(3) Evaluation of Road Projects Planned by Ulaanbaatar City

Evaluation of Road Projects Planned by UB City

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1. Background and Objective

Rural-urban migration has been increasing year by year so that more than half the national population has been accumulated in UB City. Also the number of car users has been increasing rapidly during the last decade and it causes heavy traffic congestion in the city.

Due to lack of road network capacity, Road Department of the UB City Government planned road projects to improve network connectivity and capacity. This road improvement plan developed in 2007 is up to 2020. The plan includes new road construction on missing section, improvement of road surface layer, road widening to increase lanes , etc., Road Department requested the JICA Study Team to conduct economical and environmental evaluation and to determine priority of the road projects.

2. Outline of Evaluation of Road Projects

The road improvement plan includes around 60 projects (see Table 2.1). Of them, 22 projects were already implemented from 2007 to 2008, and some of them are still under design process so far (see Table1.1). The rest of 38 projects are under planning process; accordingly evaluation was done for the 38 road sections which include:

- New road construction,

- Bridge and flyover construction, and

- Road improvement such as widening, improvement of pavement and increasing the number of lanes, etc.

Table 2.1 List of Completed and Under Design Process Projects

Area	Road	ID	Completed and Under Design Process Project	Length (km)	Pavement	Condition of November 2007
Middle	UB	1	Widening and Improvement of Khuvsgal Street	2.5	Asphalt	Completed
Middle	MR	6	Dambadarjaa - Belkh Selkh Road	2.2	Asphalt	Completed
Middle	MR	7	Dambadarjaa - Brick Plant Road	1.7	Asphalt	Completed
Middle	MR	8	Road to connect Erkhuu and Sodnom Streets	0.6	Asphalt	Completed
Middle	UB	9	Improvement of Ikh Surguuli Street	1.4	Asphalt	Completed
Middle	MR	13	Improvement of Road in front of Infectious Hospital	0.4	Asphalt	Completed
East	UB	15	Widening and Improvement of Amgalan Road	2.9	Asphalt	Completed
East	UB	16	Road from Police Academy IS to Janjin Club	1.5	Asphalt	Completed
Middle	UB	17	Improvement of Road on East Side of Wrestling Palace	0.44	Asphalt	Completed
Middle	UB	19	Gandi Street Widening and Improvement	1.0	Asphalt	Completed
Middle	UB	24	Improvement of Road in Industrial Zone	0.5	Asphalt	Completed
Middle	UB	27	Improvement of Tumurchin Street	0.6	Asphalt	Completed
West	UB	33	Gurvaljin Bridge Repair	0.11	Asphalt	Under design
West	MR	34	Improvement of Trade Union Street	1.4	Asphalt	Completed
West	MR	35	Enkhtaivan Avenue (from West Crossroads to Chingunjav Street Intersection)	1.4	Asphalt	Contract canceled
Middle	MR	38	New Road on East Side of Chandmani Center	0.7	Asphalt	Completed
Middle	UB	39	Improvement of Chingunjav Street	1.2	Asphalt	Completed
Middle	UB	44	New Road on East Side of Kino Uildver	0.8	Asphalt	Completed
Middle	MR	45	New Road and Bridge to connect Damdinsuren and Olymp streets	0.55 0.97	Asphalt	Under construction
Middle	MR	61	Ikh Toiruu (West Crossroads) – Geser Temple	1.7	Asphalt	Not yet started

			Intersection – Bayanburd Intersection			
Middle	MR	62	New Road from Chingeltei Bus Terminal to Zurkh Uul	1.8	Asphalt	Completed
Middle	MR	63	New Road connecting Khailaast and Chingeltei	1.5	Asphalt	Completed
West	UB	64	Improvement of Bridge over Channel behind 1st Khoroolol	0.017	Asphalt	Completed
Middle	UB	65	Khasbaatar Street Improvement and Widening	2.4	Asphalt	Under design

Source: JICA Study Team

3.   **Characteristics of Road Projects**

As described above the 38 projects were evaluated; out of f them, 18 projects were new road sections including one bridge and one flyover construction. The rest of 20 projects were to be improved. Characteristics including project name, length, number of lanes and type of payment of the new projects are shown in Table 3.1.   ID number in the table indicates the project number as shown in Figure 3.1. Code No shows type of project; for example, N-1   denotes *new project number 1*. Following ID number the location of the projects are shown inTable 3.1.

Table 3.2 shows the improvement project characteristics.

Table 3.1 Profiles of New Projects

| Code No	ID	Project	Project Profile		
			Length (km)	No. of lane	Pavement type
N-1	2	Road connecting Denjiin Myanga and Khuvsgal Roads	1.5	2	Asphalt
N-2	3	Extension of Denjiin Myanga Road	1.4	2	Asphalt
N-3	4	Extension of Khailaast Road	1.0	2	Asphalt
N-4	11	Tsaiz Market – Tsagaan Davaa Road	3.6	2	Asphalt
N-5	14	Road from Botanical Garden to Youth Center	3.1	2	Asphalt
N-6	21	Ikh Tenger Bridge Improvement	0.26	4	Asphalt
N-7	28	New Road in Yarmag	2.0	2	Asphalt
N-8	31	New Naran Road and Bridge (Not Designed)	3.2	2	Asphalt
N-9	37	Baruun Salaa Road and Bridge New Construction	3.5	2	Asphalt
N-10	40	Gorikii street in ger area, Bayangol District	0.6	2	Asphalt
N-11	42	Gants Khudag Road Construction	1.0	2	Asphalt
N-12	33	Gurvaljin Bridge Repair	0.11	4	Asphalt
N-13	43	New Construction of Denver street (Not Decided)	0.8	2	Asphalt
N-14	46	New Road Construction from Orbit Road to Takhilt	5.6	2	Asphalt
N-15	47	Road Construction from Chingis Avenue to Narantuul Market Intersection	3.4	4	Asphalt
N-16	45	New Road and Bridge to connect Damdinsuren and Olymp streets	0.55 0.97	4	Asphalt
N-17	48	Fly-over Construction over railway near Narantuul Market	0.2	4	Asphalt
N-18	49	Road from Tolgoit – Trade Union street Intersection to Ard Ayush Avenue (Design was stopped)	2.9	4	Asphalt

Source: JICA Study Team

Table 3.2 Profiles of Improvement Projects

Code No	ID	Project	Project Profile		
			Length (km)	No. of lane	Pavement type
I-1	5	Improvement and widening of road from 32th Rotary to Dambadarjaa Police Station	3.9	4	Asphalt
I-2	10	Improvement of Sukhbaatar street	1.4	4	Asphalt
I-3	12	Improvement and widening of Shar Khad Road	3.4	4	Asphalt
I-4	18	Improvement of Road from West Crossroads to East Crossroads	3.6	4	Asphalt
I-5	20	Improvement and widening of Ikh Toiruu Road	2.1	6	Asphalt
I-6	22	Improvement of Baga Toiruu Road	2.6	4	Asphalt
I-7	23	Improvement of Zaisan Road with Bridge	1.3	4	Asphalt
I-8	25	Widening of Sambuu street	0.8	4	Asphalt
I-9	29	Improvement of Power Plant-4 Road	6.2	4	Asphalt
I-10	30	Sonsgolon Road and Bridge Improvement	7.6	4	Asphalt
I-11	32	Improvement and widening of Ajilchin Road and Bridge	3.2	4	Asphalt
I-12	35	Enkhtaivan Avenue Improvement from West Crossroads to Chingunjav street	1.4	4	Asphalt
I-13	36	Trade Union street – Bayankhoshuu Road	3.4	4	Asphalt
I-14	41	Improvement and widening of Zaluuchuud street	0.8	6	Asphalt
I-15	50	Naadamchid Road Widening	9.3	4	Asphalt
I-16	51	Improvement and widening of road from Doloon Buudal to Sharga Morit Bridge	8.7	4	Asphalt
I-17	54	Improvement and widening of Tavan Shar – Tolgoit – Orbit – Nairamdal Road	7.0	4	Asphalt
I-18	55	Improvement and widening of Road from railway crossing to 22 Toll Gate	10.4	6	Asphalt
I-19	56	Dari Ekh – Dambadarjaa Road Improvement and widening	6.2	2	Asphalt
I-20	57	Widening of western and eastern ends of Narny Zam	2.6	4	Asphalt

Source: JICA Study Team

Figure 3.1   Location of Completed and Planned Road Projects
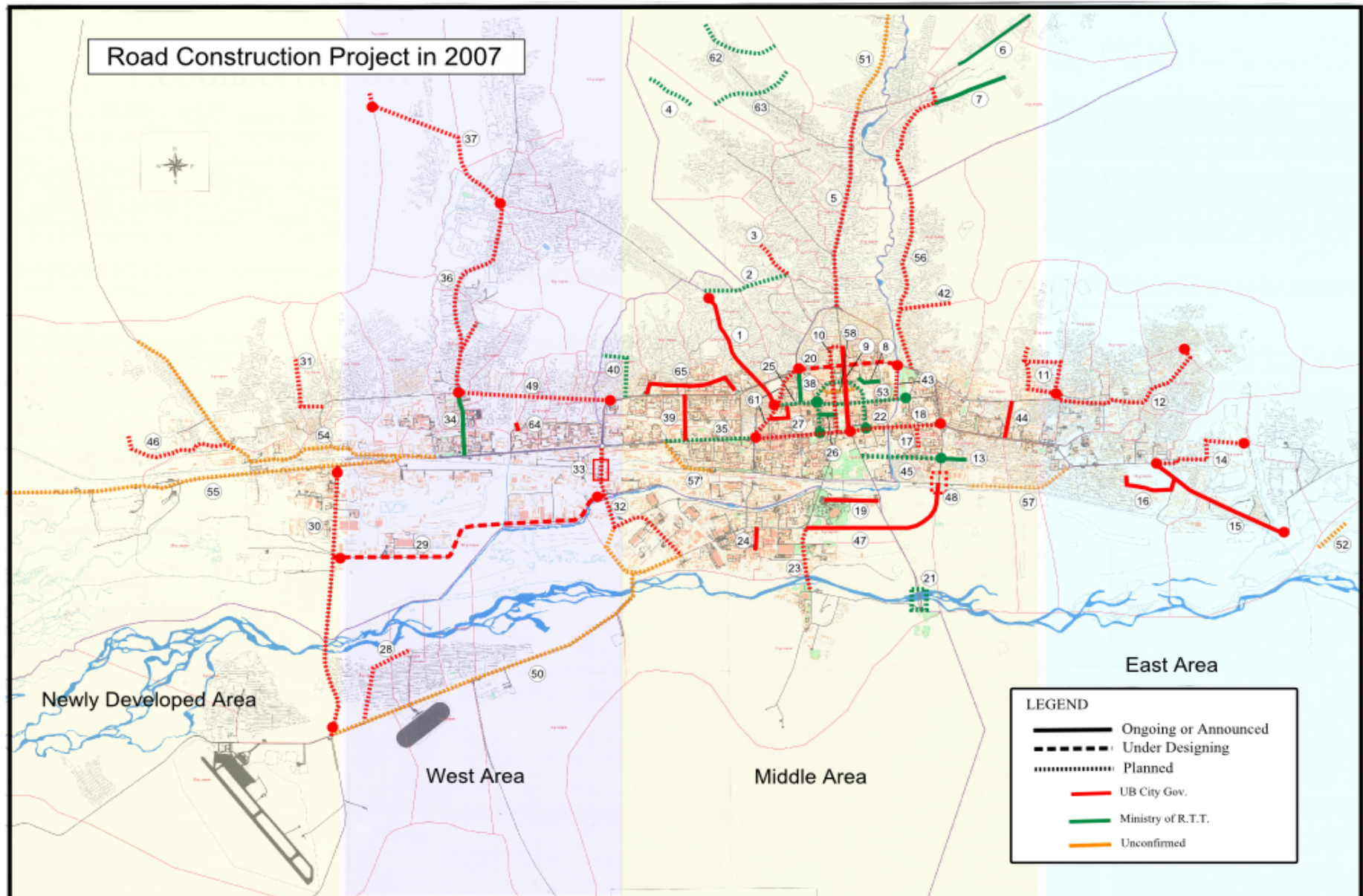
4. Evaluation Methodology

(1) JICA STRADA

JICA STRADA (System for Traffic Demand Analysis) program was adopted for determining traffic assignment on the existing and planned network. In this program the assignment procedure was estimated by using the conventional -step method. UB City consists of 9 districts; however, out of the nine, six districts in the central area, excluding the three remote districts of Nalaikha, Baganuur,and Bagakhangai, were evaluated, that is composed of 127 Khoroos as for urban development administration unit in 2007. The study area includes in total of 127 zones by dividing Khoroo for targeting road network in UB.

JICA STRADA program includes the following main sub programs for making network and assigning traffic flow.

- Matrix Manipulator to build OD table

- Network Editor to build road network and to estimate parameter

- Incremental Assignment to assign traffic flow using incremental method

- Highway Report to make sure the assignment result

Highway Report result can show the number of link volume, congested road sections and network evaluation result such as PCU-km (PCU: passenger car unit), PCU-hour, total length, V/C (volume-capacity) ratio, average speed, and capacity-km.

JICA STRADA software has been used broadly in road network planning especially in developing countries in Asia. One of the main purposes is to estimate future traffic demand and to define future network planning (see Figure 4.1)

Figure 4.1   Outline Framework for Road Network Planning
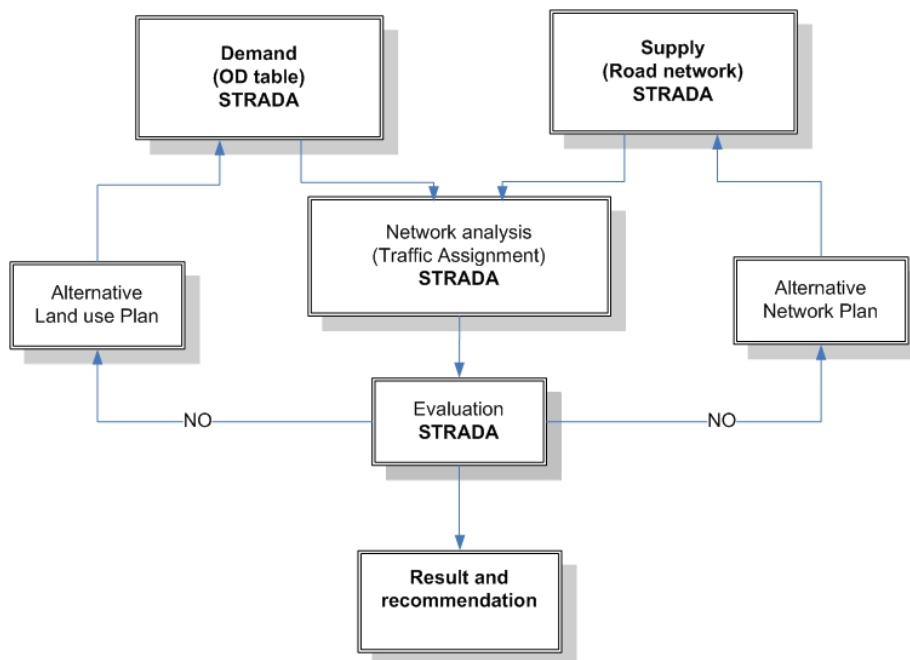
Source: JICA Study Team

(2) Evaluation indicators and data input

Evaluation indicators consist of network, economical and environmental indicators. As shown in Table 4.1 network evaluation has four indicators including PCU-km, PCU-hour, V/C ratio and Average speed. Economical evaluation has two indicators including Vehicle operation cost (VOC US$/day), Total time cost (TTC US$/day). Finally environmental evaluation has two indicators , NO_X (ton/day) and CO_2 (ton/day) that indicate environmental impact.

Table 4.1 Evaluation Indicators

Evaluation	Indicator
Network	PCU-KM (000)
	PCU-Hour (000)
	V/C Ratio
	Ave. Speed
Economical	VOC(000 US$/day)
	TTC(000 US$/day)
	Total (000 US$/day)
Environmental	NOX (ton/day)
	CO2 (ton/day)

Source: JICA Study Team

In order to conduct economical and environmental evaluation the following data were used. The data were collected by related road and traffic administration offices, and some of them were calculated based on the HIS (House interview survey) result (see Tables 4.2, 4.3, and 4.4).

Table 4.2 Data Employed for Parameter Estimation

Vehicle type	Occupancy	PCU	Time Value ($/hour)
Private (car, truck)	2.3	1.2	0.632
Public (bus, trolleybus, taxi)	15.0	2.0	0.287

Source: JICA Study Team

As shown in Table 4.2, average occupancy for private car was set up at 2.3 people according to an observation survey. As for public vehicles, average occupancy is set up at 15 people as considering average occupancy of standard bus, trolleybus, taxi and minibus. Also PCU is set up at 1.2 for private car considering private cars of all sizes such as passenger cars and small and middle sized trucks. PCU for public car is set up at 2.0 compared with the size of private car.

Table 4.3 Data Observed for Environmental Aspect

Speed (km/hour)	NO_X (g/km)		CO_2 (g/km)	
	Car	Bus	Car	Bus
5	2.81	2.00	146	309
10	2.40	1.76	99	237
20	2.05	1.55	67	182
30	1.69	1.33	54	155
40	1.41	1.12	46	137
50	1.48	1.00	42	127
60	1.62	0.88	40	122
70	1.76	0.98	39	123
80	1.91	1.06	40	129

Source: JICA Study Team

Table 4.4 VOC Subject to Time

Ownership	Private						Public			
Vehicle type	Bicycle	Motor-cycle	Car	Small truck (2ton)	Big truck (6ton)	Container truck (15ton)	Taxi	Minibus (24 pax)	Standard bus (60pax)	Articulated bus (180pax)
Financial Cost										
Depreciation	0.007	0.137	0.308	0.126	0.211	0.348	0.087	0.045	0.162	0.974
Capital Opportunity	0.013	0.273	1.478	0.454	0.684	1.130	0.255	0.291	0.727	3.507
Crew and Overhead	0.000	0.012	0.055	0.676	0.551	0.531	0.774	0.818	1.061	0.559
Total	0.020	0.422	1.842	1.257	1.445	2.010	1.116	1.154	1.950	5.040
Economic Cost										
Depreciation	0.006	0.124	0.277	0.060	0.126	0.256	0.077	0.040	0.146	0.885
Capital Opportunity	0.012	0.247	1.328	0.216	0.410	0.831	0.226	0.259	0.658	3.186
Crew and Overhead	0.000	0.012	0.015	0.669	0.511	0.474	0.770	0.811	1.052	0.552
Total	0.018	0.383	1.619	0.945	1.047	1.561	1.073	1.110	1.856	4.624

Source: JICA Study Team

(3) OD table

OD table is made by implementing a household trip survey for each member more than 6 year old. The sample size is 2% in total. Also a traffic volume survey was conducted on screen line at 10 points, a cordon line survey at 11 points and on 12 points at Intersection for adjusting estimated and observed traffic volume. Correlation between estimated and observed traffic volume, , R^2 is 0.84 which indicates high correlation .

Figure 4.1 Correlation Between Observed and Estimated Value (PCU/day)
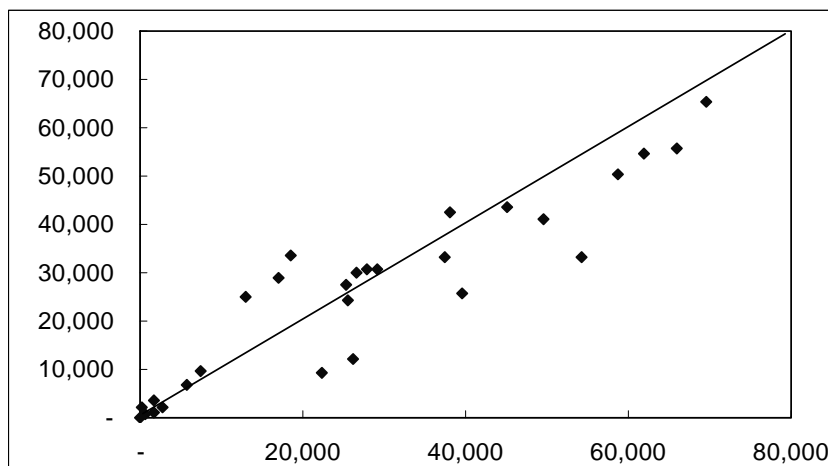
Source: JICA Study Team

(4) Road network building

Information of existing road network includes road section names and their characteristics provided by Road Department of the city government. Road inventory data are made up of the above information provided by coding each road section (link). Road network building is done by using MapInfo software program. Road network using MapInfo program consists of nodes indicating zone center node (with blue points) and link connection nodes (with red points) and link. Figure 4.2 shows the existing road network made with MapInfo software program and each road section is explained by its characteristics using road inventory data. The existing road network consists of 565 nodes and 767 links. Figure 4.3 shows a case of the network of the 38 planned projects.

Figure 4.2 Existing Road Network in MapInfo Software
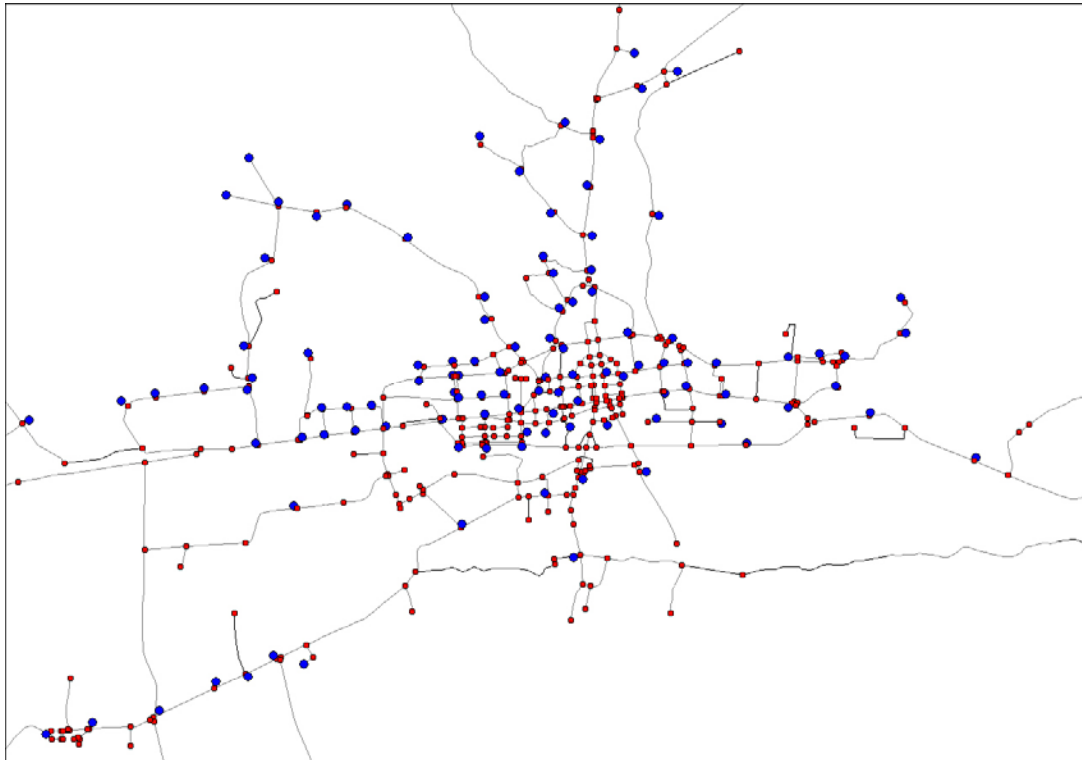
Source: JICA Study Team

Figure 4.3 Planned Road Network in MapInfo Software
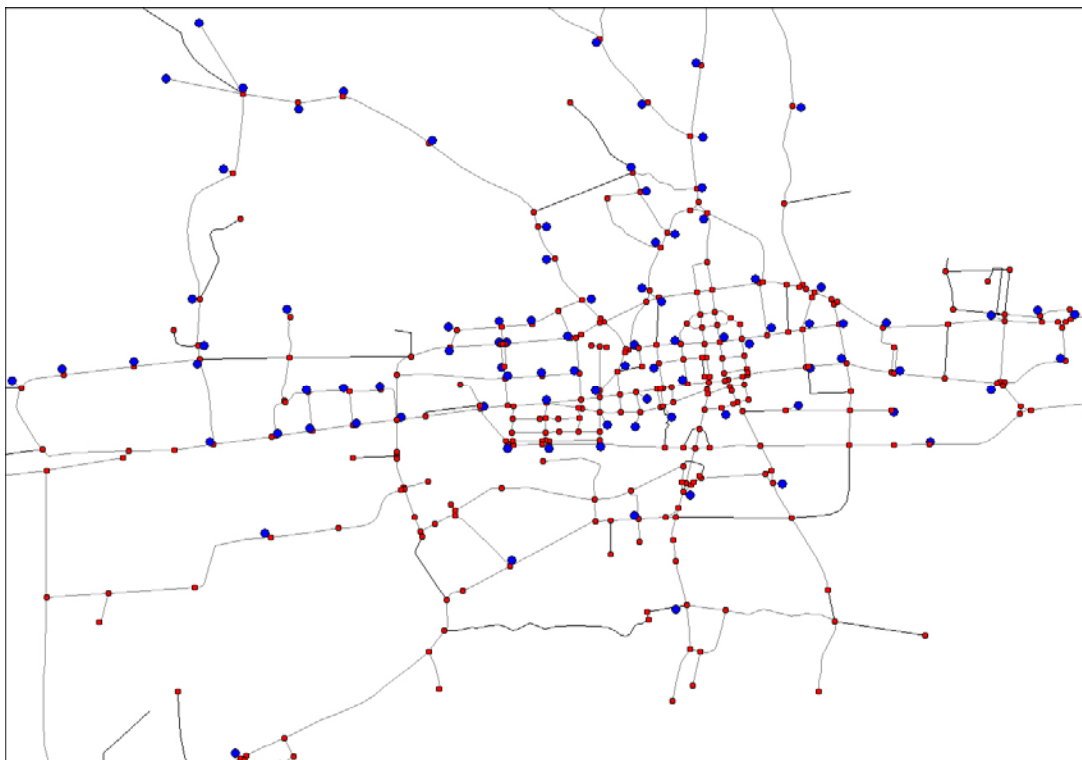
Source: JICA Study Team

(4) Link information data on existing road network

As described above in section (3), link information data employed are the following characteristics including link number (link code in MapInfo and STRADA program), lane width, carriage way, surface condition, class, max speed, construction year, number of lanes , sidewalk width, service level and pavement type, etc.

- **Link information data of improvement projects**

    Link information data of improvement projects is different between before and after the project completion. Accordingly, each project result is compared between cases with and without the project (the existing network). Table 4.5 shows link information data before the improvement projects; and Table 4.6 shows link information data after the improvement projects done .

Table 4.5 Link Information Before Improvement Projects (without case)

ID	Link No.	Length	Lane width	Carriage way	Surface	Class	Capacity	Speed	Construct year	Lane	Sidewalk width 1	Sidewalk width 2	Urban	Mixed	Service	Switch	Pavement	Evaluation	Fund type	Accidents
5	260	0.20	18	35	F	1	54675	40	1971	4,2	0	0	1	1	3	1	Asphalt	3	City	0
	616	0.22	18	35	F	1	54675	40	1971	4,2	0	0	1	1	3	1	Asphalt	3	City	0
	617	0.55	18	35	F	1	54675	40	1971	4,2	0	0	1	1	3	1	Asphalt	3	City	0
	596	1.06	18	35	F	1	54675	40	1971	4,2	0	0	1	1	3	1	Asphalt	3	City	0
	597	1.06	18	35	F	1	54675	40	1971	4,2	0	0	1	1	3	1	Asphalt	3	City	0
	265	0.66	7	25	F	1	17725	35	1971	4,3	0	0	1	1	3	1	Asphalt	1	City	0
	266	0.05	7	25	B	1	9850	35	1971	4,4	0	0	1	1	3	1	Asphalt	1	City	0
	268	0.10	7	35	F	1	17725	35	1971	4,2	0	0	1	1	3	1	Asphalt	3	City	0
10	223	0.38	14	35	F	1	42525	40	1959	4	0	0	1	1	3	1	Asphalt	3	City	0
	60	0.20	8	30	F	1	20250	35	1975	4	0	0	1	1	3	1	Asphalt	1	City	0
	59	0.24	14	35	F	1	42525	40	1959	4	0	0	1	1	3	1	Asphalt	3	City	0
	9	0.20	14	35	F	1	42525	40	1959	4	0	0	1	1	3	1	Asphalt	3	City	0
	3	0.33	14	35	F	1	42525	40	1959	4	0	0	1	1	3	1	Asphalt	3	City	0
12	284	0.55	14	65	F	2	31188	40	1977	2,4	0	0	1	1	3	1	Asphalt	1	City	0
	288	0.23	14	65	F	2	31188	40	1977	2,4	0	0	1	1	3	1	Asphalt	1	City	0
	289	0.12	14	65	F	2	31188	40	1977	2,4	0	0	1	1	3	1	Asphalt	1	City	0
	290	0.08	14	65	F	2	31188	40	1977	2,4	0	0	1	1	3	1	Asphalt	1	City	0
	624	1.51	15	65	F	2	33413	40	1977	2,4	0	0	1	1	3	1	Asphalt	1	City	0
	625	0.80	14	65	F	2	31188	40	1977	2,4	0	0	1	1	3	1	Asphalt	1	City	0
18	49	0.24	18	60	G	1	60750	40	1988	4	0	0	1	1	3	1	Asphalt	4	State	0
	50	0.30	17	25	F	1	51638	40	1988	4	0	0	1	1	3	1	Asphalt	1	city	0
	47	0.31	18	25	G	1	60750	40	1988	4	0	0	1	1	3	1	Asphalt	1	city	0
	39	0.04	18	25	F	1	54675	40	1988	4	0	0	1	1	3	1	Asphalt	1	city	0
	38	0.04	18	60	F	1	54675	40	1988	4	0	0	1	1	3	1	Asphalt	4	State	0
	34	0.12	18	25	G	1	60750	40	1988	4	0	0	1	1	3	1	Asphalt	1	city	0
	35	0.25	18	60	F	1	54675	40	1988	4	0	0	1	1	3	1	Asphalt	4	State	0
	203	0.31	18	60	G	1	60750	40	1988	4	0	0	1	1	3	1	Asphalt	4	State	0
	204	0.24	18	60	F	1	54675	40	1988	4,2	0	0	1	1	3	1	Asphalt	3	State	0
	70	0.22	18	60	F	1	54675	40	1988	2	0	0	1	1	3	1	Asphalt	3	city	0
	71	0.05	18	60	F	1	54675	40	1988	4,2	0	0	1	1	3	1	Asphalt	3	State	0
	210	0.08	18	60	F	1	54675	40	1988	4,2	0	0	1	1	3	1	Asphalt	3	State	0
	211	0.16	18	60	F	1	54675	40	1988	4,2	0	0	1	1	3	1	Asphalt	3	State	0
	213	0.69	18	60	F	1	54675	40	1988	4,2	0	0	1	1	3	1	Asphalt	3	State	0

	702	0.04	18	30	F	1	54675	40	1988	2	0	0	1	1	3	1	Asphalt	3	District	0
	190	0.56	18	30	F	1	54675	40	1988	2	0	0	1	1	3	1	Asphalt	3	District	0
20	251	0.19	16	75	F	1	48600	40	1988	4,6	0	0	1	1	3	1	Asphalt	3	City	0
	249	0.57	16	75	F	1	48600	40	1988	4,6	0	0	1	1	3	1	Asphalt	3	City	0
	1	0.22	16	75	F	1	48600	40	1988	4,6	0	0	1	1	3	1	Asphalt	3	City	0
	20	0.70	16	75	F	1	48600	40	1988	4,6	0	0	1	1	3	1	Asphalt	3	City	0
	21	0.06	16	75	F	1	48600	40	1988	4,6	0	0	1	1	3	1	Asphalt	3	City	0
	275	0.54	19	75	F	1	57713	40	1988	4,6	0	0	1	1	3	1	Asphalt	3	City	0
22	36	0.38	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	28	0.23	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	13	0.32	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	11	0.26	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	4	0.22	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	5	0.27	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	8	0.17	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	17	0.21	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	67	0.25	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	68	0.19	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	208	0.05	12	25	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	209	0.04	12	25	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
23	146	0.31	10	35	F	2	20250	35	1957	2	0	0	1	1	3	1	Asphalt	4	City	0
	149	0.35	10	25	F	2	20250	35	1957	2	0	0	1	1	3	1	Asphalt	4	City	0
	358	0.32	10	35	F	2	20250	35	1957	2	0	0	1	1	3	1	Asphalt	4	City	0
25	667	0.15	17	40	G	1	57375	40	1960	4	0	0	1	1	3	1	Asphalt	4	City	0
	668	0.27	17	40	G	1	57375	40	1960	4	0	0	1	1	3	1	Asphalt	4	City	0
	18	0.36	17	40	G	1	57375	40	1960	4	0	0	1	1	3	1	Asphalt	4	City	0
26	31	0.28	12	30	F	2	26725	40	1960	2	0	0	1	1	3	1	Asphalt	3	City	0
	707	0.06	12	30	F	2	26725	40	1960	2	0	0	1	1	3	1	Asphalt	3	City	0
29	342	0.90	10	25	B	2	11250	35	1971	2	0	0	1	1	3	1	Asphalt	3	City	0
	344	1.27	11	25	B	2	12375	35	1971	2	0	0	1	1	3	1	Asphalt	3	City	0
	641	1.56	11	65	B	2	12375	35	1971	2	0	0	1	1	3	1	Conc/t	3	City	0
	638	0.61	9	65	B	2	10125	35	1971	2	0	0	1	1	3	1	Conc/t	3	City	0
	520	0.39	9	65	B	2	10125	35	1971	2	0	0	1	1	3	1	Conc/t	3	City	0
	518	1.18	9	65	B	2	10125	35	1971	2	0	0	1	1	3	1	Conc/t	3	City	0
	410	0.05	7	25	B	2	7875	35	1971	2	0	0	1	1	3	1	Conc/t	3	City	0
30	346	1.79	12	65	F	2	26725	40	1971	2	0	0	1	1	3	1	Conc/t	3	City	0
	347	3.68	12	50	F	2	26725	40	1961	2	0	0	1	1	3	1	Asphalt	3	City	0
32	461	0.43	10	65	F	1	25313	35	1984	6,4	0	0	1	1	3	1	Asphalt	3	City	0
	459	0.23	10	65	F	1	25313	35	1984	6,4	0	0	1	1	3	1	Asphalt	3	City	0
	173	0.56	10	65	F	1	25313	35	1975	2	0	0	1	1	3	1	Asphalt	3	City	0
	170	0.41	10	65	F	1	25313	35	1975	2	0	0	1	1	3	1	Asphalt	3	City	0
	171	0.69	10	65	F	1	25313	35	1975	2	0	0	1	1	3	1	Asphalt	3	City	0
	682	0.79	14	60	F	1	42525	40	1988	2,4	0	0	1	1	3	1	Asphalt	3	City	0
35	106	0.27	21	25	G	1	70875	45	2007	4	0	0	1	1	3	1	Asphalt	3	State	0
	107	0.52	21	60	G	1	70875	45	1987	4	0	0	1	1	3	1	Asphalt	4	State	0
	108	0.48	21	60	G	1	70875	45	1987	4	0	0	1	1	3	1	Asphalt	4	State	0
	109	0.09	17	60	G	1	57375	40	2007	4	0	0	1	1	3	1	Asphalt	4	State	0
	111	0.39	17	40	G	1	57375	40	1988	4	0	0	1	1	3	1	Asphalt	4	District	0
	354	0.19	15	50	F	2	33413	40	1984	4	0	0	1	1	3	1	Asphalt	3	District	0
36	355	0.69	16	40	B	2	19800	40	1984	2	0	0	1	1	3	1	Asphalt	1	District	0
	610	2.20	15	50	B	2	18563	40	2002	2	0	0	1	1	3	1	Asphalt	1	District	0
41	61	0.35	15	40	G	1	50625	40	1960	4	0	0	1	1	3	1	Asphalt	4	City	0
	14	0.22	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0
	16	0.33	12	40	F	1	36450	40	1960	4	0	0	1	1	3	1	Asphalt	3	City	0

50	629	1.44	12	65	F	1	36450	40	1976	2	0	0	1	1	3	1	Asphalt	3	District	0
	630	0.74	12	65	G	1	40500	40	1976	2	0	0	1	1	3	1	Asphalt	4	District	0
	628	0.75	12	65	G	1	40500	40	1976	2	0	0	1	1	3	1	Asphalt	4	District	0
	348	0.61	12	65	G	1	40500	40	1976	2	0	0	1	1	3	1	Asphalt	4	District	0
	349	0.09	12	65	G	1	40500	40	1961	2	0	0	1	1	3	1	Asphalt	4	State	0
	320	2.20	12	65	G	1	40500	40	1961	2	0	0	1	1	3	1	Asphalt	4	State	0
	321	0.29	12	65	G	1	40500	40	1961	2	0	0	1	1	3	1	Asphalt	4	State	0
	317	0.38	12	65	G	1	40500	40	1961	2	0	0	1	1	3	1	Asphalt	4	State	0
	336	0.76	14	60	F	1	42525	40	1988	2,4	0	0	1	1	3	1	Asphalt	3	City	0
51	281	1.16	7	25	F	1	17725	35	1988	2	0	0	1	1	3	1	Asphalt	3	City	0
	592	0.83	7	25	B	1	9850	35	1988	2	0	0	1	1	3	1	Asphalt	1	City	0
	643	8.32	7	25	B	1	9850	35	1988	2	0	0	1	1	3	1	Asphalt	1	City	0
54	589	1.27	12	25	B	2	14850	40	1988	2	0	0	1	1	3	1	Asphalt	1	City	0
	642	1.31	10	40	F	2	20250	35	1986	2	0	0	1	1	3	1	Asphalt	3	City	0
	339	0.67	11	60	F	1	27850	35	1987	2,6,4	0	0	1	1	3	1	Asphalt	3	State	0
	685	1.71	12	25	B	2	14850	40	1987	4	0	0	1	1	3	1	Asphalt	1	State	0
	591	2.09	7	25	B	2	7875	35	1987	4	0	0	1	1	3	1	Asphalt	1	State	0
55	340	0.14	9	60	F	1	22788	35	1987	4	0	0	1	1	3	1	Asphalt	3	State	0
	341	1.13	9	60	F	1	22788	35	1987	2,6,4	0	0	1	1	3	1	Asphalt	3	State	0
	671	1.59	9	25	F	1	22788	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	588	1.15	9	25	F	1	22788	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	472	0.37	9	25	F	1	22788	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	473	0.19	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	478	0.45	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	479	0.19	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	482	0.91	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	485	0.05	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	487	0.06	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	501	0.14	9	25	F	1	22788	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	505	0.03	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	506	0.06	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	508	0.07	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
	510	0.07	7	25	F	1	17725	35	1980	4	0	0	1	1	3	1	Asphalt	3	city	0
56	627	2.73	9	35	G	2	20250	35	1980	2	0	0	1	1	3	1	Asphalt	4	City	0
	626	3.15	8	35	G	2	18000	35	1980	2	0	0	1	1	3	1	Asphalt	4	City	0
	716	0.27	8	35	G	2	18000	35	1980	2	0	0	1	1	3	1	Asphalt	4	City	0
57	307	1.48	9	50	G	1	25313	35	2003	4	0	0	1	1	3	1	Asphalt	4	City	0
	680	1.18	18	50	G	1	60750	40	2003	4	0	0	1	1	3	1	Asphalt	4	City	0
	130	0.10	18	50	G	1	60750	40	2003	2,4	0	0	1	1	3	1	Asphalt	4	City	0
	134	0.42	8	25	F	1	20250	35	2003	2,4	0	0	1	1	3	1	Asphalt	4	City	0
	242	0.08	8	50	G	1	22500	35	2003	2,4	0	0	1	1	3	1	Asphalt	4	City	0
	244	0.06	8	50	G	1	22500	35	2003	2,4	0	0	1	1	3	1	Asphalt	4	City	0
	245	0.60	8	50	G	1	22500	35	2003	2,4	0	0	1	1	3	1	Asphalt	4	City	0

Source: JICA Study Team

Table 4.6 Link Information After Improvement Projects (with case)

ID	Link number	Length	Lane width	Carriage way	Surface	Class	Capacity	Speed	Construct year	Lane	Ped width1	Ped width2	Urban	Mixed	Service	Switch	Pavement	Evaluation	Fund type	Accidents
5	260	0.20	18	60	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	616	0.22	18	60	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	617	0.55	18	60	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	596	1.06	18	60	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	597	1.06	18	60	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	265	0.66	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	266	0.05	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	268	0.10	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
10	223	0.38	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	60	0.20	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	59	0.24	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	9	0.20	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	3	0.33	14	60	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
12	284	0.55	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	288	0.23	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	289	0.12	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	290	0.08	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	624	1.51	15	65	G	2	37125	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	625	0.80	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
18	49	0.24	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	50	0.30	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	47	0.31	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	39	0.04	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	38	0.04	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	34	0.12	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	35	0.25	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	203	0.31	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	204	0.24	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	70	0.22	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	71	0.05	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	210	0.08	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	211	0.16	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	213	0.69	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	702	0.04	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	190	0.56	22	65	G	1	74250	45	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
20	251	0.19	22	75	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	249	0.57	22	75	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	1	0.22	22	75	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	20	0.70	22	75	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	21	0.06	22	75	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	275	0.54	22	75	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
22	36	0.38	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	28	0.23	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	13	0.32	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	11	0.26	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	4	0.22	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	5	0.27	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	8	0.17	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0

	17	0.21	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	67	0.25	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	68	0.19	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	208	0.05	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	209	0.04	15	65	G	1	50625	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
23	146	0.31	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	149	0.35	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	358	0.32	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
25	667	0.15	17	40	G	1	57375	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	668	0.27	17	40	G	1	57375	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	18	0.36	17	40	G	1	57375	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
26	31	0.90	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	707	1.27	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
29	342	1.56	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Concrete	4	City	0
	344	0.61	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Concrete	4	City	0
	641	0.39	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Concrete	4	City	0
	638	1.18	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Concrete	4	City	0
	520	0.05	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	518	1.79	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	410	3.68	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
30	346	0.43	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	347	0.23	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
32	461	0.56	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	459	0.41	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	173	0.69	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	170	0.79	14	60	F	1	42525	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	171	0.27	25	65	G	1	84375	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	682	0.52	25	65	G	1	84375	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
35	106	0.48	25	65	G	1	84375	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	107	0.09	25	65	G	1	84375	45	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	108	0.39	25	65	G	1	84375	45	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	109	0.19	21	65	G	2	51975	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	111	0.69	21	65	G	2	51975	45	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	354	2.20	21	65	G	2	51975	45	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
36	355	0.35	21	65	G	1	70875	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	610	0.22	21	65	G	1	70875	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
41	61	0.33	21	65	G	1	70875	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	14	1.44	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	16	0.74	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
50	629	0.75	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	630	0.61	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	District	0
	628	0.09	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	348	2.20	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	349	0.29	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	320	0.38	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	321	0.28	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	317	1.16	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	336	0.83	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
51	281	8.32	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	592	1.27	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	643	1.31	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
54	589	0.67	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	State	0
	642	1.71	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0

	339	2.09	14	65	G	2	34650	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	685	0.14	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	591	1.13	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	State	0
55	340	1.59	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	341	1.15	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	671	0.37	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	588	0.19	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	472	0.45	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	473	0.19	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	478	0.91	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	479	0.05	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	482	0.06	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	485	0.14	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	487	0.03	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	501	0.06	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	505	0.07	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	506	0.07	22	65	G	1	74250	45	to improve	6	0	0	1	1	3	1	Asphalt	4	City	0
	508	2.73	9	65	G	2	20250	35	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
	510	3.15	9	65	G	2	20250	35	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
56	627	0.27	9	65	G	2	20250	35	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
	626	1.48	14	65	G	1	47250	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	716	1.18	18	65	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
57	307	0.10	18	50	G	1	60750	40	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	680	0.42	8	25	G	1	20250	35	to improve	4	0	0	1	1	3	1	Asphalt	4	City	0
	130	0.08	8	50	G	1	22500	35	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
	134	0.06	8	50	G	1	22500	35	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
	242	0.60	8	50	G	1	22500	35	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
	244	0.20	18	60	G	1	60750	40	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0
	245	0.22	18	60	G	1	60750	40	to improve	2	0	0	1	1	3	1	Asphalt	4	City	0

Source: JICA Study Team

- **Link information data of new projects (with case)**

Link information data of new projects is input in the existing network and compared to the without-project case for evaluation. The comparison is made one by one for each project for with- and without- cases or the planned and existing network. Table 4.7 shows link information data of the new projects.

Table 4.7 Link Information Data of New Projects

| ID	Link number	Length	Lane width	Carriage way	Surface	Class	Capacity	Speed	Construct year	Lane	Sidewalk width1	Sidewalk width2	Urban	Mixed	Service	Switch	Pavement	Evaluation	Fund type	Accidents
2	729	1.57	7	40	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	State	0
3	730	1.40	7	45	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
4	728	1.01	7	60	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	State	0
11	735	0.20	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	735	0.20	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	733	0.76	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	732	0.66	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	734	0.93	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
14	741	3.12	7	35	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
21	740	0.47	12	40	G	2	29700	40	2020	4	0	0	1	1	3	1	Asphalt	4	State	0
28	737	1.06	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	738	0.92	7	30	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
31	743	0.59	7	35	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	744	3.20	7	35	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
33	762	0.05	25	65	G	1	84375	45	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
	761	0.06	25	65	G	1	84375	45	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
37	745	2.28	7	35	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
	747	0.60	6	35	G	2	13500	30	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
42	749	1.00	7	35	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
43	751	0.70	8	40	G	1	22500	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
45	729	0.64	15	65	G	2	37125	40	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
46	752	5.60	7	35	G	2	15750	35	2020	2	0	0	1	1	3	1	Asphalt	4	City	0
47	755	1.69	14	65	G	2	34650	40	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
	754	1.71	14	65	G	2	34650	40	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
48	732	0.19	14	65	G	2	34650	40	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
49	731	1.65	21	65	G	2	51975	45	2020	4	0	0	1	1	3	1	Asphalt	4	City	0
	730	1.30	21	65	G	2	51975	45	2020	4	0	0	1	1	3	1	Asphalt	4	City	0

Source: JICA Study Team

5. Evaluation Procedure

Main procedure of the project evaluation can be described as following steps:

- To build road network using MapInfo software program.

- To convert the MapInfo road network file to the STRADA network

- To open Network Editor to edit network on STRADA program (see Figure 5.1)

- To estimate parameters on Network Editor

- To open Incremental Assignment on STRADA to assign link traffic volume

- To open Highway Reporter to identify assignment result

- To analyze network evaluation indicator

Figure 5.1 Image of Road Network in Network Editor
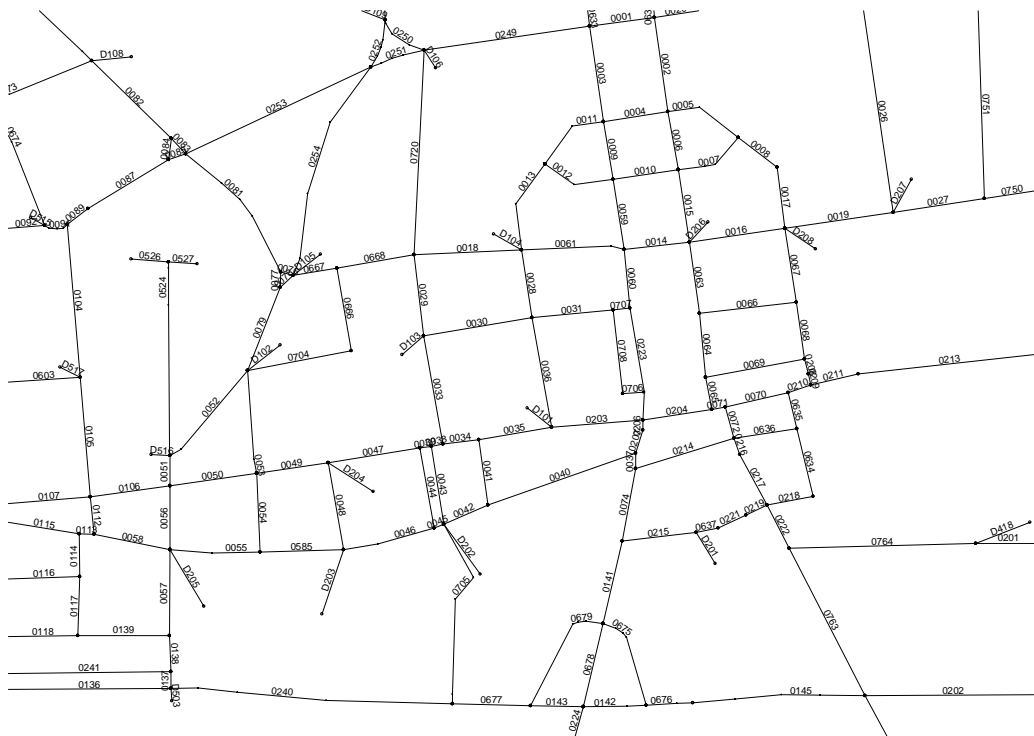
Source: JICA Study Team

Each project evaluation is done by the above described procedure comparing cases with (with-project network) and without project (the existing network) . Also results of both cases were analysed assigning OD table in 2007 and 2020. Accordingly, evaluation was done for two different assignment cases (see Table 5.1 and Table 5.2). Table 5.1 shows the evaluation result of ID-2 project with- and without-case on the existing network and also with- and without-case on the planned network. As described above, the planned network has all the38 projects assigned into the existing network.

Table 5.1 Evaluation Comparison Result of New Road ID-2 (OD-2007)

Evaluation index	A. With project on existing network	B. Existing network	Result (A-B)	C. Planned network	D. Without project on planned network	Result (D-C)
PCU-KM	4,909,711	4,949,468	39,757	4,933,983	4,966,377	(32,394)
PCU-Hour	185,540	188,789	3,249	175,695	178,383	(2,688)
V/C Ratio	0.33	0.34	0	0.30	0.30	(0)
Ave. Speed	26.5	26.2	(0)	28.1	27.8	0
VOC(000 US$/day)	671	679	8	652	659	(7)
TTC(000 US$/day)	270	275	5	256	260	(4)
Total (000 US$/day)	941	954	13	907	919	(11)
NO_X (ton/day)	6.3	6.4	0.1	6.2	6.2	(0)
CO_2 (ton/day)	280.5	284.1	4	273.4	276.4	(3)

Source: JICA Study Team

In order to maintain the accuracy of evaluation, opposite evaluation process was conducted; the opposite evaluation was conducted on a planned network which was built by putting all project link information data onto the existing road network. And the evaluation result was compared between the planned network result and without project each (see Table 5.1). As shown in Table 5.1, both comparisons of evaluation results were made in case of the new road ID-2 project using OD table 2007. Results in Table 5.2 indicate as same procedure as Table 5.1 in case of improvement project ID-5.

Table 5.2 Result on Evaluation Comparison of Improvement Project ID-5 (OD-2007)

Evaluation index	A. With project on existing network	B. Existing network	Result (A-B)	C. Planned network	D. Without project on planned net	Result (D-C)
PCU-KM	4,917,965	4,949,468	31,503	4,933,983	4,949,467	(15,484)
PCU-Hour	185,801	188,789	2,988	175,695	176,700	(1,004)
V/C Ratio	0.33	0.34	0	0.30	0.30	(0)
Ave. Speed	26.5	26.2	(0)	28.1	28.0	0
VOC(000 US$/day)	672	679	7	652	655	(3)
TTC(000 US$/day)	271	275	5	256	257	(1)
Total (000 US$/day)	942	954	12	907	912	(4)
NO_x (ton/day)	6.3	6.4	0	6.2	6.2	(0)
CO_2 (ton/day)	281.0	284.1	3	273.4	274.5	(1)

Source: JICA Study Team

As shown in Table 5.1 and Table 5.2, the results of evaluation of both cases which are conducted under the existing network (A-B) and planned network (D-C), the evaluation comparison on the planned network seems to have not much impact on the network compared to another evaluation result on the existing network (A-B); therefore the evaluation on existing network (A-B) was chosen for the next evaluation process that uses OD table in 2020 (see Table 5.3 and Table 5.4)

Table 5.3 Result on Evaluation Comparison of New Project ID-2 (OD- 2020)

Evaluation index	A. With project on existing network	B. Existing network	Result (diff A-B)
PCU-KM	9,690,920	9,757,153	66,232
PCU-Hour	611,017	620,009	8,991
V/C Ratio	0.66	0.66	0
Ave. Speed	15.9	15.7	(0)
VOC(000 US$/day)	1,620	1,641	22
TTC(000 US$/day)	993	1,007	14
Total (000 US$/day)	2,613	2,648	36
NO_X (ton/day)	13.0	13.2	0.1
CO_2 (ton/day)	774.6	783.1	8

Source: JICA Study Team

Table 5.4 Result of Evaluation Comparison of Improvement Project ID-5 (OD-2020)

Evaluation index	A. With project on existing network	B. Existing network	Result (A-B)
PCU-KM	9,739,639	9,757,153	17,514
PCU-Hour	612,200	620,009	7,809
V/C Ratio	0.66	0.66	0
Ave. Speed	15.9	15.7	(0)
VOC(000 US$/day)	1,626	1,641	16
TTC(000 US$/day)	995	1,007	12
Total (000 US$/day)	2,620	2,648	28
NO_X (ton/day)	13.1	13.2	0
CO_2 (ton/day)	777.8	783.1	5

Source: JICA Study Team

(1) Assignment result using Highway Reporter

Highway Reporter can be shown a link assignment result and network evaluation result as shown in the above table.; accordingly the link assignment result and evaluation result can be shown by Highway Reporter. Figure 5.1 and Figure 5.2 show the assignment result on the existing network (without any projects) and assignment result on the planned projects (with all projects) using OD 2007, respectively.

Figure 5.1 Assignment Result on Existing Network (OD-2007)
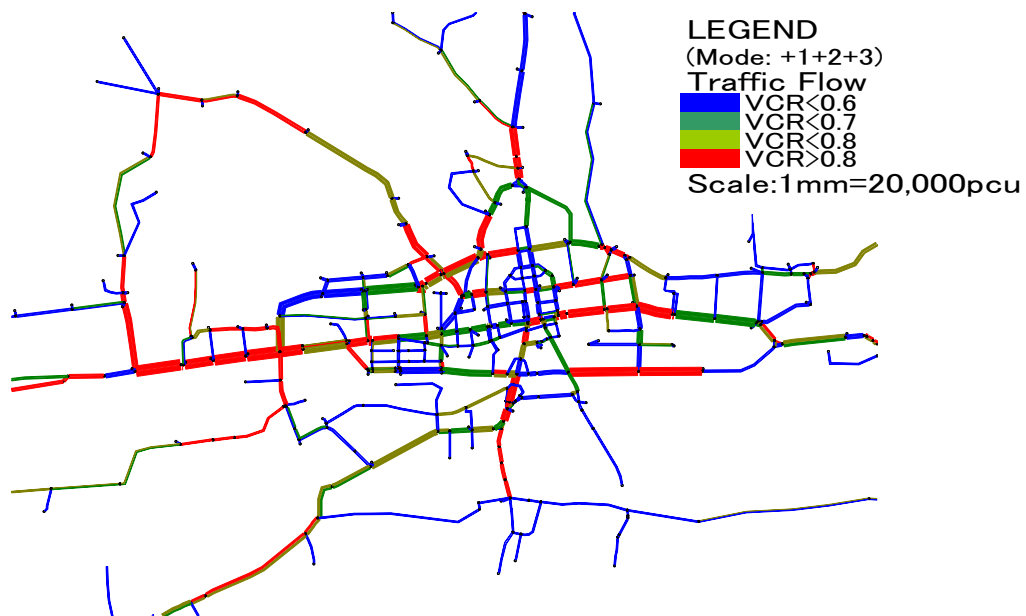
Figure 5.2 Assignment Result on Planned Network (OD-2007)

Source: JICA Study Team
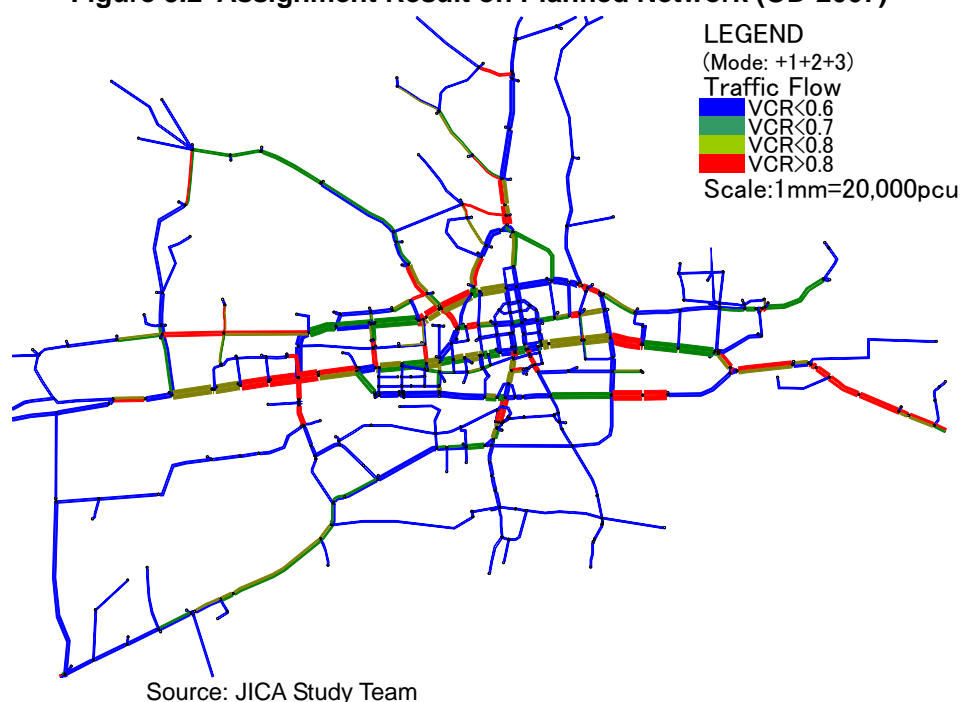
Red indicates congested road sections, green indicates not much congested and blue shows not congested. Comparing two assignment results as shown Figure 5.1 and Figure 5.2, traffic congestion will decrease substantially if all projects are implemented as improved road network connectivity.

Evaluation indicators of the assignment result using the OD table in 2007 for both existing and planned networks are shown in Table 5.5.

Table 5.5 Evaluation Result Between Existing and Planned Road Networks (OD-2007)

Evaluation indicator	Existing	Planned	Benefit
PCU-KM	4905062.81	4835476.25	69586.56
PCU-Hour	184989.36	168922.84	16066.51
V/C Ratio	0.33	0.29	0.04
Ave. Speed	26.52	28.63	-2.11
VOC(000 US$/day)	668.78	631.93	36.85
TTC(000 US$/day)	269.48	245.59	23.88
Total (000 US$/day)	938.26	877.52	60.74
NOX (ton/day)	6.33	6.00	0.32
CO2 (ton/day)	280.13	265.23	14.90

Source: JICA Study Team

As shown Table 5.5, PCU-km and PCU-hour has decreased substantially, which means that average trip length and travel time will be decreased because of better accessibility.

6. Project Priority

According to the evaluation result of each project, the Project priority order was arranged by the following steps:

- Total savings of VOC and TTC (made by descending order)

- Total reduction in environmental impacts of NO_X and CO_2 (made by descending order)

- Minimum total construction cost (made by ascending order)

The result of the above order, the priority order of the projects was determined as shown in Table 6.1 and Table 6.2; Table 6.1 and Table 6.2 show the evaluation results by assignment OD table 2007 and OD table 2020, respectively.

Table 6.1 Impacts on Network and Priority Order (OD-2007)

| Priority order | Code No. | Road ID | Network Performance | | | | | | | | Environmental impacts | | | Construction Cost (mil. MNT) |
| | | | Reduction in | | Ave. Travel Speed (km/h) | | Cost savings (000USD$/day) | | | Reduction in (ton/day) | | Network connectivity level | |
			PCU-KM/day	PCU-Hour/day	without	with	VOC	TTC	Total	NOX	CO2		
1	N-18	49	89,610	8,061	26.9	26.2	21	12	33	0	9	G	4000
2	I-4	18	33,688	4,554	26.7	26.2	11	7	18	0	4	G	2200
3	I-18	55	24,661	4,738	26.8	26.2	10	7	17	0	4	G	8500
4	N-16	45	43,359	3,800	26.5	26.2	10	6	16	0	4	F	1800
5	N-1	2	39,757	3,249	26.5	26.2	8	5	13	0.1	4	F	525
6	I-5	20	27,964	3,580	26.6	26.2	8	5	13	0	4	G	1300
7	I-6.	22	34,874	3,005	26.5	26.2	8	5	13	0	3	G	2200
8	N-17	48	22,886	3,571	26.6	26.2	8	5	13	0	3	F	2500
9	N-15	47	21,757	3,522	26.6	26.2	8	5	13	0	3	F	3000
10	I-20	57	34,469	2,885	26.4	26.2	7	4	12	0	3	G	1800
11	I-1	5	31,503	2,988	26.5	26.2	7	5	12	0	3	F	2400
12	I-13	36	28,934	3,147	26.5	26.2	8	5	12	0	3	F	2500
13	I-9	29	9,113	3,364	26.6	26.2	7	5	12	0	3	F	4500
14	I-11	32	26,682	3,111	26.5	26.2	7	5	12	0	3	F	5500
15	I-17	54	24,285	3,165	26.5	26.2	7	5	12	0	3	F	5707
16	N-13	43	32,053	2,727	26.4	26.2	7	4	11	0	3	F	450
17	N-2	3	28,311	2,556	26.4	26.4	7	4	11	0	3	B	490
18	I-14	41	33,318	2,715	26.4	26.2	7	4	11	0	3	G	1000
19	N-5	14	28,311	2,556	26.4	26.2	7	4	11	0	3	B	1100
20	I-12	35	30,902	2,886	26.5	26.2	7	4	11	0	3	G	1200
21	N-4	11	28,311	2,556	26.4	26.2	7	4	11	0	3	B	1400
22	I-2	10	34,009	2,877	26.4	26.2	7	4	11	0	3	G	1600
23	N-8	31	28,311	2,556	26.4	26.2	7	4	11	0	3	B	1800
24	I-10	30	29,664	2,638	26.4	26.2	7	4	11	0	3	F	2000
25	N-10	40	28,514	2,410	26.4	26.2	6	4	10	0	3	B	247
26	N-3	4	28,514	2,410	26.4	26.2	6	4	10	0	3	B	400
27	N-11	42	28,514	2,410	26.4	26.2	6	4	10	0	3	B	500
28	I-8	25	26,463	2,500	26.4	26.2	6	4	10	0	3	G	1000
29	I-7	23	21,670	2,500	26.5	26.2	6	4	10	0	3	B	1300
30	N-9	37	28,514	2,410	26.4	26.2	6	4	10	0	3	B	1800

31	I-3	12	27,154	2,608	26.4	26.2	6	4	10	0	3	F	2800
32	N-14	46	28,514	2,410	26.4	26.2	6	4	10	0	3	B	3000
33	I-19	56	28,691	2,415	26.4	26.2	6	4	10	0	3	F	3800
34	I-16	51	28,514	2,570	26.4	26.2	6	4	10	0	3	B	8500
35	N-7	28	28,326	2,537	26.4	26.2	6	4	10	0	3	B	900
36	N-12	33	28,752	2,478	26.4	26.2	6	4	10	0	3	F	1110
37	I-15	50	22,018	2,318	26.4	26.2	6	4	10	0	2	F	3800
38	N-6	21	16,836	2,413	26.5	26.2	5	4	9	0	2	F	

Source: JICA Study Team

Table 6.2 Impacts on the network and Priority order (by OD in 2020)

Priority order	Code No	Road ID	Network Performance							Environmental impacts		Network connectivity level	Construction Cost (Million Tugrug)
			Reduction in		Ave. Travel Speed (km/h)		Cost savings (000USD$/day)			Reduction in (ton/day)			
			PCU-KM/day	PCU-Hour/day	without	with	VOC	TTC	Total	NOX	CO2		
1	I-18	55	53,839	51,732	15.7	17.1	97	85	182	0	32	G	8500
2	N-18	49	91,463	23,762	15.7	16.2	52	38	90	0	19	G	4000
3	I-4	18	82,209	16,078	15.7	16	35	26	61	0	13	G	2200
4	I-9	29	-10,394	14,021	15.7	16.1	28	23	51	0	8	F	4500
5	I-15	50	74,017	13,034	15.7	16	29	21	50	0	11	F	3800
6	I-17	54	29,152	11,958	15.7	16	24	19	44	0	8	F	5707
7	N-16	45	69,453	10,645	15.7	15.9	26	17	43	0	10	F	1800
8	N-15	47	15,265	11,986	15.7	16	24	19	43	0	8	F	3000
9	N-17	48	10,448	11,694	15.7	16	23	18	41	0	8	F	2500
10	I-3	12	50,069	10,037	15.7	15.9	22	16	38	0	8	F	2800
11	N-1	2	66,232	8,991	15.7	15.9	22	14	36	0.1	8	F	525
12	I-14	41	62,864	9,565	15.7	15.9	21	15	36	0	8	G	1000
13	I-5	20	32,257	9,603	15.7	15.9	21	15	36	0	7	G	1300
14	I-20	57	53,990	8,949	15.7	15.9	20	14	35	0	8	G	1800
15	I-8	25	47,672	9,551	15.7	15.9	20	15	35	0	7	G	1000
16	I-2	10	41,106	9,315	15.7	15.9	20	15	35	0	7	G	1600
17	N-2	3	35,307	8,534	15.7	15.9	18	14	31	0	6	B	490
18	N-5	14	35,307	8,534	15.7	15.9	18	14	31	0	6	B	1100
19	N-4	11	35,307	8,534	15.7	15.9	18	14	31	0	6	B	1400
20	N-8	31	35,307	8,534	15.7	15.9	18	14	31	0	6	B	1800

21	I-7	23	14,290	8,815	15.7	15.9	16	14	30	0	5	B	1300
22	I-6	22	24,506	7,841	15.7	15.9	16	12	28	0	5	G	2200
23	I-1	5	17,514	7,809	15.7	15.9	16	12	28	0	5	F	2400
24	I-11	32	392	8,072	15.7	15.9	15	13	27	0	4	F	5500
25	N-12	33	35,294	6,677	15.7	15.9	15	11	25	0	5	F	1109.7
26	N-13	43	39,671	5,900	15.7	15.8	14	9	23	0	5	F	450
27	I-19	56	35,165	5,795	15.7	15.8	13	9	23	0	5	F	3800
28	I-12	35	14,845	6,098	15.7	15.9	13	10	23	0	4	G	1200
29	I-13	36	434	6,241	15.7	15.9	13	10	23	0	4	F	2500
30	N-7	28	19,332	6,273	15.7	15.9	13	10	23	0	4	B	900
31	N-6	21	-17,356	6,699	15.7	15.9	12	11	23	0	3	F	4000
32	I-16	51	30,223	5,428	15.7	15.8	12	9	21	0	5	B	8500
33	I-10	30	-13,718	5,961	15.7	15.9	11	9	20	0	3	F	2000
34	N-10	40	30,223	4,996	15.7	15.8	11	8	19	0	4	B	247.2
35	N-3	4	30,223	4,996	15.7	15.8	11	8	19	0	4	B	400
36	N-11	42	30,223	4,996	15.7	15.8	11	8	19	0	4	B	500
37	N-9	37	30,223	4,996	15.7	15.8	11	8	19	0	4	B	1800
38	N-14	46	30,223	4,996	15.7	15.8	11	8	19	0	4	B	3000

Source: JICA Study Team

As shown in Table 6.1, the top 3 projects of the highest priority project order are the new project ID-49, improvement project ID-18 and improvement project ID-55. On the other hand, according to result shown in Table 6.2, the top 3 priority projects are the improvement project ID-55, new road project ID-49 and improvement project ID-18.

7. Conclusion and Recommendation

As a result of the priority order in both cases with OD-table in 2007 and OD-table in 2020 as shown in Table 6.1 and Table 6.2 respectively, the result of Table 6.1 was chosen as the final priority order of the evaluation result. Construction cost of project ID-55 is very high compared to new project ID-49; accordingly it is not possible to implement ID-55 as the first priority order project. Therefore, as shown in Table 6.1, the following projects are recommended to implement at the first stage as priority projects.

(i)   Code number N-18 (new project code number) or ID-49 new construction road section on the Ard Ayush avenue in the southern side of Unur district

(ii)   Code number I-4 (improvement project code number) or ID-18 improvement project on the Peace avenue road section

(iii) Code number I-18 (improvement project code number) or ID-55 improvement project on the west side of Peace Avenue from the railway crossing to the 22 Toll gate.

### (1) Evaluation result on ID-49 project

ID-49 which was chosen as priority No.1 is described in the following Figures 7.1, 7.2 and 7.3 as case study. Table 7.1 shows the case where ID-49 project was assigned on existing road network in 2007.
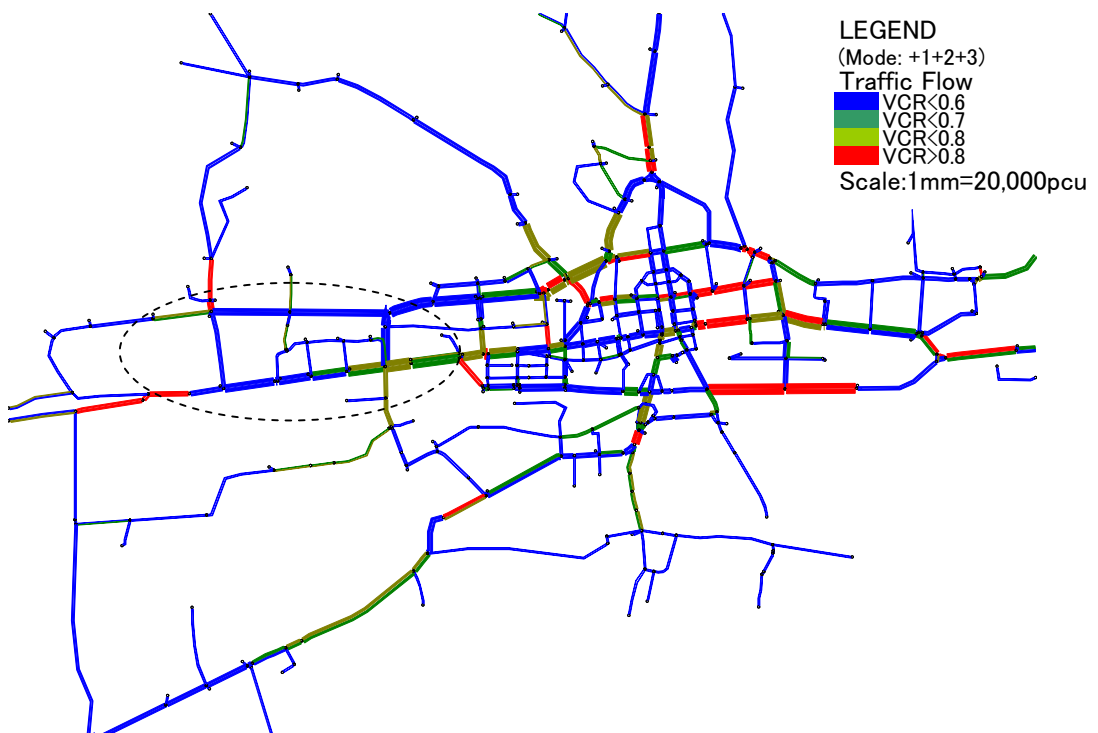
Figure 7.1 ID-49 Project on Existing Road Network
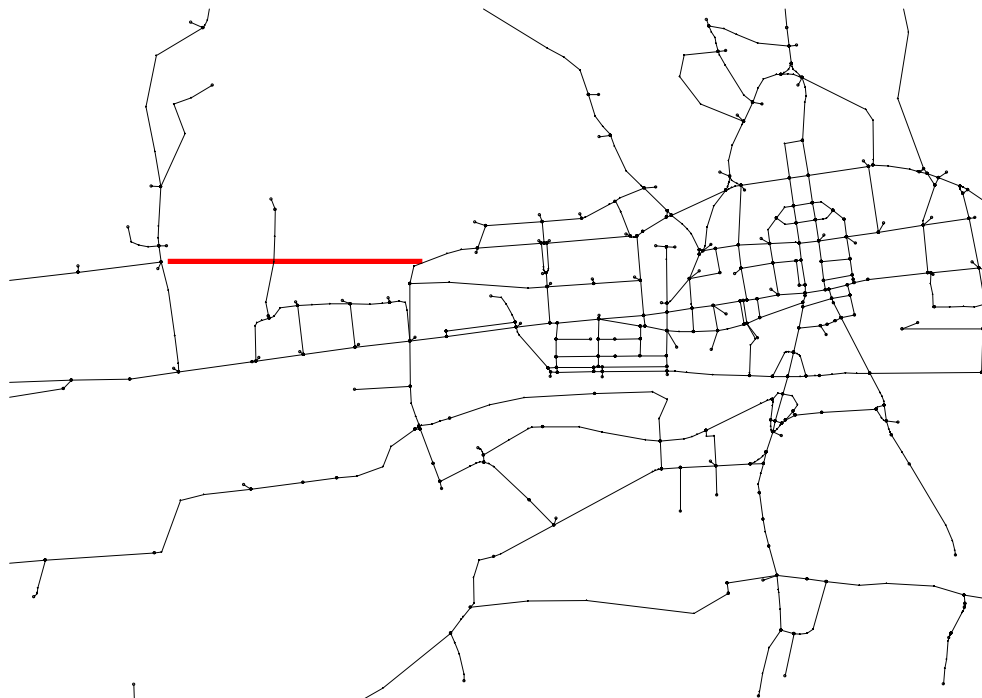
Source: JICA Study Team

Figure 7.2 Assignment Result without ID-49 Project on Existing Road Network
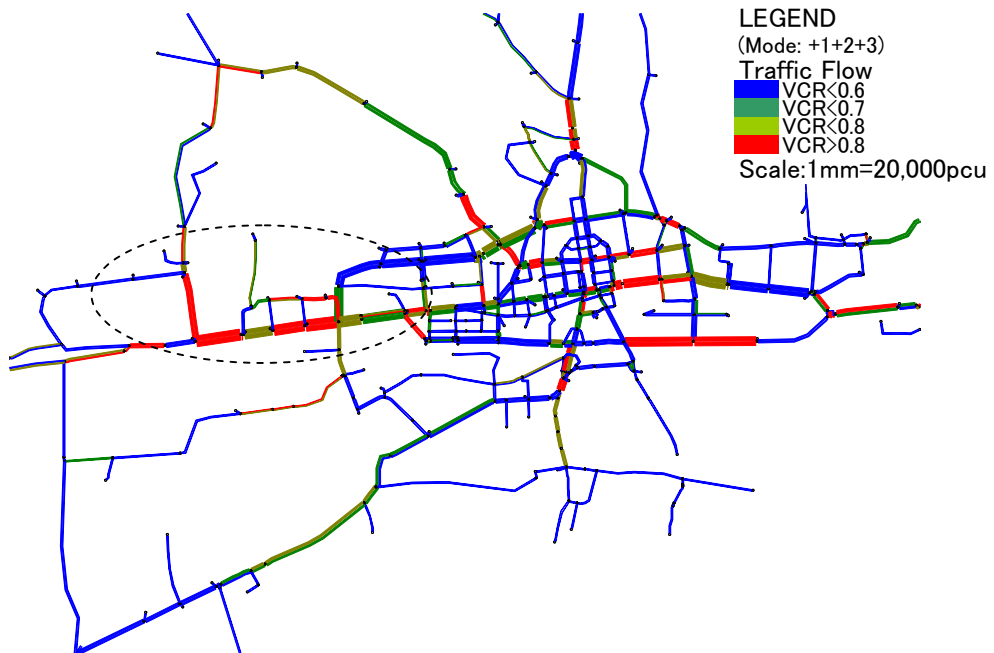
Source: JICA Study Team

Figure 7.3 Assignment Result with ID-49 Project on Existing Road Network

Source: JICA Study Team

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As compared to traffic assignment result of the with- and without-cases as shown above in Figures 7.2 and 7.3, it is clear that traffic congestion will decrease in the entire network especially on the sections around those projects.

Table 7.1 Evaluation Result of Cases With and Without ID-49

Evaluation	Indicators	With Project	Without Project	Result
Network	PCU-KM (000)	4,859	4,949	- 89 (2 %)
	PCU-Hour (000)	180	188	- 8 (4%)
	V/C Ratio	0.33	0.34	0
	Ave. Speed (km/hour)	27	26	-1
Economical	VOC(000 US$/day)	658	679	- 21 (3%)
	TTC(000 US$/day)	263	275	- 12 (4%)
	Total (000 US$/day)	920	954	- 34 (4%)
Environmental	NO_X (ton/day)	6.2	6.4	0
	CO_2 (ton/day)	275.1	284.1	- 9 (3%)

Source: JICA Study Team

Also evaluation result of cases with and without of ID-49 Project is shown in Table 7.1; PCU-km and PCU-hour reduce substantially at around 89 or 2% and can save 8 hours, respectively. Also average speed will increase 1km/hour. In terms of economical assessment, VOC and TTC reduce by 3% and 4% respectively if the project is implemented. Finally, in environmental aspect, CO_2 reduces by 3%.

Therefore the JICA Study Team recommends implementing ID-49 project in the most beginning stage.