9 EVALUATION OF THE MASTER PLAN ON PUBLIC TRANSPORT SYSTEM

9.1 The Master Plan and List of Projects of Public Transport System

9.1.1 Master Plan on Public Transport System

This section intends to integrate all the proposals discussed in the previous chapters on a Master Plan form based on the need to improve the public transport system in Chengdu. Said improvement is deemed possible by improving bus transport infrastructure and bus operation/service as discussed in chapters 7 and 8 as well as by implementing the specific plans listed below.

(1) Primary Busway Plan

The function, structure, operation and location of main busways are as follows:

- Busways will make use of the two outer lanes of existing main roads that have four to six lanes.
- Busways will strictly be used by buses only and not be accessible to other vehicles.
- Busways will be operated throughout the day.
- Buses will be guaranteed traffic privileges at main intersections by setting up special signals.
- Busways shall be on the same level as, but separated from, the other lanes. However, due to difficulty in providing enough space for the separate structure, busways will instead be paved in a different color for easy identification.
- To ensure ample traffic capacity for other vehicles, the existing four-lane roads will be converted to six lanes by changing the cross-section within the existing ROW.
- Busways will be established in the following streets:
  - Main east-west street (Shudu Road)
  - Main south-north street (Rengmin Bei-Lu, Renmin Zhong-Lu and Renmin Nan-Lu)
  - 1st Ring Road
  - 2nd Ring Road

(2) Secondary Busway Plan

The function, structure, operation, and location of secondary busways are as follows:

- The two outer lanes of existing four-lane roads will be used as busways.
- Busways will function during the peak hours of 7:00-9:00 in the morning and 4:00-7:00 in the evening.
- All vehicles other than bus will not be allowed on busways at these hours.
- Special traffic signals for buses will be installed at main intersections.
- Busways will be on the same level as other lanes.

- Busways will be separated from other lanes by traffic cones.
- Secondary busways will be established in the following roads:
  - Xin Renmin Nan-Lu - Hongxing Lu - Fuqing Lu
  - Shuanglin Lu - Wenwu Lu - Shawan Lu
  - Chadianzi Lu - Xi Da-Jie
  - Wuhouci Da-Jie - Beizhan Lu
  - Ximianqiao Lu
  - Dashi Lu
  - Dong Da-Jie

(3) Plan for Major Public Bus Terminals and Stations

The plan is to improve intra-city bus transfer facilities, inter-city bus terminals and bus stops.

- Intra-city bus transfer facilities include 11 sites within the 2nd Ring Road. These are:
  - North Railway Station
  - Tianfu Square
  - Vicinity of the 1st Ring Road and Renmin Nan-Lu intersection
  - Vicinity of the 1st Ring Road and Dongfeng Lu
  - Vicinity of the 1st Ring Road and Qinjiang Dong Lu
  - Vicinity of the 1st Ring Road and Wuhouci Da-Jie
  - Vicinity of the 1st Ring Road and Yingmenkou Lu
  - Vicinity of the 1st Ring Road and Jiefang Lu
  - Vicinity of the 2nd Ring Road and Shuanggui Lu
  - Vicinity of the 2nd Ring Road and Renmin Nan-Lu
  - Vicinity of the 2nd Ring Road and Qingjiang Zhong-Lu
- Major inter-city public bus terminals cover seven sites along the 3rd Ring Road in addition to one existing terminal and the another that is still under construction. Construction of a bus yard with vehicle maintenance facility is proposed at:
  - South Railway Station
  - Chuan-Zang Highway/Shunjiang Lu
  - Cheng-Peng Highway/Dongzikou
  - Chuan-Shan Highway/Jiangjunbei
  - Honghe Center Station
  - West Railway Station - Qinjiang Lu
  - Baliqiao
- Bus stops cover 230 sites mainly inside the 2nd Ring Road.

(4) Bicycle Lane Plan

To ensure traffic safety, it is imperative to completely segregate bicycle lanes from other lanes. Bicycle lanes should be provided on the following roads:

- Hongxing Lu-Fuqing Lu
- Wuhouci Da-Jie
- Fuqin Dong-Lu
- Shawan Lu
- Nanhe-You'an Lu
- Fuhe-Zuo'an Lu

(5) Plan to Improve Intersections

According to the basic policy of segregating bicycles from other vehicles, grade separation is proposed at the following intersections along the 1st Ring Road:

- 1st Ring Road/Renmin Nan-Lu
- 1st Ring Road/Xin Renmin Nan-Lu
- 1st Ring Road/Dongfeng Lu
- 1st Ring Road/Shuanglin Lu
- 1st Ring Road/Fuqing Lu
- 1st Ring Road/Renmin Bei-Lu
- 1st Ring Road/Beizhan Lu
- 1st Ring Road/Shawan Lu
- 1st Ring Road/Qingjiang Dong-Lu
- 1st Ring Road/Wuhouci Da-Jie

In addition, improvement of channelization at major at-grade intersections is proposed.

(6) One-way Road System Plan

Some options for a one-way traffic system in the central area were analyzed and presented in detail in Chapter 7.

(7) Plan to Improve the Environment for Pedestrians

Greenery conservation and development of pedestrian paths including malls are proposed in the central area.

(8) Plan to Privatize Bus Transport Business

A plan to encourage private companies to invest in public transport then to deregulate the restrictions on entry and to promote a competitive environment is proposed.

(9) Plan to Promote CNG Use

A plan to set up CNG filling facilities in existing gasoline stations, build more CNG stations and improve gas station service and system is proposed.

(10) Plan to Improve Bus Fare System

A plan to break up long bus routes and measures related to monthly ticket and prepaid card are proposed as well as the review of the bus fare system including the introduction of part-route fares.

(11) Plans to Improve Bus Vehicles

Improvement of bus vehicles is proposed such as promotion of CNG use, increase of air-conditioned bus fleet and encouragement of one-man bus (self-service system).

(12) Plan to Improve Public Transport Administration

The current administrative setup, which allows different organizations to adopt different policies on bus services should be improved.

The proposals listed above are illustrated in Figure 9.1.1.

9.1.2 Project List

Based on the individual plans explained in the previous chapters, the Master Plan has been formulated considering the characteristics, scale and conceptual and physical continuity of the proposed projects. The major planning areas are:

(1) Primary busway plan
(2) Secondary busway plan
(3) Auxiliary bus facilities plan
(4) Traffic control system plan

Each planning area has three to seven projects as listed in Table 9.1.1. The total number of the proposed projects in the Master Plan is 23.

Figure 9.1.1 Master Plan for the Development and Improvement of Public Transport (2010)

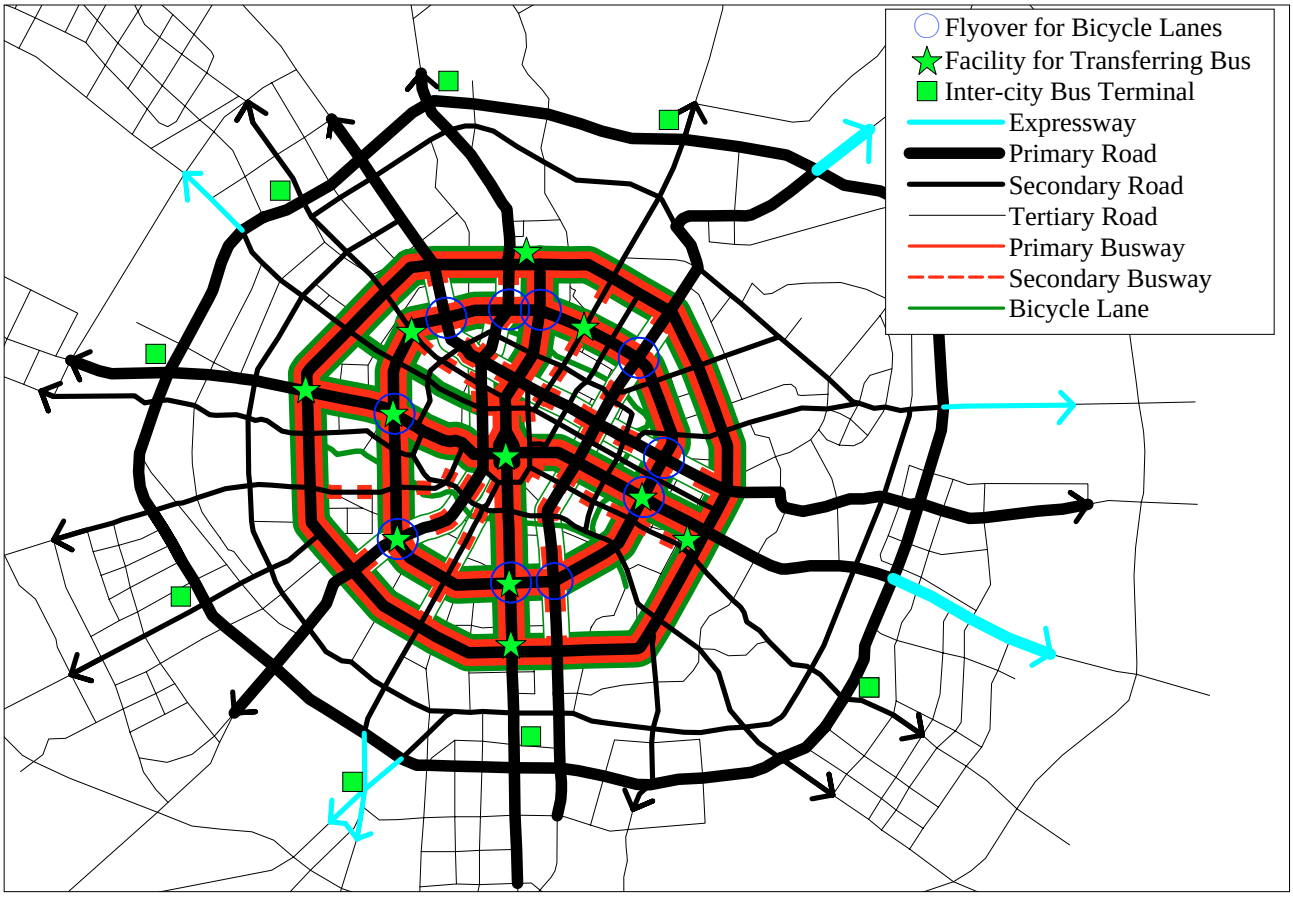


Table 9.1.1 List of Public Transport Projects in the Master Plan

Plan	Project	Contents of Project	Size
1. Primary busway (Exclusive Bus Lane)	1-1 East-west primary busway	* change in cross-section from 4-lane use to 6 lane use * introduction of exclusive bus lane * improvement of bus terminals * improvement of intersections and signals * improvement of bicycle lanes * improvement of bus transfer facilities * improvement of bus operation system	Route Length L= 9 km
	1-2 North-south primary busway		Route Length L= 8 km
	1-3 1st Ring Road primary busway		Route Length L= 19 km
	1-4 2nd Ring Road primary busway		Route Length L= 27 km
2. Secondary busway (Bus Priority Lane)	2-1 Bus Priority Lane in Xinnan Lu-Hongxing Lu	* introduction of bus priority lane * improvement of bus terminals * improvement of intersections and signals * increase of traffic signal * improvement of bicycle lanes * improvement of bus transfer facilities * improvement of bus operation system	Route Length L= 8 km
	2-2 Bus Priority Lane in Wuhouci Da-Jie-Beizhan Lu		Route Length L= 8 km
	2-3 Bus Priority Lane in Shuanglin Lu-Shawan Lu		Route Length L= 8 km
	2-4 Bus Priority Lane in the Northern Traffic Corridor		Route Length L= 4 km
	2-5 Bus Priority Lane in Northwest traffic corridor		Route Length L= 4 km
	2-6 Bus Priority Lane in Southwest Traffic Corridor		Route Length L= 8 km
	2-7 Bus Priority Lane in East Traffic Corridor		Route Length L= 4 km
3. Auxiliary Bus Facilities	3-1 Inter-city bus terminal project	* improvement of bus terminal * improvement of function, organization and operation of bus operator * expansion of bus terminals * improvement of bus facilities	7 Locations
	3-2 Bus transfer facility project [1)]		10 Locations
	3-3 Bus stop project		230 Locations
4. Traffic Control System	4-1 Intersection improvement project	* grade separation at major intersections (for bicycles) * channelization * signals control	10 Locations
	4-2 Bicycle lane project	* bicycle lane in primary road * bicycle lane in secondary road	Total Length = 80 km
	4-3 One-way system improvement project	* improvement of traffic control system in central area	—
	4-4 Pedestrian environment improvement project	* pedestrian mall project	—
5. Policies and Management System	5-1 Privatization of public transport business	* privatization of bus business * legal system improvement	—
	5-2 CNG promotion	* CNG filing stations	—
	5-3 Revision of public bus fare system	* revision of bus fare system * introduction of pre-paid card system	—
	5-4 Improvement of bus vehicles	* CNG bus * introduction of one-man bus	—
	5-5 Introduction of wide-area public transport administration	* integration of bus-related administration agencies and rationalization	—

Note: 1) Eleven (11) sites are proposed while 10 out of 11 are included in the cost estimate excluding the Tianfu Square because it is a part of the Subway No. 1 project.

9.1.3 Project Cost Estimate

The project cost was estimated in RMB at current prices as of December 2000. It includes the following:

- Construction cost: This includes direct and indirect construction expenses, taxes and construction unit profit. This is the contract amount of construction works.
- Technical survey cost: This includes the cost for necessary geographical survey, geological survey, environmental survey, natural condition survey, basic and detailed design, and construction administration. It is assumed at 10% of the total project budget.
- Contingency fund: This cost occurs when the scope or design is changed, which in general, occupies 10%-15% of the construction cost. Due to the moderate project size, 15% of the construction cost is reserved.
- Project administration cost: This is the cost for project owners on manpower, office operation and other necessary expenses during implementation. It is generally about 10% of the construction cost. This study also assumes a project administration cost of 10%.

The construction cost was estimated by multiplying the unit cost by the quantity of each work item. The unit cost was set based on published official rates, interviews with local contractors and consultation with the counterpart staff of the Study. The cost was calculated at market prices.

The total project cost was estimated based on the construction cost thus calculated and the ratio of technical survey cost, contingency fund and project administration cost to the construction cost. Table 9.1.2 shows the result. Details on the costs are presented in Appendix D.

- Four primary busways with a total length of 63 km need a total project cost of RMB 600 million or RMB 9.5 million per kilometer will be constructed.
- The cost of busways for the 2nd Ring Road is relatively low because grade separation with other main roads has been completed already.
- The project cost of the busway for the 1st Ring Road is high because grade separation for bicycle lanes is proposed at six intersections.
- The eight secondary busway projects proposed on the existing main roads have a total length of 44 km and requires a cost RMB 300 million or RMB 6.8 million for every kilometer.
- The secondary busway to be constructed on Xinnan Lu-Hongxing Lu is much higher than others because it includes widening of existing roads.

Table 9.1.2 Master Plan Project Cost Summary

Plan	Project	Project Cost (RMB 000)
1.Primary busway (Exclusive Bus Lane)	1-1 East-west primary busway	112,528
	1-2 North-south primary busway	92,209
	1-3 1st Ring Road primary busway	288,318
	1-4 2nd Ring Road primary busway	105,773
	Sub Total	598,828
2.Secondary busway (Bus Priority Lane)	2-1 Bus Priority Lane in Xinnan Lu-Hongxing Lu	99,796
	2-2 Bus Priority Lane in Wuhouci Da-Jie-Beizhan Lu	42,616
	2-3 Bus Priority Lane in Shuanglin Lu-Shawan Lu	42,996
	2-4 Bus Priority Lane in the Northern Traffic Corridor	24,759
	2-5 Bus Priority Lane in Northwest Traffic Corridor	22,815
	2-6 Bus Priority Lane in Southwest Traffic Corridor	33,155
	2-7 Bus Priority Lane in East Traffic Corridor	19,353
	Sub Total	285,490
3.Auxiliary Bus Facilities	3-1 Inter-city bus terminal project	296,429
	3-2 Bus transfer facility project	(8,940)
	3-3 Bus stop project	(36,570)
	Sub Total	341,939
4.Traffic Control System	4-1 Intersection improvement project	(269,100)
	4-2 Bicycle lane project	15,469
	4-3 One-way system improvement project	-
	4-4 Pedestrian environment improvement project	-
	Sub Total	284,569
Total		1,196,216

Note: Project costs in parentheses are included in either primary or secondary busway project and excluded from the total.

9.2 Economic Evaluation

9.2.1 Objective and Methodology of Economic Evaluation

The Master Plan is evaluated from the economic viewpoint, through the cost-benefit analysis. However, the projects from No.5-1 to 5-5 in Table 9.1.1 are not analyzed because they are so-called "software" projects and their costs are not estimated. Moreover, the projects from 3-1 to 3-3 and 4-1 to 4-4 are auxiliary projects supporting the exclusive busway, so it may be reasonable not to evaluate them separately, but to cover them in the evaluation of the exclusive busway system.

The economic evaluation is basically done through the comparison of the economic costs vis-a-vis the economic benefits to be realized from the project. The cost is the economic value converted from the financial cost. Benefits are the sum of savings in vehicle operating costs and savings in travel time due to the implementation of the project. The benefit variation "with" and "without" implementation of the project will be calculated according to the results of the traffic assignment of OD trips onto the network.

The project life of the exclusive busway is assumed at 20 years, until the urban railway (subway) network becomes operational. Therefore, the annual benefits are estimated from 2001 to 2020. The evaluation here is mainly for obtaining information necessary for project prioritization, so all the projects are presumed accomplished in 2000. The realistic investment schedule will be developed based on the prioritization.

Evaluation indices used in the analysis are the internal rate of return, the benefit/cost ratio and the net present value. The economic discount rate needed for calculating the benefit/cost ratio and the net present value is 12%, which is commonly used in China. The projects are judged economically feasible if the internal rate of return surpasses 12%.

9.2.2 Economic Costs of the Project

The project costs mentioned in the previous section (9.1) are the expenses actually needed for the implementation of the project and it is called the financial cost. For the purpose of the economic evaluation, the financial cost less all the transfer cost (taxes) is used. The cost is then referred to as the economic cost.Generally, when financial cost is converted to economic cost, several kinds of shadow price have to be applied. However, because foreign currency exchange is not controlled in China, the shadow exchange rate is not applied. And because of low unemployment, application of the shadow wage rate is also not needed.

Therefore, the financial cost, which has excluded the value added tax (17%) and sales tax (10%) can be regarded as the economic cost.

The project cost can be divided into material costs, equipment and machinery costs and labor costs. Value added tax and sales tax were imposed on material and equipment /machinery costs. The composition of these three costs varies according to the kind of the project. However, the projects making up the Master Plan are mostly road projects. According to the information of road projects in China, material cost is supposed to be 50%, equipment /machinery cost is 35%, and labor cost is 15%. As such, the coefficient for converting financial cost into economic cost is:

(0.50 + 0.35) / (1.00 + 0.17 + 0.10) + 0.15 = 0.82

This coefficient multiplied with the financial cost shown in the previous section is the economic cost, as shown in Table 9.2.1.

Table 9.2.1 Economic Cost of the Project

(Unit: RMB 1,000)

Plan	Code	Project	Financial Cost	Economic Cost	
					for Evaluation
1. Primary Busway (Exclusive Bus Lane)	1-1	East-west Primary Busway	112,528	96,999	119,613
	1-2	North-South Primary Busway	92,209	79,484	99,586
	1-3	First Ring Road Primary Busway	288,318	248,530	296,271
	1-4	Secondary Ring Road Primary Busway	105,773	91,176	159,019
2. Secondary Busway (Priority Bus Lane)	2-1	Bus Priority Lane in Xinnan Lu-Hong xing Lu	99,796	86,024	106,126
	2-2	Bus Priority Lane in Wuhouci Da-Jie-Beizhan Lu	42,616	36,735	56,836
	2-3	Bus Priority Lane in Shuanglin Lu-Shawan Lu	42,996	37,063	57,164
	2-4	Bus Priority Lane in North traffic corridor	24,759	21,342	31,393
	2-5	Bus Priority Lane in Northwest traffic corridor	22,815	19,667	29,717
	2-6	Bus Priority Lane in Southwest traffic corridor	33,155	28,580	48,681
	2-7	Bus Priority Lane in East traffic corridor	19,353	16,682	26,733
3. Auxiliary Bus Facilities	3-1	Inter-city bus terminal project	296,429	255,522	-
	3-2	Bus transfer facility project	-	-	-
	3-3	Bus stop project	-	-	-
4. Policies and Management System	4-1	Intersection improvement project	-	-	-
	4-2	Bicycle way project	15,469	13,334	-
	4-3	One-way system improvement project	-	-	-
	4-4	Pedestrian environment improvement project	-	-	-
Total			1,196,216	1,031,138	1,031,138

Note: Financial Costs of the projects with "-" mark are distributed and added to the cost of the relevant busway projects.

9.2.3 Calculation of the Benefits

One of the most direct benefits brought up by a transportation project is the mitigation of traffic congestion. Consequently, there will be a reduction in vehicle operating costs (VOC) and savings in travel time cost (TTC). Simulation of traffic assignment is conducted for both "with" and "without" implementation of a project and the economic benefit of the project is estimated as the difference of total transport costs in both cases.

The unit cost of VOC for all kinds of transport mode is listed in the appendix. There are two parts in the unit cost; one is the cost increasing proportionally to running distance which is expressed as a function of running speed, the other is proportional to running time.

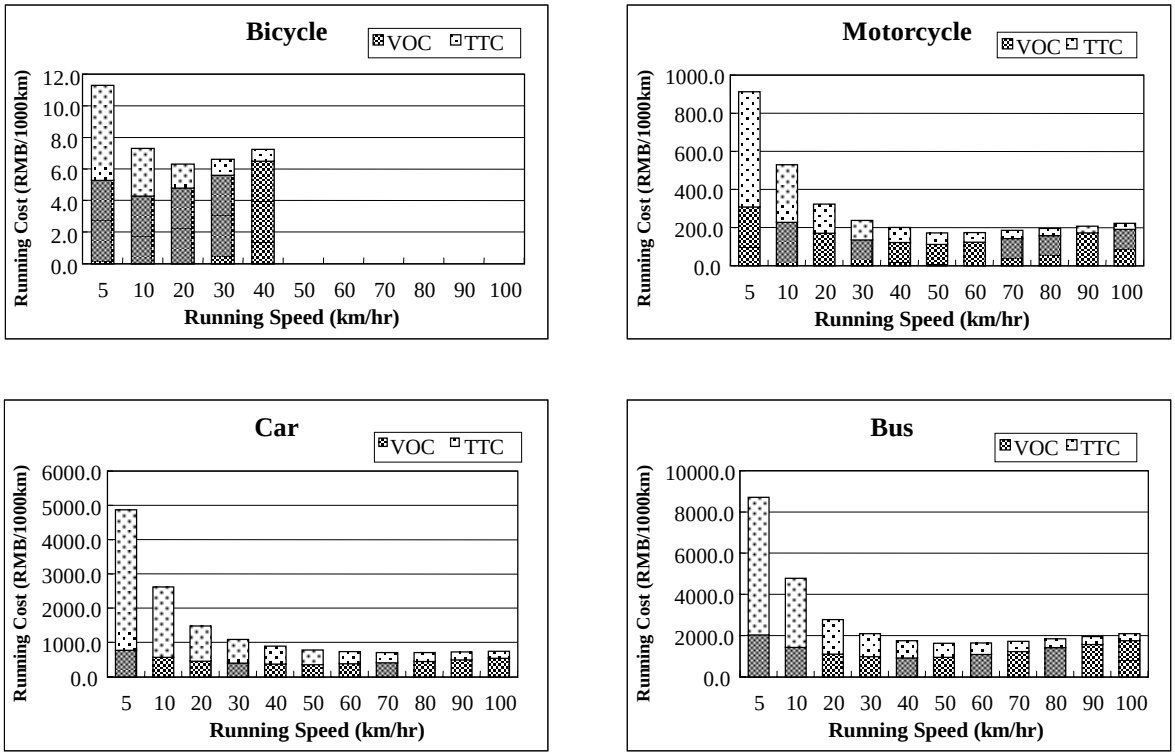
The value of passengers' time is estimated based on their income. According to Chengdu Statistical Yearbook (2000 edition), the average income of a citizen in Chengdu is RMB 7,141 in 1999. As the average annual working time is 1, 920 hours (160 hours x 12 months), the value of every working hour is RMB 3.7. Assuming that this income will increase at the same rate as the gross regional product per capita, the value of future time will be calculated as shown in Table 9.2.2. Time value referred to, however, is the time spent at work, not the travel time. As the present and future trips have been forecasted by trip purpose, it is reasonable to assume that the time value of "on business" purpose is counted at 100% and the value for "to work" or "to home" is counted at half time of the value "on business". According to the results of the person trip survey, the share of "to work" trips is 7.5%, and that of "to work" or "to home" trip is 17.5%, respectively. Thus, the travel time with economic value is about 25% (7.5 + 17.5 / 2 + 17.5 / 2) of total travel time for all purposes. Therefore, the traveling time value is 1/4 of the working time value.

Using the estimates explained above, vehicle operating cost and travel time cost are calculated for each travel speed, as shown in Figure 9.2.1. By these data, traffic data in the network as a result of computer simulation is converted to economic data.

Table 9.2.2 Calculation of Time Value

Item	Unit	Year			
		1999	2000	2005	2010
GDP per capita	RMB/person/year	22,612	24,361	35,111	51,554
Annual Income	RMB/person/year	7,141	7,693	11,088	16,281
Working time value	RMB/hour	3.7	4.0	5.8	8.5
Travel time value	RMB/hour	0.9	1.0	1.5	2.1

Figure 9.2.1 Vehicle Operating Cost and Travel Time Cost by Speed



According to the above data and method, the economic benefits of the Master Plan and of each project are estimated as listed in Tables 9.2.3 and 9.2.4.

Table 9.2.3 Total Economic Benefit of the Master Plan

(unit: RMB million/year)

Year	Case	VOC Saving	TTC Saving	Total Benefit
2000	Do nothing case	680.6	975.1	1,655.7
	Masterplan case	669.6	919.5	1,589.1
	Benefit	11.0	55.6	66.6
2010	Do nothing case	1,427.2	1,596.7	3,023.9
	Masterplan case	1,135.6	1,304.3	2,439.9
	Benefit	291.6	292.4	584.0

Table 9.2.4 The Economic Benefits of the Projects

Plan	Project		Economic Benefit (RMB 1,000 /year)					
			2000			2010		
			VOC Saving	TTC Saving	Total Benefit	VOC Saving	TTC Saving	Total Benefit
1. Primary Bus Way (Exclusive Bus Lane)	1-0	Entire Primary Busway Projects	10,987	17,939	28,926	291,672	292,329	584,001
	1-1	East-west Primary Busway	2,225	17,939	20,164	70,834	74,933	145,767
	1-2	North-south Primary Busway	1,909	19,955	21,864	49,515	49,270	98,785
	1-3	First Ring Road Primary Busway	3,091	7,570	10,661	100,574	93,604	194,178
	1-4	Secondary Ring Road Primary Busway	3,761	10,162	13,923	70,748	74,522	145,270
2. Secondary Busway (Priority Bus Lane)	2-0	Entire Secondary Busway Projects	4,094	8,757	12,851	215,200	55,517	270,717
	2-1	Bus Priority Lane in Xing Nan Lu ~Hong Xing Lu	642	624	1,266	31,697	8,338	40,035
	2-2	Bus Priority Lane in Wuhouci Lu ~Beizhan Lu	1,514	1,472	2,986	66,852	20,241	87,093
	2-3	Bus Priority Lane in Shuangling Lu ~Shawan Lu	720	699	1,419	40,418	8,278	48,696
	2-4	Bus Priority Lane in North Traffic Corridor	425	414	839	23,785	6,011	29,796
	2-5	Bus Priority Lane in Northwest Traffic Corridor	185	181	366	12,098	4,102	16,200
	2-6	Bus Priority Lane in Southwest Traffic Corridor	466	453	919	33,912	6,578	40,490
	2-7	Bus Priority Lane in East Traffic Corridor	142	139	281	7,725	2,363	10,088

9.2.4 Results of Economic Evaluation

(1) M/P Total Evaluation

By comparing the cost and the benefit, the economic cash flow of the Master Plan is estimated as shown in Table 9.2.5. As the investment schedule has not been fixed yet at this stage, all the projects are assumed accomplished in 2000. The costs after 2001 are the maintenance cost estimated at 3% of the project cost per annum. There is no forecast data after 2010. However, demand for buses will not grow at the rate of before 2010, as the subway lines are developed one by one. Therefore, the demand in 2010 is extrapolated until 2020 with no growth.

Although the economic benefits are limited only to the most direct ones, the internal rate of return of the Master Plan reaches 25%, far exceeding the economic discount rate (12%). Thus, the Master Plan is judged to be highly feasible economically. The net present value is estimated at about RMB 2,000 million, which is about double of the investment amount.

Table 9.2.5 Total Evaluation of the Master Plan

(Unit: RMB 1,000)

Year	Cost	Benefit	Net Cash Flow	Discounted Cash Flow		
				Cost	Benefit	Net Cash Flow
2000	1,031,138		**-1,031,138**	1,031,138	0	**-1,031,138**
2001	30,934	100,770	69,836	27,620	89,973	62,353
2002	30,934	127,790	96,855	24,661	101,873	77,213
2003	30,934	162,055	131,120	22,018	115,347	93,329
2004	30,934	205,507	174,573	19,659	130,604	110,944
2005	30,934	260,611	229,677	17,553	147,878	130,325
2006	30,934	330,490	299,556	15,672	167,437	151,765
2007	30,934	419,107	388,173	13,993	189,583	175,590
2008	30,934	531,485	500,550	12,494	214,658	202,164
2009	30,934	673,995	643,060	11,155	243,049	231,894
2010	30,934	854,717	823,783	9,960	275,196	265,236
2011	30,934	854,717	823,783	8,893	245,711	236,818
2012	30,934	854,717	823,783	7,940	219,385	211,445
2013	30,934	854,717	823,783	7,089	195,879	188,790
2014	30,934	854,717	823,783	6,330	174,892	168,562
2015	30,934	854,717	823,783	5,652	156,154	150,502
2016	30,934	854,717	823,783	5,046	139,423	134,377
2017	30,934	854,717	823,783	4,505	124,485	119,979
2018	30,934	854,717	823,783	4,023	111,147	107,124
2019	30,934	854,717	823,783	3,592	99,238	95,647
2020	30,934	854,717	823,783	3,207	88,606	85,399
Total	1,649,821	12,213,694	10,563,873	1,262,199	3,230,515	1,968,316

Internal Rate of Return(%)	25.5
Benefit/Cost Ratio	2.6
Net Present Value (RMB million)	1,968

(2) Sensitivity Analysis

Sensitivity analysis was conducted by changing conditions of the cash flow. As shown in Table 9.2.6, increase of the project cost will not affect much the evaluation indices. The IRR will be below 12.0% only when the cost rises to 2.55 times the original estimate. In the same way, the project will remain feasible unless more than 61% of the benefit is lost. As explained in Chapter 5, a significant demand shift is predicted from bicycles and cars to buses as the result of improvement of bus system. Even if the shift does not occur, the project is still feasible, keeping its IRR over 12%. Thus, the feasibility of the project is quite stable against various condition changes.

Table 9.2.6 Sensitivity Analysis of Economic Evaluation of Master Plan

Case		IRR (%)	B/C	NPV (RMB million)
1	Base Case	25.5	2.56	1968.3
2	Cost up			
	by 20%	22.5	2.13	1715.9
	by 50%	19.1	1.71	1337.2
	by 100%	15.1	1.28	706.1
3	Benefit down			
	by 20%	21.9	2.05	1322.2
	by 50%	15.1	1.28	353.1
	by 60%	12.3	1.02	30.0
4	No demand shift to bus	16.4	1.41	514.6

(3) Evaluation of Individual Projects

In the same way as used for evaluation of the entire Master Plan, each project of primary and secondary busways is evaluated individually. The results are summarized in Table 9.2.7, which indicates that all the projects are economically feasible, implying the internal rate of return over 12%. The economic returns of the East-west busway and the Wuhouci Lu – Beizhan Lu busway are especially high.

Table 9.2.7 Individual Evaluation of Projects

Unit: IRR (%), NPV (RMB 000)

Plan	Project		Evaluation Index		
			IRR	B/C	NPV
1. Primary Busway (Exclusive Bus Lane)	1-0	Entire Primary Busway Projects	27.6	2.8	1,468,617
	1-1	East-west Primary Busway	36.8	4.1	449,198
	1-2	North-South Primary Busway	35.3	2.7	202,265
	1-3	First Ring Road Primary Busway	19.8	1.9	310,464
	1-4	Secondary Ring Road Primary Busway	27.4	2.8	357,478
2. Secondary Busway (Priority Bus Lane)	2-0	Entire Secondary Busway Projects	24.0	2.5	666,245
	2-1	Bus Priority Lane in Xing Nan Lu-Hong xing	12.7	1.1	7,598
	2-2	Bus Priority Lane in Wuhouci Lu-Beizhan Lu	33.5	4.3	232,602
	2-3	Bus Priority Lane in Shuangling Lu-Shawan	22.6	2.3	92,310
	2-4	Bus Priority Lane in Bus Priority Lane in North traffic corridor	24.4	2.6	62,107
	2-5	Bus Priority Lane in Northwest traffic corridor	17.0	1.5	18,688
	2-6	Bus Priority Lane in Southwest traffic corridor	21.6	2.2	71,838
	2-7	Bus Priority Lane in East traffic corridor	12.5	1.0	1,387

9.3 Environmental Evaluation of the Master Plan

9.3.1 Environmental Impact of the Master Plan as a Whole

The environmental evaluation was done based on the dispersion model for the following five cases:

Case1: "Do-nothing" case in 2010;
Case2: Introduction of CNG to bus and taxi in 2010;
Case3: Improvement of public transport service (Master Plan) in 2010; and
Case4: Introduction of subway line in 2010

Figure 9.3.1 shows simulation results of CO emissions for cases, i.e., at present in 2001, Do-nothing case in 2010, introduction of CNG for bus and taxi in 2010 and introduction of subway line in 2010. The emissions will significantly increase unless any measures are taken in the future. The introduction of CNG will result in the substantial reduction of CO emissions all over the city. On the other hand, the provision of the subway service will have positive impact on the environment, especially in the neighboring areas of the subway line, e.g., Renmin Bei-Lu, Tianfu Square and Renmin Nan-Lu. The east-west corridor traversing the Tianfu Square will, however, remain a highly polluted area.

Table 9.3.1 summarizes vehicle emissions by pollutant type for "Do-nothing" case, which were quantitatively estimated based on the emission and dispersion models. On average, the vehicle emissions will increase up to 2.5 times in 2010 if no actions are taken.

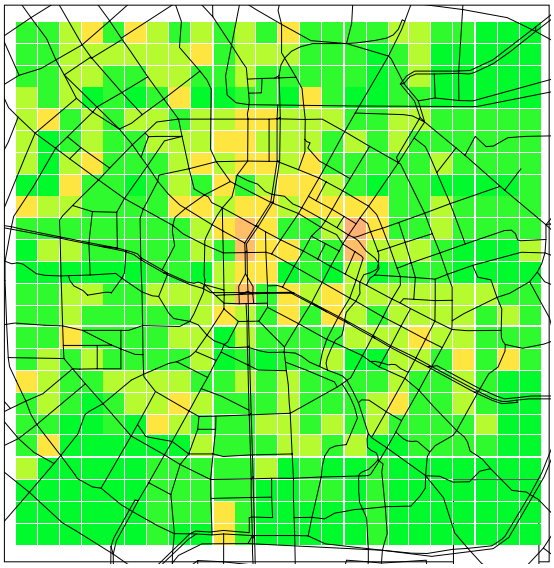
Table 9.3.2 illustrates the effect of the introduction of CNG to bus and taxi. Compared to the "Do-nothing" case, it could bring the reduction of vehicle emissions by 23 %.

Also, the vehicle emissions could, as shown in Table 9.3.3, reduce up to 32 % by giving priority to the improvement of public transport services, e.g., introduction of exclusive or priority bus lanes and bicycle lanes. Note that the estimated results are based on the assumption of making full use of all the bus and bicycle lanes proposed in the study.

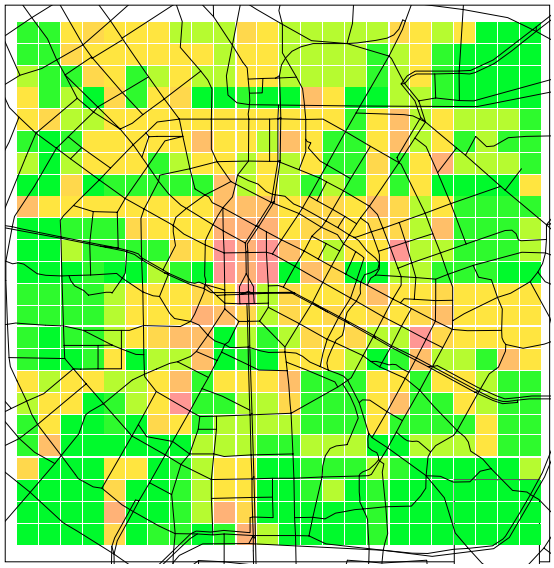
Table 9.3.4 shows the vehicle emissions for the combination of the CNG introduction and the public transport improvement. It could potentially reduce vehicle emissions up to 60 %.

In addition, the combination of the CNG introduction and the provision of the subway service could, as depicted in Table 9.3.5, reduce vehicle emissions up to 61 %. However, substantial reduction can be seen in the vicinity of the Renmin Bei-Lu, Tianfu Square and the Renmin Nan-Lu.

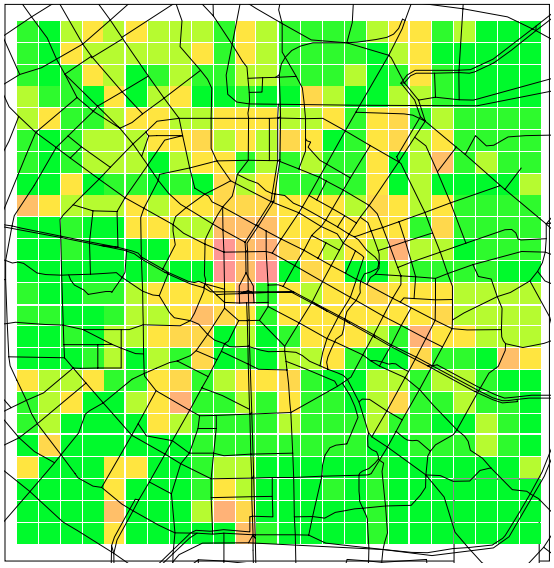
Figure 9.3.1 CO Emissions by Scenario



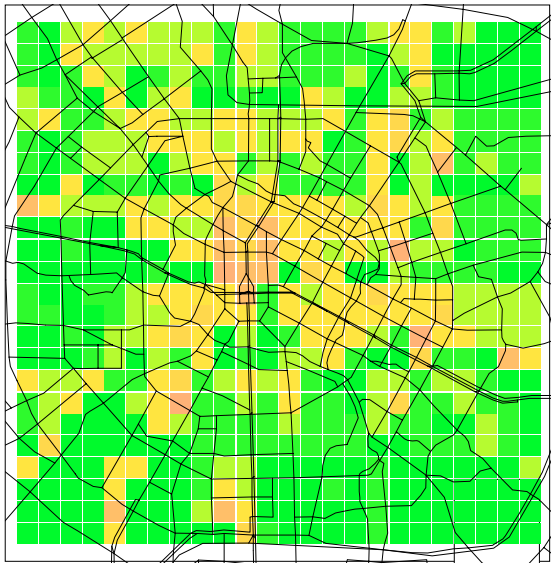
Present Situation (2000)



"No-nothing" Case (2010)



Introduction of CNG (2010)



Combination of CNG Introduction and Subway Service (2010)

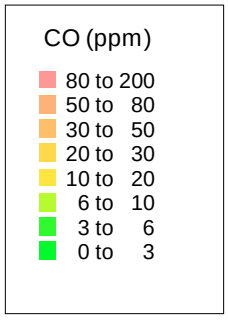


Table 9.3.1 Vehicle Emissions for "Do-Nothing" Case in 2010

(1,000 ton/year)

Emission Pollutant	Present Situation (2000)	"Do-Nothing" Case in 2010	Difference
CO	70	174	104
CO_2	2,387	5,932	3,546
THC	32	80	48
NOx	9	22	13

Table 9.3.2 Vehicle Emissions for Introduction of CNG in 2010

(1,000 ton/year)

Emission Pollutant	"Do-Nothing" Case in 2010	CNG Introduction in 2010	Difference
CO	174	134	41
CO_2	5,932	4,550	1,382
THC	80	61	19
NOx	22	17	5

Table 9.3.3 Vehicle Emissions for Improvement of Public Transport in 2010

(1,000 ton/year)

Emission Pollutant	"Do-Nothing" Case in 2010	Public Transport Improvement in 2010	Difference
CO	174	119	56
CO_2	5,932	4,033	1,899
THC	80	54	26
NOx	22	15	7

Table 9.3.4 Vehicle Emissions for Combination of CNG Introduction and Public Transport Improvement in 2010

(1,000 ton/year)

Emission Pollutant	"Do-Nothing" Case in 2010	Combination of Two Measures in 2010	Difference
CO	174	70	104
CO_2	5,932	2,380	3,553
THC	80	32	48
NOx	22	9	13

Table 9.3.5 Vehicle Emissions for Combination of CNG Introduction and Subway Service Provision in 2010

(1,000 ton/year)

Emission Pollutant	"Do-Nothing" Case in 2010	Combination of Two Measures in 2010	Difference
CO	174	70	105
CO_2	5,932	2,372	3,561
THC	80	32	48
NOx	22	9	13

9.3.2 Necessity of EIA for Selected Projects

Some projects could have substantial impact on the environment and an EIA shall be implemented in detail for these projects. For this reason, analysis is required on the necessity for an EIA for the selected projects comprising of the master plan.

Table 9.3.6 shows the analysis results and the characteristics revealed are as follows:

- Exclusive or priority bus lanes don't accompany any large-scale construction but make full use of existing main roads. Therefore, little impact is anticipated on living environment and historical heritage sites, even though it could have minor positive or negative impact on economic or urban activity, transport and public facility and solid waste. With respect to pollution, it is expected that the project could somewhat have negative impact on air pollution, noise, vibration and bad odor but no impact on underground water and ground sinking.
- Bus related projects could bring a lot of people to specific areas and have negative impact on solid waste, health and sanitation. Also, it could have negative impact on transport and public facility and positive impact on economic and urban activities. However, no impact will take place by bus terminal project. As for pollution, especially inter-city bus terminal could have negative impact on air pollution, noise, vibration and underground water.
- Transport system management and institution will have minor impact on the environment. Note, however, that specific projects are expected to somewhat have impact on the environment as follows: negative impact of intersection improvement project on air pollution, noise and vibration, positive impact of living space improvement project on ecology and landscape, positive impact of private company participation to bus operation on economic activity, positive impact of CNG introduction on air pollution and positive impact of comprehensive traffic system improvement on traffic safety.

Table 9.3.6 Evaluation of Selected Projects

Project Classification	Name of Project	Social Environment									Nature Environment								Social Effects of					
		1.Transfer Residents	2.Economical Activities	3.Traffic, Resident Facilities	4. Setting Zones	5. Historic Site and Culture Property	6. Privilege of Water Conservancy and Entrance	7.hygiene	8. Rubbish	9. Disaster	10. Landform geology	11.Soil Corroding	12.Groundwater	13. Information of Lakes and Rivers	14.Shore and Maritime Space	15. Animals and Plants	16.Atmosphere	17. Outlook	18.Air Pollution	19. Cloudy Degree of Water	20. Soil Pollution	21. Noise and Vibration	22. Sinkage of foundation	23. Foul smell
1. Introducing Exclusive Bus Lane	1) Introducting Exclusive Bus Lane To East-West Corridor	D	B	B	D	D	D	D	B	D	D	D	D	D	D	B	D	B	A	D	D	A	D	C
	2) Introducing Exclusive Bus Lane To South-North Corridor	D	B	B	D	D	D	D	B	D	D	D	D	D	D	B	D	B	A	D	D	A	D	C
	3) Introducing Exclusive Bus Lane To The 1st Ring Road	D	B	B	D	D	D	D	B	D	D	D	D	D	D	B	D	B	A	D	D	A	D	C
	4) Introducing Exclusive Bus Lane To The 2nd Ring Road	D	B	B	D	D	D	D	B	D	D	D	D	D	D	B	D	B	A	D	D	A	D	C
2. Introducing Priorty Bus Lane	1) Introducing Priority Bus Lane From Xinnan Lu To Hongxing Lu	D	B	B	D	D	D	D	C	D	D	D	D	D	D	B	D	B	A	C	D	A	D	C
	2) Introducing Priority Bus Lane From Wuhouci Da-Jie To Beizhan Lu	D	B	B	D	D	D	D	C	D	D	D	D	D	D	B	D	B	A	C	D	A	D	C
	3) Introducing Priority Bus Lane From Shuanglin Lu To Shawan Lu	D	B	B	D	D	D	D	C	D	D	D	D	D	D	B	D	B	A	C	D	A	D	C
	4) Introducing Priority Bus Lane To The North Corridor	D	B	B	D	D	D	D	C	D	D	D	D	D	D	B	D	B	A	C	D	A	D	C
	5) Introducing Priority Bus Lane To The North-West Corridor	D	B	B	D	D	D	D	C	D	D	D	D	D	D	B	D	B	A	C	D	A	D	C
	6) Introducing Priority Bus Lane To The East-South Corridor	D	B	B	D	D	D	D	C	D	D	D	D	D	D	B	D	B	A	C	D	A	D	C
	7) Introducing Priority Bus Lane To The East Corridor	D	B	D	D	D	D	D	D	D	D	D	D	D	D	B	B	B	A	B	D	A	D	C
3.Providing Bus Related Facilities	1) Providing Inter-city Bus Terminal	B	B	B	D	C	D	B	B	D	C	D	C	D	D	B	D	C	A	B	D	A	D	C
	2) Providing Intra-city Bus Terminal Connecting Facility	D	C	C	D	D	D	C	D	D	D	D	D	D	D	C	D	C	B	C	D	B	D	C
	3) Providing Main Road Connecting Facility	D	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	C	D	D	C	D	C
4.Implementing Transport System Management	1) Implementing Intersection Improvement	D	D	C	D	D	D	D	D	D	D	D	D	D	D	C	D	C	B	D	D	B	D	D
	2) Implementing Bicycle Network Improvement	D	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	C	D	D	C	D	D
	3) Implementing One-way Network Improvement	D	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	C	D	D	C	D	D
	4) Implementing Living Space Improvement	D	C	C	D	D	D	B	C	D	D	D	D	D	D	B	D	B	C	C	D	C	D	D
5.Strengthening Institution	1) Strenthening Private Compacy Participation To Bus Operation	D	A	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	2) Enhancing use of CNG	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	A	D	D	D	D	D
	3) Managing Public Transport Fare	D	B	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	4) Improving Bus Vehicles' Quality	D	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B	C	D	D	D
	5) Improving Comprehensive Traffic System	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D

Note: A: Substantial Impact, B: Minor Impact, C: Unknown, D: No Impact.

9.4 Comprehensive Evaluation of the Projects and Implementation Schedule

9.4.1 Comprehensive Evaluation of the Projects

The evaluation of the proposed projects discussed in the preceding sections is summarized in Table 9.4.1. The major findings are:

- The proposed plans do not include large-scale new infrastructure development, thus having a relatively lower cost. Therefore, the economic and environmental advantages are large, and the projects foresee no serious technical difficulties.
- The anticipated negative effect is limited to the displacement of residents/informal settlers in the widened road sections and the traffic management difficulties during the construction.
- The projects expected to have the most positive effect include: 1-1) East-West primary busway project, 1-2) North-South primary busway project, 1-3) 1st Ring Road primary busway project, 1-4) 2nd Ring Road primary busway project, 2-2) Wuhouci-North railway station bus priority lane project, 4-1) Intersection improvement project, 4-2) Bicycle lane project, and 4-4) Pedestrian environment improvement project. Among them, 1-1), 1-2), and 2-2) are highly economically viable with an EIRR of over 30%.

Based on the above consideration, East-West primary busway project was selected as suitable for the conduct of a feasibility study due to:

- Its EIRR is the highest at 37% among the projects economically evaluated.
- Although the EIRR is also high for the North-South primary busway project, the role of busway is not so clear because a subway is scheduled to be implemented by 2010.
- The project includes some intersection improvement projects, bicycle lane projects and pedestrian environment improvement projects that have been highly evaluated. Therefore, the result of the feasibility study could be utilized as a model to be applied for the whole city.

In addition, the project “Privatization of public transport business” (5-1) was also taken up for the subsequent feasibility study as a “software” project in contrast to the “hardware” project of busway mentioned above. This project would be one of the key policies to improve the public transport system of Chengdu.

Table 9.4.1 Comprehensive Evaluation of Projects Proposed in the Master Plan

Plan	Project	Economy	Safety	Environment			Magnitude of Demand	Consideration for Vulnerable People	Technical	Overall Evaluation
				Social	Nature	Pollution				
1. Primary busway (Exclusive Bus Lane)	1-5 East-west primary busway	+ + +	+ + +	*	*	+	+	*	*	+ + +
	1-6 North-south primary busway	+ + +	+ + +	*	*	+	+	*	*	+ + +
	1-7 1st Ring Road primary busway	*	+ + +	*	*	+	+	*	*	+ + +
	1-8 2nd Ring Road primary busway	+	+ + +	*	*	+	+	*	*	+ + +
2.Secondary busway (Bus Priority Lane)	2-8 Bus Priority Lane in Xinnan Lu-Hong xing Lu	*	+	–	*	+	*	*	–	*
	2-9 Bus Priority Lane in Wuhouci Da-Jie-Beizhan Lu	+ + +	+	*	*	+	*	*	*	+ + +
	2-10 Bus Priority Lane in Shuanglin Lu-Shawan Lu	+	+	–	*	+	*	*	-	+
	2-11 Bus Priority Lane in the Northern Traffic Corridor	+	+	*	*	+	*	*	*	+
	2-12 Bus Priority Lane in Northwest traffic corridor	*	+	*	*	+	*	*	*	+
	2-13 Bus Priority Lane in Southwest Traffic Corridor	+	+	*	*	+	*	*	*	+
	2-14 Bus Priority Lane in East Traffic Corridor	*	+	*	*	+	*	*	*	+
3. Auxiliary Bus Facilities	3-4 Inter-city bus terminal project	*	*	*	*	*	+	+	*	+
	3-5 Bus transfer facility project	+	+	*	*	*	+	+	*	+
	3-6 Bus stop project	+	+	*	*	*	+	+	*	+
4. Traffic Control System	4-5 Intersection improvement project	+	+ + +	+	*	*	+	+	–	+ + +
	4-6 Bicycle lane project	*	+ + +	+	*	*	*	+ + +	*	+ + +
	4-7 One-way system improvement project	*	*	*	*	*	*	*	*	*
	4-8 Pedestrian environment improvement project	*	+ + +	+	*	*	*	+ + +	*	+ + +
5. Policies and Management System	5-6 Privatization of public transport business	+	*	+	*	*	*	*	*	+
	5-7 CNG promotion	+	*	*	*	+ + +	*	*	*	+
	5-8 Revision of public bus fare system	*	*	+	*	*	*	*	*	+
	5-9 Improvement of bus vehicles	*	+	*	*	*	*	+	*	+
	5-10 Introduction of areawide public transport administration	*	*	+	*	*	*	+	*	+

Note): + + +: Excellent, +: Positive, *: Neutral, —: Negative

9.4.2 Implementation Schedule

In consideration of the results of project evaluation, time required for implementing each project and the recent policy directions in Chengdu (i.e. project readiness), the implementation schedule of the proposed projects was prepared as presented in Table 9.4.2. In principle, the projects with higher EIRRs are commenced earlier, and for the projects with high cost or foreseen difficulties in implementation, the period for implementation was set longer.

At the bottom line of Table 9.4.2, annual investment amount required to implement the proposed project according to this schedule is indicated. In the peak year of 2006, about RMB 215 million is required, and from 2001 to 2005 the necessary investment reaches RMB 140 to 170 million. These amounts correspond to 32-48% of the investment on roads of RMB 444 million in 1999 and to 1.4-2.2% of the tax revenue of RMB 9,865 million of Chengdu City in the same year. Though not impossible, various financial arrangements including the subsidy from the central government are certainly needed, particularly when the subway construction is taken into account. In this Master Plan, it is recommended to curtail the subsidy to bus operation of about RMB 60 million a year in relation to the privatization of bus business. In addition to this, various measures should be tested such as increase of road user charges.

Table 9.4.2 Implementation Schedule of Proposed Projects

Range of Project	Name of Project	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. Primary busway (Exclusive Bus Lane)	1-9 East-west primary busway											
	1-10 North-south primary busway											
	1-11 1st Ring Road primary busway											
	1-12 2nd Ring Road primary busway											
2.Secondary busway (Bus Priority Lane)	2-15 Bus Priority Lane in Xinnan Lu-Hong xing Lu											
	2-16 Bus Priority Lane in Wuhouci Da-Jie-Beizhan Lu											
	2-17 Bus Priority Lane in Shuanglin Lu-Shawan Lu											
	2-18 Bus Priority Lane in the Northern Traffic Corridor											
	2-19 Bus Priority Lane in Northwest traffic corridor											
	2-20 Bus Priority Lane in Southwest Traffic Corridor											
	2-21 Bus Priority Lane in East Traffic Corridor											
3. Auxiliary Bus Facilities	3-7 Inter-city bus terminal project											
	3-8 Bus transfer facility project											
	3-9 Bus stop project											
4. Traffic Control System	4-9 Intersection improvement project											
	4-10 Bicycle lane project											
	4-11 One-way system improvement project											
	4-12 Pedestrian environment improvement project											
5. Policies and Management System	5-11 Privatization of public transport business											
	5-12 CNG promotion											
	5-13 Revision of public bus fare system											
	5-14 Improvement of bus vehicles											
	5-15 Introduction of areawide public transport administration											
Required Annual Investment (RMB million)		74.1	148.2	146.6	171.6	161.5	156.5	214.9	116.9	5.8	-	-

Note: Main Project ▬▬ Preparing, Appending Project ——