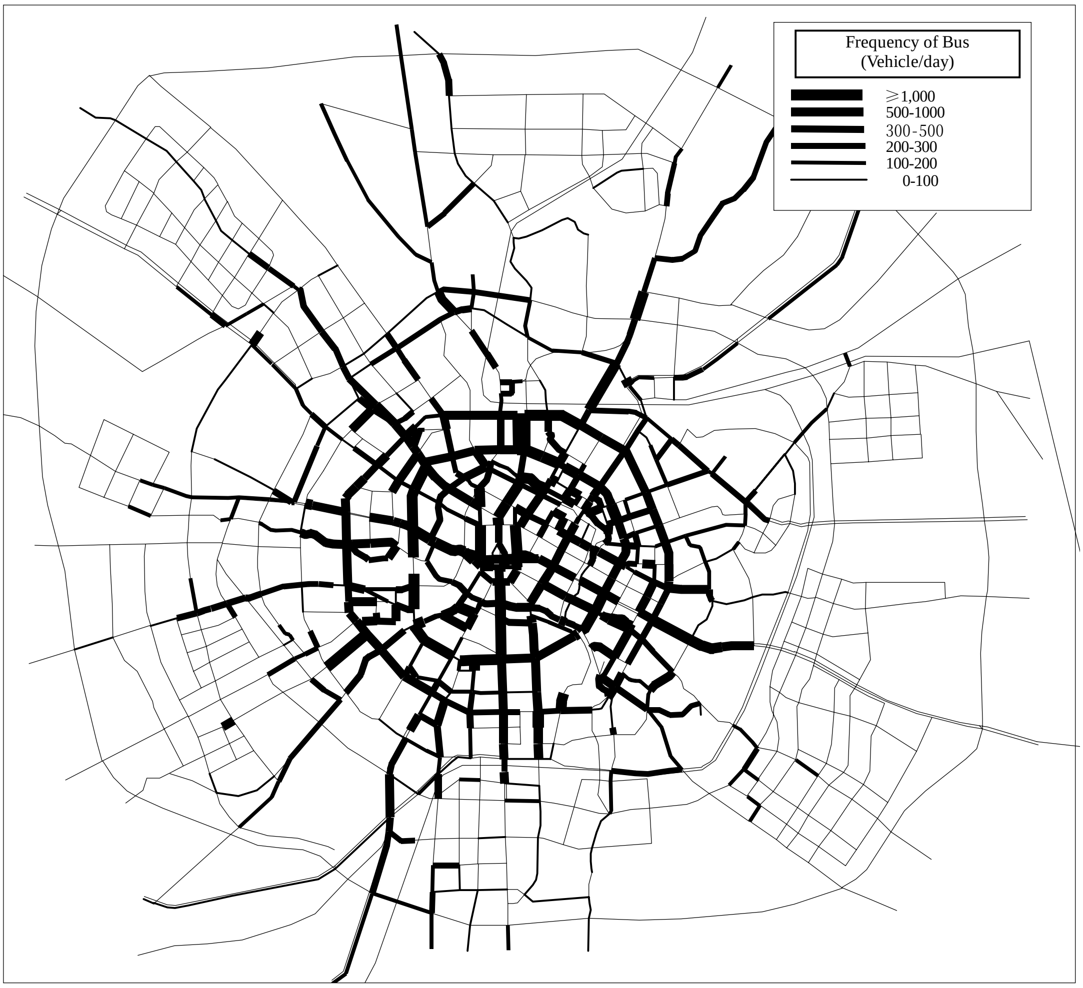


### 5.3.8 Accessibility to Bus Service

#### (1) Accessibility to Public Traffic Network

The following figure presents the accumulated bus service frequency by road link. More than 1,000 buses are supplied per day on the 1st Ring Road, East-West Road and roads around the north railway station.

**Figure 5.3.18 Frequency of Bus by Road Link**



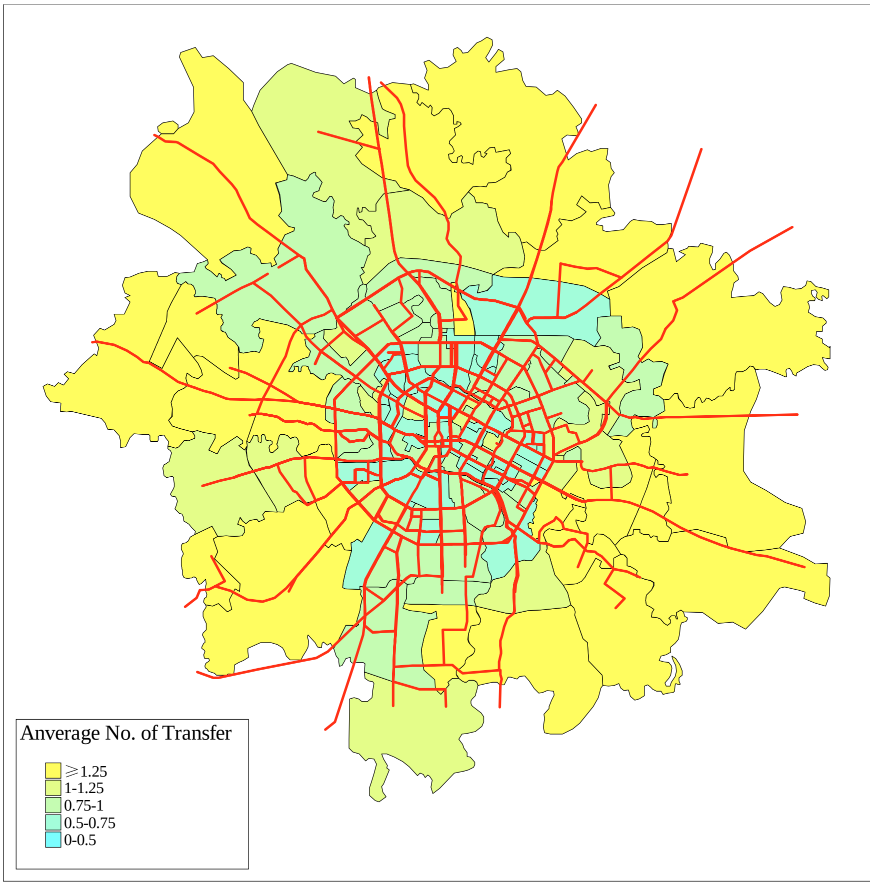
### (2) Accessibility to Public Transport

By using the existing bus route network, the average number of transfers between zones is calculated and accessibility by zone are defined through the following equation:

$$A_i = \frac{1}{(n-1)} \sum_j R_{ij}$$

Where: Ai: Accessibility of public transport in Zone i
Rij: Average number of transfers between zone i and j
n: Number of traffic zones

**Figure 5.3.19 Accessibility by Traffic Zone**



### 5.3.9 Development Impact of Subway Line 1

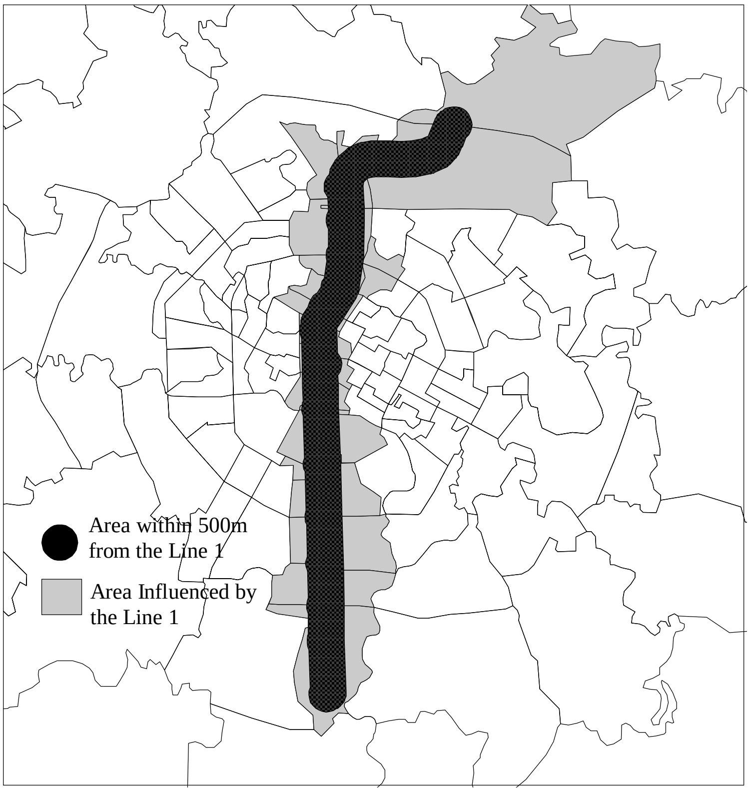
In Chengdu City, subway network development plan is in progress. Line 1 is one of the projects assumed completed by 2010. It is, therefore, necessary to grasp the impact of Line 1 in planning for public transport system.

In this section, based on the information collected from the city government and future demand forecast models, the future demand of Line 1 is estimated and its impacts are measured and evaluated.

#### (1) Areas Covered by Line 1

According to the information from the government as of November 2000, the route of Line 1 is from the intersection of the Third Ring Road and Zhaojuesi Lu in the north to the south railway station in the south passing through Renmin Nan-Lu and Renmin Zhong-Lu with total length of 17.9km. It passes through the center of Chengdu City and will formulate the north-south axis of public transport.

**Figure 5.3.20 Areas Covered by Subway Line 1**




In Figure 5.3.20 above, the dank area presents the area within a 500m distance from the Line 1 and 29 zones indicated as gray area are the influence zones. The total population in the influence zones is 647 thousand in the future. Compared with the present population of 644 thousand, its seems that there are no changes but development of residential buildings are ongoing and the population is growing in the adjoining zones. In the central area, its population will be decreasing. The population distribution will change. According to the results of the demand forecast, the future number of trips by public transport is estimated to increase from 227 thousand trips in 2000 to 448 thousand trips in 2010, about twice that of the present. The destination of these trips is distributed within the entire study area.

Among the generated public transport trips, the number of trips attracted in the Line 1 influence area will be 108.2 thousand in future. It can be said that about 100 thousand trips might be the minimum demand for Line 1 considering that trips with a distance of less than 2 km will not use the subway.

**Table 5.3.9 Projected Traffic Demand for the No.1 Subway**

| Indices | Duration | Coverage |
|---|---|---|
| No. of zones influenced | - | 29 traffic zones |
| Area - within 500m distance | - | 1,929 ha |
| - Influence area | - | 5,954 ha |
| Population | Present | 643,600 |
| | Future | 646,600 |
| No. of generated trips for public transport | Present | 227.4 thousand trips |
| | Future | 448.3 thousand trips |
| No. of trips between zones in the influence area | Future | 108.2 thousand trips |
| Of which trips with distance of less than 2km | Future | 100.8 thousand trips |

### (2) Demand for Subway and Bus

Table 5.3.10 shows the results of transit assignment. The public transport OD matrix with peak hour volumes were assigned on the bus route network. The following three cases are set for comparison: 1) assigning 2000 public transport OD trips on the existing bus routes, 2) assigning 2010 public transport OD trips on the existing bus routes, and 3) assigning 2010 public transport on the existing bus routes and Subway Line 1 (travel speed is faster than bus and fare is higher). The detailed conditions can be referred to in the previous sections.

As a result, the demand for Line 1 will be 25.9 thousand during peak hour. The peak hour OD table was prepared by peak hour rate of 10%. Thus, daily demand is expected at about 260 thousand. On the other hand, the bus demand will decrease only 2.3% because inasmuch as some bus users shifted to subway, other mode users shifted to bus in order to use the subway. The average number of transfers is estimated at 1.17 times and it is 0.11 times higher than when the Line 1 is not available.

The average trip length of subway user is 7.5km, about twice the distance of the bus. It is considered that the impedance of bus transfer is lower than subway because bus fare is lower and it will be used as access mode to subway stations.

**Table 5.3.10 Forecast of Subway Demand**

| Index | Unit | 2000 | 2010 | | | |
|---|---|---|---|---|---|---|
| | | | Without Subway | With Subway | | |
| | | Bus | Bus | Bus | Subway | Total |
| Vehicle-hour | (vehicle-hour) | 1,558 | 3,230 | 3,186 | | - |
| Vehicle-km | (vehicle-km) | 22,789 | 47,323 | 46,711 | | - |
| Average Speed | (km/h) | 14.6 | 14.7 | 14.7 | | - |
| Average V/C Rate | (V/C) | 0.50 | 0.77 | 0.70 | | - |
| No. of Passengers | (‘000 pax) | 68.0 | 163.8 | 160.1 | | 163.7 |
| No. of Passenger loading/unloading | (‘000 pax) | 139.0 | 336.8 | 329.2 | 25.9 | 355.2 |
| Passenger-hour | (‘000 pax-hour) | 28.0 | 91.8 | 81.3 | 6.5 | 87.8 |
| Passenger-km | (‘000 pax-km) | 441.4 | 1,389.0 | 1,232.5 | 195.1 | 1,427.6 |
| Average Trip Length | (km) | 3.2 | 4.1 | 3.7 | 7.5 | 4.0 |
| Average No. of Transfers | (times) | 1.05 | 1.06 | | | 1.17 |

### (3) Impacts to Car Transport

When the use of subway is promoted, bus traffic volume is reduced because the number of bus users is reduced. By this, road traffic conditions will be better and the users of other road transport modes such as cars will benefit. Impact of subway to the road traffic is estimated based on this mechanism.

The bus traffic volume by route is estimated from the results of the transit assignment. The travel speed on road is calculated by incremental assignment of car and bicycle with initial load of bus traffic volume. Based on this, impact of subway to the other road transport modes including bus can be estimated.

The following table shows the summary of the subway impact to the road traffic in the study area. The following are the highlighted impacts:

- Improvement in total vehicle-km 0.5%
- Improvement in total vehicle-time 1.5%
- Improvement in travel speed 1.1%

**Table 5.3.11 Impact of Subway to Road Traffic**

| Index | Unit | Without Subway | | | With Subway | | |
|---|---|---|---|---|---|---|---|
| | | Car | Bus | Total | Car | Bus | Total |
| Vehicle-km | (‘000 PCU×km) | 7,526 | 1,680 | 9,200 | 7,514 | 1,639 | 9,153 |
| Vehicle-hour | (‘000 PCU×hour) | 233 | 101 | 333 | 231 | 97 | 328 |
| Average Travel Speed | (km/h) | | | 27.6 | | | 27.9 |

### (4) Reduction in Air Pollution

Based on the forecasted subway demand, reductions in air pollution were calculated as shown in Table 5.3.12. Upon the completion of Line 1, $CO_2$ and NOx will be reduced by 8,191 tons/year and 30 tons/year, respectively.

**Table 5.3.12 Reduction in Air Pollution Due to the Subway**

| Contamination | Without Subway 2010 (tons/year) | With Subway 2010 (tons/year) | Reduced Amount (tons/year) |
|---|---|---|---|
| CO | 69,953 | 69,712 | 241 |
| $CO_2$ | 2,379,851 | 2,371,660 | 8,191 |
| THC | 32,092 | 31,981 | 111 |
| NOx | 8,654 | 8,624 | 30 |