Republic of Nicaragua
Municipality of Managua

PROJECT FOR URBAN DEVELOPMENT MASTER PLAN FOR MANAGUA CITY IN REPUBLIC OF NICARAGUA

FINAL REPORT

Part - II: The Master Plan

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PROJECT FOR
URBAN DEVELOPMENT MASTER PLAN FOR MANAGUA CITY IN REPUBLIC OF NICARAGUA

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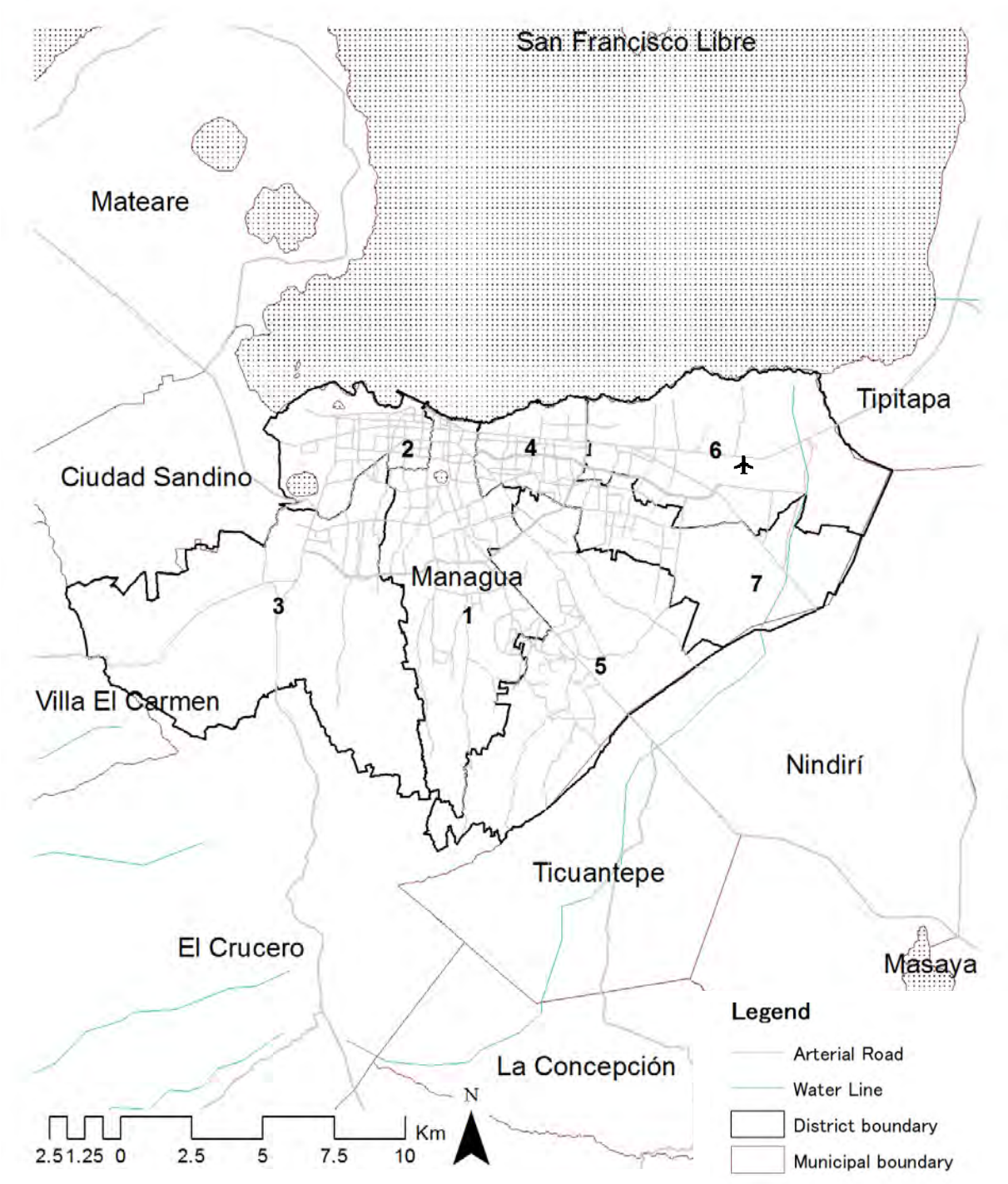
LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AGT	Automated Guideway Transit
ALMA	Municipality of Managua
AMUSCLAM	Storm water Drainage and Development Management Sub Watershed III
APP	Public Private Partnership
ATN	Nicaraguan association of transporters
BAC	Bank of Central American
BCIE	Central American Bank for Economic Integration
BCN	National Bank of Nicaragua
BDF	Finance Bank
BEI	European Investment Bank
BOD	Biochemical Oxygen Demand
BTR (BRT)	Bus Rapid Transit
CACONIC	Nicaraguan Chamber of Commerce
CCTV	Closed-Circuit Television
COBAPRED	Barrio Community of Prevention, Mitigation and Attention of Disasters
COD	Chemical Oxygen Demand
CODIPRED	District Community of Prevention, Mitigation and Attention of Disasters
COMMEMA	Municipal Corporation of Managua Markets
COMUPRED	Municipal Community of Prevention, Mitigation and Attention of Disasters
CONAPAS	National Commission of Water and Sewerage
DBO5	Biochemical Oxygen Demand
DDV	Right of Way
DGA	Directorate General of Customs Services
DGAC	General Directorate of Civil Aviation
DGO	Official Gazette Daily
DGTT	General Directorate of Land Transportation
DQO	Chemical Oxygen Demand
DWT	Deadweight Tons
E/N, C/N	Exchange of Notes
EA	Environmental Evaluation
EAAI	International Airport Administration Company
EAE	Strategic Environmental Assessment
ECLAC/CEPAL	Economic Commission for Latin America and the Caribbean
EHMP	Household Survey to Measure Poverty
EIA	Environmental Impact Assessment
EMTRIDES	Company of Integral Solid Waste Treatment
ENACAL	The Nicaraguan Company Water Supply and Sewerage
ENATREL	The National Company of Electricity Transmission
EPN	National Port Authority
FIDEG	International Foundation for Global Economic Challenge
FMAM	Global Environment Facility
FND	Nordic Development Fund
FOS	Land Occupancy Factor
FOT	Total Occupancy Factor
FS	Feasibility Study

FSLN	Sandinista National Liberation Front
FTA	Free Trade Agreement
FTZ/ZF	Free Trade Zone / Zona Franca
GDP, PIB	Gross Domestic Product
GEF	Global Environment Facility
GIS/SIG	Geographical Information System
GIZ	German International Cooperation Company
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
HIPC/ PPME	Heavily Indebted Poor Countries
IACR	Kreditanstalt für Wiederaufbau / German Reconstruction Credit Institute
ICES	Emerging and Sustainable Cities Initiative (IDB)
IDA, AIF-BM	International Development Association - World Bank
IDB, BID	Inter-American Development Bank
IDR	Rural Development Institute
IEE	Initial Environmental Examination
IMF	International Monetary Fund
IMO	Organization Marine International
INAA	The Nicaraguan Institute for Water Supply and Sewerage
INAC	Nicaraguan Institute of Civil Aeronautics
INAFOR	National Forestry Institute
INATEC	National Technological Institute
INETER	Nicaraguan Institute of Territorial Studies
INIDE	National Statistical Institute
INIFOM	Nicaraguan Institute of Municipal Development
INVUR	Institute for Urban and Rural Housing
IRTRAMMA	Regulating Institute of Transport of the Managua City
ITS	Intelligent Transportation System
JICA	Japan International Cooperation Agency
KEXIM	Export-Import Bank of Korea
LAIF	Latin America Investment Facility
LRT	Light Rail Transit
M/M	Minutes of Meeting
MAGFOR	Ministry of Agriculture, Livestock and Forestry
MARENA	Ministry of Environment and Natural Resources
MECD	Ministry of Education, Culture and Sports
MEM	Ministry of Energy and Mines
MHCP	Ministry of Finance and Public Credit
MIFAMILIA	Ministry of Family
MIFIC	Ministry of Development, Industry and Trade
MINED	Ministry of Education
MIGOB	Ministry of Interior
MINREX	Ministry of Foreign Affairs
MINSA	Ministry of Health
MITRAB	Ministry of Labour
MRT	Mass Rapid Transit
MTI	Ministry of Transport and Infrastructure
MWWTP	Managua City Wastewater Treatment Plant
NBI	Unsatisfied Basic Needs

NTON	Nicaraguan Mandatory Technical Standard
O/D	Origen and Destination
ODECA	Organization of Central American States
OFID	OPEC Fund for International Development
PDUM	Urban Development Master Plan of Managua City
PISASH	Sectorial comprehensive program of Water and Human Sanitation in Nicaragua
PM	Master Plan
PNB	Gross National Income
PND	National Development Plan
PNSER	National Program for Sustainable Electrification and Renewable Energy
PNT	National Transport Plan
PPP	Plan Puebla-Panama
PRASMA	Water and Sanitation Program for Managua
PT	Personal Trip
RD	Minute Meetings
RICAM	International Network of Mesoamerican Highways
RPCE	Poverty Reduction and Growth Facility
SICA	Central American Integration System
SINAP	National System of Protected Areas
SINAPRED	National System for Disaster Prevention, Mitigation and Attention
TDR	Terms of Reference
TELCOR	Nicaraguan Institute For Mails and Telecommunications
TEU	Twenty-foot Equivalent Unit
TLC	Free Trade Agreement
TLC RD	Dominica Republic - Central America Free Trade Agreement
TM	Metric Ton
TPM	Deadweight Tons
UNAN-CIRA	National Autonomy University of Nicaragua, Center for Research for Aquatic Resources of Nicaragua
UNDP/ PNUD	United Nations Development Programme
VAO	High Occupancy Vehicle



Source: JICA Study team

LOCATION MAP

CHAPTER 8 DEVELOPMENT FRAMEWORK

8.1 Setting Vision for Managua City 2040

8.1.1 Previous Discussion on Vision of Managua City

(1) Vision for Managua City in 2010

In 2002, ALMA published the Master Plan for Municipal Development [*Plan General de Desarrollo Municipal*] for the city development with a horizon of 2010. The future vision of Managua City was analyzed through a participatory consultation of different scenarios for Managua City development. The "desired Managua" resulted to be a composition between two scenarios: "compact Managua" and "composed Managua", based on the concept of decentralization of the city function through the concentration of urban development in satellite cities and medium densification in urbanized area. The scenario also includes an improved articulation of the metropolitan structure through an efficient public transport and the preservation of natural area as ecological corridor between urban centers and sub-centers.

Managua's vision in conclusion was to be a "city with a comprehensive and balanced development, safe from social, economic, territorial, and environmental vulnerability". The report continued, "the future city should be an important regional center for business and touristic development. Managua City would be a functional and attractive metropolitan city with high public services coverage. Managua City would promote integrated education creating opportunity and social progress. The city would also keep promoting local identity, cultural diversity, environmental consciousness, and citizen participation"

(2) Vision for Managua City in Action Plan for Sustainable Managua

The Action Plan is part of the Emerging and Sustainable Cities Initiatives (ESCI). In the process, a public opinion survey was done to prioritize the issues related to urban development in the metropolitan area. The results of the survey were then discussed and validated with local and national governments. According to the survey, the most important challenges are: a) water including drainage, sanitation, and drinking water supply; and b) territorial planning; while other challenges includes vulnerability to natural events, adaptation to climate changes, and economic competitiveness and employment. Public safety is also a significant issue for the Managua's inhabitants.

In this planning document, the future Managua City was envisioned as a smart growth city taking into account the necessity for adaptation to climate change into land use and territorial planning. "The ideal scenario is to preserve expansion of actual urban footprint until 2030 through a policy of densification", which should be supported by social and multi-family housing next to an improved massive transportation system. Transport intervention should be associated to the creation of public spaces, pedestrian, and bicycle trails to promote non-motorized accessibility. Inhabitants and public authorities also expected an important potential for green corridors, connecting the natural resources of the area.

8.1.2 Vision for Managua City 2040

In the first Steering Committee Meeting held on February 11, 2016, there was a series of discussion related to the desired vision for Managua City in 2040. Some of the phrases and slogan proposed chiefly by the counterpart members therein are listed below.

- Clean City [*Ciudad Limpia*]
- Green and pretty [*Verde y bonita*]
- Managua, Beautiful Managua [*Managua Linda Managua*]
- Managua beautiful and safe [*Managua linda y segura*]
- Managua - environmental friendly [*Managua amigable al medio ambiente*]
- Lovely Managua [*Bella Managua*]
- Transformation and opportunities.

It can be seen that people tend to think of Managua City in the future as a beautiful, clean, safe, and environmental friendly city or the city of transformation and opportunities.

In April to October 2016, the counterpart group and the JICA Study Team continued to discuss on this topic in the form of Joint Technical Working Groups on urban planning and transport planning. In the process of formulating the vision, definition of various terms as well as topics in land use, urban densification, and transportation were also discussed. The overall process and methodology of translating the city's vision into concrete actions were also clarified. In parallel to the discussion of backcasting approach mentioned in the subsequent section, a slogan was adopted for Managua City in 2040:

Managua sustainable, orderly, safe and with opportunity for all

This adopted slogan not only calls for a beautiful green city but also defines Managua as a city of opportunities for all which is a statement for inclusiveness. Not only were there genuine intentions and strong desires to beautify the city and better enhance its natural and historical assets, but there were also concerns about citizens being disadvantaged or left out by urban developments, or their current way of life not being considered in the design of any new environment. A sense of balance and social fairness, or a concern of the well-being of all citizens, often permeated in the numerous discussions.

In order to describe the vision of the city in greater details and to formulate the strategies and actions for the master plan, six "pillars" are established. The six vision pillars are as follows:

Sustainable City: A city which can harmonize with the natural environment, grow, and sustain itself over time.

Attractive City: A city which attracts tourists and citizens alike, with its cleanness, charm, and character.

Resilient City: A city which is strong and robust against natural disasters and able to mitigate its effect.

Economically Active City: A city where people can earn his/her living with sound economic activities and opportunities.

Accessible City: A city where people can move as they like with ease and comfort.

Socially Equitable City: A city where people have equal access to essential services and equal opportunities.

These six pillars define and clarify the vision with substance, and serve as guiding principles for strategies and actions. For example, the strategies are categorized as follows under the six pillars.

Source: JICA Study Team

Figure 8.1.1 Strategies in Six Pillars

In addition to the definition of the master plan's vision, various ideas were also clarified for the members in the Joint Technical Working Group. The sequence of translating the vision into enactable actions was described by the JICA Study Team and adopted by the working group. The sequence is shown in Figure 8.1.2.

Source: JICA Study Team

Figure 8.1.2 Sequence from Vision to Actions (Policy Packages)

With the above overview, members were able to visualize the process, relate the initial vision to the final policy actions that are to be implemented, and understand the necessary steps involved.

8.2 Planning Framework

8.2.1 Population Framework

With regard to the setting of future population framework, there are several methods of population forecasting. One of the major methods is the cohort-component method; however, it is difficult to apply it to the case of Managua City due to lack of necessary information such as the demographic data and migration data. Accordingly, the JICA Study Team considered the population growth trend comparing with the growth trend of the national level, and set the population growth scenario with reference to the existing projections of future population growth rates published by the National Statistical Institute (*Instituto Nacional de Informacion de Desarrollo*: INIDE) and UN organizations. Then, the JICA Study Team analysed the urbanization and recent demographic situation of Nicaragua and Managua City to examine and select the suitable scenario for the master plan.

(1) Proposed Growth Scenario

Focusing on the impact of urbanization of Nicaragua and Managua City, and assuming the natural increase being consistent with the national level, three levels of the growth scenario which are Low Growth Scenario, Middle Growth Scenario, and High Growth Scenario will be proposed as follows: The corresponding population growth rates refer to the projection published by INIDE and the United Nations Economic Commission for Latin America and the Carribean (UN ECLAC).

1) Low Growth Scenario: In the Low Growth Scenario, the population growth pattern of Managua City will remain at the same pattern as projected by INIDE in 2012. It assumes that the population of Managua City will grow only by the natural increase and will have negative net migration. Low Growth Scenario will employ the growth rate projected by INIDE.

2) Middle Growth Scenario: The Middle Growth Scenario assumes that the population of Managua City will increase at the projected pace of natural growth of Nicaragua and will have almost no net migration. Middle Growth Scenario will employ the growth rate of Nicaragua

national level projected by ECLAC. This is a moderate growth rate which is expected to have the natural increase at the same level as the average population growth rate of Nicaragua.

3) High Growth Scenario: In case of High Growth Scenario, it is assumed that the implementation of the master plan projects will promote more organized urbanization and development in Managua City and more migration to Managua City than Middle Growth Scenario. The economic development of Managua City will attract people from rural areas for education and employment opportunities and also lead to decrease the international out-migration. High Growth Scenario will employ the growth rate of the urban area in Nicaragua projected by ECLAC.

The estimated population and growth rates of each scenario are listed in Table 8.2.1. Furthermore, ALMA published its own population projection of 2018, 2024, and 2028 as shown in Table 8.2.1. Figure 8.2.1 illustrates the proposed population forecast according to the three scenarios and that of ALMA.

Table 8.2.1 Proposed Growth Scenario

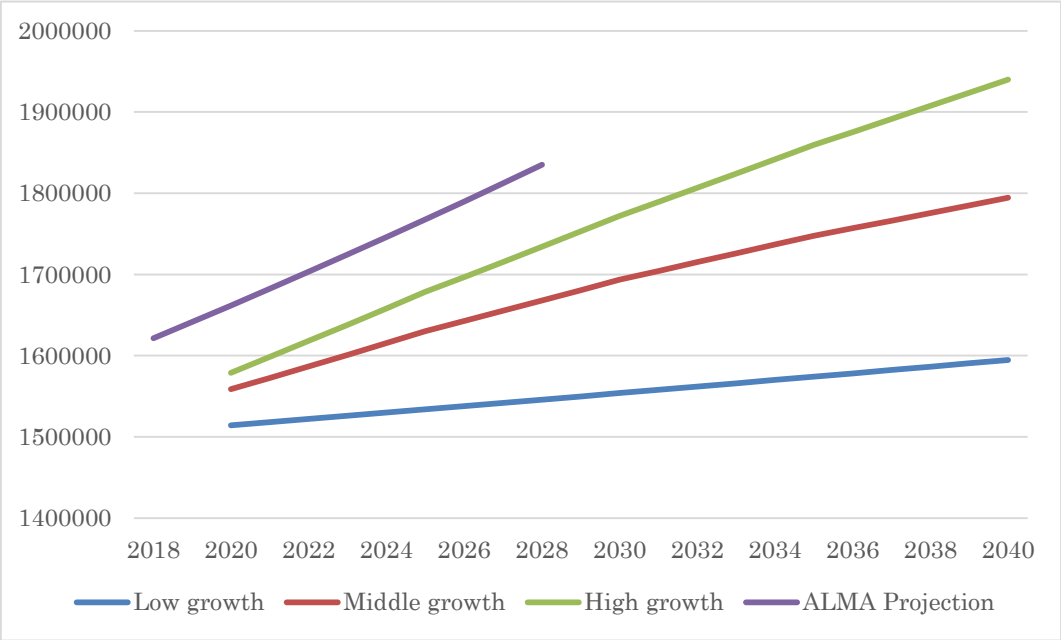
	Estimated Population (thousand people)					Population Growth Rate (annual average)					
	2020	2025	2030	2035	2040	2016-20	2020-25	2025-30	2030-35	2035-40	2016-40
Low Growth	1,514	1,534	1,554	1,574	1,595	0.31%	0.26%	0.26%	0.26%	0.26%	0.27%
Middle Growth	1,559	1,630	1,694	1,748	1,795	1.04%	0.90%	0.77%	0.63%	0.53%	0.77%
High Growth	1,579	1,679	1,772	1,860	1,940	1.37%	1.23%	1.09%	0.97%	0.85%	1.10%

Source: compiled by the JICA Study Team

Table 8.2.2 Population Projection by ALMA

	2018	2024	2028	Growth Rate (Annual average) 2018-28
Population Projection (ALMA)	1,621,260	1,746,028	1,834,979	1.25%

Source: ALMA, "Propuesta Del Plan De Desarrollo Del Municipio De Managua" (2013), calculation by JICA Study Team



Source: Compiled by the JICA Study Team

Figure 8.2.1 Proposed Population Scenario

(2) Examination of the Scenario and the Trend of Population Growth of Managua City

To examine and select the most suitable scenario, the trend of population growth and the fitness of the assumed growth rate in each scenario will be analyzed with reference to the collected data.

1) Urbanization in Nicaragua and Managua City

The urbanization has been a wide-spreading phenomenon in the world and the Latin American countries tend to have high population concentration in large urban cities. However, the current urbanization rate is relatively low in Nicaragua compared with other Latin American countries. The percentage of population in the urban area in Nicaragua is presently approximately 56% and the percentage is projected to reach 64.3% in 2040. It is expected that the rural-to-urban migration will continue to raise the urban population in Nicaragua. Managua City is the largest and economically active city in Nicaragua, so it may tend to face more population pressure compare with other medium and small cities.

Table 8.2.3 Estimation and Projection of Percentage of Population in Urban Area (estimation and projection) (%)

	2000	2010	2020	2030	2040
Latin America and the Caribbean	70.5%	73.0%	78.4%	81.0%	83.0%
Central America	65.1%	67.2%	72.2%	75.2%	77.7%
Nicaragua	52.3%	53.5%	57.3%	60.5%	64.3%

Source: UN Urbanization Prospects, 2015

2) Demographic Situation in Managua City in Recent Years

The Central Registry of Civil Persons Status ("*Regisro Central Del Estado Civil de las Persnas*") in ALMA keeps the record of births and deaths and the change of addresses filed by residents as listed in Table 8.2.4. Although the number of deaths might be underrun the actual cases, both the natural increase and social increase could be more than the estimation of INIDE (as shown in Table 8.2.6) according to these data. With reference to these data and other data as the approximation to supplement necessary information such as the death rate and international migration, Table 8.2.5 shows the estimation of the total population growth rate in 2016, which is estimated as 1.41%. Although this estimated total growth rate cannot be credible due to the incompleteness of the data, it still suggests that the initial growth rate of High Growth Scenario is at the reasonable level.

Table 8.2.4 Number of Registration to the Registry Office of ALMA

Item of Registration	2010	2011	2012	2013	2014	2015	2016*[1]	Total
No. of Birth	21,737	23,247	24,010	23,782	22,970	23,350	17,472	156,568
No. of Death	3,260	3,361	3,463	3,620	3,892	4,421	3,552	25,569
Replenishment Registration of Birth*[2]	6,296	7,591	5,047	6,222	4,422	822	653	31,053
ReplenishmentRegistration of Death	56	117	125	93	130	103	54	678
Change of Address to Managua City (Move-in)	-	28,776	16,532	22,278	25,474	28,090	14,699	135,849
Change of Address from Managua City (Move-out)	-	12,861	7,551	10,164	12,083	14,759	10,688	68,106
Net Move-In	-	15,915	8,981	12,114	13,391	13,331	4,011	67,743

Source: ALMA

*[1] Until the end of September 2016

*[2]The number of replenishment of births dropped since 2015 because there was a change in the family code and the expiration date of replenishment was extended.

Table 8.2.5 Estimation of Approximate Population Total Growth Rate, as of the end of 2015

Total Growth Rate = Crude Birth Rate － Crude Death Rate + Net Migration Rate		Note
Crude Birth Rate	(23,350+1,119*1)/1,495,385=1.64%	*1 Estimated replenishment registration in 2016 (which is assumed to be born in 2015) ((653/7) x 12)
Crude Death Rate	0.49%*2	*2 Crude Death Rate of Nicaragua (ECLAC 2015)
Net Migration Rate	(13,331-9,396*3)/1,495,385 = 0.26%	*3 Estimation of international migration from total emigration
Total Growth Rate	1.64% - 0.49% + 0.26% = 1.41%	

Source: JICA Study Team

(3) Analysis of Projections by INIDE, UN, and ECLAC

1) INIDE (Low Growth Scenario)

The projection of the population growth rate of Managua City was published by INIDE in 2007 and 2012. Indeed, the estimated future population growth rate of Managua City by INIDE was remarkably low compared with the rate of national level as shown in Table 8.2.6. One possible reason is that the total net migration rate of Managua City was estimated at the low level, lower than that of Nicaragua national level (also shown in Table 8.2.6). This means that this projection assumes that Managua City will always have both domestically and internationally out-migration. However, according to the data and estimation in Table 8.2.4 and Table 8.2.5, the domestic net migration of the ALMA record is positive and also the total net migration including the international migration is estimated to be positive. It could be assumed that the projection of population growth by INIDE might have underestimated the social increase and so been lower than the actual growth trend.

Table 8.2.6 Estimation and Projection of Population Growth Rate (Annual Average)

	2005-10	2010-15	2015-20	2020-25
Population Growth Rate				
Nicaragua	1.30%	1.22%	1.04%	1.04%
Managua City	0.97%	0.66%	0.31%	0.26%
Total Net Migration Rate				
Nicaragua	-0.442%	-0.395%	-0356%	-0.3%
Managua City	-0.71%	-0.634%	-0.567%	-0.48%

Source: INIDE (2007, 2012)

2) UN and ECLAC (Middle and High Growth Scenario)

The UN ECLAC have individually made population projection of Nicaragua of total, rural, and urban area in their reports, the World Urbanization Prospects (UN Population Division, 2014) and the Demographic Observatory (ECLAC, 2014). According to these reports, the urbanization in Nicaragua was expected to continue and the population growth rate in the urban area would exceed the growth rate of both rural and national level. In terms of the speed of the growth, the projection of ECLAC was more moderate than that of the UN World Urbanization Prospects, so the projection of ECLAC was used for the Middle and High Scenario.

Table 8.2.7 Estimation and Projection of Population Growth Rate (Annual Average) in Nicaragua and Urban Area

Source	2005-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40	2015-40
Nicaragua (Total)								
UN WUP (2014)	1.30%	1.44%	1.27%	1.09%	0.98%	0.83%	0.68%	0.97%
ECLAC DO (2014)	1.32%	1.22%	1.04%	0.90%	0.77%	0.63%	0.53%	0.77%
Nicaragua (Urban area)								
UN WUP (2014)	1.77%	1.96%	1.84%	1.69%	1.60%	1.43%	1.26%	1.56%
ECLAC DO (2014)	1.62%	1.51%	1.37%	1.23%	1.09%	0.97%	0.85%	1.10%

Source: UN WUP: UN World Urbanization Prospects 2014
ECLAC DO: ECLAC Demographic Observatory 2014

With regard to the accuracy of the projection by UN, it is argued that the population projections for developing countries by UN tend to overestimate because of the unforeseen change in the trend such as the fall of birth rate or increase of outmigration, and the incompletion of necessary statistical data (Keilman, 1998[1]). However, it is also said that the accuracy has been improved overtime, as the average absolute error rate at the country level decreased from about 18% to about 4% from the early 1970s to the 1990s, possibly because of the improvement of the quality of baseline data (O'Neil et al 2001[2]).

In case of a series of population projection by ECLAC, the same tendency can be observed. Table 8.2.8 shows the population projected by ECLAC in the past. The "absolute error rate" in Table 8.2.8 means the difference of each projection and the current estimated population of corresponding year by ECLAC. The absolute error rate of population projection made in the 90s was notably high, especially the long-term projection such as 20 or 25 years. However, the accuracy of the projection made in 2006 has been improved, where the absolute error rate of

[1] Nico Keilman, "How Accurate Are the United Nations World Population Projections?", Population and Development Review, Vol 24, 1998
[2] Brian C. O'Neil, Deborah Balk, Melanie Brickman, Markos Exra, "A Guide to Global Population Projections", Demographic Research, Volume 4 Art. 8, 203-288 pp, 2001

population projection in 2015 (nine years after the time of projection) was 1.7%, which is lower than the absolute error rate of projections made in 1990 and 1993 for similar duration, respectively. Because there is no actual population data later than the present year, the accuracy of long-term projection made in the 2000s cannot be evaluated. However, it can be assumed the accuracy of long-term projection might be improved as well as the short-term projection. Even so, the longer the period of projection is, the bigger the error rate tends to be. It is important to review the framework regularly after the completion of the master plan.

Table 8.2.8 Population Projection by ECLAC and Absolute Error Rate

	Population Projection made in 1990					
	2000	2005	2010	2015	2020	2025
Nicaragua (000)	5,261	6,029	6,824	7,631	8,435	9,219
Absolute Error Rate	4.7%	12.1%	18.9%	25.4%	-	-

	Population Projection made in 1993					
	2000	2005	2010	2015	2020	2025
Nicaragua (000)	5,169	5,940	6,728	7,522	8,310	9,079
Absolute Error Rate	2.8%	10.4%	17.2%	23.6%	-	-

	Population Projection made in 2006					
	2000	2005	2010	2015	2020	2025
Nicaragua (000)	5,106	5,457	5,825	6,192	6,538	6,855
Absolute Error Rate	1.6%	1.4%	1.5%	1.7%	-	-

Source: ECLAC (Demographic Bulletin 1990, Demographic Bulletin 1993, Demographic Observatory No. 2, 2006) and calculation by the JICA Study Team

(4) Selection of the Population Development Scenario

The Socioeconomic TWG was held to discuss with ALMA based on the above examination and the High Growth Scenario was selected for the framework of the master plan. The first reason is that the latest demographic data obtained by ALMA suggested that the population increase in the recent years are at the higher pace than the projection of INIDE and close to the initial rate of High Growth Rate.

Futhermore, as discussed in Appendix-1 about the results of the backcasting assessment, the items such as international competitiveness and skilled human resources are prioritized and promotion of local industial development policies is proposed. Then ALMA is keen to expand economic opportunites in Managua City and make Managua City more attractive. At the same time, this strategy aims to attract people to Managua City from the surrounding cities such as Ciudad Sandino, Mateare and Tipitapa where population has been growing recently. With the consideration of visions and discussions in the Joint TWG, ALMA, and JICA Study Team agreed that Managua City will set out to continue population growth and domestic migration from other areas. With these visions and targets, the population of Managua City is expected to grow faster than the average rate in Nicaragua, so the High Growth Scenario was selected. To realize these visions and accommodate population growth, the strategies and actions will be discussed in details.

(5) Population by Gender and Age Group and Labor Force

The population estimation by gender and age group until 2040, in case of the High Growth Scenario, is estimated as shown in Table 8.2.9. The future population by age group and labor participation rate are estimated based on the estimation and projection by INIDE. The economically active population is also estimated until 2040 in accordance with the High Growth Scenario. The estimated population of labor force including the commuting population from outside cities is listed in Table 8.2.10.

Table 8.2.9 Estimation of Economically Active Population in Managua City

	Male				Female			
	2016	2020	2030	2040	2016	2020	2030	2040
0- 4	66,540	62,028	61,666	35,318	68,429	63,789	52,796	36,321
5- 9	70,913	67,804	68,789	47,583	72,927	69,730	61,780	48,934
10-14	63,836	71,250	75,090	83,279	65,649	73,273	79,016	85,644
15-19	65,363	63,003	68,217	54,823	67,219	64,792	62,864	56,380
20-24	67,252	64,739	65,280	43,966	69,162	66,578	58,123	45,215
25-29	63,851	66,049	67,354	61,747	65,664	67,925	66,497	63,501
30-34	66,191	62,018	71,819	64,684	68,071	63,779	67,842	66,521
35-39	58,126	65,295	72,912	89,775	59,777	67,149	79,078	92,324
40-44	47,313	56,293	70,084	103,233	48,656	57,891	80,803	106,165
45-49	39,413	45,618	57,447	81,657	40,532	46,913	64,753	83,976
50-54	34,808	38,321	47,967	63,172	35,796	39,409	52,112	64,966
55-59	30,607	34,209	40,950	52,722	31,477	35,180	44,471	54,220
60-64	23,270	29,506	34,717	52,880	23,931	30,344	41,198	54,382
65-69	13,183	21,223	28,011	55,699	13,558	21,826	37,686	57,281
70-74	10,365	11,377	19,932	32,617	10,659	11,700	22,740	33,544
75-79	7,816	9,352	10,002	12,200	8,038	9,618	10,814	12,547
80+	8,378	10,377	13,389	21,102	8,616	10,672	15,859	21,702
Sub-total	737,225	778,463	873,625	956,459	758,160	800,569	898,433	983,620
Grand total	1,495,385	1,579,032	1,772,058	1,940,078				

Source: JICA Study Team

Table 8.2.10 Estimation of Economically Active Population in Managua City

	2016	2020	2030	2040
Primary	16,959	16,740	14,069	8,913
Secondary	195,799	213,659	249,685	276,650
Tertiary	613,942	687,635	858,524	1,017,863
Total	826,700	918,034	1,122,278	1,303,426

Source: JICA Study Team

8.2.2 Economic Framework

In order to set the economic framework for the future economy and its growth of Managua City, Gross Regional Domestic Product (GRDP) will be used as the major economic indicator. However, the governmental institutions such as INIDE and the central bank confirmed that there is no statistical data about GRDP or other regional economic activity in Nicaragua. Then the JICA Study Team estimated GRDP of Managua City by estimating the productivity of workers by three sectors in Managua City based on the long-term projection of gross domestic product (GDP) and working population by three sectors in Nicaragua and Managua City.

(1) Projection of National GDP growth

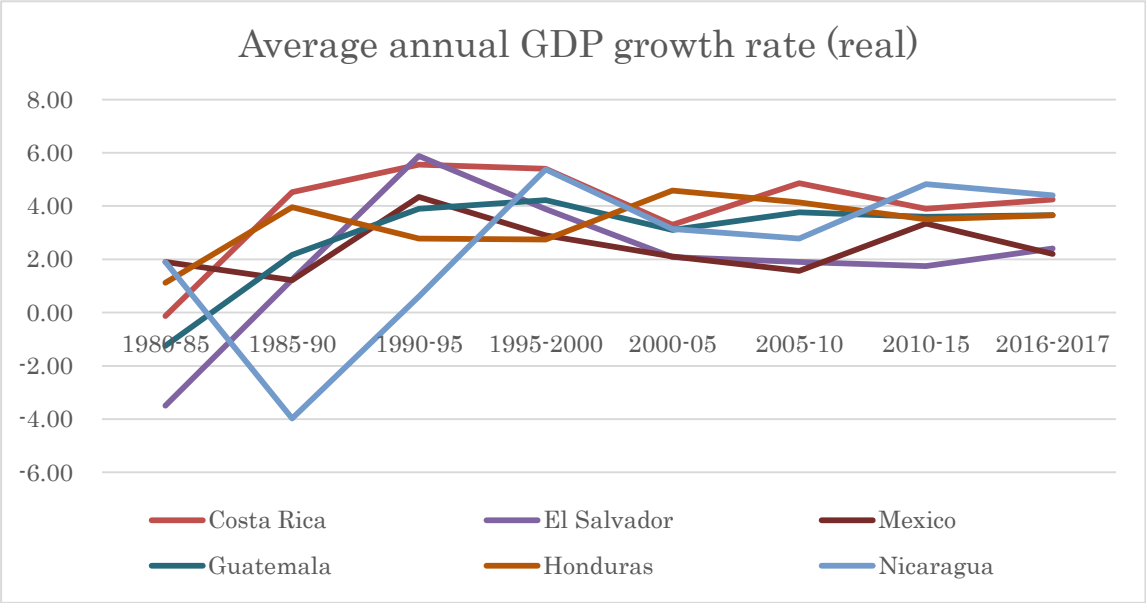
Firstly, the projection of national GDP growth until 2040 is examined to obtain future national GDP growth scenario. The JICA Study Team sets three growth scenarios for future GDP growth by referring the historical trend of GDP growth of Nicaragua and other countries in Central America.

Table 8.2.11 shows the projected economic growth of Nicaragua. More recent projection announced by the International Monetary Fund (IMF) says that the GDP growth will reach 4.7% in 2016 and the Central Bank of Nicaragua projects the growth rate of 2016 is between 4.5% and 5%. The latest economic growth of Nicaragua in 2016 is reported to be robust, so the economic growth rate in the short term is supposed to sustain the high rate as that of recent years. In addition, considering the historical trend of economic growth in Central America described in Figure 8.2.2, the economic growth rate tends to gradually decrease after the high growth in the middle and long term.

Table 8.2.11 Projection of GDP Growth

	2015	2016	2017	2021
Nicaragua	4.9%	4.5%	4.3%	4.0%

Source: IMF (October 2016)



Source: World Development Indicators

Figure 8.2.2 Average Annual GDP Growth Rate

The national GDP framework is set as shown in Table 8.2.12. Then the middle growth scenario is adopted as the national economic framework

Table 8.2.12 Estimation and Projection of Growth Rate and National GDP of Nicaragua

Average GDP Growth Rate (annual)			
	2015-20	2021-30	2031-40
Low Growth Rate	4%	3.5%	3.5%
Middle Growth Rate	**4.6%**	**4%**	**4%**
High Growth rate	5%	4.5%	4.5%

Source: JICA Study Team

GDPand GDP per Capita at the National Level (USD=2015)				
GDP (USD in Million)	2016	2020	2030	2040
Low Growth Rate	13,327	15,591	18,517	21,992
Middle Growth Rate	**13,327**	**15,893**	**19,336**	**23,525**
High Growth Rate	13,327	16,199	20,187	25,157
GDP per Capita (USD)	2016	2020	2030	2040
Low Growth Rate	2,106	2,364	3,047	4,056
Middle Growth Rate	**2,106**	**2,410**	**3,259**	**4,553**
High Growth Rate	2,106	2,456	3,485	5,108

Source: JICA Study Team

(2) Economic Framework of Managua City

The current and long-term GRDP in Managua City will be estimated based on the estimation of labor force population in Managua City, as proposed in Table 8.2.10 and the GDP per worker by industrial sector in Nicaragua and Managua City. The GDP per worker by sector means the labor productivity by sector. The labor productivity is assumed to be higher than that of the national level, adjusted by the difference of the workers' average wage in Nicaragua and Managua City according to the data of Nicaraguan Institute of Social Security (*Instituto Nicaragüense de Seguridad Social* : INSS).

Thus, the GDP per worker by sector in Nicaragua and Managua City are estimated as shown in Table 8.2.13. The estimation and projection of the national GDP and labor population by sector are estimated based on the JICA National Transport Plan Project (2014).

Table 8.2.13 Estimation of Labor Productivity by Sector in Nicaragua and Managua City

GDP per worker by sector (NIO)	2016	2020	2030	2040
Nicaragua				
Primary	51,715	56,314	69,301	88,590
Secondary	116,164	132,546	173,267	227,276
Tertiary	118,050	133,114	173,314	233,884
Managua City				
Primary	63,093	68,703	84,547	108,080
Secondary	141,720	161,706	211,386	277,277
Tertiary	144,021	162,399	211,443	285,338

Source: JICA Study Team

The future projection of GRDP is estimated by multiplying the GDP per worker in Managua City by the estimated number of labor population in each sector and summing up them for each year from 2020 to 2040. Socioeconomic TWG members discussed that the economy of Managua City would continue to be the center of Nicaraguan economy and it would grow steadily and also the share of Managua economy in Nicaragua would increase in the future. These opinions of TWG members had been considered in the estimation of the economic framework.

As a result, GRDP of Managua City until 2040 is estimated as shown in Table 8.2.14 and this was proposed as the economic framework for the master plan. The Socioeconomic TWG was held for several times to discuss the future economic growth of Nicaragua and Managua City.

Table 8.2.14 Economic Framework of the Master Plan

	2016	2020	2030	2040
GRDP (Managua City) (NIO in Million, NIO=2015)	117,239	147,371	235,499	368,107
Primary	1,070	1,150	1,190	963
Secondary	27,749	34,550	52,780	76,709
Tertiary	88,421	111,671	181,530	290,435
GRDP Share of Managua City in Nicaragua	32.3%	34.0%	36.7%	38.8%
GRDP per Capita, Managua City (NIO, NIO=2015)	78,401	93,330	132,896	189,738
GRDP per Capita, Managua City (USD, USD=2015)	2,876	3,424	4,875	6,960

Source: JICA Study Team

8.2.3 Land Use Framework

Based on the socioeconomic framework in Managua City described in the above section, future demands of land use need to be estimated in order to prepare a coherent future land use plan.

In order to accommodate the future population here in Managua City, necessary size of built up area in 2040 is calculated based upon the result of Household Interview Survey, the existing land use map, and the future socioeconomic framework.The built up area could be divided into four: residential areas, industrial areas, commercial areas, and other built up areassuch as public facility area and road.

First, with regard to the future housing area, the floor size per household is estimated to enlarge from 94 sqm in 2016 to 102 sqm in 2040 with basis of the trend of housing size by household income according to the result of Household Interview Srurvey and the future GRDP. Furthermore, the household size estimates to reduce from 4.3 in 2016 to 3.4 in 2040. Based upon these estimations, the average housing size per person suppose to increase from 46 sqm in 2016 to 63 sqm in 2040. Second, industrial area needs to expand from 375 ha in 2016 to 530 ha in 2040 for accommodating roughly 277,000 secondary sector workers in total. The average floor size per worker was 19 sqm in 2016 and it could be applied in the calculation of 2040. Generally, floor size per worker of heavy industries and labour-intensive industries are likely to be smaller compared with that of Managua. However, such industries tend to be concentrated in neighbouring cities such as Ciudad Sandino and Tipitapa as these cities have road accesses and enough land spaces. For taking account of the current trend and land capacities, such industries are unlikey to be brought in Managua. Thus, the total industrial area is estimated at around 500 ha in 2040. Third, the commercial area is also expected to increase with the growth of the working population in the tertiary sector from 613,943 in 2016 to 1,017,863 in 2040. In other words, another 400,000 workers need to be accommodated in Managua in 2040. In view of the increasing internationalization of business and commercial sector, the average floor size per worker suppose to be

reduced from 23 sqm in 2016 to 18 sqm[3] in 2040. Although the working population density supposes to be higher, more than 1,800 ha would be necessary for the commercial area in 2040. Finally, the other built up area including public facility area and roads is calculated at 4,300 ha in 2016 to 5,600 ha in 2040 with a basis of the average floor size of 29 sqm per person.

As a result of these estimations explained above, the future built up area in Managua is calculated at around 20,200 ha in 2040 as shown in Table 8.2.15.

Table 8.2.15 Estimation of Built Up Area in 2040

Housing Area (ha)

Year	Population	Average Land Size per Person (sqm/person)	Housing Area (ha)
2016	1,495,385	46	6,880
2040	1,940,078	63	12,220

Industrial Area (ha)

Year	Working Population in Secondary Sector	Average Land Size per Worker (sqm/person)	Industrial Area (ha)
2016	195,798	19	375
2040	276,650	19	530

Commercial Area (ha)

Year	Working Population in Tertiary Sector	Average Land Size per Worker (sqm/person)	Commercial Area (ha)
2016	613,943	23	1,434
2040	1,017,863	18	1,830

Other Built Up Area (ha)

Year	Population	Average land size per person (sqm/person)	Other Built Up Area (ha)
2016	1,495,385	27	3,956
2040	1,940,078	27	5,240

Total of Built Up Area (ha)

2016	**12,646**
2040	**19,820**

Source: JICA Study Team

[3]The data source is "Office size per person of Foreign Enterprise, Land White Paper", MLIT Japan

CHAPTER 9 URBAN DEVELOPMENT MASTER PLAN

9.1 Urban Structure

9.1.1 Spatial Structure of Managua City

(1) Characteristics of Urbanization by Area

In Managua City, every barrio[1] is categorized by the Alcaldia de Managua (ALMA) into three areas, namely: "Urban Area", "Sub Urban Area", and "Rural Area", as illustrated in Figure 9.1.1. As explained in Chapter 3.5.4. of Chapter 3, these three areas have different natures in terms of land use and density.

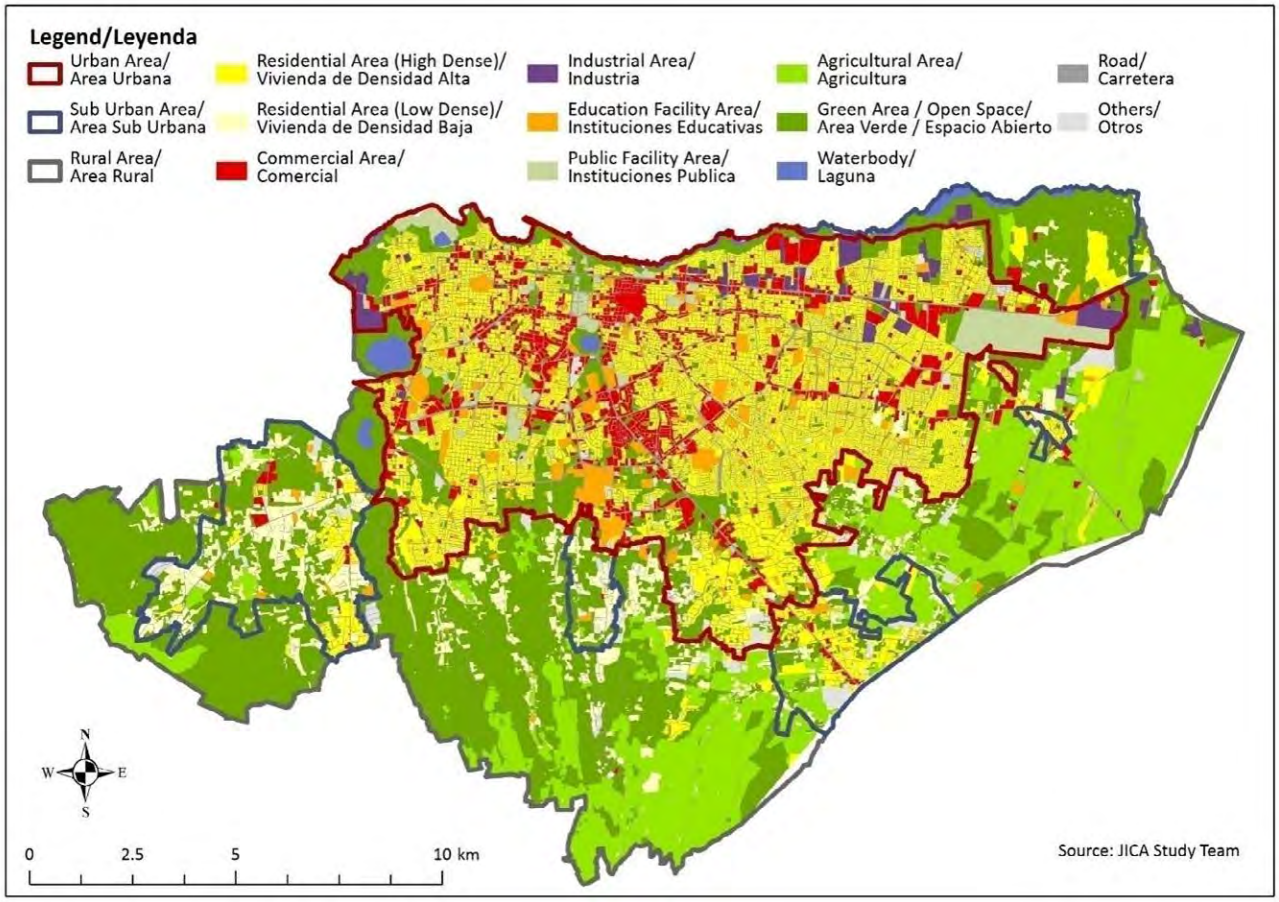
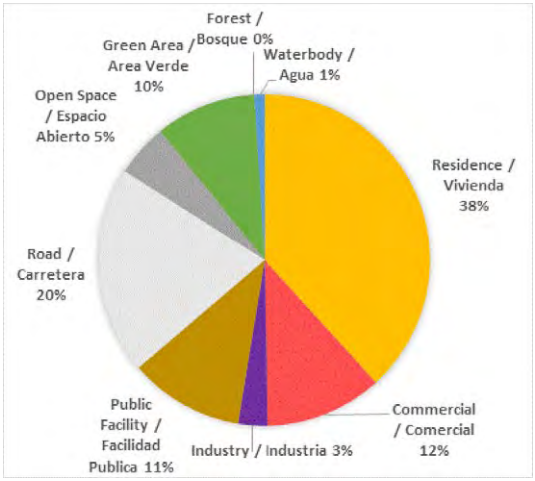
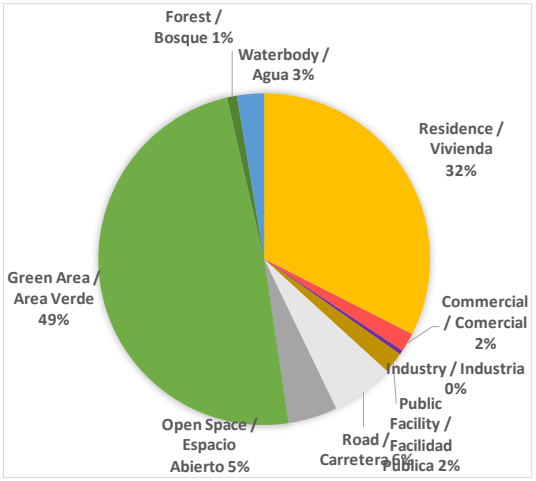


Figure 9.1.1 Existing Land Use by Area

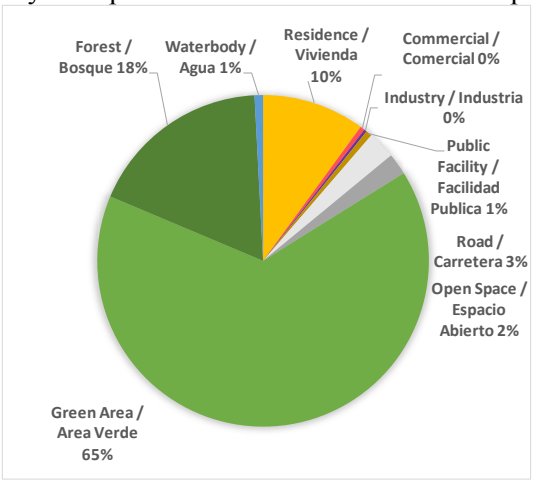
[1] Barrio is neighborhood boundary under district boundary.



Urban Area
Net Pop. Density: 142 person/ha



Sub Urban Area
Net Pop. Density: 67 person/ha



Rural Area
Net Pop. Density: 39 person/ha

Figure 9.1.2 Composition of Land Use by Area in 2016

The urban area is situated in the center of Managua City with a total area of approximately 11,400 ha, and accounts for 42% of the total land area. The land use is mixed with residential, commercial, and public facilities. Meanwhile, the sub urban area chiefly covers the newly developed area outside the urban area and along the major arterial roads. The dominant lands are usually occupied by housings and green areas, and there are not many commercial and public facilities. The rural area is located in the outskirts of Managua City and the area is covered mostly by agricultural lands or forests, including small sporadic housing areas.

Table 9.1.1 Area by Urban Characteristics

Type of Urbanization	Area (ha)		Built Up Area (ha)	Population 2016	Net Population Density* (per/ha)
Urban Area	11,382	(42%)	9,208	1,309,956	142
Sub Urban Area	4,239	(16%)	1,816	121,610	67
Rural Area	11,577	(43%)	1,622	63,819	39
Total	27,198	(100%)	12,646	1,495,385	118

Note: Net Population Density = Population/Built Up Area

Source: Calculated by the JICA Study Team based on the GIS data provided by ALMA

For taking into account the differences in characteristics of land use, planning for future land use, especially land demand and population density, should be considered by area separately.

(2) Road Network

1) Existing Roads

The road network in Managua City consists chiefly of radial roads which connects the city center to the suburban areas, the environ, and ring roads which circles the city center of Managua in a circumferential direction.

The major radial roads of Managua are the following:

- Route No. 28 towards *Ciudad Sandino* onwards to the west;
- Route No. 12, the old road towards Leon;
- Route No. 1 – Pan-American South;
- *Carretera a Masaya* towards Masaya; and
- Route No.1 – Pan-American Northeast and northeast towards Tipitapa.

The major ring roads of Managua City are the following:

- Zero Ring Road – Colon Road;
- First Ring Road – Pista Benjamin Zeledon;;
- Second Ring Road – Juan Pablo II Road; and
- Third Ring Road – *Carretera Suburbana* Road.

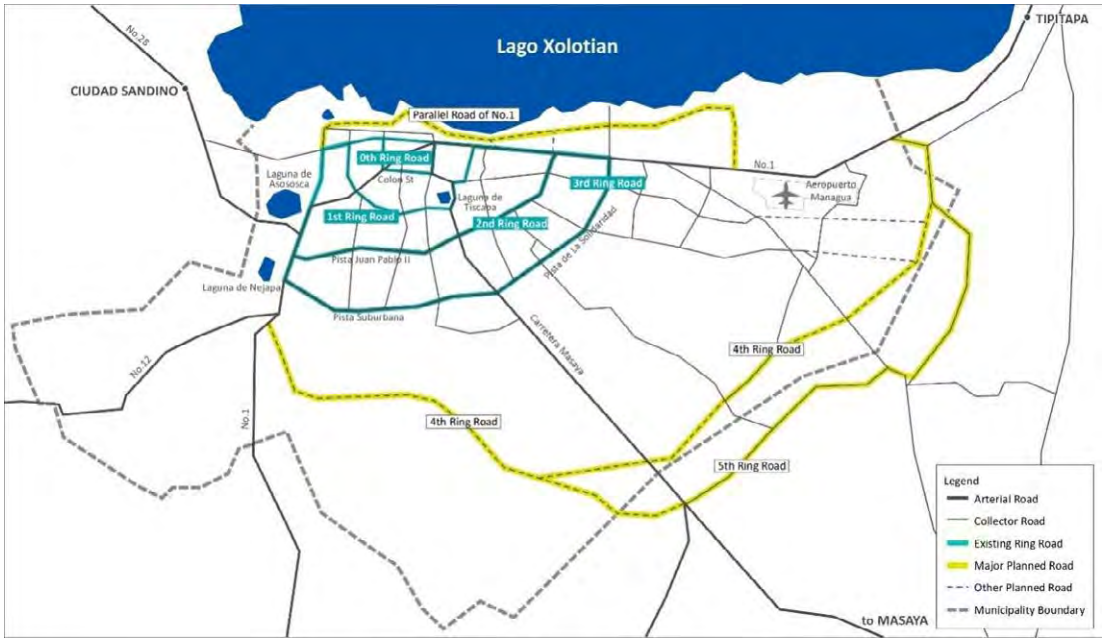
These roads are the backbone of Managua City. Traffic is concentrated on these roads and the increasing traffic volume would result to many accidents. Traffic congestion and traffic accidents occurred frequently especially on *Carretera a Masaya*, which connects the north and south direction of Managua City. The traffic volume of the ring roads, which provide access to *Carretera a Masaya*, have been concentrated and the vehicle speed through these roads are decreasing. Since the road capacity of these ring roads are less than *Carretera a Masaya* and the inflow of public transport and freight vehicles are also increasing, thus, serious traffic congestion have been occurring on these ring roads. There are many roundabout type intersections in Managua City between the radial and ring roads. These roundabouts have become one of the causes of traffic congestion because the intersection capacity was shortened due to the increase in traffic volume. In recent years, intelligent traffic signals have been installed along these main roads, but they are still under the introduction stage and there is still no coordination between the existing signals and newly installed ones. Therefore, the adjustment in traffic flow due to the intelligent traffic signals has little effect.

2) Planned Roads

According to a hearing from ALMA and from some documents of the related projects, some of the major road construction and/or improvement projects are as follows:

- Outer ring road (Ring Road No. 4) from the intersection of Route 1 and Route 12 in the western part of Managua City towards *Carretera a Masaya* (planned by the Ministry of Transport and Infrastructure (*Ministerio de Transporte e Infraestructura*: MTI) as an intercity road);
- Outer ring road (Ring Road No. 4) from *Carretera a Masaya* towards the airport of Managua City including a link built through a Japanese counter fund;
- Outer ring road (Ring Road No. 5) from *Carretera a Masaya* outside of Managua City's boundary towards Route No. 1 *Carretera* Pan-American North (planned by the MTI as an intercity road); and
- Road parallel to No. 1 *Carretera* Pan-American North near Managua Lake along the lakeside park, which could be used as a bypass of Route No. 1; and
- A connector road between Jean Paul Geni and Suburbana.

These plans assume to give a great influence on the traffic movement. Although it is necessary to consider the constraints on land and disaster prevention, it would also be necessary to develop an outer ring road for controlling and managing the traffic flow in the future Managua City because traffic volume is increasing year by year. Passing through vehicles go outside the Managua City should be prohibited to avoiding concentration of traffic in the city. Development of the outer ring road is effective for detouring traffic and mitigating traffic congestion in the center area, although it is necessary to develop logistics bases or terminals for the truck. In addition to the implementation of the structural measures, it is necessary to consider a utilization measure of public transport. In order to consider this matter, appropriate operation measures are required such as examination and development of the connection bases between intercity and intracity buses and establishing connection method.



Source: JICA Study Team

Figure 9.1.3 Existing Road Networks and Planned Routes

(3) Natural Reserved Area

In order to keep sustainability, urban development needs to take into account the environmental perspectives since land development is irreversible for natural environment. Furthermore, the water resources such as lagoons and aquifer land need to be protected to keep providing water supply for citizens. Based upon a series of interviews and discussions with the counterparts including ALMA and the Ministry of the Environment and Natural Resources (*Ministerio del Ambiente y los Recursos Naturales*: MARENA), and through examining the natural conditions of Managua City, the reserved areas were identified as illustrated in Figure 9.1.4. These natural reserved areas could be described in the following four categories: 1) Natural Reserves by MARENA, 2) Protected Area defined by the land use regulation, 3) Lakeside Area, and 4) Aquifer Area.

- Natural Reserves:
  MARENA defines three natural reserves in Managua City, namely: Tiscapa, Asososca, and Nejapa lakes and its surrounding areas. These three areas should be protected from any urban development to protect the ecosystems. Notably, Asososca is one of the major water supply resources for drinking water in Managua City.
- Protected Area defined by the Exiting Land Use:
  The existing zoning designates some areas in the outskirts of Managua City as protected zones which mainly covers the forests, steep slopes, and erosion prone areas. Based on this policy, such protected zones are identified using an existing land use map since the zoning has not been updated in a long time, as illustrated in Figure 9.1.4. In terms of disaster prevention and protecting the ecosystem, these protected zones should be respected as reserved areas for future development.
- Lakeside Area:

According to the Coastal Law, the maritime coastal area, which is 200 m from the end of the coast towards the land, is basically prohibited from development except for public use. The lakeside areas in Managua City are covered by this rule. Notably Asososca Lake should be kept from any developments because they are important water resources. In addition, ALMA has developed a recreational space in a part of the coastal area of Managua Lake. Taking into account tourism resource and living environment, the lakeside area should be preserved from development, especially from industrial development.

- Aquifer Area:

  Apart from the Asososca Lake, the aquifer area located in the south of the airport plays an important role as a water supply resource for Managua City.

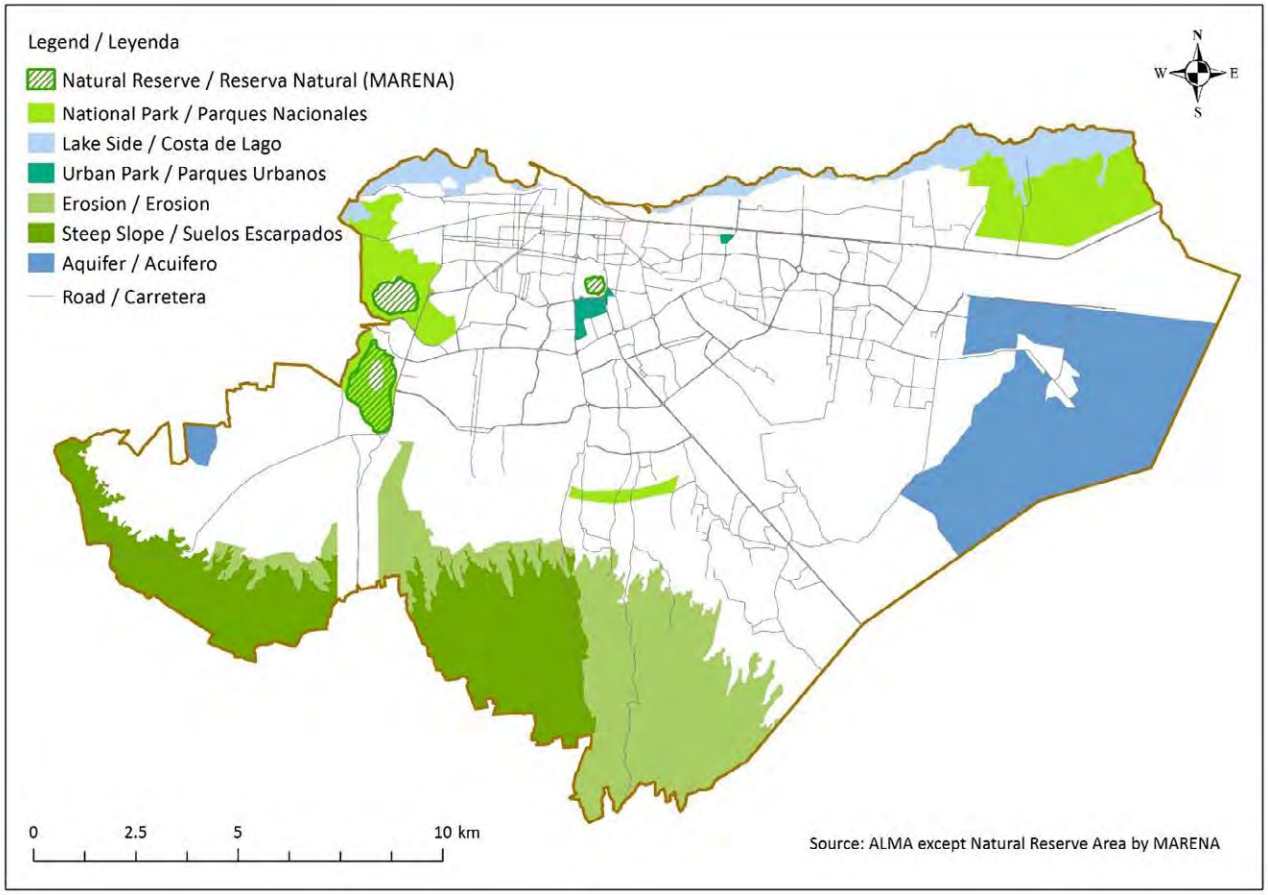


Figure 9.1.4 Natural Reserved Area

9.1.2 Concept of Urban Structure

(1) Alternative Urban Structure

As discussed in Section 8.2, the main engine for the growth of Managua's economic output will be the tertiary sector which includes all types of services, administration, and businesses. The output of the tertiary sector will double from 2016 to 2040, and the working population of the tertiary sector will increase from 613,000 in 2016 to 1,028,000 in 2040. In order to accommodate this growing tertiary sector, the commercial area will have to be increased from 1,430 ha in 2016 to 1,830 in 2040. On the

other hand, Managua does not have a clear urban center where large-sized office buildings and shopping complex, hotels, and carparks are concentrated. If this situation continues in the future, Managua will have an all mixed urban area where small offices, various shops, and residences will be crammed along narrow streets with no parking spaces. This will be hazardous to the future of Managua, and thus, the JICA Study Team and ALMA started a series of dialogue as a solution to the growing demands for business and commerce in Managua.

Alternatives of urban structure were discussed in terms of urban center, transport, and land use including environment and densification as illustrated in Figure 9.1.5. The present situation of Managua is like a case of "without urban center", where the city administration and civic functions (e.g., central government buildings, district offices, and hospitals) and business/commercial functions (e.g., offices, shopping centers, and markets) are not concentrated in one single urban center, but are dispersed over a number of locations. While the Oriental Market plays a pivotal role in the commerce of the city, the historical center, despite proper zoning and numerous planning efforts, was not established as the single most important center with the intensity and complexity of activities that is expected from an international central business district (CBD). This is partly due to the planning effort to implement multiple urban centers after the earthquake by dispersing city functions, commerce, and population, which would contribute to risk mitigation and recovery as a city.

For land use alternatives, the present density of urban area is maintained, and the urban area will be expanded in size over the green area around the urbanization, while densification case may keep the urbanization compact. The transport alternatives include the case with private cars and the other with introduction of mass public transport.

Urban Centers:

Without urban center

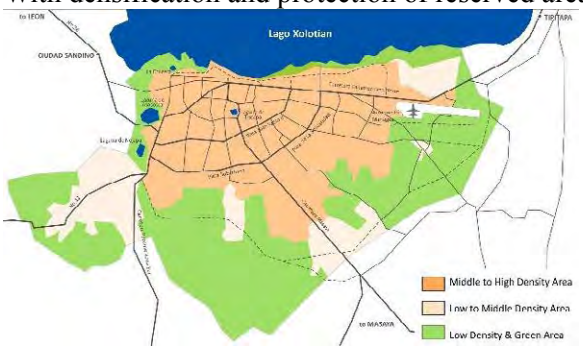
With single urban center

With multiple urbancenters

Land Use

Without densification

With densification and protection of reserved area



Transport

Private vehicle and existing public transport

Mass transit and public transport

Source: JICA Study Team

Figure 9.1.5 Alternatives of Urban Structure

As described in previous section, it is necessary to establish urban centers with the proper spaces, infrastructure, and transportation in order to reorganize and optimize civic and commercial activities, while providing further opportunities and framework for growth and expansion. The city already bears some characteristics of a multiple-center model, and the multiple-center model is considered appropriate to accommodate and distribute the projected population and economic growth while providing a centralized location for commerce, industries, and habitats. In order to achieve diversification in the urban structure, the urban centers will have the same services and functions but at the same time have their own characters. In comparison of urban structures, the multiple-center model is considered to be superior than the single-center structure:

-By distributing operations and growth over the multiple urban centers, the risk of concentrated damage in the event of a major earthquake is avoided and post-disaster government and administration operations may continue on a more localized level.

- Public facilities (transport hubs and hospitals) are dispersed over multiple sub centers, and the amenities are made equally accessible to all citizens, thus contributing to social equality and avoiding the creation of slums or neighborhood.

- With localized concentration of habitats and places of high employment, distances between work and home are minimized, reducing the amount of travelling and burden on the transportation network. With the projected economic growth and the expected increase in traffic volume, the current transport network will soon approach its capacity with the worsening congestion. Public transport with mass transit between urban centers can minimize these congestions.

- Multiple centers can promote growth along major transport corridors and thus strengthen the connection with the neighboring cities and towns.

- In the current single-center structure, urban sprawl has grown over the natural reserve outskirts in an uncontrolled manner. Instead of growing from a single nucleus, population and commerce accumulate in a number of urban centers where densification policies will intensify growth between centers and minimize the worsening of urban sprawl.

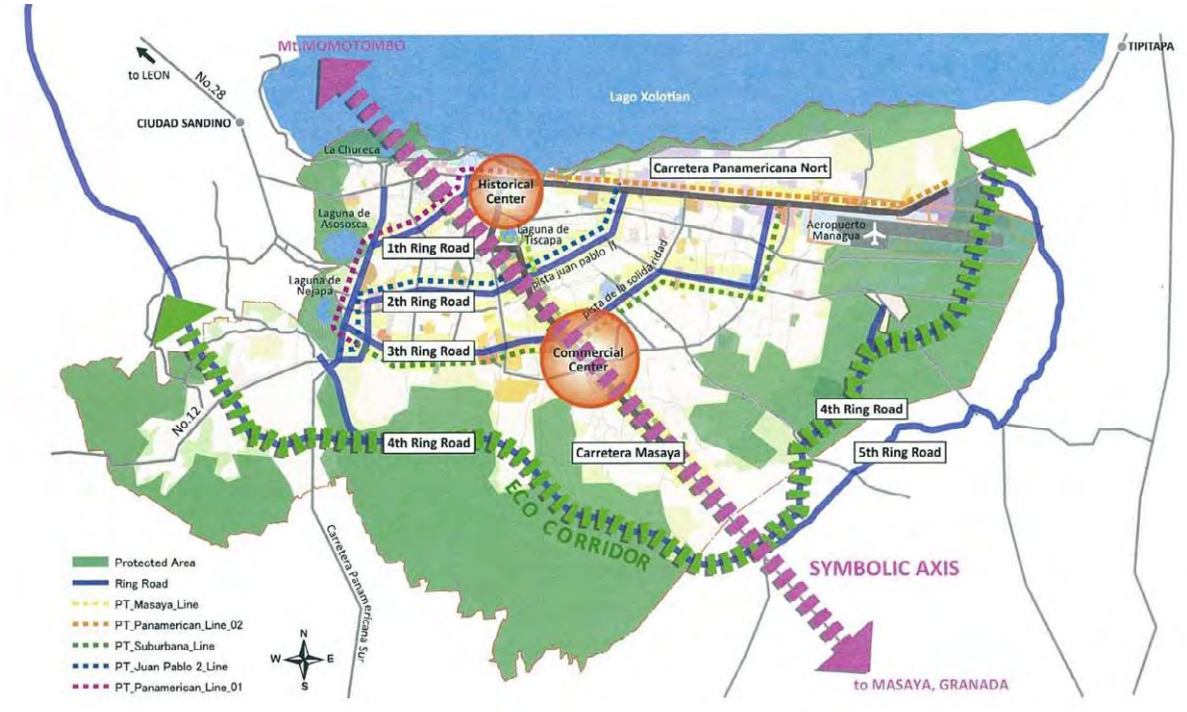
(2) Proposed Concept of Urban Structure

Based on the foregoing, the proposed urban structure of Managua in 2040 will be:

Managua will be a compact city with the effective use of limited land in the city, high quality environment, and efficient mobility for all residents and visitors.

This will be achieved by the following:

- Multiple urban center structure to accommodate the required urban functions and services and a balanced connection with the effective transports routes and major corridors;
- A symbolic axis is set to run through Managua from NW to SE, connecting Managua with Mt. Momotombo in the NW and Masaya and Granada in SE.
- The primary road network consisting of five radial roads connecting the neighboring cities and five ring roads around it;
- Public transport routes in the selected main roads;
- Environmentally sensitive areas will be protected which buffers the urban area from outside and urban parks and open spaces in urban areas; and
- Land use shall be face lifted with densification of land use to make built up area compact so as to protect more natural environment from development pressure.



Source: JICA Study Team

Figure 9.1.6 A Structure Plan for Managua City 2040

Managua has been formed between the two major cities of Nicaragua, Leon and Granada, and thus the important economic and social connections exist in the northwest to southeast directions. Furthermore,

the beloved Momotombo Mountain is in the direction of northwest. It is important to set the symbolic axis from northwest to southeast in order to coexist the past, present and future. The symbolic axis provides the back bone of Managua connecting two of the city's important urban centers, and provide a major corridor for development of Managua

9.2 Scenarios for Urban Structure

9.2.1 Urban Centers

(1) Candidate Sites for Urban Centers

The urban center primarily provides for business center function such as administration and service provision including commerce. As Nicaragua seeks to establish Managua as a regional hub city, the urban center function is required in order to have international business operations supported by high quality infrastructure such as disaster resilient lifeline, reliable utilities, abundant greenery, and open space as an effective transport mode at the historical area or elsewhere in the city. At the same time, the urban center area also wants to strengthen the attractiveness of the townscape, environment, and mobility.

The central part of the city is a historical area, or the “Traditional and Heritage Center” denoted by the IDB (Inter-American Development Bank) project. The Traditional and Heritage Center is an area where the city's historical heritage dated back in the colonial era is concentrated and thus, attracts tourism. The development of the historical area is under the preparation of IDB as of April 2017. A wide range of urban functions required for the development of Nicaragua and Managua City will be located in the historical area.

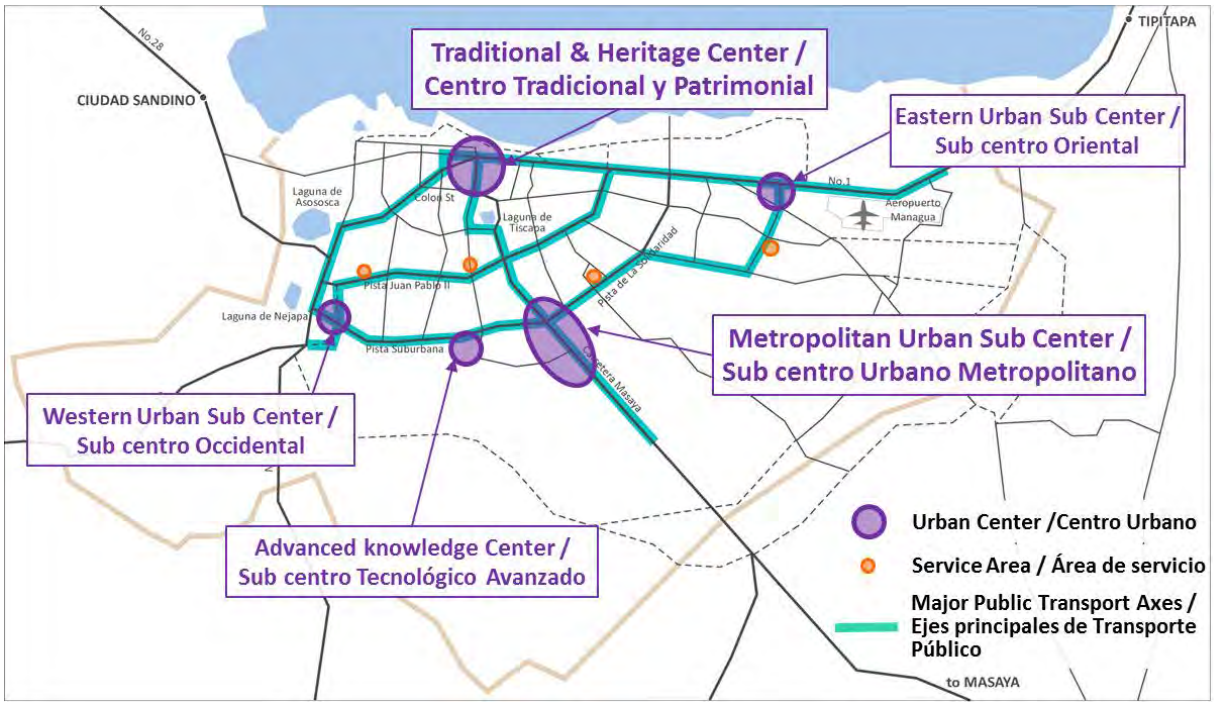
In order to balance the planning policy and this master plan formulation, a series of discussion were held among the Japan International Cooperation Agency (JICA) Study Team and the counterpart in a form of a Joint Technical Working Group (TWG) meetings. ALMA’s planning policy is found and illustrated in Figure 8.1.1. In the meetings held, a number of locations were found where a variety of activities took place. These locations rely on the existing patterns of traffic and transportation modes, the concentration of civic and public buildings, as well as commercial functions (e.g. markets, main shopping places), and administrative functions including district administration offices and hospitals. These existing patterns are a result of the urban planning after the earthquake in 1970’s and its recovery afterwards when ALMA launched a multiple-city center policy in order to distribute civic and commercial functions as risk mitigation and city management. Despite the planning regulations, the lack of clear political will and instrument for effectively controlling settlements and commercial activities has resulted to unplanned and unregulated growth of the city. As the transportation network is now reaching its capacity, opportunities and structure (planned spaces and infrastructure) for growth and expansion in these locations lack increasingly.

In order to reorganize and enhance the existing functions of these hubs and to promote and accommodate further growth and development, the locations of the new urban sub centers are identified based on the

existing land use and transportation patterns. The candidate sites for the new urban centers were discussed in a series of TWG meetings.

In recent years, new businesses have dramatically increased along *Carretera a Masaya* and in the ring roads such as Pista Suburbana and Juan Pablo II, as well as in the area of the Traditional and Heritage Center zone. These areas emerged as the candidate sites for Managua's new urban sub centers. Another type of center is also being proposed to provide a place for education and advanced technology, in coordination with the institutional setting such as National Autonomous University of Nicaragua (UNAN) and Central American University (UCA).

A number of candidate sites for the new urban sub centers have been proposed and evaluated in great length over a number of Joint TWG meetings between July and November 2016, hosted by the JICA Study Team and participated by the panels of the urban and transportation personnel of ALMA. Following an early consensus on an urban spatial structure comprising multiple urban centers, the discussions encompassed details such as the number, location, size, and distribution of functions of such urban centers (see Chapter 3 and Section 7.3.4 above), as well as their relationship with the existing historical center, impact on current transport network, social and economic impacts, and lifestyle and culture of residents. The candidate sites for urban center and sub centers are summarized as follows:



Source: JICA Study Team

Figure 9.2.1 Location of the Candidate Sites for the New City Centers

The future working population in the services sector is projected to increase for another 400,000 by 2040, which will be an engine for the growth of Managua City. Of this working population of the services sector, half of the population, say 200,000, is assumed to be accommodated in the urban centers. The distribution number of each center is shown in Table 9.2.1.

Table 9.2.1 Overview of the Candidate Sites for the New City Centers

Candidate Sites	Approximate Area	Working Population
Traditional and Heritage Urban Center	CBD: 30 - 40 ha Historical Area: 520 ha	60,000 in CBD
Metropolitan Urban Sub Center	30 – 40 ha	60,000
Eastern Urban Sub Center	20 – 30 ha	30,000
Western Urban Sub Center	20 – 30 ha	30,000
Advanced Knowledge Urban Sub Center	20 – 30 ha	20,000

Source: JICA Study Team

(2) Traditional and Heritage Center

The current city center functions, such as business and commercial, are scattered within the city; some in the historical quarter along the *Carretera a Masaya*, while some along the lakeside promenade along Managua Lake (*Lago Xolotlan*) and the Oriental Market. The lakeside promenade includes a number of relatively new tourist attractions, while the historical quarter comprises a number of conserved but underutilized historical buildings. The lakeside promenade attractions are popular among locals and tourists, although the historical buildings are inadequate and the quarter is in need of revitalization (see Section 3.7). The cultural significance and heritage values of these buildings warrant greater display and presentation. Some hotel facilities are also located within the historical and heritage center area.

The Oriental Market forms the eastern part of the traditional and heritage center. The market has seen years of uncontrollable growth and has become irregular in form, spreading in all directions by vendors who joined at will. It is not only popular among local traders, who purchase goods from the market and resell elsewhere, but is also highly popular among locals during festive seasons who purchase goods and gifts for celebrations. The market also attracts a moderate number of international visitors. While the exact value cannot be quantified, it is indisputable that the market makes a substantial contribution to the economy of the city. Due to unregulated growth over the years, the roads that used to run through the market are now occupied by vendors, thus, making the market inaccessible to any vehicles (including emergency vehicles). The lack of adequate infrastructure (water, sewerage, and electricity) also meant severe hygiene problems and high fire hazard for the market, while the lack of law enforcement inside the market also creates safety and security issues.

A number of central government buildings, which include the Presidential Palace, the National Assembly Parliament Building, the National Judicial Complex, federal ministries (i.e. finance, military), and the central bank are in middle of the center. These buildings play a great part in the central function of the city and the country, but they are centralized in the part of the country that is prone to earthquake. Therefore, the operations in the country may be disrupted shall these buildings suffer serious damage from a large-scale earthquake. While these government administration buildings conduct matters of national importance, they are different to those district offices, which conduct the municipal operations of the seven districts of Managua City and are located outside the traditional and heritage center.

The western part of traditional and heritage center is mostly covered by single- or two-story houses. Some houses can also be found in the northeast side of this center along Managua Lake. Due to lack of sanitary and law enforcement, that part of the city is turning into a slum and is considered unsafe by many locals.

The traditional and heritage center is expected to continue to carry out many functions such as central administrative services, disaster management and operations, recreation and sport facilities, hotel/convention/exhibition functions, residential and commercial centers, a central transportation hub, and the city's major tourist attractions.

A master plan for this area was executed by IDB in coordination with ALMA and the JICA Study Team. The JICA Study Team has been sharing information such as traffic survey data and road network strategy with the consultants, while IDB's consultants have been providing updates of their master plan report. At the time of writing, the master plan for the CBD and the historical area is expected to conclude in May 2017, followed by the enactment and implementation of key actions and recommendations.

These key recommendations include:

- Naturalization of the Managua Lake Coast, with light industrial usage at both eastern and western ends;
- Axial reinforcement from Managua Lake to Tiscapa Lake by use of greenery;
- Green areas along seismic fault lines to minimize the number of buildings subject to hazard;
- Overall densification with three to four-story residential buildings;
- Introduction of "superblock" with larger scale commercial buildings around the block perimeter (up to ten stories high in the highest scenario);
- All heavy truck movements to be diverted away from the traditional and heritage center; and
- The drafting of criteria for a future master plan for the Oriental Market

For details, refer to the "Revitalization Plan of the Traditional and Patrimonial Center of Managua" (Second report, Oct. 2016) by *Ezquiaga Arquitectura Sociedad y Territorio S.L.* (EAST).

It must be noted that under the present and proposed zoning for the traditional and heritage center, there are very few quality large areas that can cater to the needs of international businesses, thus, limiting the capacity to become an international business and finance center. The lack of large sites and major rezoning means few opportunities for large scale residential developments.

While the master plan for the traditional and heritage center contains models for intensification of city development, it does not contain details on the relationship between this urban center and the overall Managua City or the greater metropolitan area, in terms of economic projection, industry needs, population growth, and transportation strategy. In that regard, it is substantially different to the master plan report by the JICA Study Team, which contains current condition surveys, future projecions, and holistic analysis covering all aspects in detail for the whole Managua City.

Source: JICA Study Team

Figure 9.2.2 Location of Traditional and Heritage Center

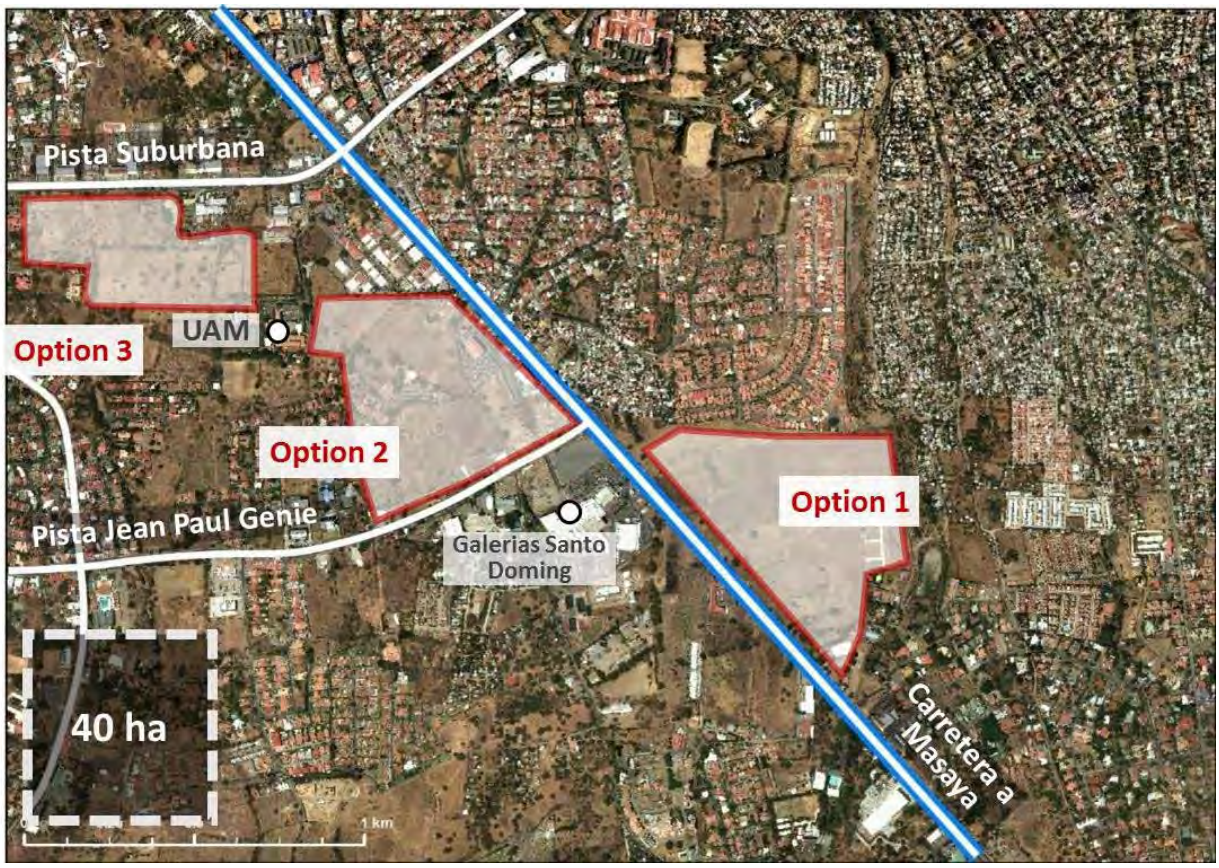
(3) Metropolitan Urban Sub Center

A new urban center, called Metropolitan Urban Sub Center, is situated on *Carretera a Masaya* (Highway N4), a major road that connects Managua City with Masaya City. The new center is expected to cover the shortcomings of the traditional and heritage center, and serve as a new international business and financial center by providing large areas (through rezoning) for offices for international organizations (such as non-government organizations (NGOs)) as well as high-rise residential and shopping complexes. The Metropolitan Urban Sub Center is at the intersection of two planning axes. Along the east-west axis, the Metropolitan Urban Sub Center is situated between the east and west service centers, with the three city centers connected by *Pista Suburbana* and *Pista de La Solidaridad* (Third Ring Road). Along the north-south axis, it is situated between the current urban center and the Masaya City connected by *Carretera a Masaya*.

As it is located at the intersection of the planning axes, it can also serve as a major transport hub with a public transport terminal that allows commuters, especially those going to or arriving from Masaya City, to interchange between modes of transportation such as a bus rapid transit (BRT), buses, taxis, or cars. Due to its central location, commuters can travel to other new city service centers along *Pista Suburbana* or *Pista de La Solidaridad* and *Pista La Sabana* (Third Ring Road) with much convenience. Thus, it is expected to reduce the amount of traffic entering into the central part of Managua City. The creation of

such transport hub will greatly enhance the capacity of the Metropolitan Urban Sub Center to serve as the new business district, and thus help establish it as an international business and finance center.

Three options in site selection were being discussed and reviewed by ALMA, the Technical Working Groups, and the JICA Study Team. While the three site options offer comparable site area, they facilitate different degrees of convenience and impact to traffic circulation and offer different opportunities and constraints for various functions. The final form and location of the sub centers will be the subject of continuous planning study sessions.



Source: JICA Study Team

Figure 9.2.3 Location of the Metropolitan Urban Sub Center

(4) East Urban Sub Center

The East Urban Sub Center is situated on the current site of the *Mercado El Mayoreo* (a popular market used by the locals) and the adjacent bus depot. The sites are situated in close proximity to the west of the airport. A number of large single-story simple buildings cover the market, and a number of major popular bus routes are currently operating through and/or terminating inside the market, providing major access for the locals. In the depot, buses are parked in the open (unsheltered) in a highly inefficient pattern, while many of the buses are also parked along *Pista del Mayoreo*. Both facilities in their current form cover a large area and both sites are considered underutilized.

The redevelopment of the facilities into a service city center will reprogram and restructure the current commercial (market), transportation and residential functions, to substantially improve land use

efficiency. It will provide a place for residents to live, shop, and work with an improved amenity and accessibility. With the creation of a transport interchange hub, residents will also be able to travel elsewhere for lifestyle and employment. Municipal administrative services and public facilities will also be included in the redevelopment to cater to the residents' daily lifestyle needs. Redevelopment plan is also being considered by the local authorities in parallel to this master plan study.

As the subject site is close to the city's aquifer area, any new development must avoid negative environmental impact. In addition to planning controls and approval restrictions, environmental controls must be implemented throughout the construction stage, and long-term regular monitoring should also be in place in order to avoid any risk of contamination of the aquifer.

Source: JICA Study Team

Figure 9.2.4 Location of the East Urban Sub Center

(5) West Urban Sub Center

The West Urban Sub Center is situated in the west of the city, immediately to the east of *Laguna de Nejapa* and Highway No. 1, which serves as a route to nearby cities such as San Rafael del Sur, Jinotepe, and Diriamba.

Laguna de Nejapa is part of a large natural reserve, which serves as a boundary of the westward development of the city. The new city center will be positioned between Pista Juan Pablo II and Pista Suburbana (Second and Third Ring Roads), providing two alternative routes to the rest of the city. While a large area of land is currently undeveloped, the Central Bank of Nicaragua and the Embassy of Brazil

are two major institutions established in the area, as well as small number of commercial facilities (local shopping malls, gas stations) nearby. The close proximity to *Ciudad Sandino* is also a major geographical advantage to the Western Service Center.

Three options in site selection were reviewed. The new service center will provide municipal administrative services with commercial, transportation, and residential functions. It will serve as a service hub not only to Managua residents but also those outside Managua City working or living in the nearby cities.

A major bus route is expected to run along Pista Juan Pablo and an extension will operate between/within the new city center and Pista Juan Pablo, thus providing public transport between the new city center and the rest of the city.

The final form and location of the sub centers will be the subject of continuous planning study sessions.

Source: JICA Study Team

Figure 9.2.5 Location of the West Urban Sub Center

(6) Advanced Knowledge Urban Sub Center

As part of the ultimate goal to diversify and upgrade the country's economy, the Advanced Knowledge Urban Sub Center is a city center dedicated to the research and development of new technology and innovation. The location of this center is determined by the proximity from the existing tertiary educational institutions in the city such as Ibero-American University of Science and Technology, National Autonomous University of Nicaragua (UNAN), Thomas More University, and Americana

University. The well reputed Central American University, Managua (UCA), and National University of Engineering, Nicaragua are located further to the north within short driving distance. American Nicaraguan School, a prestigious international school, is also situated in the precinct. Together with high accessibility via Masaya Road (N4) and *Pista Suburbana* (Third Ring Road), the area is considered appropriate for educational and research and development (R&D) functions.

Based on the science park models in the developed countries, foreign businesses or academic institutions will be given incentives to form joint ventures with Nicaraguan universities to create intelligent innovations and products while sharing training, R&D, and conference facilities. Such incentives may be in the form of financial assistance, tax relief, relaxation in regulations, or the provision of physical infrastructure such as buildings and laboratories. Knowledge-based industries such as information and communication technology (ICT), software, business process outsourcing (BPO), such as call centers and pharmaceutical, may be particularly suited. Different to other commercial and business centers, this city center will be integrated with a natural environment or park-like setting in order to nurture creativity, promote the sharing of ideas and communication, as well as to cater to the lifestyle needs of the foreign and young talents and professionals.

By attracting foreign investment and importing advanced knowledge and skills, it will help to initiate a smart economy and create knowledge-based products and services for export and higher-level skill jobs in the future.

Source: JICA Study Team

Figure 9.2.6 Location of the Advanced Knowledge Urban Sub Center

(7) Summary

Based on the foregoing, the basic character of the five proposed urban centers is summarized in Table 9.2.2.

Table 9.2.2 Functions of the Candidate Sites for the Urban Centers

Main functions \ Core alternatives	Traditional & Heritage Center	Metropolitan Urban Sub Center	West Urban Sub Center	East Urban Sub Center	Advanced Technology Urban Sub Center
Central Function	✓		✓	✓	
Touristic and cultural attraction center	✓				
Residential	✓	✓	✓	✓	
Transport Hub	✓	✓	✓	✓	
International Exchange and Gateway	✓	✓			
Commercial and Trade	✓	✓	✓	✓	
Education	✓				✓
International Business and Financial Activity	✓	✓			✓
Administration	✓	✓	✓	✓	
Social Service	✓		✓	✓	✓
Other	Disaster Management				

Source: JICA Study Team

9.2.2 Axis

Managua has started out in its history as a new colonial town along the shore of Managua Lake, just halfway between the rival cities of Granada and Leon. From Managua, Mt. Momotombo, a symbol of Nicaragua, is clearly seen in the NW direction beyond Managua Lake, with a perfectly symmetrical shape. On the other hand, Managua is chiefly developing towards Masaya City in the SE direction. Thus, the NW to SE direction is considered as a symbolic axis for the development of Managua.

9.3 Urban Planning Measures

Other than the development of the new urban sub centers, there are other urban planning measures that are required for the overall master plan and development of Managua City. Based on the current city zoning and regulations as well as the existing land use patterns, these measures are formulated in conjunction with the transportation strategy in order to accommodate and distribute the forecast economic and population growth.

9.3.1 Residential Area Development

Currently, main commercial activities take place predominantly along the major roads. Between the roads, a large part of Managua City is covered by one- to two-story low-rise dwellings, limiting spaces for public amenities such as green parks and open spaces as well as opportunities for local businesses. The horizontal spreading nature of low scale residential development is also a contributing factor to

urban sprawl. The existing residential areas need to be improved in terms of living environment by providing small parks and public facilities.

In order to provide stimulant for growth and create a better living environment, it is necessary to densify parts of these low-rise residential areas and encourage residential development of higher density. Based on the projected population growth, it is proposed that collective housing blocks of up to four stories are to be built in those areas to be rezoned as densified residential area. It is estimated that such middle-rise residential developments will provide a pleasant and comfortable living environment, while providing sufficient housing stock to accommodate the projected population growth.

In order to improve the amenities for residents, the residential area development will incorporate communal open space and open car park. Ground floor shops may also be included to stimulate commercial/retail activities on a grass-root level, improve residents' convenience, and strengthen neighborhood identity.

This development measure will help to intensify housing development and distribute population growth more evenly over the city. Such intensified residential development should be encouraged for sites along or near public transportation routes in order to maximize the use of public transportation. The densification strategies are discussed below in Section 9.4.3.

9.3.2 Industrial Area Development

Industrial area development is proposed in the northeast area of the city, including the east side of the airport. This will be accommodated in the Land Use Plan, and thereafter, be consolidated in the zoning scheme. The location of the industrial area takes advantage of its proximity to the airport, Pan-American Highway, as well as the proposed east urban sub center. There are two industrial categories: the northern part of the Pan-Americana Highway is to be used for logistics, packing, storage, and distribution to light industries with minimal environmental impact, as well as to small scale commercial including retails, restaurants, and residences. The east area of the airport will have an exclusive industrial area, which will contain heavy industries and large factories. It should be noted that this area has already started accumulating factories and stockyards. The exclusive industrial area could contribute to the creation of an industrial service center that will help to develop appropriate industrial environment and smooth logistics.

9.4 Land Use

9.4.1 Land Evaluation

In order to make a land use plan, the first land potential evaluation for the entire city was carried out. Land potential evaluation aims at identifying the urbanization factor of Managua City. In general, urbanization tends to be affected by the protected areas, disaster prone areas, and the service areas of infrastructure. Taking into account these aspects, land potential evaluation was carried out in terms of the five broad categories shown below: natural and social conditions, disaster prone condition, and accessibilities of transport and infrastructure.

Natural Condition (Natural Protected Area):

- Protected area defined by MARENA
- Protected area by the Coastal Law
- Steep and slope area
- Aquifer area
- Forest area
- Agricultural and green lands in the Rural Area
- Lake and lagoon

Disaster Prone Condition[2]:

- Landslide
- Fault
- Earthquake impact
- Flood
- Volcanic impact

Social Condition (Social Protected Area):

- Airport
- Cemetery
- University
- Religious facility
- Dumping Site
- Park and recreation area

Accessibility of Transport:

- Availability of major road
- Availability of road
- Proximity of bus route
- Proximity of bus stops and terminals

Accessibility of Infrastructure:

- Availability of water supply
- Availability of electricity
- Availability of Sewage

The evaluation adopted a scoring system of over 100 m grids covering the entire Managua City. More precisely, land was evaluated by a total of 27,577 mesh data in this study. The results of the land evaluation by category explained above and the resultant comprehensive evaluation are illustrated in Figure 9.4.1 to Figure 9.4.7.

(1) Natural Protected Area Analysis

Natural Protected Area Analysis aims to identify the critical protected areas in Managua City from the following natural environmental viewpoints. On the other hand, this analysis could clarify the area for urban development. These seven evaluation categories are confirmed by the existing land use. The detailed evaluation category and weight are described in Table 9.4.1.

Table 9.4.1 Evaluation Category of Natural Protected Area Analysis

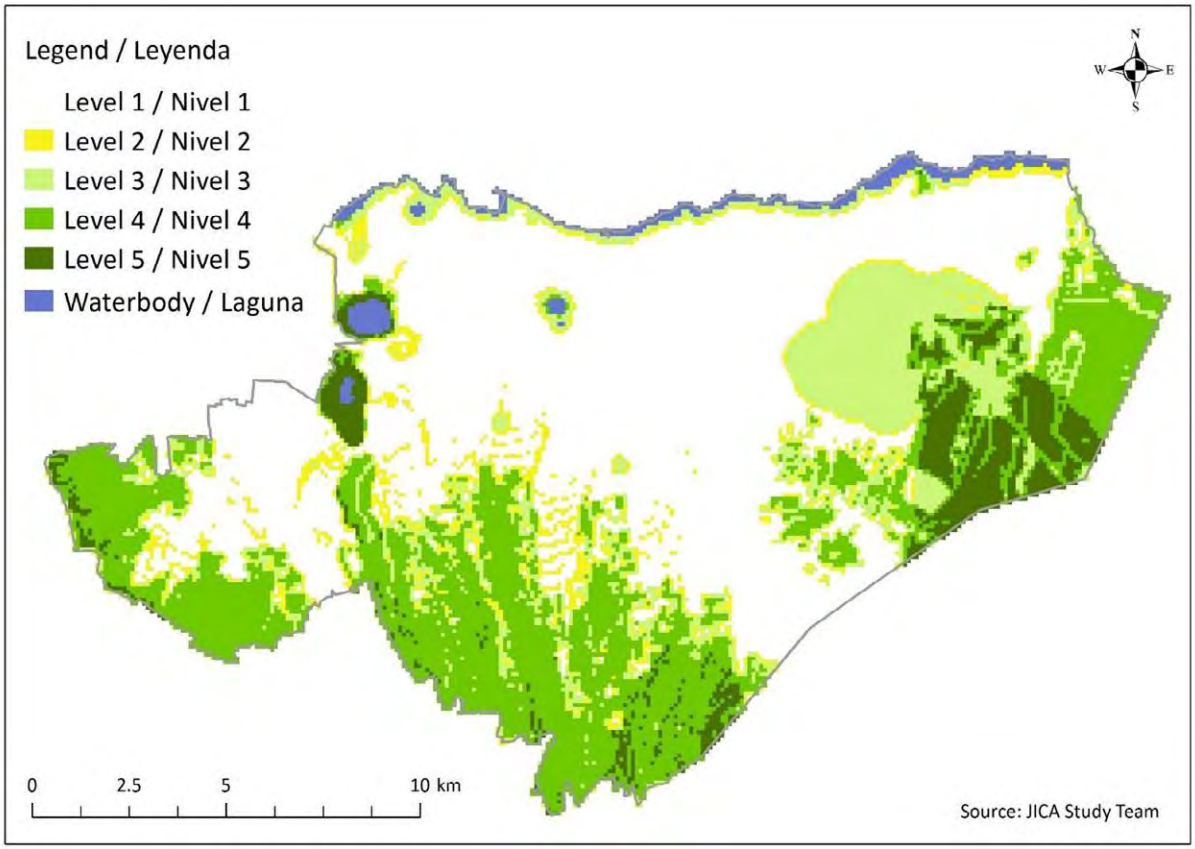
Evaluation Category	Evaluation Criteria and Weight
1. Protected area defined by MARENA (Tiscapa, Asososca, and Nejapa)	• Tiscapa: 1.0 • Asososca: 1.0 • Nejapa: 1.0
2. Protected area by the Coastal Law (200 m from Managua Lake and 150 m from Lagoon)	• 200 m buffer from Managua Lake: 1.0 • 150 m buffer from Tiscapa,: 1.0 • 150 m buffer from Asosoca: 1.0 • 150 m buffer from Nejapa: 1.0
3. Steep and slope area (evaluated by the degree of slope)	• More than 30 degrees: 1.0 • 20 to 30 degrees: 0.75 • 10 to 20 degrees: 0.5 • 5 to 10 degrees: 0.25
4. Aquifer area (southern area of the airport)	• Inside the aquifer area: 0.5
5. Forest area (defined by the existing land use)	• Forest area: 1.0

[2] Disaster prone condition is from the results of INETER

6. Agricultural and green lands in the Rural Area (defined by the existing land use)	• Green area in the Rural Area: 0.5 • Agricultural area in the Rural Area: 0.5
7. Waterbody (lake and lagoons)	• Nejapa: 5.0

Source: JICA Study Team

Figure 9.4.1 shows the result of the Natural Protected Area Analysis and the suitability of land development in terms of natural environmental condition. The white and yellow colored areas are evaluated as good and suitable for land development and have relatively flat land without environmental sensitivities. Meanwhile, the dark green colored area should be protected from any developments and has environmental sensitivities such as natural reserve, steep slope, lakeside, and green area.



Level 1	Good for Development	Level 4	Protect
Level 2	Suitable for Development	Level 5	Well Protect
Level 3	Not Suitable for Development	Waterbody	No Development

Figure 9.4.1 Natural Protected Area Analysis

(2) Disaster Risk Analysis

Disaster Risk Area Analysis aims to identify the high risk areas in Managua City from the following five disaster types. On the other hand, this analysis could clarify the area for urban development. The disaster data used in this analysis came from INETER (Instituto Nicaragüense de Estudios Territoriales). The detailed evaluation category and weight are described in following table.

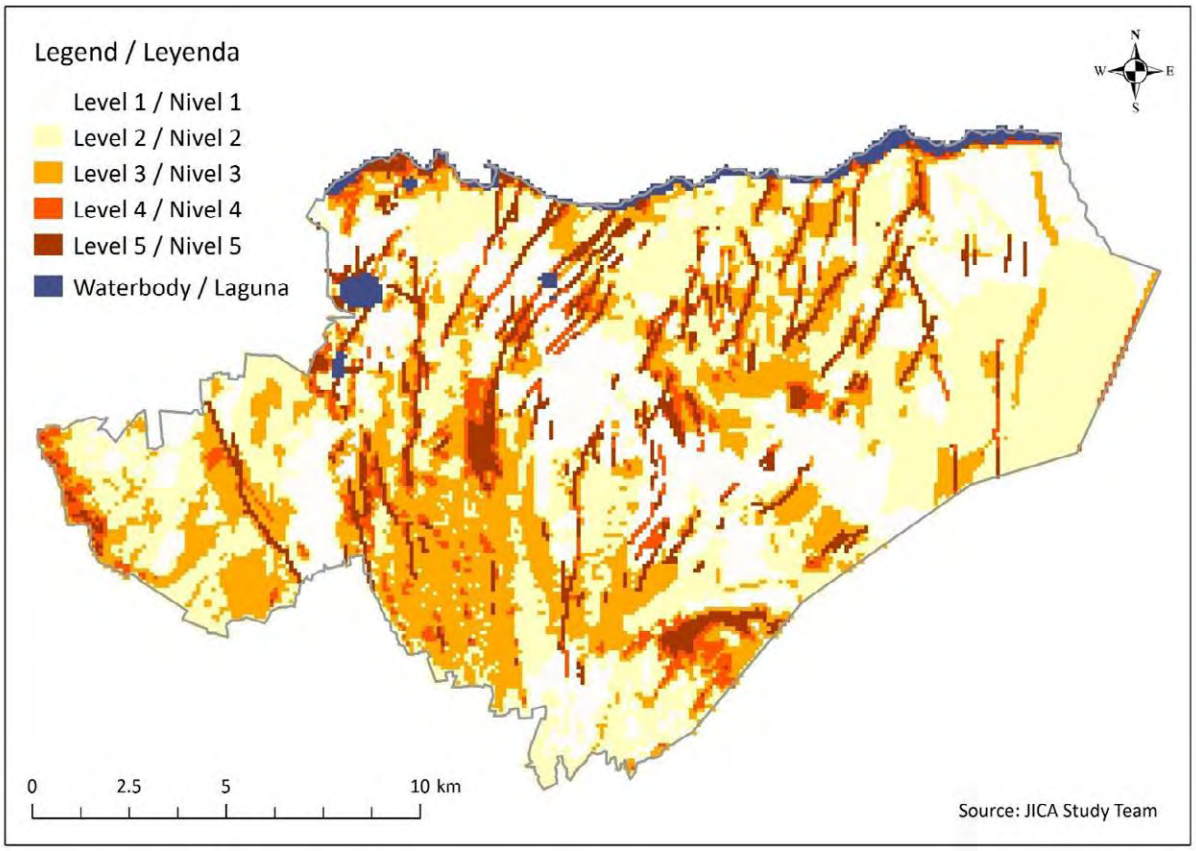
Table 9.4.2 Evaluation Category of Disaster Risk Analysis

Evaluation Category	Evaluation Criteria and Weight

1. Land slide	• Land slide prone area: 1.0
2. Fault	• Verified Fault: 1.0 • Unverified Fault:0.5
3. Earthquake impact	• High impact area by earthquake: 1.0
4. Flood	• Flood prone area: 1.0
5. Volcanic impact	• High risk area by eruption: 0.5

Source: JICA Study Team

Figure 9.4.2 illustrates the result of the Disaster Risk Analysis and the disaster prone areas from earthquake, landslide, flood, and eruption in Managua in which the dark red colored area is evaluated as the highest risk of natural disasters where it could be exposed to many hazards. This analysis could provide information that land development with important facilities such as government buildings should be avoided in the high risk areas.



Level 1	Small Impact	Level 4	Medium to Large Impact
Level 2	Small to Medium Impact	Level 5	Large Impact
Level 3	Medium Impact	Waterbody	Not evaluated

Figure 9.4.2 Disaster Risk Analysis

(3) Social Protected Area Analysis

Social Protected Area Analysis aims to identify the critical protected areas in Managua City from the following social viewpoints. These six facilities tend to be difficult to redevelop for other purpose. The airport, large-sized educational facilities, and dumping sites do not have any relocation plan so far.

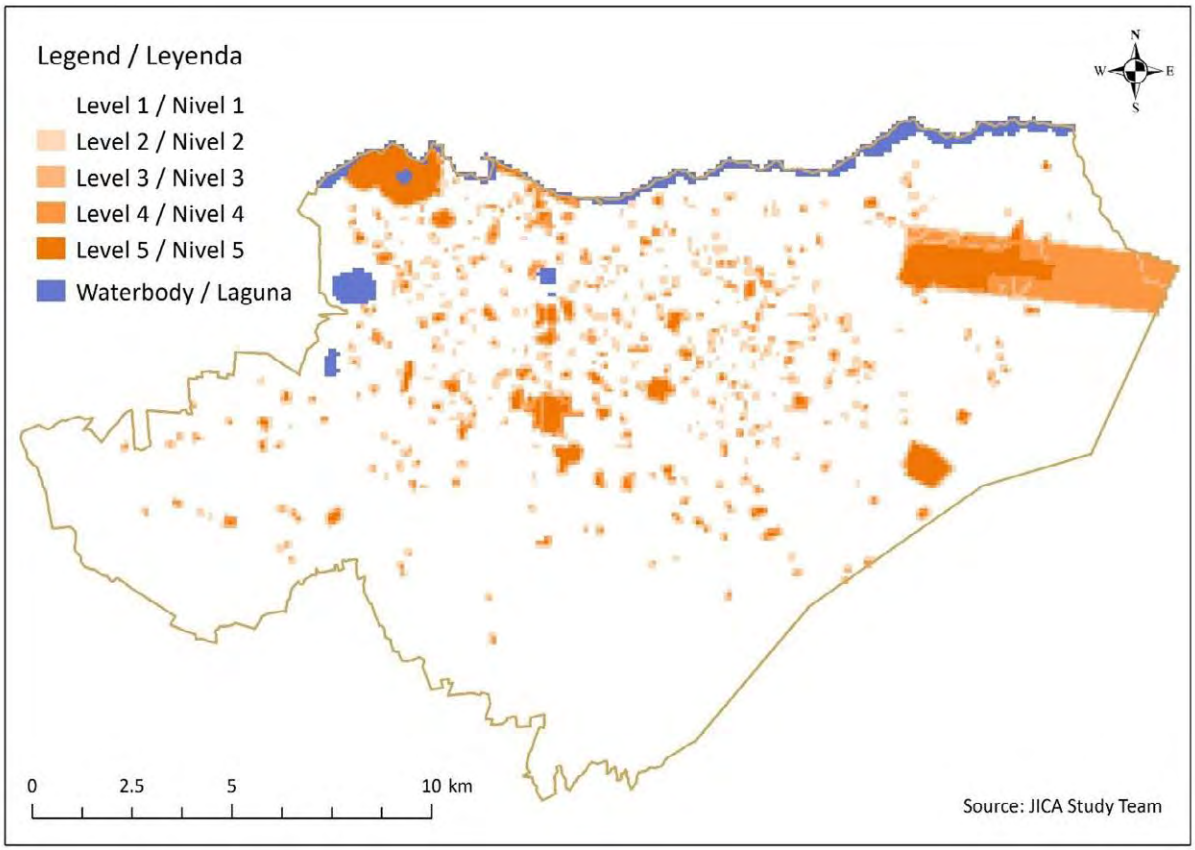
Cemeteries and religious facilities are in close relation with social life and are difficult to relocate into other areas. Besides, since urban parks and recreational areas lack in comparison to the urban population compared to other cities; therefore, these urban green areas should be kept for the future. In summary, this analysis could clarify the area for the new urban development. The detailed evaluation category and weight are described in Table 9.4.3.

Table 9.4.3 Evaluation Category of Social Protected Area Analysis

Evaluation Category	Evaluation Criteria and Weight
1. Airport	• Airport area: 1.0 • Airport extension area: 0.5
2. Educational Facilities (Large-sized school larger than 5,000 m^2 including university, college, and vocational school)	• Large-sized Educational Facilities: 1.0
3. Dumping Site	• Dumping site: 1.0 • 500 m buffer from the Dumping site: 1.0
4. Cemetery (Large-sized cemetery larger than 1,000 m^2)	• Cemetery: 1.0
5. Religious facilities (Large-sized religious facility larger than 1,000 m^2 including church, mosque, and temple)	• Religious facility areas: 1.0
6. Park and Recreational Areas (park, sport field, and recreation area)	• Park and recreational areas: 1.0

Source: JICA Study Team

Figure 9.4.3 shows the result of the Social Protected Area Analysis and the suitability of land development in terms of social environmental condition. The white colored area is evaluated as good for land development where there is no or little obstacle, while the dark orange colored area should be avoided for urban development due to the existence of unmovable facilities such as dumping sites, airport, cemetery, and religious facility.



Level 1	Good for Development	Level 4	Protected
Level 2	Suitable for Development	Level 5	Well Protected
Level 3	Not Suitable for Development	Waterbody	Not for Development

Figure 9.4.3 Social Protected Area Analysis

(4) Transport Accessibility Analysis

Transport Accessibility Analysis aims to identify the well-serviced areas in Managua City from the following transport viewpoints. As explained in Chapter 3, the existing condition of the road transports are mainly utilized for the citizens in the study area. The detailed evaluation category and weight are described in following table.

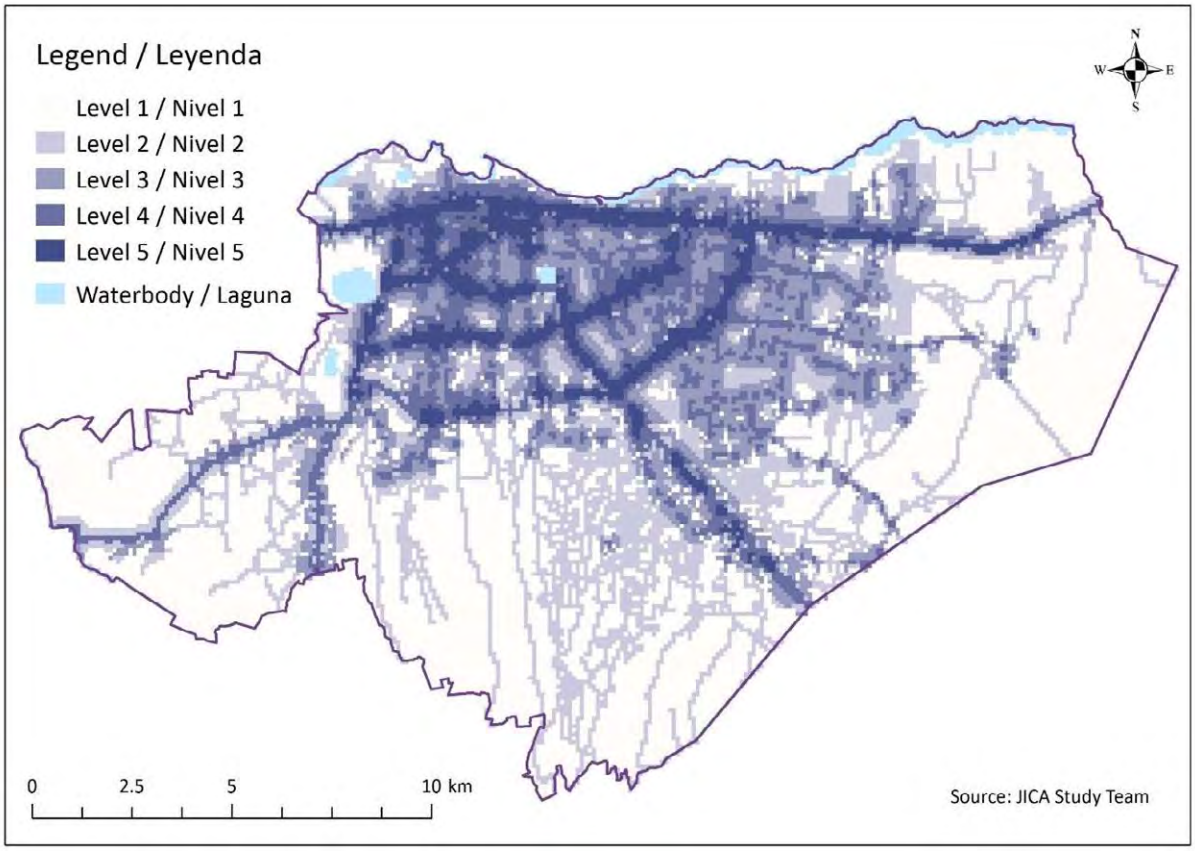
Table 9.4.4 Evaluation Category of the Transport Accessibility Analysis

Evaluation Category	Evaluation Criteria and Weight
1. Availability of major road (RN-1, RN-4, RN-12, Juan Pablo II, and Subrubana)	• 0-100 m from the road: 1.0 • 100-200 m from the road: 0.8 • 200-300 m from the road: 0.6 • 300-400 m from the road: 0.4 • 400-500 m from the road: 0.2
2. Availability of road (all roads except the major road shown above)	• More than one road in 100 grid: 1.0
3. Proximity of bus route	• 0-100 m from the bus route: 1.0 • 100-200 m from the bus route: 0.8 • 200-300 m from the bus route: 0.6 • 300-400 m from the bus route: 0.4 • 400-500 m from the bus route: 0.2
4. Proximity of bus stops (all bus stops and terminals)	• 0-100 m from the bus stops: 1.0 • 100-200 m from the bus stops: 0.6

	• 200-300 m from the bus stops: 0.3

Source: JICA Study Team

Figure 9.4.4 illustrates the result of the Transport Accessibility Analysis. The dark blue colored areas mean good accessibility to roads and public transport services including proximity to bus route and bus stops. Meanwhile, the white and light blue colored areas are out of or far from the service network. In summary, the well-serviced areas have better potential for land development and redevelopment, and are worth being considered for efficient land use.



Level 1	Very Poor Service	Level 4	Well Serviced
Level 2	Poor Service	Level 5	Very Well Serviced
Level 3	Moderate Service	Waterbody	Not Evaluated

Figure 9.4.4 Transport Accessibility Analysis

(5) Infrastructure Accessibility Analysis

Infrastructure Accessibility Analysis aims to identify the well-serviced areas in Managua City from the following infrastructure viewpoints. As explained in Chapter 3, the existing condition of the following four basic infrastructures is provided for the citizens in the study area. In terms of communication infrastructure, since the mobile telephone service covers the entire study area, the communication service was not included in this analysis. The detailed evaluation category and weight are described in Table 9.4.5.

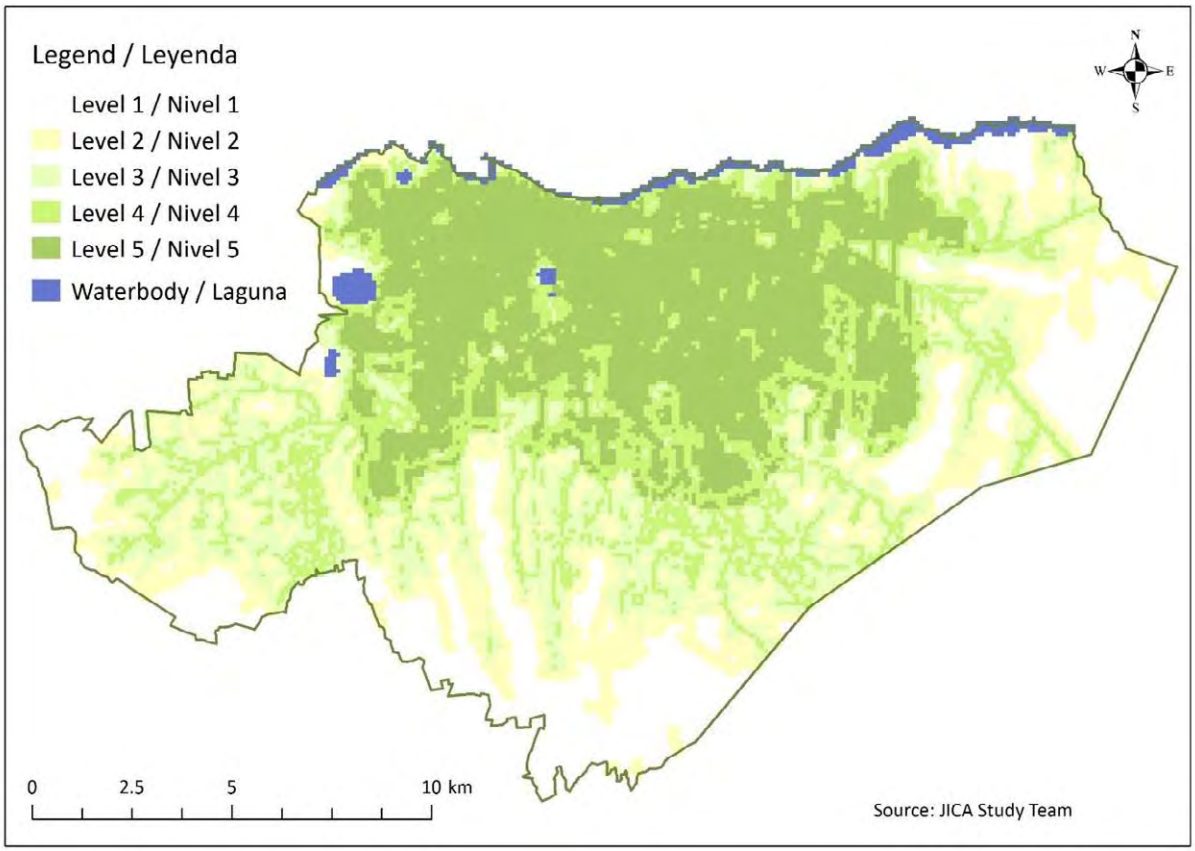
Table 9.4.5 Evaluation Category of the Transport Accessibility Analysis

Evaluation Category	Evaluation Criteria and Weight
1. Availability of water supply	• 0-100 m from the water pipe: 1.0

	• 100-200 m from the water pipe: 0.8 • 200-300 m from the water pipe: 0.6 • 300-400 m from the water pipe: 0.4 • 400-500 m from the water pipe: 0.2
2. Availability of electricity	• 0-100 m from the electric line: 1.0 • 100-200 m from the electric line: 0.8 • 200-300 m from the electric line: 0.6 • 300-400 m from the electric line: 0.4 • 400-500 m from the electric line: 0.2
3. Availability of sewage	• 0-100 m from the sewage pipe: 1.0 • 100-200 m from the sewage pipe: 0.8 • 200-300 m from the sewage pipe: 0.6 • 300-400 m from the sewage pipe: 0.4 • 400-500 m from the sewage pipe: 0.2

Source: JICA Study Team

Figure 9.4.5 shows the result of the Infrastructure Accessibility Analysis. The dark green colored area is covered by the services of the water supply, electricity, and sewage, while the white and yellow colored areas are out of or have few of such services. In summary, the well-serviced areas have better potential for land development and redevelopment and are worth considering for efficient land use.

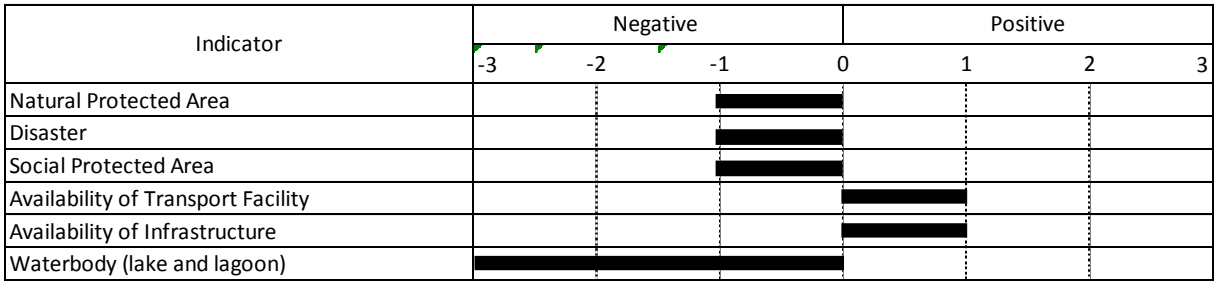


Level 1	Very Poor Service	Level 4	Well Serviced
Level 2	Poor Service	Level 5	Very Well Serviced
Level 3	Moderate Service	Waterbody	Not Evaluated

Figure 9.4.5 Infrastructure Accessibility Analysis

(6) Comprehensive Land Evaluation for the Development of the Existing Condition

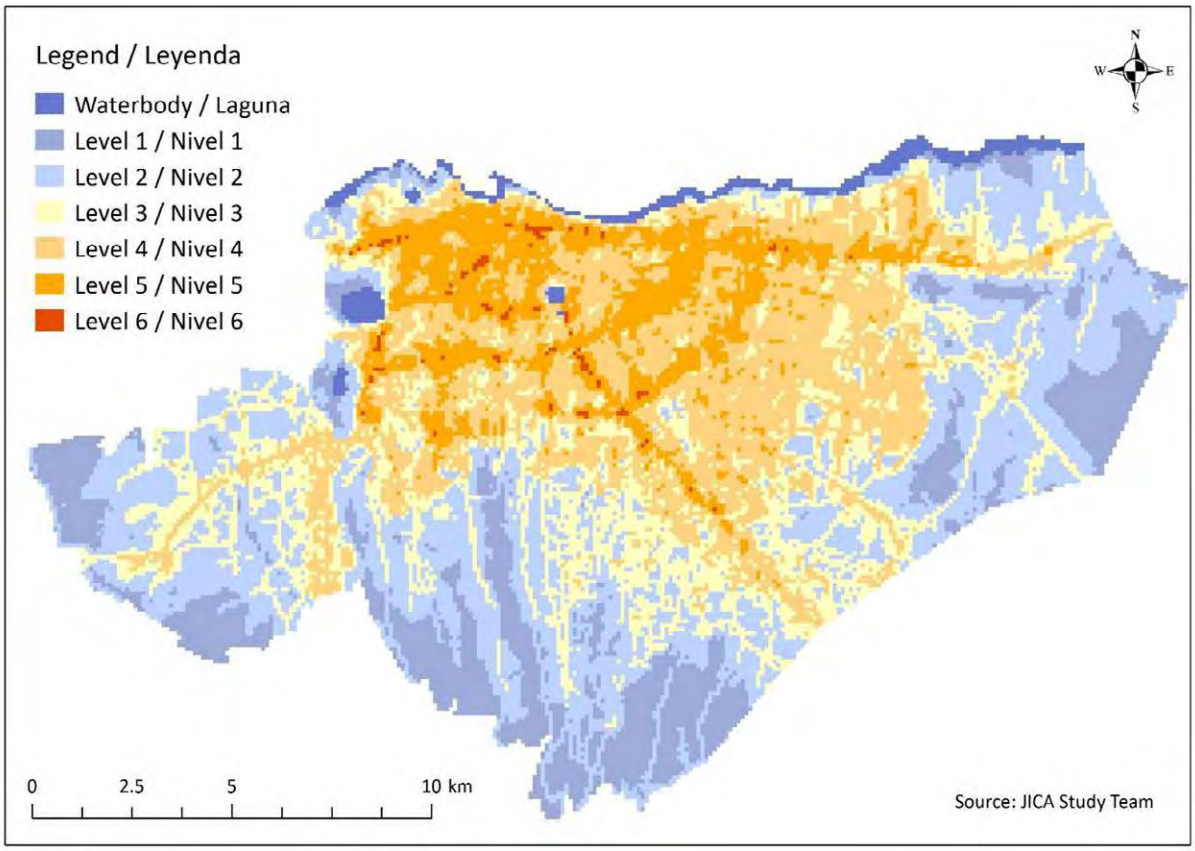
Figure 9.4.7 shows the comprehensive evaluation which was gained by compiling all the data shown above and evaluated comparatively. To be more precised, all 27,577 grids covering the entire study area were scored by the following six indicators with weight, and the score was divided with equal interval into seven levels including the waterbody. The red and dark orange colored areas indicate good potential for urban development, while the blue colored areas have unsuitable or unfavorable condition for developments.



Source: JICA Study Team

Figure 9.4.6 Weight of Land Evaluation

This evaluation result was utilized in the Urbanization Simulation explained in the following section and in the selection of urban redevelopment area for introducing the densification measure. Notably, "very suitable" area shown in the following figure means high potential land in terms of less impacts on natural environment, less risk from natural disaster, and well-serviced with transport and infrastructure. In contrast, "protect" and "not suitable for development" areas include natural sensitive areas, social obstacles, and high risk of disaster areas. In case there is a development of such unsuitable land, it should have disaster prevention measures and infrastructure invested costs as well as it will cause large impact on the natural environment such as slope failure and deforestation.



Waterbody	Not for Development	Level 4	Moderate for Development
Level 1	Protect	Level 5	Suitable for Development
Level 2	Not Suitable for Development	Level 5	Very Suitable for Development
Level 3	Less Suitable for Development		

Figure 9.4.7 Existing Land Development Analysis

9.4.2 Urbanization Simulation

Development of Urbanization Simulation aims to estimate future urbanization direction based on the identified urbanization factors in Managua City that were mentioned above. This model attempts to show dynamics of future land potential, future land use with and without policy intervention, and future population allocation.

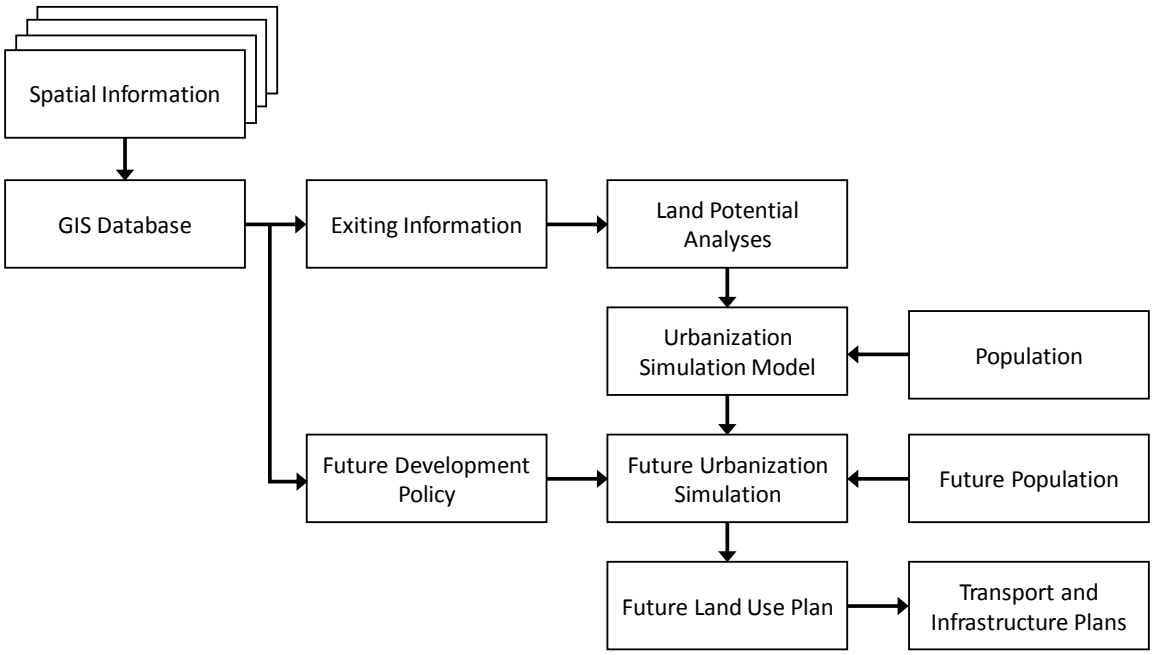
(1) Methodology

An urbanization simulation model was formulated with the geographic information system (GIS) database and the result of land potential analyses of the existing situation described in the previous section. Major steps to develop the simulation model are the following:

- To establish GIS database gathering with spatial information,
- To conduct land potential analyses in the current condition based upon the GIS with the grid and scoring systems,
- To develop urbanization simulation based upon the result of the land potential analyses by changing indicators of the scoring system,
- To coordinate with the urbanization simulation and population,

- To determine existing urbanization area on the simulation model,
- To check the confidence of the model by conducting calibration,
- To carry out future land potential analyses,
- To run future urbanization simulation based upon the future land potential analyses, and
- To coordinate with the future urbanization simulation and future population in 2040.

The methodology is illustrated in Figure 9.4.8.



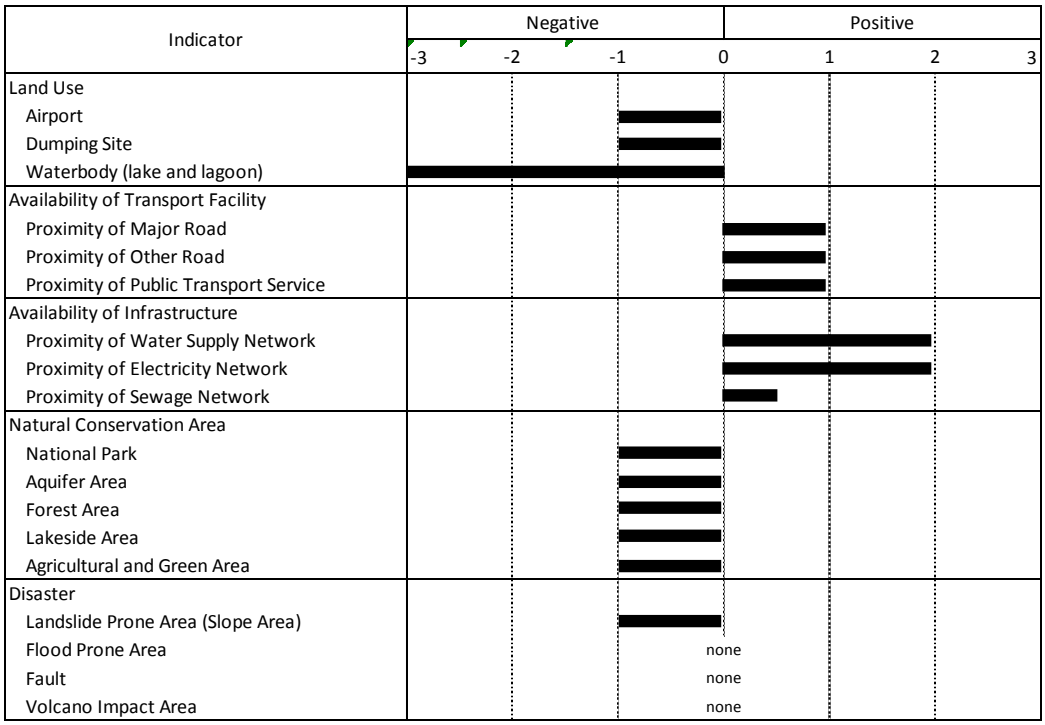
Source: JICA Study Team

Figure 9.4.8 Methodology of Urbanization Simulation

(2) Calibration

Based on the result of the land potential analyses, the Urbanization Simulation Model was developed. In order to confirm confidence of this simulation model, a calibration was conducted so that the validity of future urbanization estimation becomes certain. For the calibration, the simulation model of the existing condition must fit the actual urbanization pattern as much as possible. The actual urbanization pattern is identified on the basis of the existing land use.

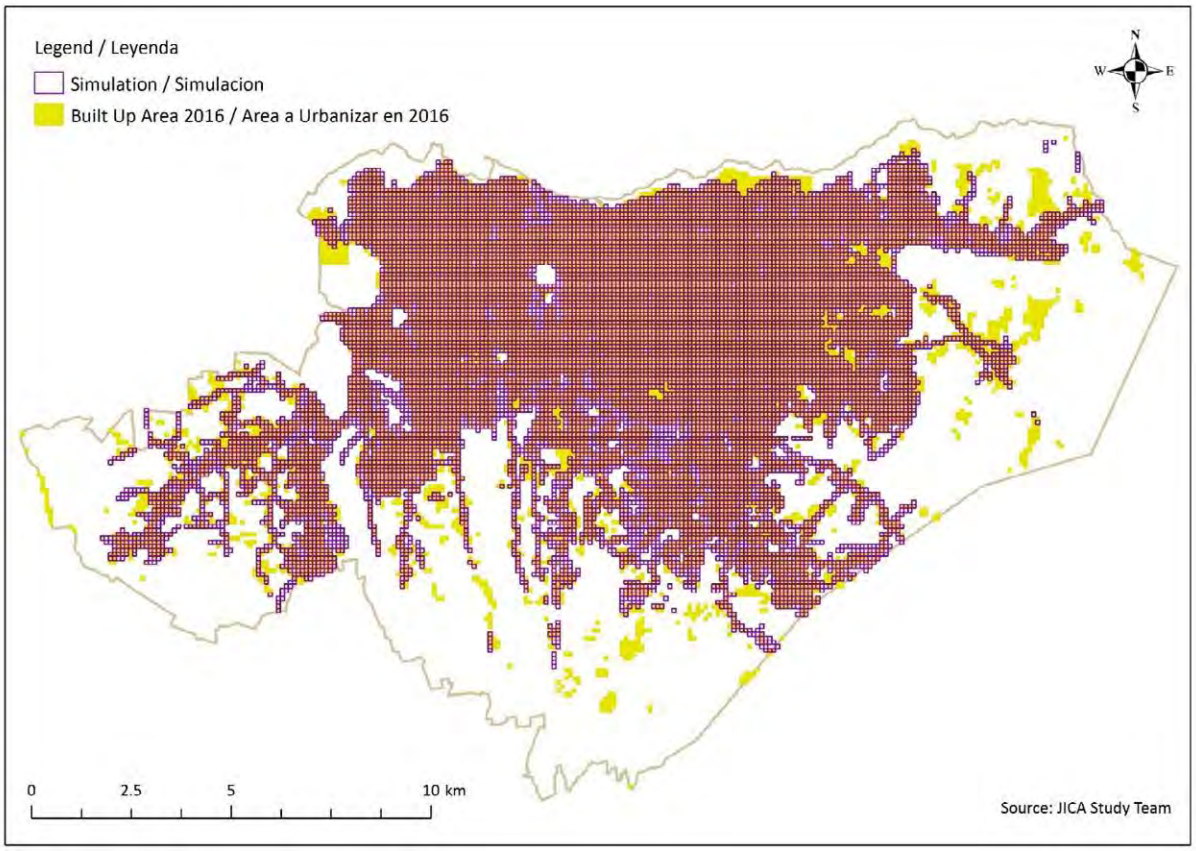
To obtain a high confidence rate of calibration, a scoring system of the analyses was made and was constantly changed through a trial and error process until the urbanization simulation model fits most of the actual urbanization pattern. The fitted scoring system is indicated in Figure 9.4.9.



Source: JICA Study Team

Figure 9.4.9 Scoring System of the Urbanization Simulation Model

Strong factors which affect the cause of urbanization in Managua in the model was found to be the accessibility to infrastructure, in particular, for water supply, electricity, and transport services. Urbanization tends to sprawl from a fringe of the serviced area and to expand in flat land. Finally, the confidence rate turned out to be 87% at the highest. The result of calibration is illustrated in Figure 9.4.10. The yellow colored areas are the urbanization areas in 2016 which includes residential, commercial, public, industry, mixed use, and religious areas selected from the land use. Some uncovered areas in the eastern part of the city are the sites used for the social housing projects of ALMA which might be an exception from the pattern of land development because these locations are in the conservation area.



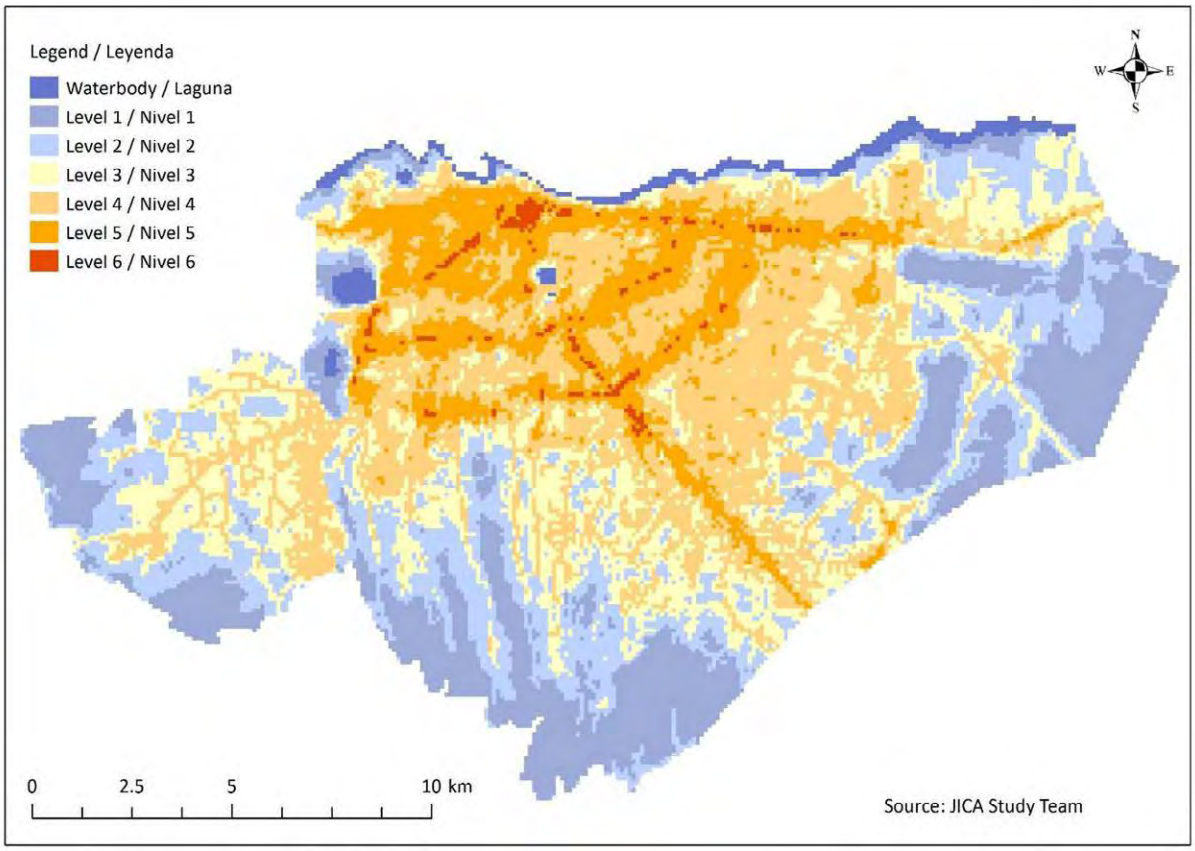
Source: JICA Study Team

Figure 9.4.10 Result of the Calibration on Urbanization Simulation

(3) Future Land Potential Evaluation

Future Land Potential Evaluation was carried out in an attempt to show the future urbanization pattern in Managua City. This evaluation was carried out in the same manner as the land potential analyses of the current condition. Some indicators, however, had to be modified in order to take into account the future development plan, such as the expansion of road network and public transportation, avoidance of disaster high risk area, and protection of environmental sensitive area in 2040. The result of the integrated land potential analysis in 2040 is depicted in Figure 9.4.11.

As shown in Figure 9.4.11, the dark and light orange colors indicate the future urbanization area. This area tends to expand from the center of Managua City stretching outward along the main roads.



Waterbody	Not for Development	Level 4	Moderate for Development
Level 1	Protect	Level 5	Suitable for Development
Level 2	Not Suitable for Development	Level 5	Very Suitable for Development
Level 3	Less Suitable for Development		

Figure 9.4.11 Land Potential Evaluation in 2040

9.4.3 Densification of Land Use

As explained in Chapter 8, Managua City will need to accommodate a larger number of population in the future than today. A conventional way of urban expansion to Sub Urban and Rural areas would lead not only to consume and revert a large part of land resource that of which are protected area but also to require large costs for development of basic infrastructure. This could hamper the sustainability and might disturb the economic developments in Managua City. In order to avoid such unfavorable social impacts and to guide urban development appropriately, a suitable population density in the urban area with regard to land capacity for development needs to be examined for the future. These analyses were also linked to the urban development vision, land use plan, and the future review of the land zonings in the study area of ALMA.

(1) Analysis of Future Urban Development without Densification

Based on the land use demand described in Section 8.2.3 of Chapter 8, the built up area needs to expand from roughly 13,000 ha in 2016 to 20,200 ha in 2040 in order to accommodate the future population and workers.

Table 9.4.6 Estimation of the Required Land Size for Built Up Area in 2040

Year	Housing Area (ha)	Industrial Area (ha)	Commercial Area (ha)	Other Built Up Area (ha)	Total (ha)
2016	6,880	375	1,434	3,956	12,646
2040	12,220	530	1,830	5,240	19,820

Source: Calculated by the JICA Study Team based on the GIS data provided by ALMA

Based on the urbanization model, the built up area in the worst case prediction, which will not take any land densification measure simulated to expand, is shown in Figure 9.4.12. The blue area illustrates the shape of the future built up area that would be equivalent to 74% of the total land. According to this result, the urbanization area seems to extend to environmental sensitive areas such as slope, aquifer, and forest areas.

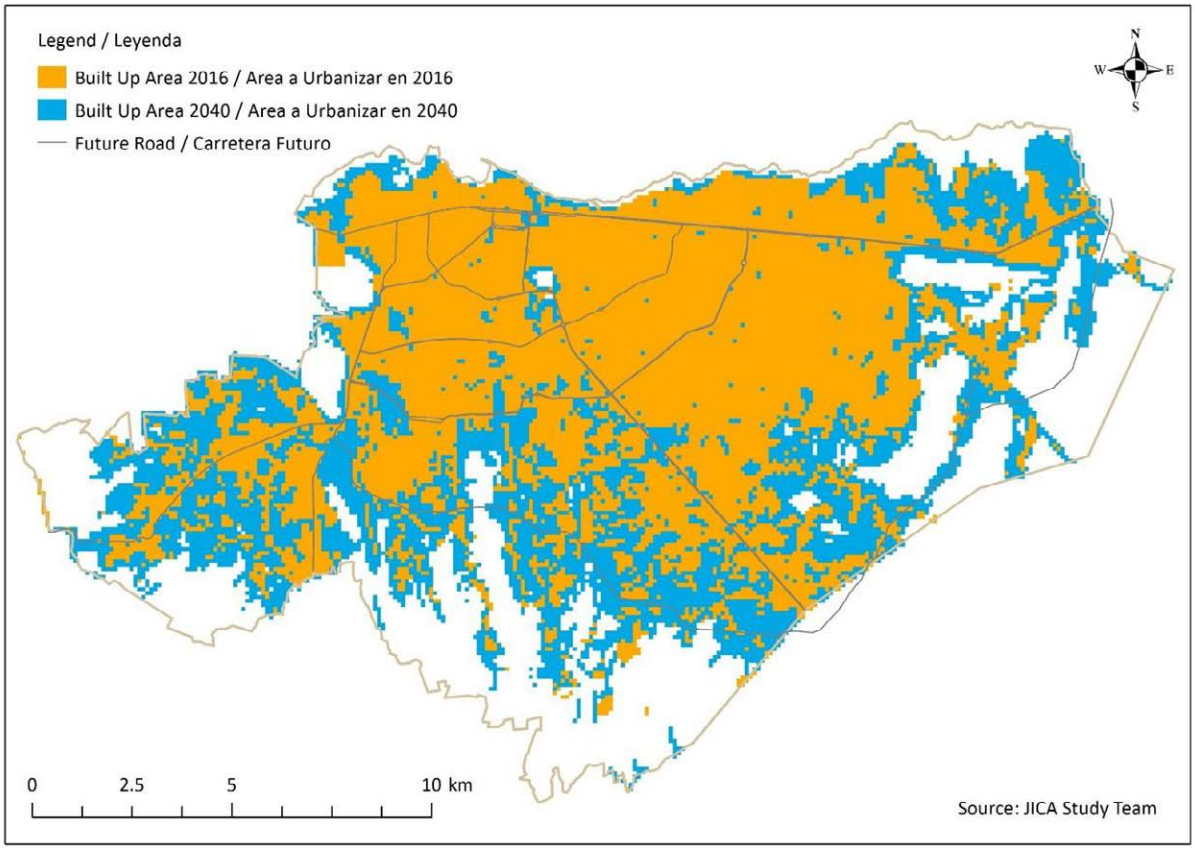


Figure 9.4.12 Analysis of the Future Built Up Area without Densification Measure in 2040

(2) Basic Methodology of Densification

In order to avoid the worst scenario explained in the previous section, densification measure is necessary to bring healthy urban development and sustainability. The densification scheme could be considered in Managua City by following these four measures: 1) fill-in development of unused land and open spaces inside built up area, 2) stimulation of densification by revising the current zoning system, 3) redevelopment of the existing housing plots in the Urban Area, and 4) new development in Sub Urban Area. In terms of investment cost and time, these four measures need to be combined for densification in Managua City.

1) Fill-in Development

In Managua City, there are still many unused land plots and open spaces inside the built up area that is approximately 1,300 ha[3] of open space in the Urban and Sub Urban areas. Since these areas have good accessibility to infrastructure services such as road, water supply, and sewage, they should promote urban development first to these areas. Besides, this kind of development could attract private investors in terms of investment cost and time.

2) Stimulation of Densification by Revising the Current Zoning System

According to the result of the Household Interview Survey (HIS), 57% of the people answered that they could live in an apartment type of house. In addition, more than 64% of the younger generation, such as teens and those who are in their twenties, do not mind living in apartments. Revising the current zoning could stimulate change in the housing trend, from detached house into apartments, since the current zoning for houses regulates low height. Also enlightenments for citizens to promote living in apartments are necessary in order to make compact city. These social changes, however, might take a certain time and will need to have a strong promotion by ALMA.

3) Redevelopment of the Existing Housing Area in the Urban Area

Redevelopment of the current residential area should be promoted to make high density area with good accessibility, such as near the public transportation routes. Managua City cannot avoid having high density urban structure in order to stop urban sprawl; however, for taking into account the housing preference data of HIS, 43% of the residents do not accept living in apartments. To create high density area by redevelopment is necessary by 2040. Also, three- or four-story buildings are reasonable for high density housing according to the HIS results. In addition, urban redevelopment takes a long time because of achieving consensus from residents and the preparation for the costs. So as to promote to make high dense areas, ALMA needs strong policies including enlightenment of horizontal development for citizens.

4) New Development in Sub Urban Area

New development outside the built up area attracts private investors and urban developers. Based on the recent trend of land development in the Sub Urban Area, quite low density development was common. In order to avoid further urban sprawl, new development should be in the limited area. Also, requirement of minimum density needs to be applied, or otherwise low density development would continue in the future. Thus, a new zoning scheme should be considered.

[3]Calculated by GIS based upon the land use map in 2016

(3) Densification Scenario

As discussed in the previous section and in Section 3.5.4. of Chapter 3, the built up area should be considered separately, say by area types (Urban Area, Sub Urban Area, and Rural Area). Densification measures by area are shown in Table 9.4.7.

Table 9.4.7 Basic Scenario for Densification by Area

Type of Area	Character of the Area	Basic Scenario of Densification
Urban Area	• Mixed land use • Basic infrastructure is already developed • Limited open and green areas	• Increasing the densification in the housing areas by revising the current zoning • Fill-in development • Redevelopment of the existing built up areas into high dense areas
Sub Urban Area	• Housing and green area • Some development at potential areas along major roads such as Masaya Road and Pan-American South • Basic infrastructure is already developed in a limited area	• Increasing the densification in the housing areas by revising current zoning • Fill-in development • New development of built up areas
Rural Area	• Dominantly agricultural and forest area • Limited housing area and infrastructure	• Prohibits new development

Source: JICA Study Team

Based on the average floor size of the households, floor area ratio (FAR) of the house and the number of household size according to the HIS result, land use map and socioeconomic framework, future net population densities were estimated as follows:

1) Urban Area

In the Urban Area, the average floor size of a household is expected to increase in accordance with the economic growth. The HIS results indicated that the total floor size was 94 m^2 for a household in average. In 2040, the gross regional domestic product (GRDP) per capita in Managua City estimates to NIO 193,101 equivalent to NIO 16,092/month.[4] On the report of the HIS result on the housing size by income level, the housing size by household who has an income between NIO 15,000 and 20,000/month was indicated to be 102 m^2. Therefore, the future housing size was estimated to increase from 94 m^2 in 2016 to 102 m^2 in 2040 in accordance with the economic growth projected in the future.

The average FAR of a house is expected to increase by shifting citizen's awareness toward densification and housing trend. According to the HIS result, the average FAR was 0.72[5] and

[4] Details are explained in Chapter 8.
[5] Average FAR = average size of total floor/average size of land

FAR value is allowed between 0.68 and 2.12 based on the existing zoning for housing area[6]. Judging from this numerical data, most of the houses could be said to be a one-story building. On the other hand, the result of the questionnaire regarding their preferred house[7] indicated that around 60% of the respondent answered that two-story houses were favorable for them in the future. Therefore, the future average FAR could be calculated at 1.09 based on the percentage that 40% of the total keeps the average FAR at 0.72 and 60% of that increased their FAR to 1.44.

The future FAR is expected to change from 0.72 in 2016 to 1.09 in 2040. The average number of household is estimated to decrease from 4.3 in 2016 to 3.4 in 2040 in the socioeconomic framework explained in Chapter 8. Based on the future average housing and household sizes, the size of the future housing floor per person is calculated at 30 m^2/person. In a hectare of the Urban Area, the total floor size is calculated at around 4,300 m^2 based on the land use data and the HIS result. Accordingly, the average future density is estimated to be 156 person/ha.[8] Furthermore, for high densification scenario, the average FAR in higher dense area assumes at 2.0 which consists of four-story apartments. Hence, high density is calculated at 288 person/ha[9] along the same calculation manner above.

Based on such estimation, 160 person/ha in average housing area and 300 person/ha in high dense area are proposed to be employed in the densification scenario in the Urban Area.

2) Sub Urban Area

In the Sub Urban Area, it has low dense housing area as explained in Section 3.5.4 in Chapter 3. However, recent new housing area tends to be developed with little higher density compared to the existing ones. This type of development is assumed to keep continuing in the existing built up area. According to the case study of such new housing development, the average floor size for one house is around 140 m^2, and the average FAR is 0.52. The future floor size per person is estimated at 45 m^2/person based on the comparison between the housing sizes in the Urban and Sub Urban areas.

Besides, the future average FAR could be considered to keep similar rate in the existing built up area and taking into account the development trend. In the Sub Urban Area, the ratio of the housing area to the built up area is higher than that of the Urban Area due to less facilities for commercial, industrial, and public utilities. Therefore, the total floor size per hectare is calculated at around 6,800 m^2 based on the land use data and the HIS result. Accordingly, the average future density is estimated at 79 person/ha[10] for the existing built up area. For the new

[6] Source from ALMA
[7] The questionnaire survey was carried out in the HIS,
[8] The future density=(total floor size per hectare (4,300 sqm/ha) x future average FAR (1.13)) / future floor size per person (30 sqm/person)
[9] The future high density=(total floor size per hectare (4,300 sqm/ha) x future average FAR (2.00)) / future floor size per person (30 sqm/person)
[10] The future density=(total floor size per hectare (6,800 sqm/ha) x future average FAR (0.51)) / future floor size per person (47 sqm/person)

built up area, the average FAR might be higher than 0.83 according to the same manner of calculation done for the Urban Area. Hence, the future density of the new built up area is estimated at 126 person/ha.

In the Sub Urban Area, 80 person/ha is the average housing area for the existing built up area and 130 person/ha for the new development area were set for the scenario based on the assumptions explained above.

3) Rural Area

In the Rural Area, the concept does not allow any new developments to keep the green lands and avoid urban sprawl. The density and area is assumed to be the same as the existing condition.

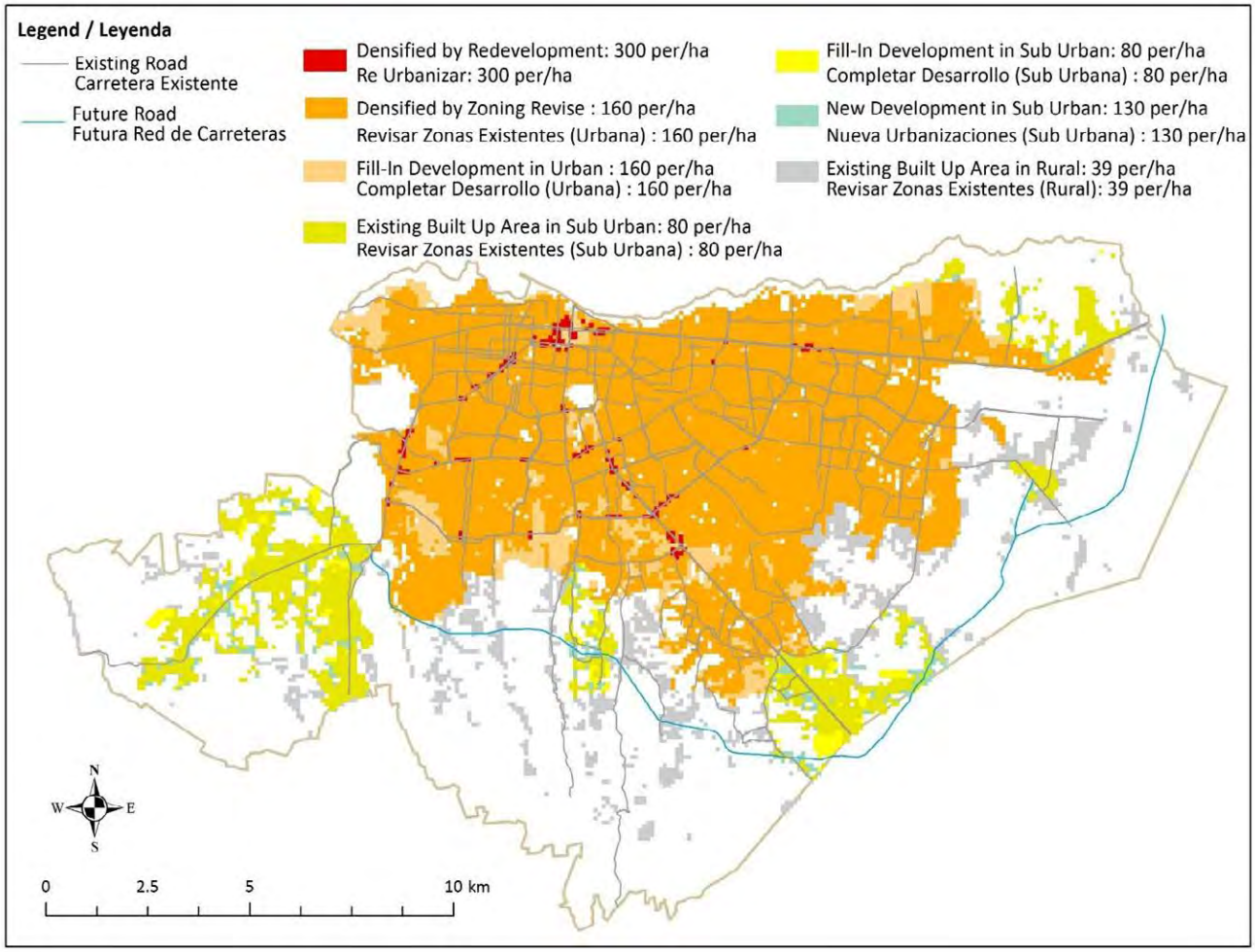
Table 9.4.8 indicates the future density, the built up area, and future population.

Table 9.4.8 Densification Scenario by Area

Type	2016			2040		
	Area (ha)	Net Pop. Density (person/ha)	Population	Area (ha)	Net Pop. Density (person/ha)	Population
Built Up Area in the Urban Area	9,208	142	1,309,956	**10,360**	**162**	**1,678,600**
Existing Built Up Area by the Revised Zoning				9,100	160	1,456,000
Fill-in Development				1,110	160	177,600
Redevelopment				150	300	45,000
Built Up Area in the Sub Urban Area	1,816	67	121,610	**2,300**	**87**	**199,000**
Existing Built Up Area by the Revised Zoning				1,800	80	144,000
Fill-in Development				200	80	16,000
New Development				300	130	39,000
Built Up Area in the Rural Area	1,622	39	63,819	**1,622**	**39**	**63,819**
Total of the Built Up Area and Population	**12,646**		**1,495,385**	**14,282**		**1,941,419**
Population Forecast in 2040						**1,940,078**

Source: JICA Study Team

By using a Built Up Simulation Model established in GIS, the distribution of the densified area along the densification scenario is illustrated as shown in Table 9.4.8. “Fill-in Development Area” is an open space which is suitable for urban development. Meanwhile, the “Redevelopment Area” in the Urban Area and the “New Development Area” in the Sub Urban Area are selected with a basis of the land evaluation analysis. The small dot shows the 100 m grid equivalent to 1 ha. Each category consists of the same number of grid for the required land. For example, there are 150 red dots that exist in this because the required land is 150 ha. The size of the area is determined by the densification scenarios and the increased population from 2016 to 2040.

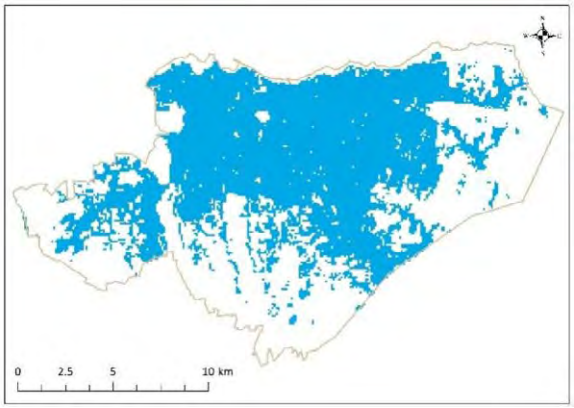


Source: JICA Study Team

Figure 9.4.13 Distribution of the Densified Area in 2040

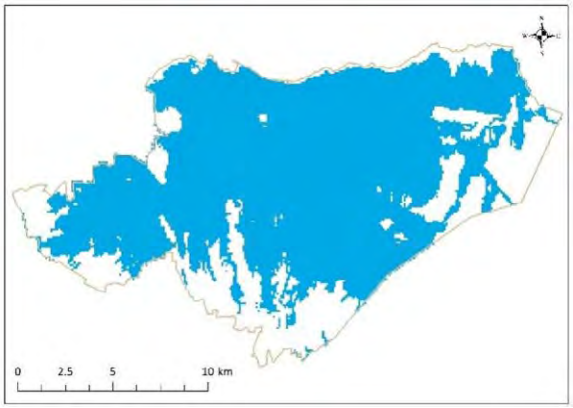
Based on the Built Up Area Simulation, the total built up area calculated was around 14,300 ha based on the densification scenario, while the worst case prediction was calculated at around 20,200 ha in the case of keeping the existing urban density. Figure 9.4.14 shows the comparison figures of the worst and optimal cases of the Built Up Area Simulation. Marked difference between them is recognized.

Optimal Case



Total Built Up Area: 14,300 ha

Worst Case



Total Built Up Area: 20,200 ha

Source: JICA Study Team

Figure 9.4.14 Built Up Area Simulation in the Worst and Optimal Cases in 2040

9.4.4 Land Use Plan

(1) Land Use Planning Policy

The future land use consists of twenty-one practical categories[11] in terms of the following six major land use characteristics: 1) Conservation, 2) Mix Used, 3) Housing, 4) Commercial, 5) Industry, and 6) Public Facility for taking into account the existing land use pattern and zoning system. Planning policy for each category is described below.

1) Conservation Area

The Conservation Area, which should keep the existing condition without any new urban developments in the future, is proposed to be categorized into the following five categories: National Park, Environmental Sensitive Area, Urban Green Area, Sub Urban Green Area and Waterbody. National Park Area consists of three lagoons and its surroundings defined by MARENA, namely, Tiscapa, Nejapa, and Asososca. Environmental Sensitive Area should also be kept away from land developments, comprising the coastal area of Managua Lake, the aquifer area in the east, and steep slope area in the south of Managua City. Sub Urban Green Area contains agricultural and green lands and is located in the fringe of the built-up area. In order to regulate urbanization expansion and to keep away from sprawling, these areas laid between Environmental Sensitive Area and the built-up area in general. Lastly, Urban Green Area includes urban parks and recreation area is mainly located in Urban Area. Since the number of urban park is not enough in Managua City compared to other foreign cities, the potential land for urban park development should reserve for the future. The details of urban park development will be explained in later discussion.

2) Mixed Used Area (Urban Center and Sub Center)

Mixed Use Area has established for urban centers and sub centers. This could be categorized into the following four areas: Traditional and Heritage Center, Metropolitan Urban Sub Center, Other Urban Sub Centers, and Serviced Area. In terms of land use, these areas expect to hold office buildings, commercial facilities such as shopping mall, theater, and hotel, administrative office public service facilities, and transport terminal.

Since the Historical Center and Metropolitan Urban Sub Center was assumed to be the main hubs in Managua in terms of politics and economics, they should have central business district, large-sized commercial facilities, residence and so on. Metropolitan Urban Sub Center should allow having relatively large-sized facilities, modern infrastructure, and high-rise buildings in order to become an icon of the modern capital city and vertical development. Meanwhile, the land use of Traditional and Heritage Center has been planned by IDB, namely, “Plan Integral de

[11] Historical center is counted one category

Revitalización del Centro Tradicional y Patrimonial de Managua" and the Plan Maestro para el Desarrollo Urbano del Municipio de Managua (PDUM) respects their future plan.

Other urban sub centers, namely East, West, and Advanced Technology Urban Sub Centers are also proposed to comprise administrative office, commercial, residence, public facilities, and transport terminal though the building volume will be smaller than the Metropolitan Urban Sub Center and Traditional and Heritage Centers. Lastly, the Service Area, which are the four areas allocated in the vacant area of the bus terminal removal[12], shall have public services such as hospital and administrative office and some commercial accumulations. This area also has less development volume compared to major urban centers; however, it is expected to provide the local services at the district level.

3) Housing Area

A variety of housing areas are proposed and are the following: High-rise Residential, Middle-rise Residential Area, Low-rise Residential Area, Exclusive Low-rise Residential Area, and Sub Urban Low-rise Residential Area. High-rise Residential Area is included in Mix Use Area and to be from five- to fifteen- story apartment or condominium in the proposed urban sub centers. Middle-rise Residential Area is expected to trigger densification in Managua located within 500 m from the future public transport route so as to keep the accessibility. Three- or four-story apartments are considered to be dominant in this area. Accumulation of people along the public transport route is expected to increase public transportation users and to reduce traffic congestions. Besides, the house with good transport accessibility could attract people to live in collective housings rather than detached houses.

Low-rise Residential Area, consisting of one or two-story house and apartment, is proposed to be divided into three categories by area. Low-rise Residential Area to be similar with existing housing form and to be applied to existing residential areas. The difference between Low-rise Residential Area in Urban and Sub Urban Areas is the capacity of the building such as floor area ratio and building coverage. From this aspect, the house in Sub Urban Area is considered to be more spacious than in the Urban Area.

Exclusive Low-rise Residential Area, which is only allowed to have housings without any commercial developments, is established in the east side of the Traditional and Heritage Center so as to avoid further sprawling of the Oriental Market. For tackling this issue, restriction rules of land use conversion from residence to commercial are also necessary to apply such as an ordinance of development permission. Fundamental redevelopment plan for the market should also be considered as a matter of course.

[12] Existing but terminals are proposed to relocate into Urban Sub Centers as explained in Chapter 10.

Lastly, some existing built-up areas located in the south of the airport and rural areas are proposed as an Environmental Sensitive Area to prevent further developments taking into account that the land belongs to the aquifer area or the unsuitable development area.

4) Commercial Area

As for the commercial area, two categories are proposed: Commercial Area and Neighborhood Commercial Area. Commercial Areas should have relatively large-sized plots with office, shopping mall, hotel, and other businesses but not for residences, and should be located in a good accessible area such as along the future public transport route and major roads. On the other hand, Neighborhood Commercial Area is proposed to be of mixed land use not only for businesses and commercial facilities but also for residences. The expected commercial functions in this area are retail, small-scale office, and services. This area is supposed to be located along the future public transportation route.

5) Industrial Area

As for the Industrial Area, two categories are proposed: Industrial Area and Exclusive Industrial Area. In consideration of the existing industrial location that is in the northern part of Managua City, more precisely mainly in between the Pan-American Highway and the Managua Lake, these areas are categorized as Industrial Area where there are existing light industry, small-scale factory, small-sale commercial including retails and restaurants, and residences. Meanwhile, the Exclusive Industrial Area, which is located at the east of the airport, should have light industries, export processing and large-sized factories only. This area has already started accumulating the factories and stockyards. Exclusive Industrial Area could contribute to formulate industrial cluster in order to develop appropriate industrial environment and smooth logistics.

6) Public Utility Area

In taking account of the function, Public Utility Area is divided into the following four categories: Public Institution Area, Educational Facility Area, Transport Facility Area, and other Public Facility Area. In general, the public utility areas are to be allocated as they are located now, except for the Transport Facility Area since the existing seven bus terminals are proposed to be moved and integrate into three terminals in the urban centers.

7) Land Use Category

From all the aspects of the land use planning policy explained above, the land use categories are summarized as follows:

Table 9.4.9 Category of Future Land Use 2040

Land Use Category		Description	Remarks
CONSERVATION	Urban Green Area	Location • Mainly located in the Urban Area.	In addition to the existing urban park, some open

Land Use Category		Description	Remarks
		Purpose • Providing resting and recreation places for citizens • Betterment of landscape • Improving urban environment Applied Area • Urban park • Recreation area • Golf course	space proposed as Urban Green Area where there is lack of urban park.
	Sub Urban Green Area	Location • Mainly located in Sub Urban Area between built up area and Environmental Sensitive Area Purpose • Buffer against urban sprawl Applied Area • Agricultural area • Green area and open space • High risked area of natural disaster in Urban Area	New land development is prohibited.
	National Park	Location • Tiscapa, Asososca, and Nejapa lagoons and surroundings Purpose • Protecting Natural Reserve Area defined by MARENA • Protecting water resource Applied Area • National Parks • 150 m buffer from coastal line of lagoon	Land development is prohibited.
	Environmental Sensitive Area	Location • South and east area of Managua City Purpose • Protecting natural resources such as forest, slope, and aquifer areas • Avoiding land development in high risk disaster area • Controlling urban sprawl Applied Area • Steep and slop area • Agricultural area • Coastal area • Aquifer area • Existing residential area in part of Sub Urban and Rural Areas	New land development is prohibited.
	Waterbody	Location • Managua Lake, Tiscapa, Asososca, Nejapa and Acahualinca Lagoons Purpose • Protecting water resources and environment	Land development is prohibited.

Land Use Category		Description	Remarks
		Applied Area • Lake and Lagoon	
MIX	Metropolitan Urban Sub Center	Location • Facing the public transport axis • Along Masaya Road between Suburbana and Jean Paul Genie Roads Purpose • Formulation of urban core and supporting Historical Center • Providing working places for accommodating increased working population • Enhancement of economic activities for attracting private and international investor • Providing transportation hub Expected Function • High-rise Apartment and condominium • Large-sized office and business with international standards • Large-sized commercial including shopping mall • Recreation facility • Large-sized hotel • Conventional hall • Intermodal transport facility including public transport terminal • Administrative office	High-rise building is available.
	Other Urban Sub Center	Location • Facing the public transport axis • West Urban Sub Center: along Subrubana near Nejapa Lagoon • Advanced Technology Urban Sub Center: along Suburbana near the American University and UCA • East Urban Sub Center: along Panamerican Highway near the airport Purpose • Formulation of urban core and supporting Metropolitan Urban Sub Center • Providing working places for accommodating increased working population • Enhancement of economic activities for attracting private investor • Providing transportation hub • Establish knowledge center* Expected Function • Apartment and condominium • Large-sized office and business • Large-sized shopping mall • Large-sized hotel	Middle-rise building is available.

Land Use Category		Description	Remarks
		• Intermodal transport facility including public transport terminal • Administrative office • Research center* • Conference hall*	
	Historical Center	*Refer to the IDB's plan*	
	Serviced Area	Location • Vacant area of bus terminal removal Purpose • Formulation of local center for supporting Urban Sub Centers • Providing social services Expected Function • Local administrative office • Social services such as hospital, educational facility, and police office • Middle-scale commercial	Middle-rise building is available
HOUSING	Middle-rise Residential Area	Location • Mainly along the public transport axis (500 m from the route) Purpose • Enhance densification and contribution to control urban sprawl for making compact city • Increase public transport users Expected Function • House and apartment • Small scale industry • Small scale commercial	Middle-rise building is available. Expected density ranges between 142 and 300 person/ha.
	Low-rise Residential Area	Location • Mainly existing housing area beyond Middle-rise Residential Area Purpose • Keeping existing housing area Expected Function • House and apartment • Small scale industry • Small scale commercial	Low-rise building is available. Expected density ranges between 142 and 160 person/ha.
	Exclusive Low-rise Residential Area	Location • Mainly eastside of Oriental Market Purpose • Controlling the expansion of Oriental Market • New commercial and industry developments are not allowed • Providing better quality housing area Expected Function • House and apartment	Low-rise building is available. Expected density ranges between 142 and 160 person/ha.

Land Use Category		Description	Remarks
		• Existing commercial and industry	
	Sub Urban Residential Area	Location • Mainly southwest of Managua City in Sub Urban Area Purpose • Providing low dense housing area Expected Function • House and apartment • Small scale industry • Small scale commercial	Low-rise building is available. Expected density ranges between 80 and 136 person/ha.
COMMERCIAL	Commercial Area	Location • Mainly facing the public transport axis and major roads Purpose • Providing middle-scaled commercial activity area • Keeping existing commercial area Expected Function • Office • Retail and shop • Market • Hotel and tourist accommodation • Restaurant	Middle-rise building is available
	Neighborhood Commercial Area	Location • Mainly along the public transport axis and major roads Purpose • Providing area for small- to middle-scaled commercial activity • Keeping existing local commercial area Expected Function • Small-sized office • Small-sized retail and shop • Local market • Small hotel and tourist accommodation • Restaurant • House / shop house (dwelling with shop)	Middle-rise building is available
INDUSTRY	Exclusive Industrial Area	Location • Westside of Managua City near the airport Purpose • Providing area for heavy industry • Centralizing large-scale factories for increasing efficiency and less impacts on social impacts such as traffic congestion of large-size vehicle and air and water pollution Expected Function • Heavy industry • Light industry • Large-sized factory • Small-scale commercial	Housing and large-scale commercial development is prohibited.

Land Use Category		Description	Remarks
	Industrial Area	Location • Northwest of Managua City near Panamerican Highway (existing location of industrial accumulation) Purpose • Keeping existing industrial activity Expected Function • Small-sized factory • Small scale commercial • House	
PUBLIC FACILITY	Public Institution Area	Location • Existing location of public institution area Purpose • Keeping existing function Expected Function • Government office • Institutional office • Small-scale commercial	
	Educational Facility Area	Location • Existing location of large-sized educational facility Purpose • Keeping existing function Expected Function • University / college • Vocational school • Higher educational school • Other large-sized school • Dormitory • Small-scale commercial	
	Transport Facility Area	Location • Airport and port: existing location • Depot for mass transit transport (northeast of Managua City near the Masaya Road and west of the city near West Urban Sub Center) Purpose • Keeping existing function (airport and port) • Securing the land for depot looking ahead to public transport development Expected Function • Airport • Port • Depot for mass transit • Other transport related facility	

Land Use Category		Description	Remarks
	Public Infrastructure Facility	Location • Existing location of public infrastructure facility Purpose • Keeping existing function Expected Function • Infrastructure facility • Dumping site	
	Other Public Facility Area	Location • Existing location of other public facility Purpose • Keeping existing function Expected Function • Religious area • Sport field • Recreation facility	

Note: * is only Advanced Technology Urban Sub Center
Source: JICA Study Team and ALMA

The proposed land use category in 2040 consolidates the idea of existing zoning mostly. Comparative categories between the zoning and future land use are summarized in Table 9.4.4.

Table 9.4.10 Comparison of Existing Zoning and Future Land Use 2040

Existing Zoning	Land Use Category 2040	Remarks
Mixed Use		
• Commercial Zone (Ce1)(Ce2) • Housing Zone (Vac1)(Vac2-1)(Vac2-2) • Service Mix Zone (Sm) • Housing and Service Mix Zone (Mvs1)(Mvs2) • Special Commercial Zone (Ce) • Cultural Zone (Cu1)(Cu2)(Cu3) • Government Institutional Zone (Ig) • Institutional Zone (It) • Recreation Zone (Rac-1)(Rac-2) • Tourism Zone (T) • Sport Zone (D) • Public Transport and Terminal Zone (Tt1)(Tt2)	• Traditional and Heritage Center	Refer to IDB's Plan
• Sub Center Zone (C-2) • Public-Private Investment Zone (Z-IPP)	• Metropolitan Urban Sub Center • Service Area	
• Distichal Sub Center Zone (C-3)	• Other Urban Sub Center • Service Area	
Housing		
• High Density Housing Zone (V-1)	• Middle-rise Residential Area	
• Medium Density Housing Zone (V-2) • Low Density Housing Zone (V-3)	• Low-rise Residential Area • Exclusive Low-rise Residential Area	
• High Density Housing Zone in Farm Area (ZQ-1)	• Sub Urban Low-rise Residential Area	Some areas

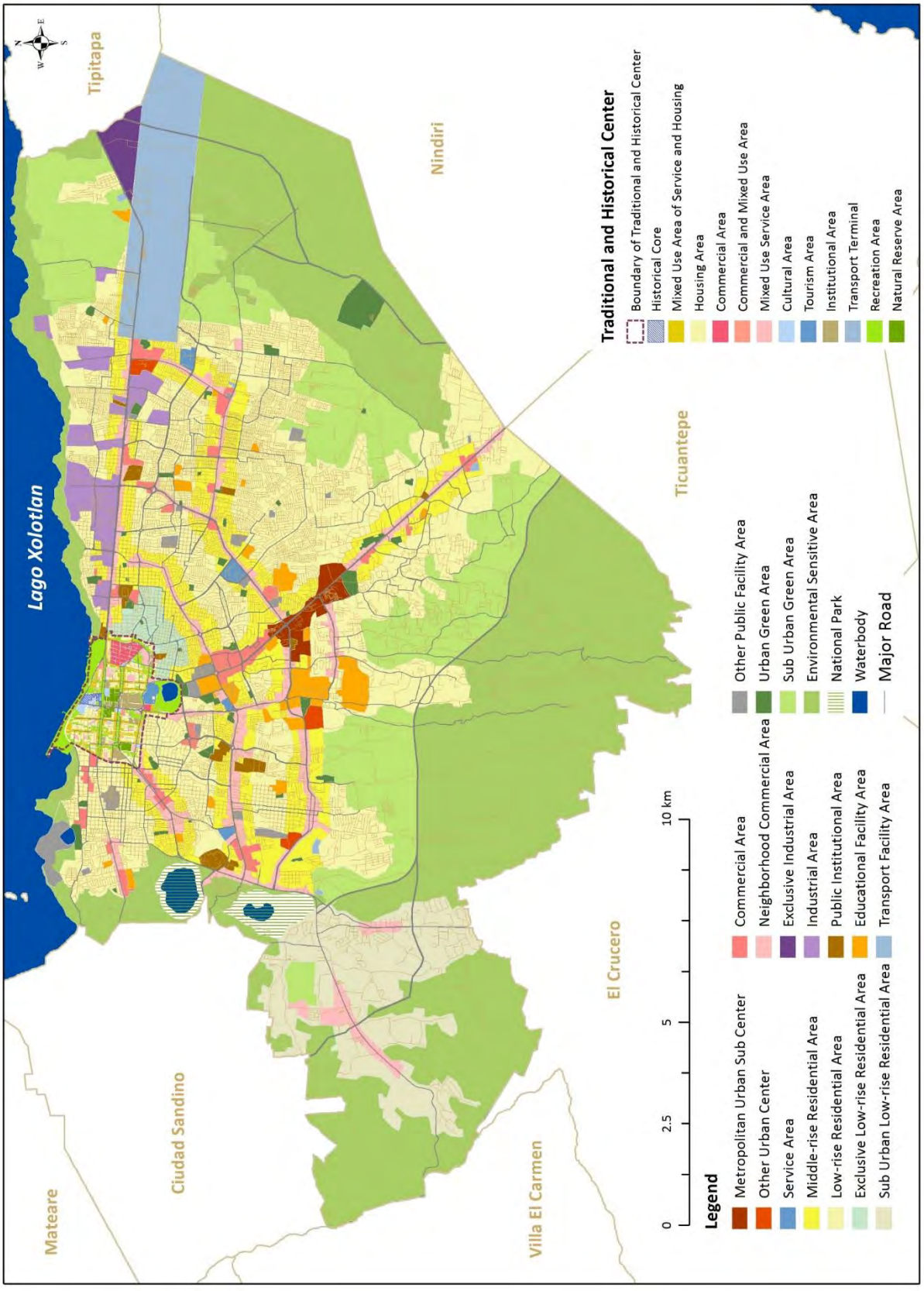
Existing Zoning	Land Use Category 2040	Remarks
• Medium Density Housing Zone in Farm Area (ZQ-2) • Low Density Housing Zone in Farm Area (ZQ-3) • Village Concentrate Zone (PB)		belong to Sub Urban Green Area or Environmental Sensitive Area
Commercial		
• Commercial and Service Corridor Zone (C-S) • Commercial and Tourism Corridor Zone (C-CT)	• Commercial Area	
• Housing and Service Corridor Zone (V-S) • District Level Commercial and Service Zone (C-SD) • Access Corridor Zone to Sub Urban Area (CA-1) • Access Corridor Zone to Sub Urban Agricultural Production Area (CA-2) • Access Corridor Zone to Metropolitan Area (CA-3)	• Neighborhood Commercial Area	
Industry		
• Light Industry Production Zone (PI)	• Exclusive Industrial Area	
Newly proposed	• Industrial Area	
Public Facility		
• Special Institution Zone (EI-E)	• Public Institution Area	
	• Educational Facility Area	
• Air Transport Zone (ET-1) • Urban, Interurban and Rural Land Transport Zone (ET-2)	• Transport Facility Area	
• Natural Reserve in Cemetery Zone (RN-4)	• Other Public Facility Area	
Conservation		
• Natural Reserve in Urban Park Zone (RN-3)	• Urban Green Area	
• No Intensive Agricultural Production Zone in Rural Area (PA-1) • Intensive Agricultural Production Zone in Rural Area (PA-2) • High Density Housing Zone in Farm Area (ZQ-1) • Medium Density Housing Zone in Farm Area (ZQ-2) • Low Density Housing Zone in Farm Area (ZQ-3) • Village Concentrate Zone (PB)	• Sub Urban Green Area	Some areas belong to Sub Urban Low-rise Residential Area
• Natural Reserve in National Park Zone (RN-1)	• National Park	
• Protection Zone of Erosion in Rural Area (PC-1) • Protection and Conservation Zone of Steep Slop Area (PC-2) • Protection Zone of Forest and Aquifer Area (PC-3) • Natural Reserve in Coastal Zone (RN-2)	• Environmental Sensitive Area	

Existing Zoning	Land Use Category 2040	Remarks
• LAGUNA	• Waterbody	

Source: JICA Study Team and ALMA

(2) Land Use Plan 2040

For taking account of the basic planning policies explained above, the future land use plan is established and is illustrated in Figure 9.4.15. This land use plan is based upon the existing zoning map, aerophoto image in 2015, the existing land use in 2016, disaster analysis data, land evaluation data, and other relevant spatial data.



Note: The Future Land Use Plan is Version 3.0 as of May 12, 2017

Figure 9.4.15 Future Land Use Plan 2040

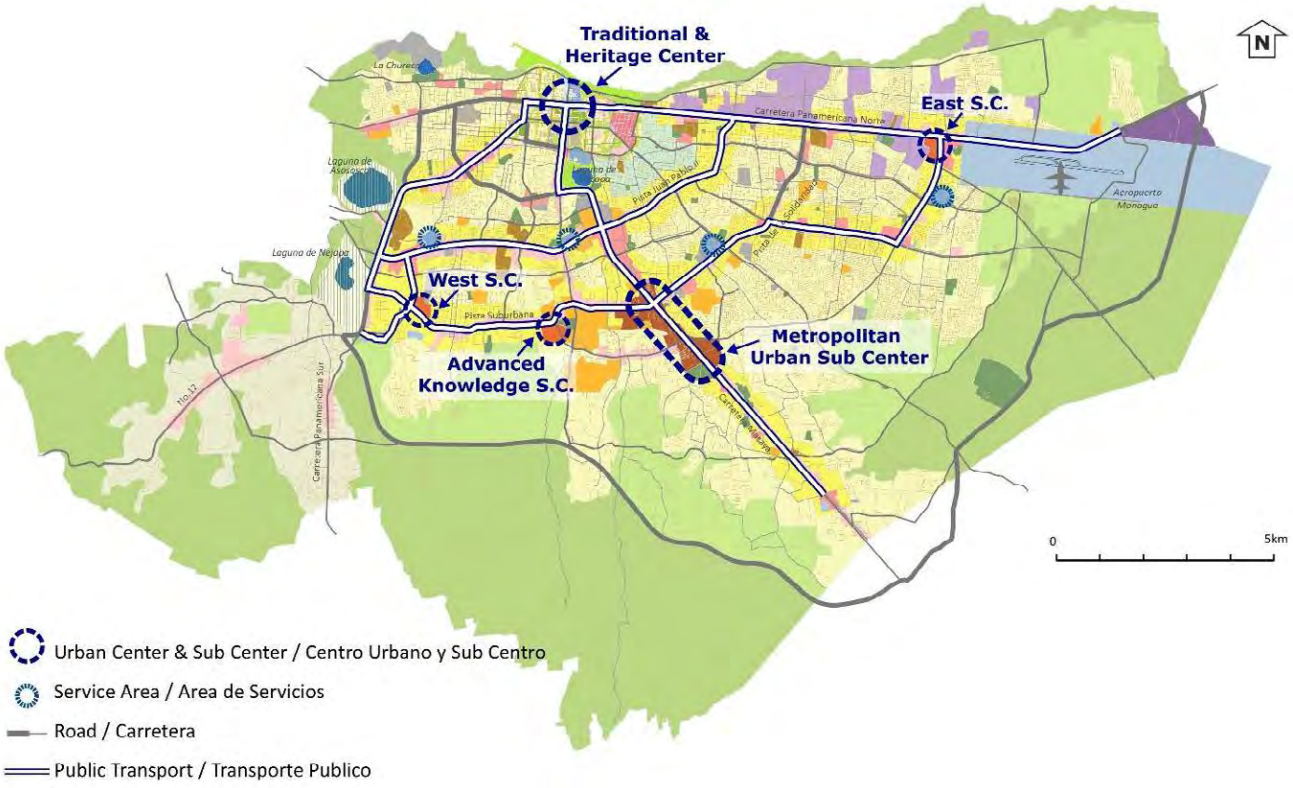
The area of each category in the future land use plan is calculated and shown in Table 9.4.5. The urbanization area is around 13,700 ha which accounts for 51% of the total land based on the future land use plan.

Table 9.4.11 Category of Future Land Use 2040

Land Use Category	Area (ha)
Mix Use Area	**870**
Metropolitan Urban Sub Center	160
Other Urban Sub Center	60
Historical Center	590
Serviced Area	60
Residential Area	**9,320**
Middle-rise Residential Area	2,060
Low-rise Residential Area	5,610
Exclusive Low-rise Residential Area	200
Sub Urban Low-rise Residential Area	1,450
Commercial Area	**1,280**
Commercial Area	320
Neighborhood Commercial Area	960
Industrial Area	**570**
Exclusive Industrial Area	130
Industrial Area	440
Public Facility Area	**1,680**
Public Institution Area	120
Educational Facility Area	350
Transport Facility Area	1,010
Other Public Facility Area	200
Conservation	**13,240**
Urban Green Area	270
Sub Urban Green Area	3,190
National Park	290
Environmental Sensitive Area	9,480
Waterbody*	10
Urbanized Area	**13,700**
Conservation Area	**13,260**
Total	**26,960**

Note: Waterbody is only Laguneta de Acahualinca. Tiscapa, Asososca, and Nejapa are included in National Park.
Source: JICA Study Team

The spatial relation between the future urban structure and land use is illustrated in Figure 9.4.16.



Source: JICA Study Team

Figure 9.4.17 Urban Structure and Land Use Plan 2040

9.4.5 Further Steps for Land Control

The future land use plan is a general plan to show the development direction of Managua City. So as to control the land use appropriately to achieve the high anticipation of urban development in the future, detailed zoning map and its scheme need to be updated. As mentioned in Chapter 3, the current zoning system has problems such as variances with the existing land use, insufficiency of zoning map, complicated zonings, and openness of information to the public. New zoning map will be needed based on the future land use map discussed above, with a detailed scale, say less than 1:10,000, and simplified zoning categories and rules are recommended to prepare. Notably, revising the zonings for housing is essential in enhancing densification in Managua.

9.4.6 Proposal of Urban Development Promotion Zone

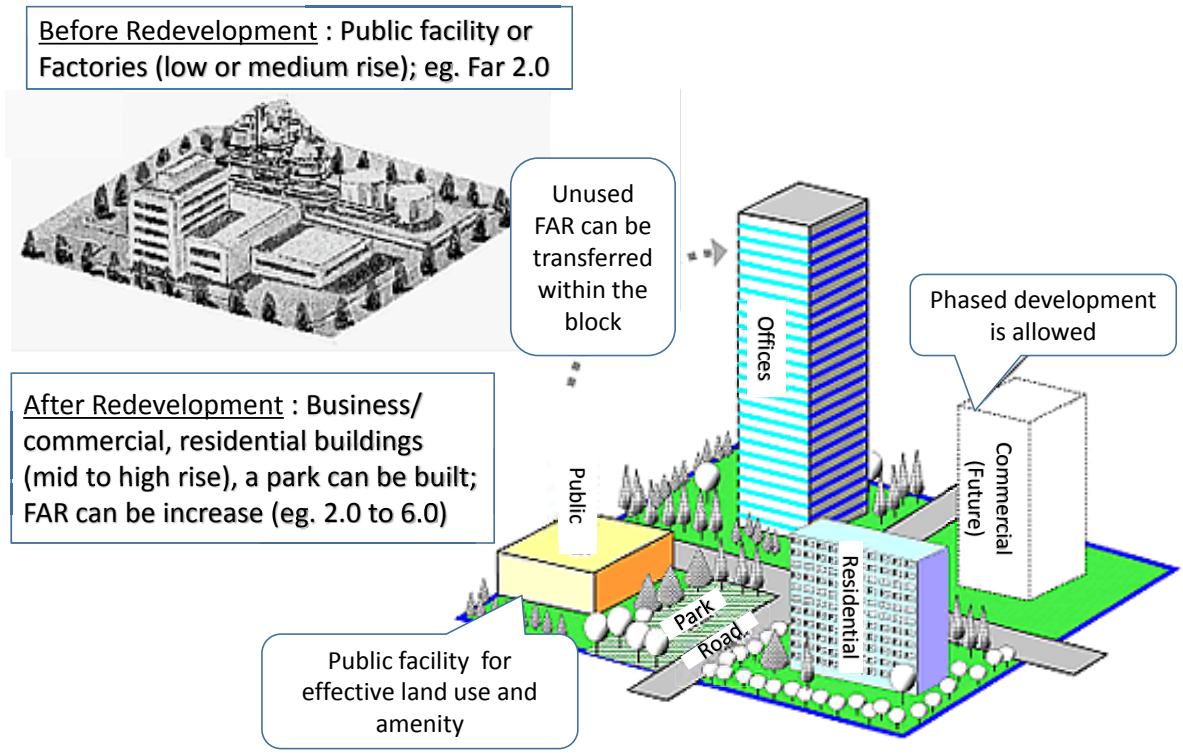
In order to promote redevelopment to convert unused or under used land into a high quality urban center or sub centers, a new system, called Urban Development Promotion Zone, is proposed below. Figure 9.4.18 shows a schematic chart of Urban Development Promotion Zone. Before the development, the block was typically of low-rise factories and or residential or administrative buildings. If the Urban Development Promotion Zone would be designated on this block, the whole block could be considered

as one plot of land, so that the unused FAR (say over a public building or a park) could be transferred for a high-rise building that may need an additional FAR.

Also, on the condition that good urban environment would be created with necessary roads, a park, and/or transport facilities such as a bus terminal, a bonus of FAR could be given for the block, say from 6.0 to 8.0 and height of the building could be 10 to 12. The bonus FAR would be a motivation for the private sector to introduce public facilities within the site. The public sector would bear the cost of building the facilities.

The urban development promotion zone is proposed to stimulate redevelopment of existing predominantly low rise, and low density zone into an urban center with effective use of land with high-rise office and/or commercial facilities with public facilities such as a park and/or a bus terminal. Most of the offices and/or commercial buildings will be built by the private sector and it will be easier for the public sector to secure land for the public facilities within the project site.

This method is called Incentive Zoning and is widely practiced in a number of countries including Japan and the United States of America (USA).



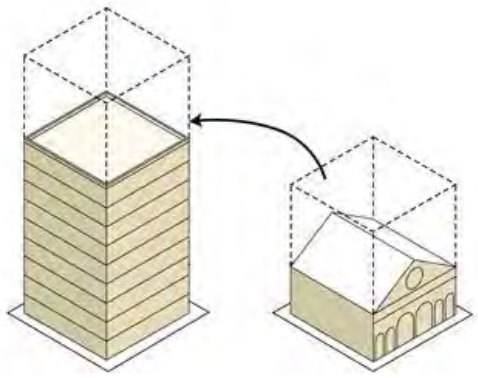
Source: JICA Study Team

Figure 9.4.18 Scheme of Urban Development Promotion Zone

Column

Transfer of Development Right (TDR) is a method to preserve historical heritages and to generate some funding to restore or rehabilitate the building practice in a number of countries. TDR was introduced in New York City in early part of the 20th century as a step to conserve historical heritage buildings. When a historical building with heritage value exists in the city center, often the height of the building is low and a large part of the designated FAR is left unused over the building. TDR enables this unused FAR be traded to other neighboring land plots where urban development is being considered. The unused FAR could be traded with transfer of money.

In recent years, TDR was successfully applied to the redevelopment of Tokyo Station in Tokyo and the money needed for the conservation and rehabilitation of Tokyo Station was paid by the trading of unused FAR by TDR. TDR may be considered for Managua in future.



Source: New York City

Figure Scheme of Transer of Development Right

9.5 GIS

9.5.1 GIS for Urban Planning

Variety of data, information, and maps were collected through this Project from ALMA, government agencies, and relevant agencies, in addition to data developed by the JICA Study Team. These collected data have been compiled/integrated in the numerical format or in the format of geographical data, so called GIS format and prepared as GIS database, for making further analysis and supporting to formulate the master plan.

GIS provides a means of integrating information to understand issues and problems facing Managua City today such as uncontrolled urbanization and traffic congestion. GIS shall help organize data regarding these issues and to understand their spatial relationships and patterns. These understandings shall lead to more sensitive and intelligent decision-making.

The following are basic features of GIS:

- Digitized geospatial data
- Data overlay
- Linkage to tabular data (attribute data)
- Data share
- Instrument for easy update of data

The above basic features allow users to develop GIS data, overlay wide range of data layers, and label or symbolize data using attributes from linked attribute tables. Multiple users can work with the same dataset independent of each other to browse and analyze data or to create maps of nearly any size or level of quality. In addition, updates posted to a centralized GIS database can be immediately available to all users.

In this master plan study, GIS was utilized not only as a database but also as one of the planning tools such as tools to evaluate land potential or to simulate urbanization as mentioned in Section 9.4 in this report. In addition, the primary objective of this GIS database development effort is for formulation of this urban development master plan, at the same time, it is expected to be used for further planning activities by the people concerned in the field of urban planning of Managua City.

9.5.2 Outline of GIS Database

A GIS database developed for this master plan study covers Managua City. This GIS database expects to utilize as a comprehensive planning tool for Managua City not only as a mapping tool. All of the GIS data included in this database were prepared in the same coordinate system to analyze multiple data analysis in spatially.[13]

The outline of GIS database is shown in Table 9.5.1.

Table 9.5.1 Outline of GIS Database

Dataset	GIS data	Remarks
Administrative Boundary	• Municipality boundary • District boundary • Barrio boundary • UTB	
Other Boundary	• Urban/ Sub-urban/ Rural area • Historical area • SEZ • Traffic Analysis Zone (TAZ)	
Land Use	• Existing land use 2016	
Natural Condition	• Slope condition • Elevation • Contour • Waterbody • Fault	

[13] All data was prepared in coordinate system “WGS1984/UTMZone16N

Hazard Information	• Flood prone • Land slide prone • Evacuation point	
Transport	• Road network • Bus stops • Bus routes	
Urban Infrastructure	• Water supply • Electricity supply • Sewage • Solid waste collection route	
Facilities	• Religious facility • Public facilities	
Development Constraints	• Natural reserve • Aquifer • Coastal zone • Forest • Green area	
Future Plans	• Sub centers • road network plan • public transport plan • land use plan	
Others	• Zoning map (current)	Converted from CAD format to GIS format and cleaned by PDUM
Satellite Imagery/ Aero photo	• Aerial photo	2002, 2005, 2010, and 2015 (year)

Source: JICA Study Team

9.5.3 Data Sharing and Dissemination

(1) Current Data Sharing and Dissemination Efforts by ALMA

There are various spatial data which are developed and managed by ALMA to provide better services to the public. Historically, spatial data in ALMA was developed by microstation. After the 1990s, it gradually started to develop spatial data in GIS format, but still, both formats exist in ALMA. To accommodate these various data and data format, Latino server was developed and managed by ALMA.

To access spatial data in ALMA, it is necessary to access via application which is developed by ALMA for the user purpose, while most of applications need to obtain permission for installation by ALMA management for data security and control of access level.

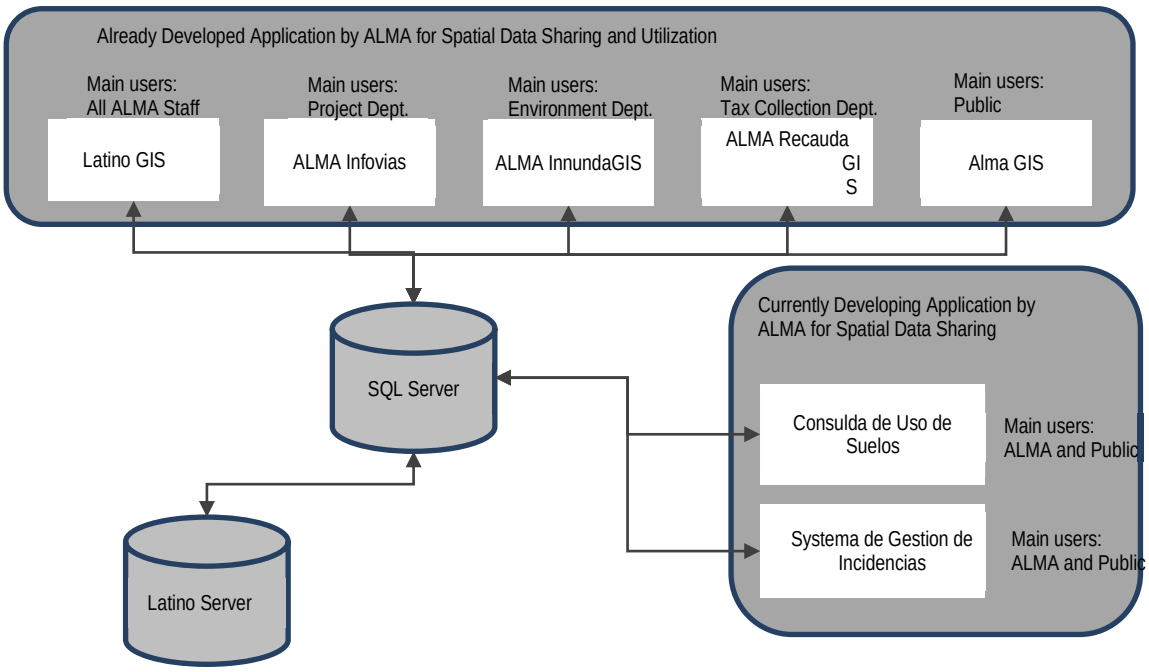
All of spatial data are stored in Latino server organized and managed properly by ALMA System department. The following are currently operating and developing application by ALMA.

Table 9.5.2Current Data Sharing Application in ALMA

Application	Main purpose	Main Function	Accessibility
Latino GIS	• General spatial data viewer for ALMA staff • Data editing (only for designated person)	• View, search, print spatial data • Some customized analysis tools • Data editing (only for designated person)	• Need access permission by ALMA • Data access level is controlled by ALMA
ALMA Infovias	• Spatial data viewer for Project Dept.	• View, search, print spatial data • Some customized analysis tools	• Need access permission by ALMA • Data access level is controlled by ALMA

ALMA Innunda GIS	• Spatial data viewer for Environment Dept.	• View, search, print spatial data • Some customized analysis tools	• Need access permission by ALMA • Data access level is controlled by ALMA
ALMA Recauda GIS	• Spatial data viewer for Tax Collection Dept.	• View, search, print spatial data • Some customized analysis tools	• Need access permission by ALMA • Data access level is controlled by ALMA
Alma GIS	• Spatial data viewer for Public	• View, search, print spatial data	• Anyone can access through WEB
SISCATNET	• Registering property information for taxation and provide property tax information to Public	• View, search, print spatial data	• Need access permission by ALMA • Data access level is controlled by ALMA
Consulda de Uso de Suelos (underdevelopment)	• To examine zoning system and related regulation by land plot to submit construction permit	• To examine zoning system and related regulation by land plot to submit construction permit	• Anyone can access through WEB
Systema de Gestion de Incidencias (under development)	• Information sharing with Public, such as Public facility location	• Information sharing with Public, such as Public facility location	• Anyone can access through WEB

Source: JICA Study Team



Source: JICA Study Team

Figure 9.5.1 Image of Spatial Data Sharing System in ALMA

(2) Newly Developing Application to Share Data with Public

In ALMA, efforts are being made to open data for the Public such as development of new web-based application named "Consulda de Uso de Suelo" mentioned in the previous section, and these efforts

would expand to provide better services to the Public. GIS and open data would provide various benefits and the following are possible benefits of GIS and open data[14]:

GIS and open data would provide:

- Improve basic functions of democracy and access to information.
- Provide a platform of innovation.
- Promote civic engagement.
- Encourage cross-jurisdictional and -agency data collaboration.
- Drive economic growth and value.
- Layer complex data to improve decision-making and reduce costs.
- Improve transparency for citizen engagement.
- Improve communications during a crisis.
- Improve data quality and create standards.
- Improve data quality because of the information being shared.

In the current system design of "Consulda de Uso de Suelos", data that would be able to access through the application are only "land plot", "administrative boundary", "zoning boundary", and "regulation and information", and it allows users limited functions such as "view" or "search" data. In a view from better and effectiveness of urban development process and contributing further in securing the transparency of ALMA activities, it should consider to open more data to the Public for their secondary use after fully considering data security and privacy. Opening data to Public is expected producing new or additional public services in collaboration with ALMA, private sector, and citizens.

The following data should be examined to open for the Public:

- Public facilities (government office, school, health facility, mercado, sports facility, parks)
- Public service: garbage collection location, public transport, evacuation area
- Urban infrastructure: road, bus route, water supply system, drainage system, power, power line (or electricity sully areas)
- Hazard information (flood, landslide, seismic, etc.)
- Population
- Urbanized area
- Land use plan
- Current land use

9.5.4 Next Steps of Utilization of GIS for Urban Planning

The database management, spatial data editing, mapping, and spatial analysis functions of GIS are useful in variety of areas of urban planning. Better planning shall be achieved through better data and

[14] GIS & OPEN DATA: Better Understanding Our World, govloop/ ESRI

information, and better data and information will come from better flow of data and information system including better data sharing.

As mentioned in the previous section, GIS database was developed and this GIS database will be handover to ALMA at the end of the Project. The JICA Study Team considers that the periodical updating of GIS database after the completion of this study would be indispensable for revising urban development master plan based on the updated land use, road network, and socioeconomic data with proper data management.

Regarding management of database, the IT section in ALMA manages Latino server which accommodate data from all departments include GIS data and the level of data management is quite well. Currently each department develop their GIS data, and submit it to the IT section, and then IT section integrates in the Latino server and manage it. This effort should continue to manage integrated database in ALMA otherwise data will be scattered and it might lead overlapping work among departments within ALMA.

(1) Formulate GIS data Update Plan

It is significantly important to update and manage GIS data and system properly in the view from sustainability. To manage data, including data update, is time consuming, needs budget, and requires a lot of manpower, but without proper management of data and system, the entire system will quickly be outdated and difficult to provide proper services to the public and ALMA staff. Thus, setting up proper procedure of managing data and system is essential to provide benefit to both public and ALMA.

Table 9.5.3 List of GIS Data to be Update (Recommendation)

Data	Update cycle	Remarks
Land plot	Every month	
Administrative boundary	Upon change occurs	
Zoning	Upon revision	Depends on update cycle of zoning
Land use plan	Upon update	Depends on update cycle of land use plan
Public facilities	Every year	ALMA has developed data in 2012
Public services	Every year	
Road, Bus route	Every year	
Bus route	Upon change occurs	
Water supply system, drainage system, power, power line	Every year	
Hazard information	Every 3-5 year	
Population	Every year	
Urbanized area	Every 3-5 years	
Current land use	Every 5-10 years	

Note: Data update cycle should fully considered urban development planning cycle
Source : JICA Study tTeam

(2) Standardization of GIS data

ALMA develops various GIS data and utilizes them for many purposes. To utilize valuable GIS data in various ways, there is still room to improve their capacity in a view from data management. To make managing data and system easier, it is strongly recommended the preparation of all spatial data in the same GIS format and using same coordinate system. Standardization of data would expand additional usage of data and system. Especially, it is essential to use GIS data prepared in projected coordinate system, not in geographic coordinate system, when user analyze multiple layer overlay.

Table 9.5.4 Recommended GIS Data Format

Vector Data Format	ESRI Shapefile or ESRI Geodatabase
Raster Data Format	ESRI Grid or Geotiff ※ECW (Enhanced Compression Wavelet) for Orthophoto
Coordinate System	Projected coordinate system: WGS84/ UTM16N

Source: JICA study team

(3) Data Sharing and Dissemination

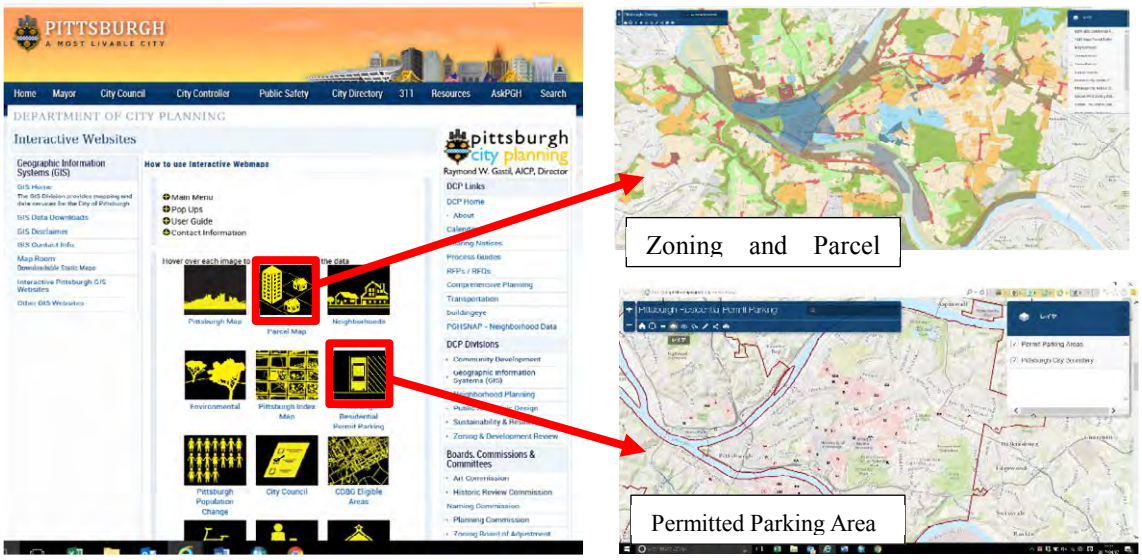
ALMA has already developed various applications to access GIS data within ALMA, and developing some web-based application to access GIS data by Public, but it is not yet a developed application to disseminate data related to urban planning with some analysis functions. Sharing data and information with Public would build better connection between Public and ALMA and achieve more efficient work within ALMA. Many of the cities have already introduced web based GIS application or GIS web portal to share and disseminate urban planning data, maps, and some analysis tools to Public to improve the efficiency and sophistication of operations of the city government activities. In urban planning operations in ALMA, it is possible to utilize web based urban planning GIS for providing information to public, speeding up the provision of information and data via internet and reducing time and space constraints, in addition to accumulate data for evaluation and revision of the master plan.

Table 9.5.5 Levels of Data Dissemination by Method

Level	Outline of contents	Available functions	Direction of information/ data	Remarks
Non-computerized	Provide thematic maps in hard copy (e.g. zoning map, land use map, transport network map, etc.)		ALMA to Public	
Simple Website	Provide thematic maps on web	View map only user cannot customize	ALMA to Public	
Web GIS App.	Provide maps with some basic functions (Web GIS techniques)	Search POI, Provide info about POI, Print/ Export Map as Image (PDF, jpg, etc.) User cannot customize	ALMA to Public	*"Alma GIS" and "Consulda de Uso de Suelos" developed by ALMA are this level of web application*
Advanced Web GIS App.	Provide maps with some analysis functions	In addition to functions above, download data, find	Interactive information	

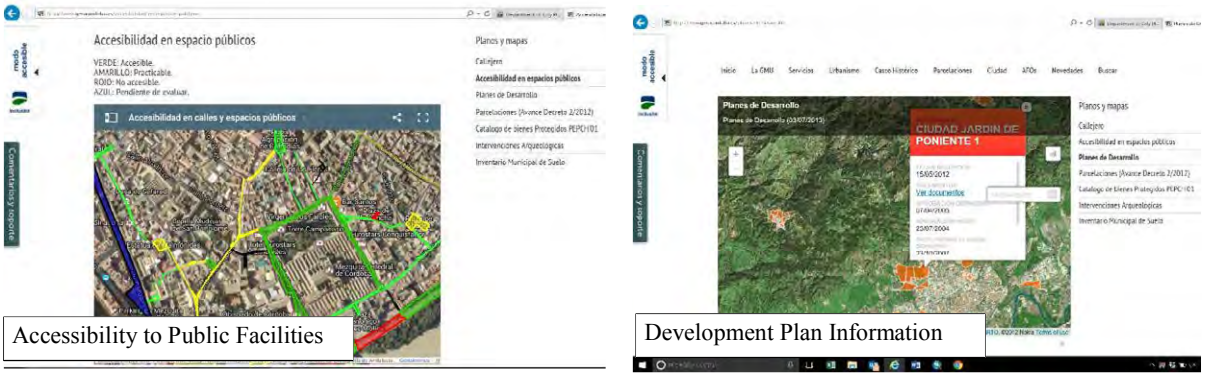
		nearest facility, and analyze service coverages, etc.	exchange between ALMA and Public	

Source: JICA study team



Source: http://pittsburghpa.gov/dcp/gis-webmaps-new

Figure 9.5.2 Sample of Data Sharing using Web GIS (Pittsburgh, USA)



Source: http://www.gmucordoba.es/servicios/planos-y-mapas

Figure 9.5.3 Sample of Data Sharing using Web GIS (Cordoba, Spain)

(4) Development of Micro-level GIS data

Currently, it is difficult to understand population distribution in Managua City in micro level such as population by Barrio and this leads to a kind of difficulty to allocate optimal public services and facilities. Since ALMA already developed land plot data in GIS format and maintain the data daily basis, it is better to utilize land plot data with demographic information and accumulate data for further analysis such as service coverages of public facilities and allocation of urban infrastructures. In Nicaragua, last population census survey implemented in year 2005 and next survey will be carried out in a few years by INIDE. Therefore, ALMA should coordinate with INIDE in implementing population census to utilize their micro level demographic data to enhance detailed urban analysis.

9.6 Proposed Projects (Long List) for Urban Planning Sector

In order to implement the master plan explained above, the necessary projects for urban development are identified as listed below.

Table 9.6.1 List of Proposed Projects for Urban Development

Project Name	Objective	Implementation organization	Project Component	Cost (USD)
Urban Planning Capacity Building Project	The capacity of Urban and Environmental Department, ALMA is enhanced	Urban and Environmental Department (ALMA)	Capacity Building for Urban Planning • Zoning Schemes for Entire Managua City • Applied Use of GIS System in Managua • Pilot Project for Survey and Planning of Metropolitan Urban Sub Center • Pilot Project for Residential Area Redevelopment Area	1.43 million for personnel expense
New CBD Development Project in Carretera Metropolitan Urban Sub Center	• To create a new CBD accommodating business, commercial, and some public administrative functions in harmonized environment and good transport services; • To improve transportation network by creating a multimodal terminal where people can switch from public transport such as intercity mass transit to intra city services • To provide a model for four other proposed CBD and/or Service Centers	Project Department (ALMA) Planning Department (MTI)	(1) Survey of Current Land Use • Land use and ownership of the new CBD zone • Land use and ownership of Options 1, 2, and 3 (2) Zonal Plan for New CBD Area • Basic Zonal Development Plan for New CBD area • Proposal of New Zoning Plan for New CBD area • Basic Infrastructure Plan for New CBD area • Basic Plan for New CBD Core (30 to 40 ha) (3) Development of New CBD Core • Overall coordination of Public and Private Partnership • Infrastructure Development (Public) • New CBD Core (Public Portion) Development • New CBD Core (Private Portion) Development	1,231 million
Residential Zone Redevelopment Project	• To densify low-rise residential area with one- or two-story housing units into Middle-rise Residential Area with collective housing units; • To provide a model for comfortable and pleasant urban living environment; and • To densify the population density to make way for a “compact city”	Project Department (ALMA)	(1) Survey of Current Land Use • Selection of project site • Survey of present land use and urban characteristics of the site (2) Zonal Plan for Redevelopment • Basic zonal development plan • Consideration of private development scheme for implementation	1,667 million

			• Role of public sector in smooth implementation (3) Implementation of Residential Zone Redevelopment Project • Temporary resettlement planning • Site preparation • Construction of collective housing units and common Service facilities • Commissioning	
Urban Park Development Project	To develop new large sized parks such as urban and neighborhood parks in Urban Area	Architecture / Project Department (ALMA)	• To keep the potential land for urban parks in un-serviced area • To develop new parks in open space • To redevelop the government land into urban parks by means of relocation of government offices	265 million
Public Awareness Project for Compact City Planning	• To distribute the information of the master plan and concept of compact city by means of brochure, leaflet, poster, seminar, and media. • To assist increasing earthquake proof buildings • To promote living in mid-rise housing • To encourage public transport users	Planning, Architecture, and Project Department	• Distribution the information of the master plan and promotion of moving from low-rise house to mid-rise house • Support of earthquake proof buildings by means of benefits such as technical assistance, subsidy and deregulation.	25,000 for information distribution
Revision of Address System Project	The capacity to deliver services by Urban and Environmental Department, ALMA is enhanced	Cadastral Department and Urban and Environmental Department (ALMA)	Capacity building to deliver better services by Urban and Environmental Department, ALMA • Formulate revised address system • Develop GIS based address map and data • Design and development of web portal to utilize and disseminate revised address system • Management and maintenance of GIS data and web portal • Pilot Project: Utilization of revised address system (one or two districts in Managua) • Preparation of draft bill for revised address system	1.0 million for personnel expense

Source: JICA study team

9.6.1 Technical Assistance Project for Urban Planning Sector

The master plan needs to be implemented and revised regularly by ALMA after PDUM. It is, thus, necessary to update the zoning system (revised in 2004) in accordance with the future land use plan considered in PDUM. However, the capacity of the Urban and Environmental Department, ALMA, who is in charge of the zoning system, is weak due to inexperience in the revision of zoning including the preparation of zoning map, appropriate revision of zoning terms, and the procedures regarding participatory approaches. Besides, the publishing of the zoning system is urgently required to lead and encourage suitable urban developments for the private sector. Furthermore, since the master plan should be reviewed periodically for keeping healthy urban development, the necessary data related to review such as socioeconomic data, infrastructure data, and traffic data should be collected regularly and analyzed for urban development. GIS is one of the appropriate tools to manage an integrated database and is useful to spatial analysis. Even with the capacity to use GIS, the Urban and Environmental Department is simply unfamiliar with such data management and analysis.

In addition, the proposed middle-rise residential development and Metropolitan Urban Sub Center development are both essential to lead and stimulate the compact city development, while ALMA is not experienced in the preparation and implementation of such plans.

In PDUM, a series of TWG meetings and on-the-job training (OJT) for GIS operation as one of capacity building activities had been carried out during the entire study period[15]. The TWG meeting had many opportunities to discuss on the zoning scheme and middle-rise housing development by introducing practical examples in foreign countries including Japan, while OJT for GIS includes how to operate the systems. However, since the urban planning sector is still broad even though focusing on relevant topics, more practical skill deems to be improved for implementation of the MP. Therefore, technical assistance for capacity building is expected in the following fields: 1) applying zoning scheme based on the future land use plan followed by its publishing, 2) relevant information collection and analyses by using GIS for revising the master plan periodically, and 3) encouraging middle-rise housing development along the public transport corridors.

9.6.2 New CBD Development Project for Metropolitan Urban Sub Center

As mentioned in 9.2.1, it is necessary to create a new urban center in order to accommodate growing business and commercial demands. A new center along Masaya Avenue will serve as a new international business and finance center, providing areas for large-scale or international businesses that require space for developments such as regional headquarters and branch offices. In addition, Metropolitan Urban Sub Center will also include high-rise hotel and residential development as well as amenities such as shops and open space to support both business and residential populations. Therefore, the new sub center is expected to be a hub of living, working, and leisure, and consistent with the concept of compact city.

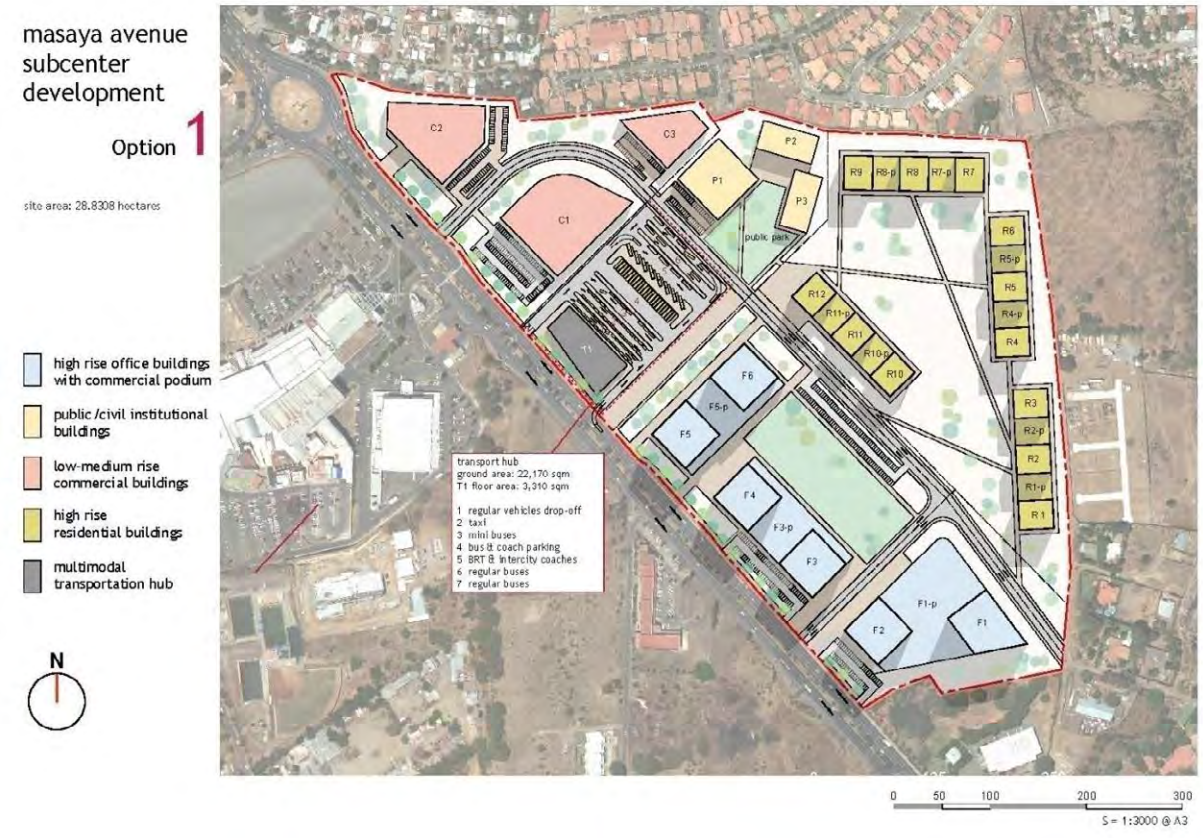
[15] Details of TWG meeting is explained in Chapter 6

With its strategic location at the intersection of major transit corridors on Masaya Avenue, the new center will also include a multimodal transportation interchange. Such interchange will substantially improve the current transportation network, allowing people to switch from public transport such as intercity mass transit to intracity services, thus, reducing reliance on private transport modes when travelling between home and work.

A major part of the new center will accommodate offices and retail functions, and thus, should be initiated by the private sector who seeks to build office buildings and/or shopping center and/or a hotel. It is advisable to have participation of international and domestic developer in collaboration with the public sector.

Part of the sub center will be dedicated to public facilities such as municipal offices, town halls, hospitals, and libraries. By locating some civic functions in the new sub center and with the connection of public transport, services will become more accessible and convenient to citizens.

With its integration of commercial, residential, public, and transportation functions, it will serve as a model for the other proposed service centers.



Source: JICA Study Team

Figure 9.6.1 Example of the Metropolitan Urban Sub Center Development

9.6.2 Housing Redevelopment Project

A large part of Managua City's built-up area is predominantly covered by one- to two-storey dwellings, providing little opportunities for public amenities such as green park and open space, car park, as well as spaces for small local businesses and retail. The horizontal spreading nature of low scale residential development is also a factor for urban sprawl. In order to densify the low-rise residential area and create a better living environment, residential development of higher density should be encouraged. Middle-rise residential area with collective housing blocks of up to four stories can provide a pleasant and comfortable living environment, while providing sufficient housing stock to accommodate the projected population growth. The creation of such housing redevelopment project should be considered a high priority, providing a prototype to the local residents in housing redevelopment.

The residential area development will include: 1) a review of the current land use of the candidate sites, 2) the preparation of a rezoning plan for the redevelopment, and 3) the construction of the redevelopment project and associated service facilities. Public consultation on areas to be promoted for redevelopment, as well as consultation over the use of public funding for housing should also be an integral part of the redevelopment process. In addition, consideration of private development scheme for implementation should also be made.

In the consideration of candidate sites for residential area development, it is also necessary to consider the current and proposed transport network. Sites along public transport corridors will greatly enhance the mobility of residents and minimize the use of private transport.

The Housing Redevelopment Project shall be initiated by the private sector, with some partial involvement of the public sector, which may provide for essential infrastructure such as road, sewerage, and/or public schools. Zooning scheme has to adapt to the needs of the Housing Redevelopment Project by providing a relaxed FAR, for example, in suitable areas. In total, there are 150 site areas presumed for the Housing Redevelopment Project in Managua.

Source: JICA Study Team

Figure 9.6.2 Examples of Medium-rise Residential Redevelopment Project

9.6.3 Urban Park Development Project

The area of the parks was approximately 295 ha in total, equivalent to 1.87 m^2/person in Managua in 2016. Compared to other cities such as 3.0 m^2/person in Tokyo and 11.6 m^2/person in Paris[16], Managua could be said to have insufficient urban parks and open spaces. Urban parks and open spaces can contribute to the following roles for a living environment improvement:

- Improvement in urban environment: the green lands can cut air pollution by vehicle emissions and mitigate heat island effect.
- Contribution to disaster management: the open spaces could be used as evacuation and recovery spaces and play a role of buffer zone when occurrence of fire spread.
- Providing recreation space: the urban parks supply places for recreation and communication of citizens.
- Betterment of urban landscape: the green sceneries can make the city attractive.

Compared to Sub Urban and Rural Areas where there are verdant areas as shown in the land use analyses (refer to Figure 9.1.1), there are limited green lands in the Urban Area. As illustrated therein Figure 9.6.3, there are several large and small parks, yet, the service area does not cover the entire Urban Area. Therefore, existing open spaces and green lands are recommended to be kept and developed for the new urban parks and open spaces, and in particular, be promoted for the uncovered service area of the Urban Area.

[16] Ministry of Land, Inrastructure, Transport and Tourism (MLIT) Japan, 2016

The total area of the unused lands such as open spaces and green lands in the Urban Area was approximately 1,500 ha in 2016, in which, 400 ha of land were located in the unserviced area. These unused lands were situated as shown in Figure 9.6.3 and could be clarified into the area for urban development and for future park according to the service area. The orange colored areas are appropriate for urban development, while the green colored ones are recommended to be kept for urban park or open spaces.

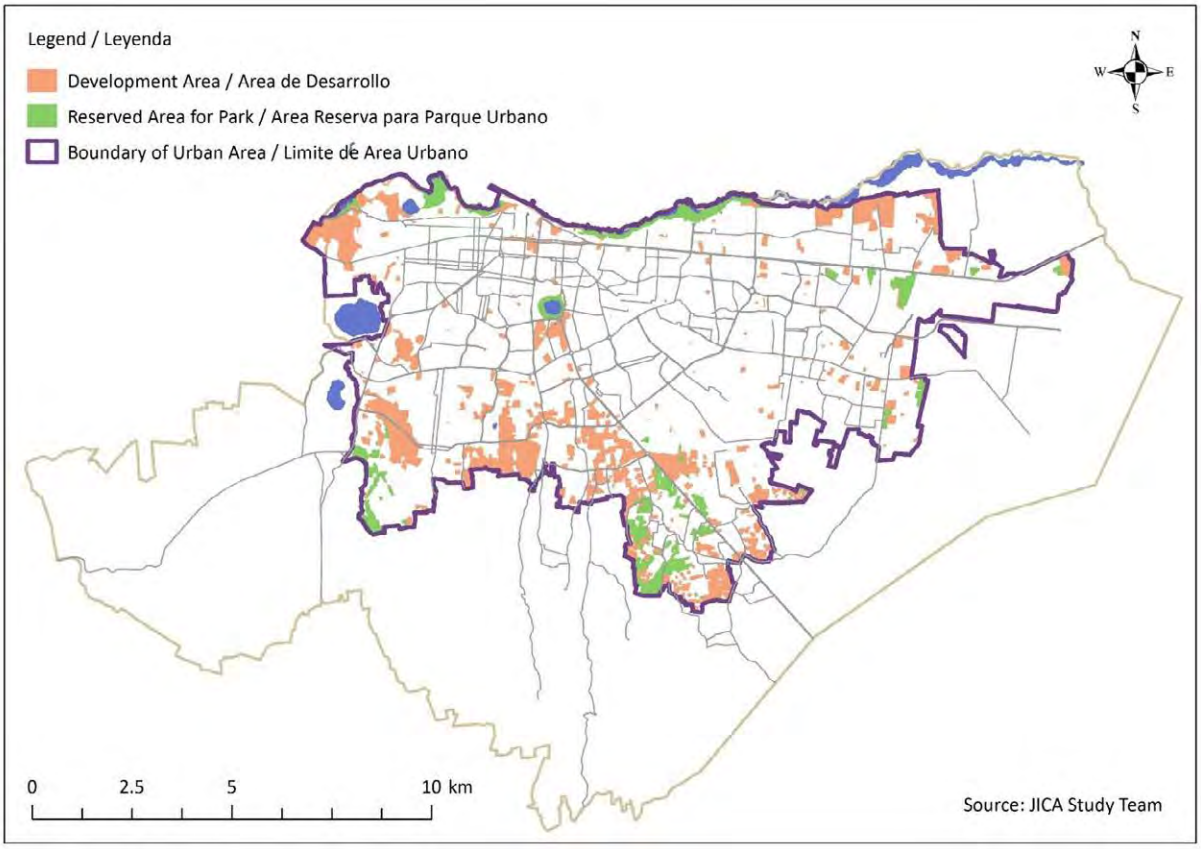
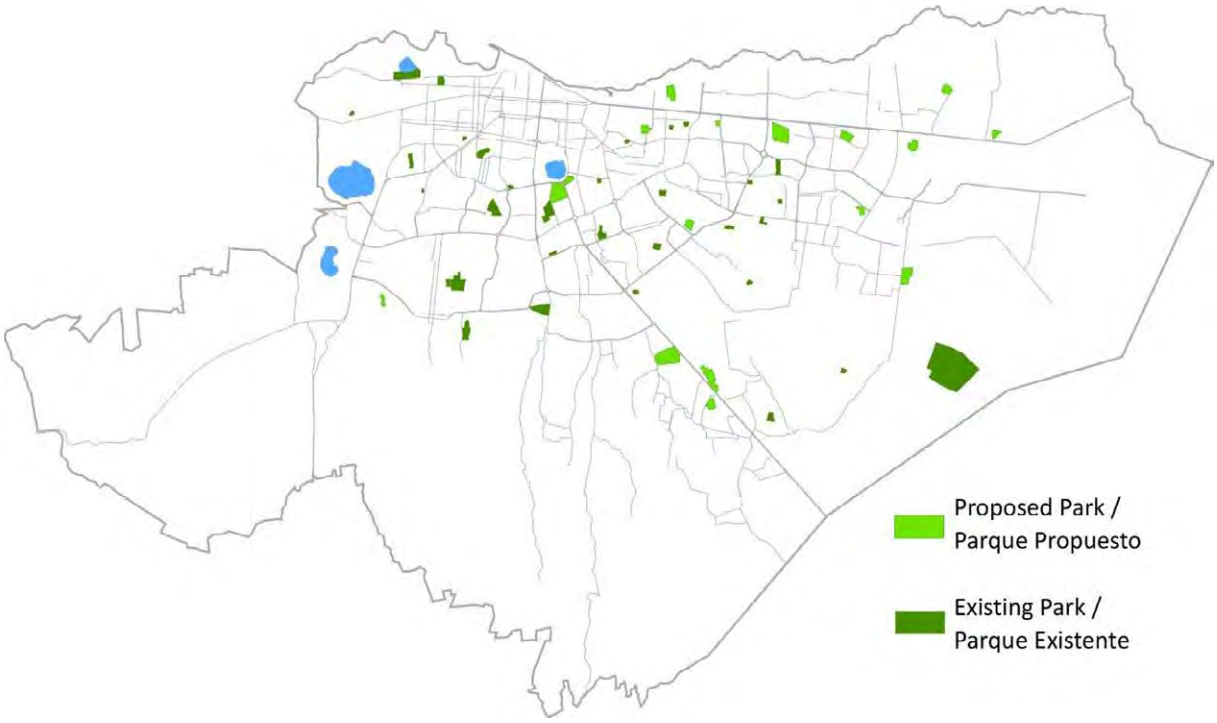


Figure 9.6.3 Open Space and Green Area for Development and Reserve

In accordance with the increase of urban population in 2040, new urban parks are recommended for the development in Managua. Especially in the large-sized potential lands such as open spaces, agricultural lands, and government lands, and should be kept for the development of urban and neighborhood parks because securing large spaces of land is difficult once the land is developed. The total area of the proposed park is around 117 ha as shown in Figure 9.6.4. Each land is over 2.0 ha which is appropriate for an urban and a neighborhood park. The park development could contribute to the rise of the average area of urban park per citizen.



Source: JICA Study Team

Figure 9.6.4 Land of Proposed Park Development

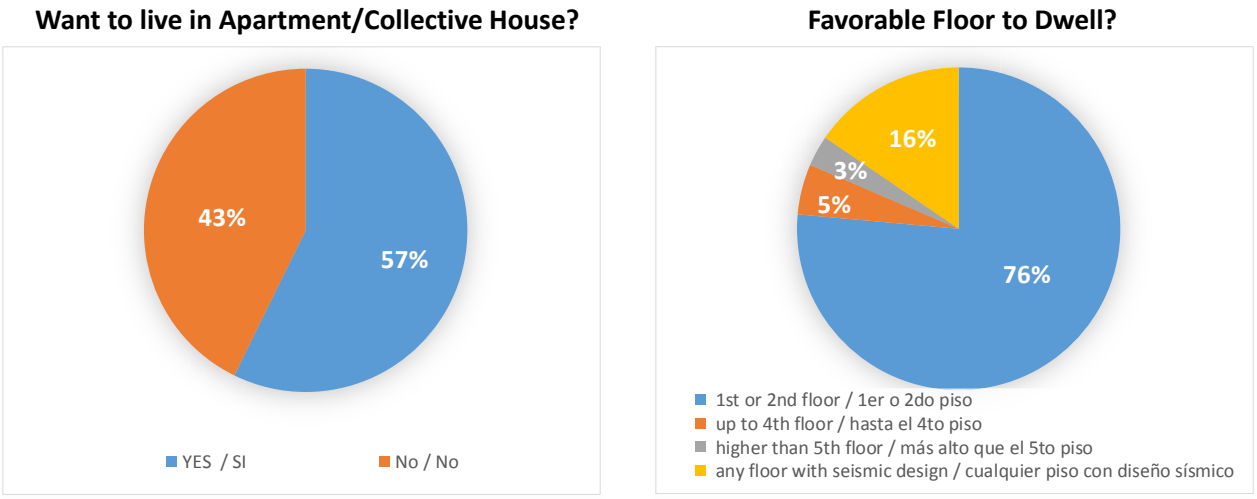
Table 9.6.2Urban Park and Population 2016-2040

Year	Total Area of Park (ha)	Population	Average Size of Park per person (m^2/person)
2016	295	1,579,032	1.87
2030	358	1,772,058	2.02
2040	412	1,940,078	2.12

Source: JICA Study Team

9.6.4 Public Awareness Project

In the master plan, the densification measure is advocated in order to make a compact city in Managua, the citizen's awareness and understanding of the master plan is vital for bringing it forward. Notably, according to the result of HIS, the people in Managua prefer living on the lower floor of the buildings than the upper ones, due to their persistent fear of earthquakes as shown in the following data of favorable houses.



Source: JICA Study Team

Figure 9.6.5 Favorable House: Result of HIS 2016

In case the existing low-rise development is kept continually, the urbanization would disperse outwards, which would be the opposite direction of a compact city. As the master plan said, middle-rise housing needs to become dominant in Managua. Therefore, public awareness aimed at the encouragement of the people moving from low-rise house to middle-rise apartment should be taken by ALMA. More practically, the information of the master plan especially the direction of urban development and structure should be widely shared with citizens by consecutive activities through poster, brochure, media, and workshops in order to promote living in middle-rise housing. Also, to assist the increasing seismic design of buildings is important by means of revising building code and exchanging opinions with private developers and construction companies.

9.6.5 Revision of the Address System Project

An Addressing System (AS) is a framework that provides the public with the naming of areas, numbering of properties and/or buildings/parcels of land and to facilitate the identification and location of a parcel or dwelling on the ground. AS is one of the tools in managing an area efficiently under a governmental initiative to provide great benefits to the public.

The current AS in Nicaragua uses reference points from where they start describing a certain address. There are many well-known buildings, companies, churches, or other reference points, which are used to get a general idea where something is located. The next is to state how far away the particular address lies from the reference point. However, sometimes, the reference points are no longer existing or have changed names. Therefore, it is difficult to access the exact place. To apply clear and user-friendly AS means that the area or the plot can easily be identified by everyone, this simple thing would bring various benefits to all, not only for the people living or working in Managua City, but also for the tourists and investors. Table 9.5.5 shows the possible benefits of a clear AS;

Table 9.6.3 Possible Benefits of the Introduction of the Clear Address System

Individual Level	To be recognized formally as a member of the community. To have an easy access to the points of interest. To take on the rights and obligations attached to his/her social role. To easily participate in the national and international markets. To receive prompt and efficient public services.
Organizational Level (e.g., government)	To help individuals protect their rights. To facilitate planning and implementation of public utilities and services (e.g., water and electricity). To respond effectively and timely on incidents (e.g., natural disasters, accidents, fire, and diseases) by providing aid/emergency services. To reinforce security. To facilitate tax collection.
Businesses Level (e.g., private organization)	To locate clients and providers easily. To promote and facilitate access on products and services. To manage on delivering goods systematically. To facilitate on sending goods/products and developing new markets.

Source: JICA Study Team based on "Address System in Malaysia including History and Efficacy on Malaysia's Economy"

Since 1967, there are several challenges related to the introduction or revision of the AS and all of the challenges were not properly implemented. The following are the major reasons why it was not implemented:

- Proposed AS cannot accommodate the newly developed areas (lack of versatility);
- It is difficult to name all of the roads from scratch for the proposed road based AS; and
- Proposed zones for the AS do not correspond to other administrative units such as barrio or district, so it was difficult to understand the area intuitively by Public.

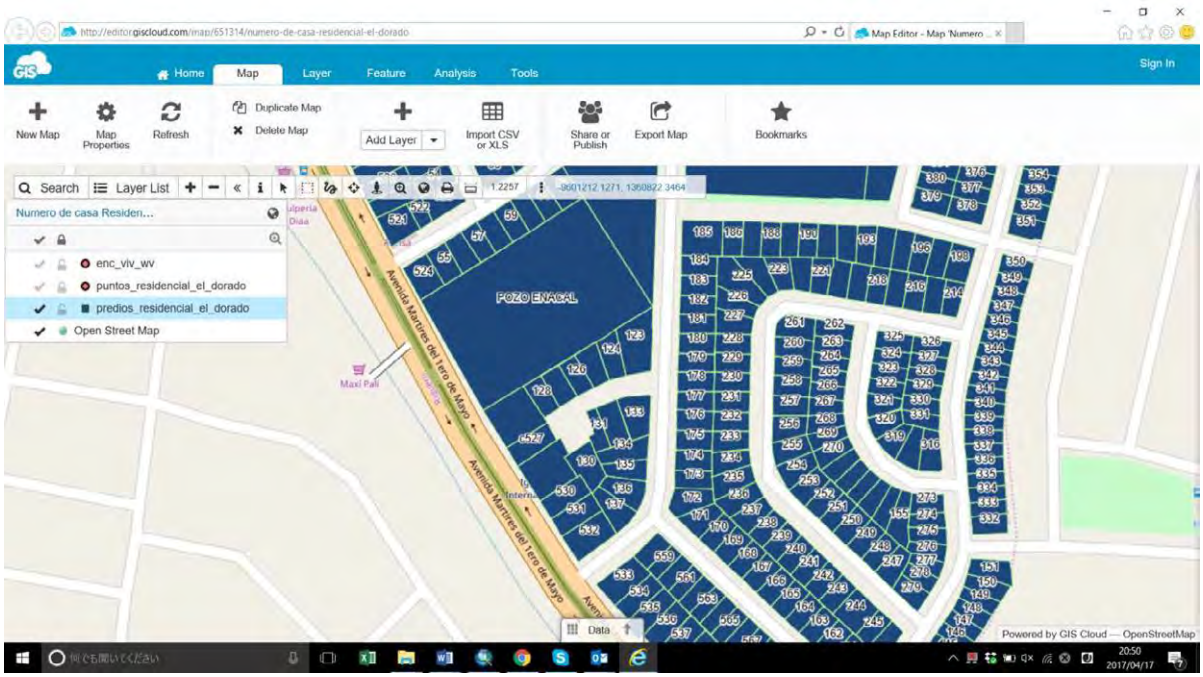
Table 9.6.4 Summary of the Challenges of the Revision of the Address System in Managua

Year	Challenges	Reasons Not to Implement	Remarks
1967	AGUADORA (current ENACAL) set-up address system to collect fees of water	Was implemented by AGUADORA and the National District, currently, ALMA uses this address system.	
1980	In accordance with the city expansion, the Ministry of Housing (MINVAH) set-up a new system, approved, and published in the official gazette.	It has been partially implemented, with the installation of maps and signalization in some few intersections.	Partially approved but abandoned.
1996	Based on the 1980 system, set-up of the new AS was tried, but it was not completed.	Proposal was limited to the discussion on based axis of address system	Was never approved as a regulation.
2000	In accordance with the city expansion, which is the basis of the 1967 system, quadrant AS was proposed but not implemented.	No interest to implement it.	Approved by the Municipal Order
2008	Proposed by a Mexican engineer, the new quadrant AS was proposed and set-up 76 zones in Managua.	Lack of budget to continue the proposal that was not completed and the house numbering system is pending.	Not approved.

Source: JICA Study Team based on the interview with ALMA

Revision of the AS is a huge task with legal issues, but it has great benefits for all levels of people, so it is worth it to challenge the big issue from a long-term perspective.

Through historical challenges by ALMA regarding the revision of the AS in the year 2008, all of the land plots that existed as of 2008 were given an assigned plot number as shown in Figure 9.5.4. The utilization of this land plot number would be a great advantage in revising the AS.



Source: Sistemas GeoInformáticos S.A.

Figure 9.6.6 Sample of Land Plot Number Assigned in 2008

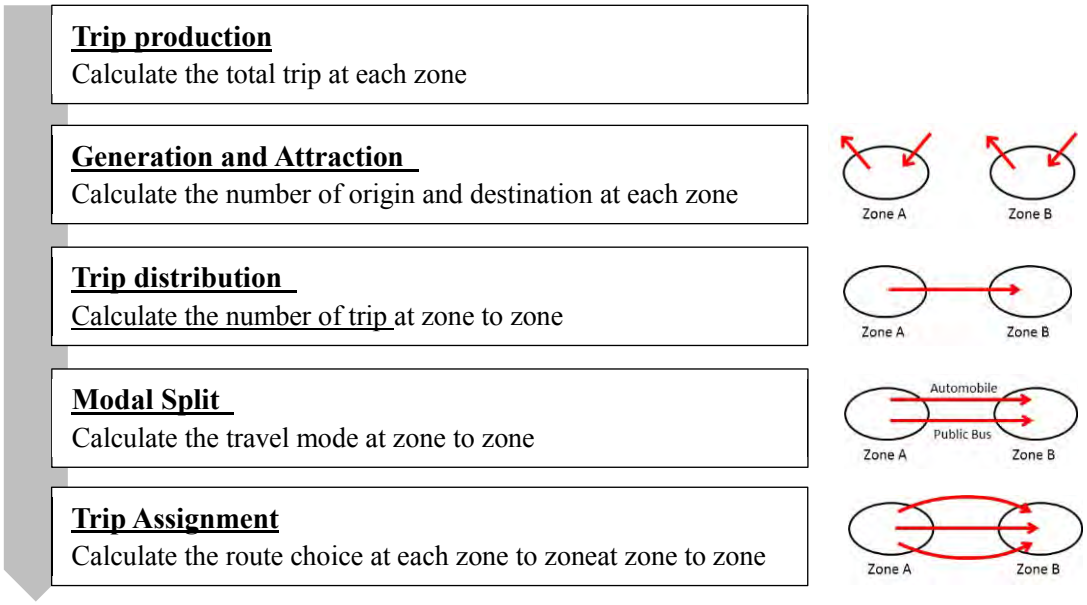
CHAPTER 10 TRANSPORT DEVELOPMENT MASTER PLAN

10.1 Traffic Demand Forecast

Traffic demand forecast is one of the most important analysis for validating necessity of update of transportation plan. One of the important objectives of traffic demand forecast in a transportation master plan study is to examine the concepts and policies in proposed plans by numerically indicators. It is, thus, to check whether plans provide sufficient capacity and structure performs functionally and effectively for the estimated demand, and to provide most favorable plans responding to the demand. The JICA Study Team conducted traffic demand forecast based on the result of traffic survey, which contains traffic count and OD survey and household interview survey, and future economic flamework. Result of traffic survey is shown in the Appendix 2.

10.1.1 Methodology

A widely practiced method in traffic demand forecast is the four-step method. The JICA Study Team also applied four-step method for the traffic demand forecast, which is the most basic analysis method and it was applied previous transport master plan. Four-step method composed i) trip generation and attraction, ii) trip distribution, iii) modal split, and iv) trip assignment. The flow and outline of the four-step method is shown in Figure 10.1.1. Formulation of traffic demand forecast and modelling such as reproducibility of present condition by the models and detailed calculations of each step are shown in Appendix 3.



Source: JICA Study Team

Figure 10.1.1 Outline of Flow of Four-Step Method

The JICA Study Team forecasted and analysed future traffic demands of both existing case and future Do-nothing caseby using this method. Do nothing case in 2040 was forecasted under the same road network and condition in 2016.

10.1.2 Major Premises

(1) Target Area and Traffic Analysis Zone

A target area for traffic demand forecast is Managua City and Ciudad Sandino area. Ciudad Sandino area is stated neighboring Managua City, and the traffic movement from this city to Managua City should be considered in the calculation. Traffic analysis zone (TAZ) for the forecast is basically a medium zone system which is described in Appendix 3. The total number of zones is 121 for the Study area.

(2) Forecasting System

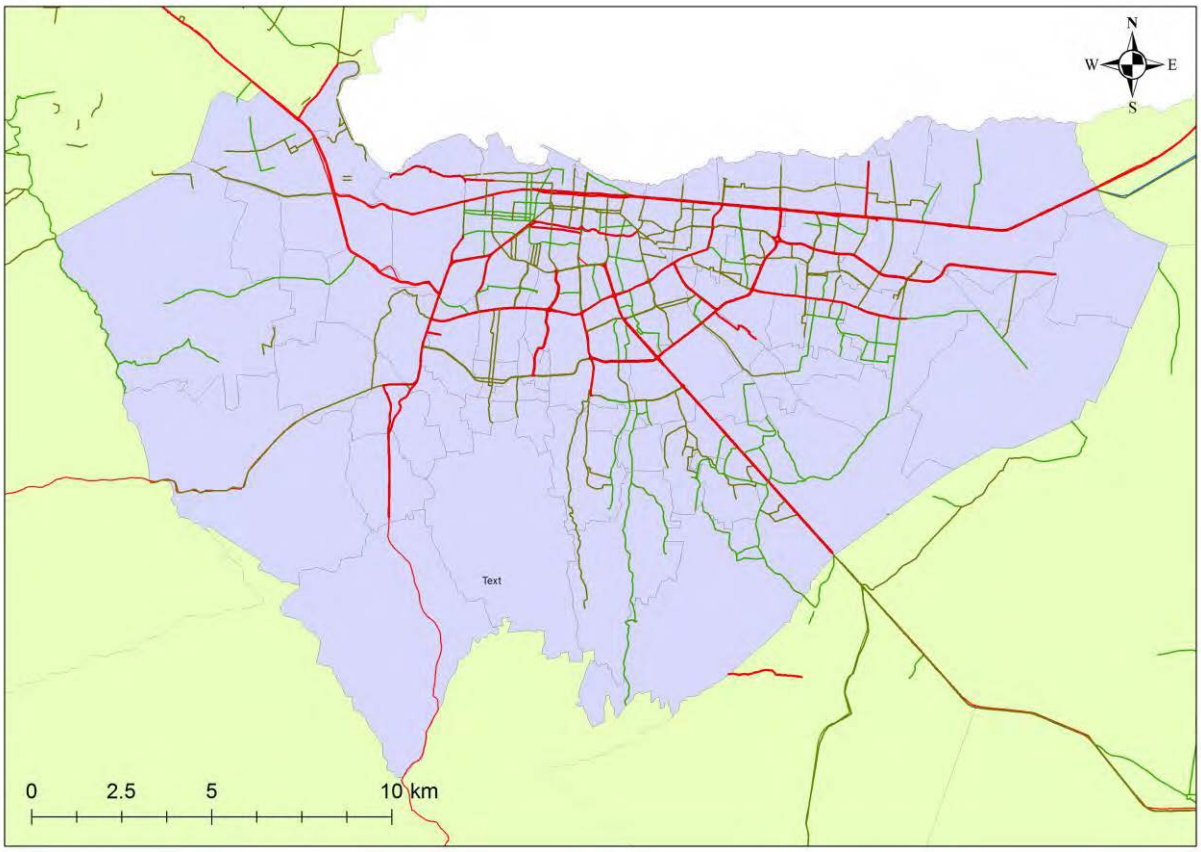
The JICA Study Team used JICA STRADA, which was developed by JICA, for Traffic Demand Analysis, and spreadsheets are used for some calculation for the model building and transport demand forecast. The JICA STRADA is capable of assigning future traffic volumes and showing the results visually. Then, Excel spreadsheets are used in the process in which traffic is assigned based on the person trip survey data. The traffic assignment method is the user equilibrium assignment method, which is also widely practiced.

(3) Target Year

Target year for this analysis is 2040. However, the JICA Study Team set several period, Short term (-2020), Mid term (-2030), and Long term (-2040) for understanding the change of traffic demand and movement.

(4) Existing Road Network

The base year road network was prepared by selecting major roads: primary distributor road, primary collector road, secondary collector road, and some major streets in the whole Managua City and Ciudad Sandino. For the selected network links, physical characteristics were surveyed by making a field investigation and standard of road classification in Regulatory Plan, and the recorded information was stored on a database with GIS software. The information of each link is used for the calculation of assignment capacity for the simulation. The established base year network is shown in Figure 10.1.2.



Source: JICA Study Team

Figure 10.1.2 Existing Road Network for Traffic Demand Forecast

10.1.3 Traffic Demand Forecast

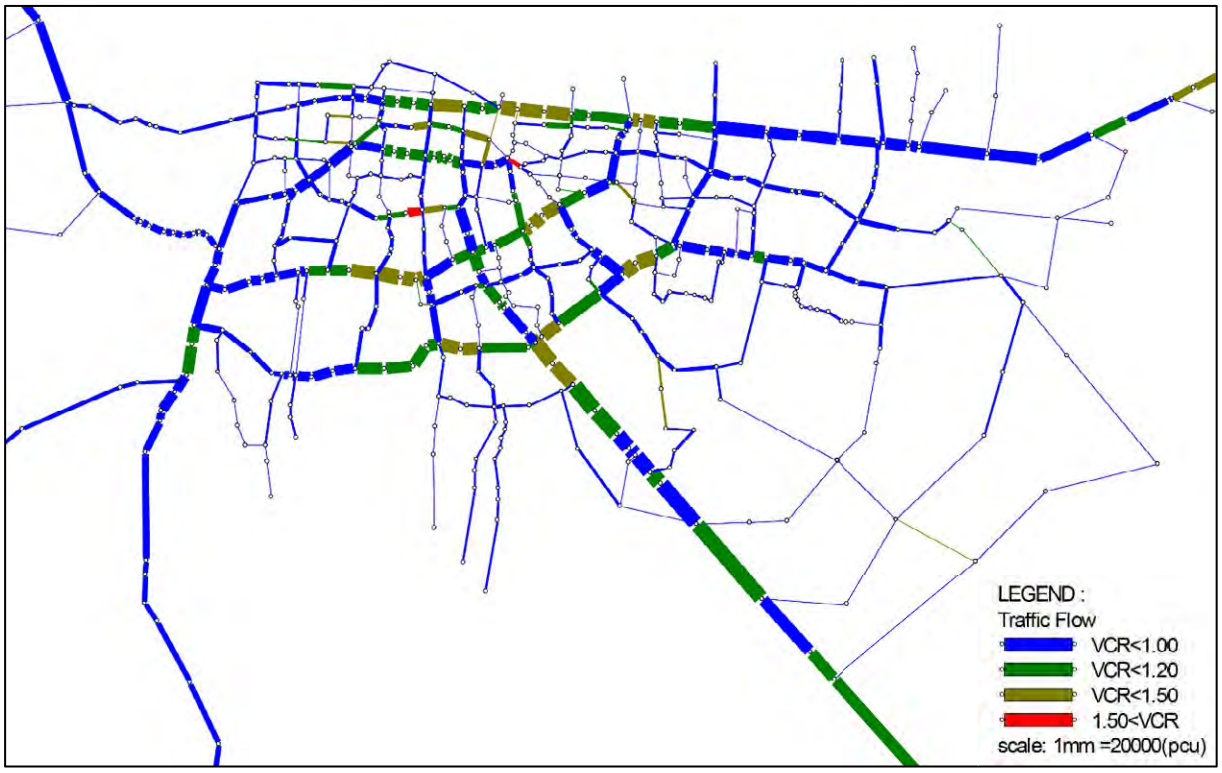
Traffic demand forecast to existing transport network was conducted for model building and analysis of present traffic condition. The JICA Study Team conducted two cases; 1) present traffic demand (2016) on existing transport network (Existing Case), and 2) Future traffic demand (2040) on exisitng transport network (Do-Nothing Case). The former case was calculated to confirm the accuracy of traffic models and to analyse the traffic, and the latter was calculated to analyse where traffic issues appear if the network is not improved. The calculation of the demand forecast was shown in Appendix 3. The primary indices of traffic demand forecast for the Existing Case and the Do-Nothing Case are summarised in Table 10.1.1. Traffic assignment results for the Existing Case and Do-Nothing Case are shown in Figure 10.1.3 and Figure 10.1.4, respectively.

Table 10.1.1 Primary Indices by Vehicle Assignment Results in Existing and Do-Nothing Case

Case	Year of Traffic Demad	Year of Road Network	Vehicle-km Total (PCU-km) ('000)	Vehicle-hours Total (PCU-Hour)	Average VCR*
Existing	2016	2016	6,071	121,479	0.55
Do-Nothing	2040	2016	13,444	643,507	1.44

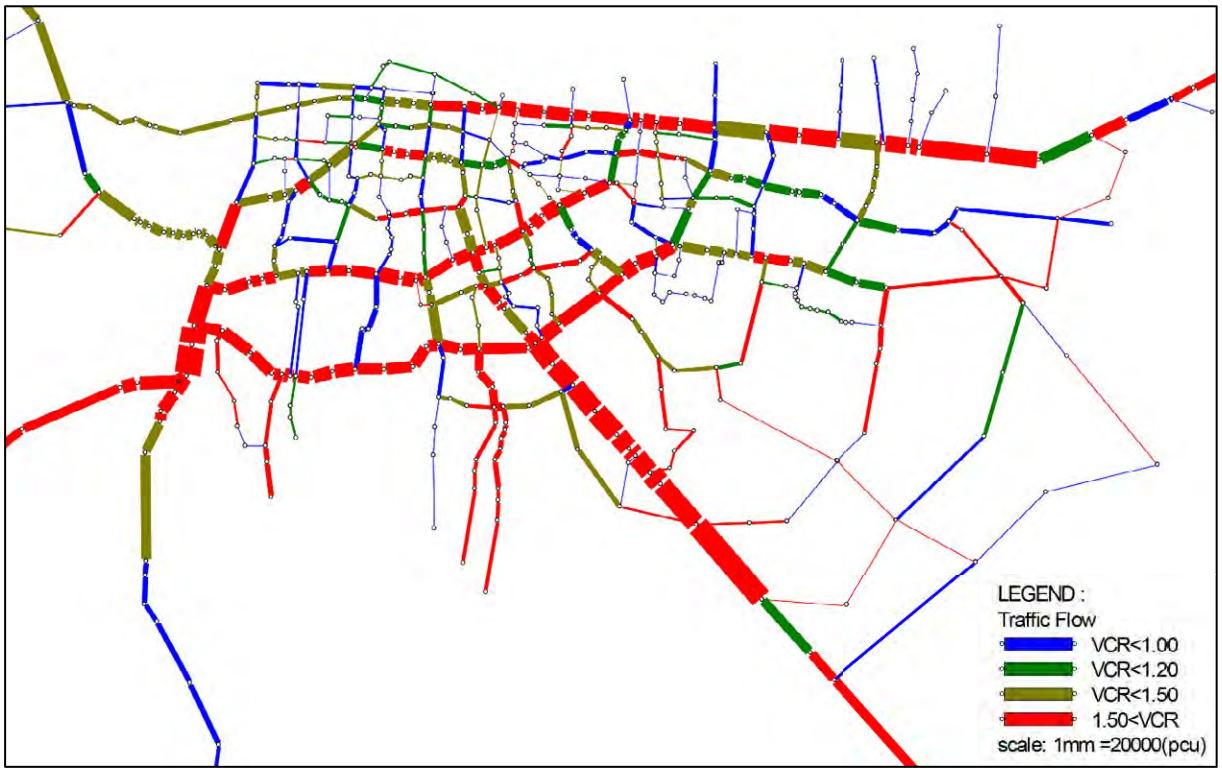
*: Vehicle Capacity Ratio

Source: JICA Study Team



Source: JICA Study Team

Figure 10.1.3 Vehicle Assignment Result in "Existing Case" (2016)



Source: JICA Study Team

Figure 10.1.4 Vehicle Assignment Result in "Do-Nothing Case" (2040)

Blue color shows congestion rate is less than 1.0. It means that traffic congestion does not happen because road capacity is larger than traffic volume. Green color shows that road congestion can be seen in the specific time such as morning and evening peak time. Red color shows chronically heavy traffic jam at present. Furthermore, heavy line means high traffic volume and thick line means low traffic volume in spite of the capacity.

In the Existing Case, traffic congestion occurs during the peak time in main road such as Pan-American North, Carretera a Masaya, Pista Juan Pabro II, and Pista Surburbana. It seems to be effected concentration of traffic to these roads as a current situation, since other roads are not so congested on the whole.

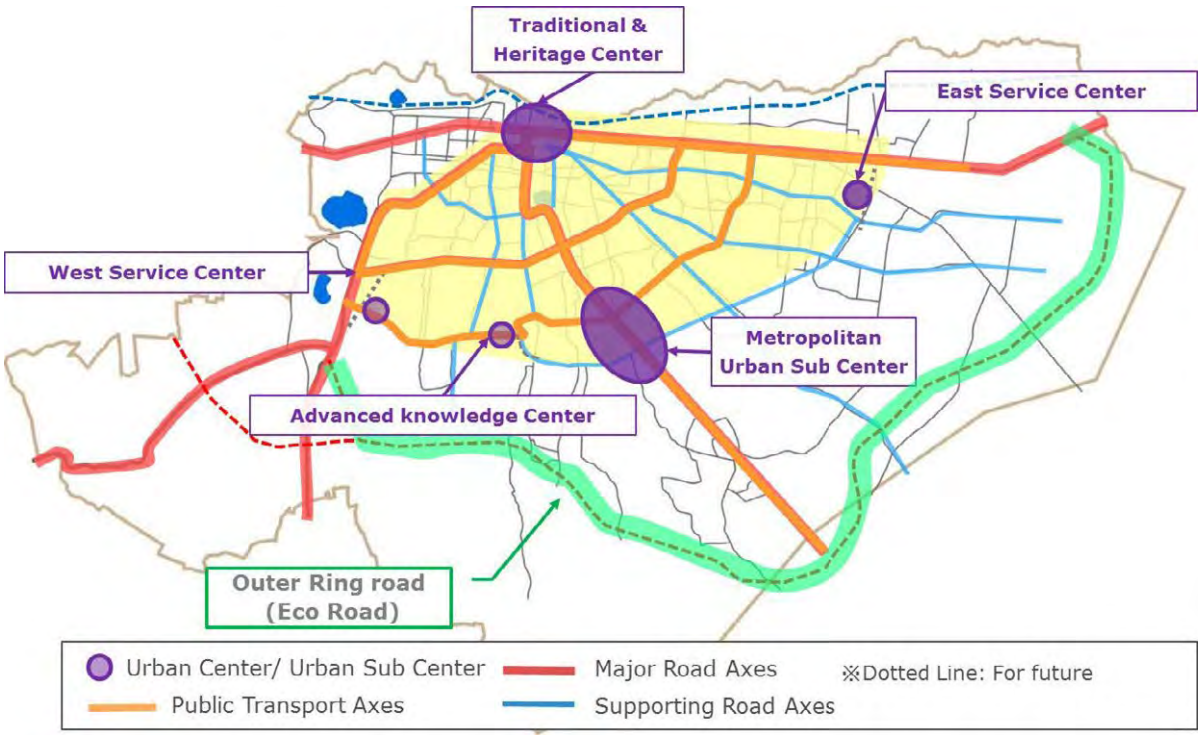
In the Do-Nothing Case, many roads, especially main radial and ring road are heavily congested. If any other counter-measures will not be taken, it's clear that Managua City don't have enough capacity to deal with the future traffic demand volume. Traffic volume will increase rapidly and road service level will become poorer than the existing condition. Economic activity will also become diminished by road function become impaired. Although vehicle capacity ratio is not over 1.0 in many road in Managua City so far, road capacity of these roads in Managua City is almost maximum. Therefore, several countermeasures which will decrease automobile traffic in the future and increase public transportation will be extremely necessary.

The future traffic demand forecast with road, public transport, and traffic management project was also carried out. Detail is shown in Chapter 10.4.4.

10.2 Transport Planning Scinario

10.2.1 Policy and Strategy

Based on the future urban structure and traffic demand forecast, the JICA Study Team puts importance to future transport system that 1) strengthening connection between CBD and Sub-center, 2) stimulating economy at the city center, and 3) inhibiting urban sprawl by 1) and 2). As mentioned above, road capacity is limited due to traffic congestion as present traffic situation and traffic accident will be increased as to the traffic growth. There will be traffic by private/logistic vehicle passing through the city center because major roads such as Pan-American North/South and Carretera a Masaya connect there. Public transport vehicles including urban bus and intercity bus are also congesting the city center since it is concentrated in Managua City. Future transportation system should improve these situations utilizing future urban structure. The JICA Study Team is considering two roles for managing future traffic flow: 1) Area for prioritized public transport, which surrounds the CBD and Sub-center, and 2) Area for connecting to area 1) and passing through area 1), as shown in Figure 10.2.1.



Source: JICA Study Team

Figure 10.2.1 Future Transportation System

Idea of each network, road network, public transport network, and traffic management is shown in the following clause:

(1) Road Network

Chracteristics of the spatial structure of Managua City is a road network consisting of five radial roads and four ring roads. The fourth ring road located in western half is a planned road, which is a planned

by MTI as a new inter-city road, and the eastern half, which is a proposed road by ALMA incorporating the ongoing road construction with Japanese counter fund.

The proposed fourth ring road, together with the existing Pan-American North and South makes a one important circular road for Managua City with a supplemental new link is proposed in the eastern part of Pan-American North West of the city with a bypass along the lake shore line. This circular road is set near the boundary of urbanization and is proposed as a green corridor type of a road with trees in the median or on the both sides to connect the reserved areas and water areas alongside.

Since these major roads are formed as backbone of the city, Pan-American North, Pan-American South, and Carretera a Masaya should be strengthened as the city's main axis. These roads have heavy traffic as these roads are the basis of movement for the road user and have a function of connection between cities and countries. Therefore, it is important to maintain the function of these roads (control of traffic movement and processing traffic behavior), otherwise, traffic flow cannot be controlled. At the same time, improvement and maintenance of ring roads for supporting these roads is needed. Juan Pabro II, which has many traffic and outer ring road (Fourth Ring Road), which is expected to have high effect on traffic diversion for normal vehicle and truck traffic and increasing traffic capacity should be positioned as main axes as well.

First Ring Road, Third Ring Road, and radial road will be positioned as second axis in order to support and back up the main axis. These roads have the function of access to the main axis and have a function of connection between main areas in the city. These roads are important for a citizen’s life (to shopping, to school, to commute). In addition, these roads also have function of alternative roads with main axis.

Urban public transportation route will be positioned as third axis for improving the processing capacity by public transport. Public transport is one of major mode for citizens; however, the condition of some routes is not good, and it has become a cause of traffic congestion because of delay of travel speed. Therefore, the JICA Study Team put as third axis the improvement of public transportation. The map, which described the above policies, is shown in Figure 10.2.2.

Source: JICA Study Team

Figure 10.2.2 Road Network

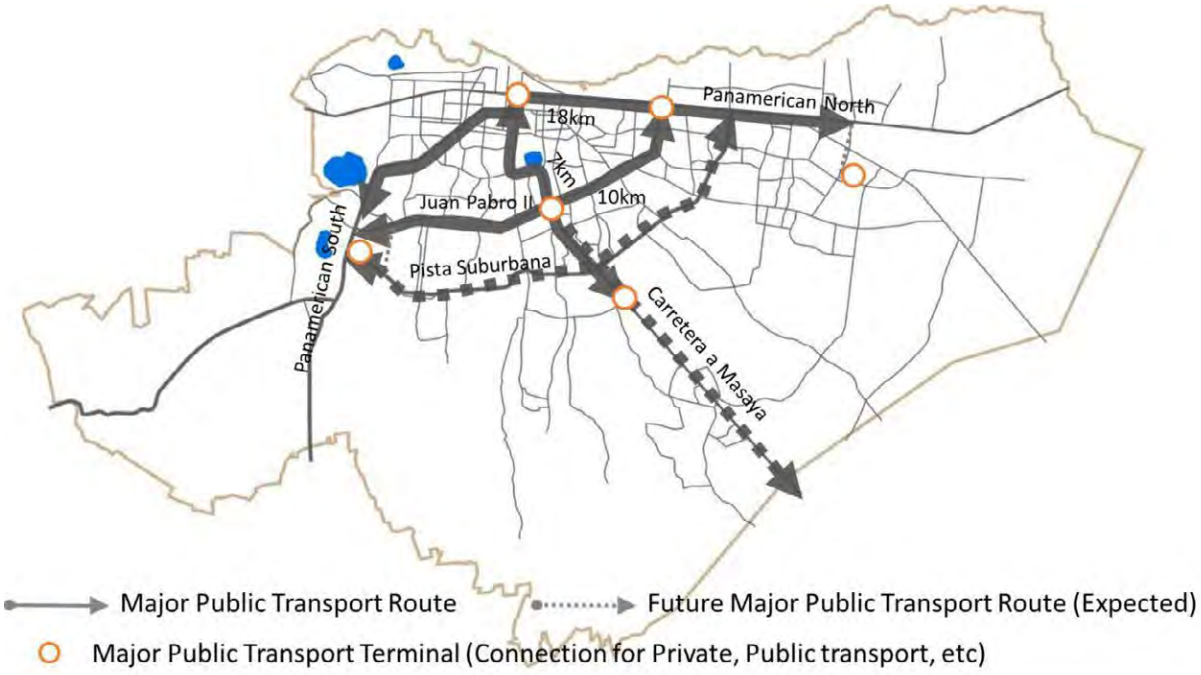
(2) Public Transport Network

Although there are urban buses and intercity buses in the city, it is difficult to manage both operations strictly because bus operation administrators are different. Both buses are indispensable for citizens coming and going to Managua City and it is also important as a major traffic mode. On the other hand, these buses become one of the causes of traffic congestion by concentration of bus traffic in Managua City and bus operations in the city should be managed and coordinated. Therefore, the JICA Study Team considered that it is important to divide the function of intercity buses and urban buses; intercity buses should have less stops inside the city, and urban buses should fulfil the demand of urban mobility within the city including the passengers coming from out of Managua City.

Strengthening and promoting of public transport route should be done by clarified connection for both buses and setting major public transport routes. Bus operation routes will be set up on the main axis of the road network, taking into account the future urban structure. Pan-American North/South, Juan Pabro II, and Carretera a Masaya should be set as major public transport based on traffic volume and existing urban public bus routes. These routes are connected to each new city center as mentioned above, function of intra-city and inter-city is divided in major public bus terminal in each center. These terminals also have a function of several transportation mode hubs including private car, taxi, etc. It is expected that addition and extension of bus operation route will be needed in the future along the Carretera a Masaya and Pista Suburbana with increasing traffic volume. Existing urban bus routes will be considered to

change as reinforcement of these routes such feeder bus. National Transport Plan, which was formulated by MTI with JICA assistance, also recommended the development of local transport plan. The JICA Study Team proposed the mode, structure, and bus connection site based on the traffic demand, and it is shown in chapter 10.4. This planning policy is shown in Figure 10.2.3. Strengthening of public transport is also expected to have a benefit for resolution of the gender and poverty issues because public transport would give a opportunity for mobility to citizen fairly.

Although the plan for the intercity railway has been announced by PRONicaragua, the JICA Study Team has not shown the current planned route here since the detail such as implementation period, cost, etc. are still undecided.



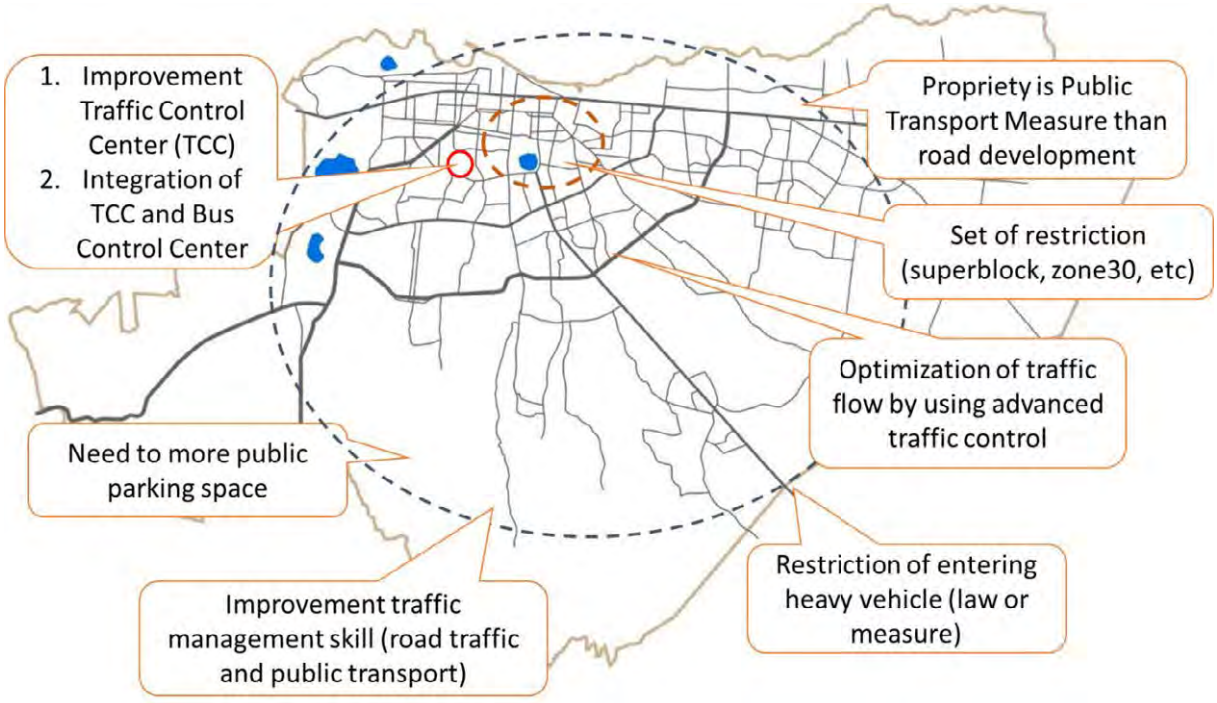
Source: JICA Study Team

Figure 10.2.3 Public Transport

(3) Non-structure measure for transport planning (Traffic Management)

In the formation of the future traffic and transportation axis, it is necessary to support not only the structural measures but also the non-structure measure. It is also necessary to conduct several traffic management measures. For instance, ITS which effectively utilize existing transport facility (i.e. expansion of traffic signal, integration of traffic and public transportation control center, congestion information provision by variable message signboard (VMS)), development of parking facilities to prevent reduction of road capacity by street parking onlocal road, TDM measure such as zone 30, implementation of new transporation system, etc. In addition, since there is no specialized organization for traffic planning in Managua City and the role of traffic-related organization is unclear. Therefore, it is necessary to strengthen the ability for traffic management and planning and clarify and integrate the roles of traffic-related organization. There is also room for consideration about the constitution of new

organization for traffic planning. Some expected necessary non-structure measures are shown in the Figure 10.2.4.



Source: JICA Study Team

Figure 10.2.4 Traffic Management

10.2.2 Road and Traffic Management Plan

Road Plan and Traffic Management Plan were prepared based on the urban and transport Development policy and strategy. It was also considered existing and future land use, socio-econmic data and road inventory in accordance to road classification, type of road pavement and their conditions, and the number of lanes.

One of the important outputs is the result of traffic analysis by zones and by modes; the result of the traffic volume, average speed, and the origin and destination. Ideal future road nettwork was determined in short, mid and long term. Road network is much related to Traffic Management and Public Transport Plan. Therefore, This Road Plan was considered both plans.

(1) Basic principle of road and traffic management planning

The road newtork of Managua City has increased without any plan or capacity control. Almost all the traffic flows are concentrated in the main road such as Pan-American North, Pan-American South, Carretera a Masaya, Pista Juan Pablo II, Pista Suburbana. Most of the roads have one lane or two lanes on both directions and some section of the lane have damage by the concentration of vehicle.

Transport development plan considers the Managua vision and its 6 pillars which was set this project, and basic principle of the road plan is based on the followings; 1) To respect for the Land Use Plan, 2)

To respect for the Road function, 3) To characterize and define urban and suburban traffic, and 4) To withstand natural disasters and have function for the evacuation.

Managua is a very vulnerable city, which has not only earthquakes, but also floods and landslides caused by the rains. A disaster evacuation routes should be coordinated and specified with the districts and ALMA. These routes are complemented by major road of road network, and it need to install traffic guide sign that identifies location of shelters, safety zones and evacuation routes. This is included as new project of disaster prevention measures.

Table 10.2.1 The Six Pillars of Managua Vision to 2040 in regards to the Road Plan

Sustainable City:	A competitive city has a road network with all services and with good maintenance. It is important to reduce the environmental pollution generated by congestion.
Attractive City:	With good connectivity of road and public transport, and adequate guide plate and display for the citizens and tourists.
Resilient City:	With a resistant road network and much capacity for ensuring movility for citizen when disaster occured.
Economically Active City:	With a connected road network and a good level of service, which allows reducing the vehicle operating costs, travel times of the drivers, passengers and the goods.
Accesible City:	
Socially Equitable City:	To provide fare access quality and transportation services.

Source: JICA Study Team

The analysis of the road network and traffic management planning was conducted based on the policies and strategies of the urban transport planning for Managua City. The basic idea of road network planning was identified for the mitigation of traffic congestion in Managua City. Considering the problems and issues to be resolved with respect to the existing road network and future traffic conditions, the following measures are needed for road network planning.

a) To mitigate raffic congestion
b) To develop effective road network by heriachy of roads
c) To ensure the road function based on the future demand
d) To maintain the optimum environmental conditions of the city
e) To ensure the traffic safety and reduce a number of traffic accidents
f) To harmonize road and public transport network

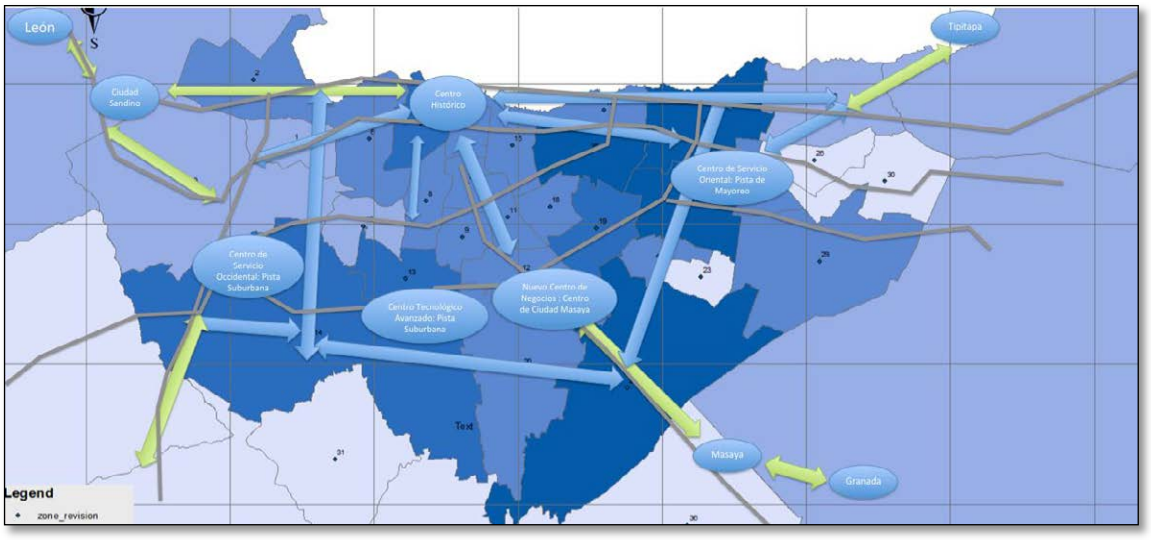
(2) Road network and traffic management planning

For achiving above measures, the following scinarios was identified based on the traffic analysis and the existing road network.

1) Strengthen the radial road network

As a result of the different traffic analysis including 1) allocation of present and future traffic demand, 2) analysis of future traffic characteristics, and 3) desire line for person trip, the most

of traffic volume concentrate to the six radial roads as shown in Figure 10.2.5. Therefore, the radial roads should be strengthened in order to reduce the traffic congestions.



Source: JICA Study Team

Figure 10.2.5 Transport Hubs to be Strengthen

The Regulatory Plan is the only legal standard, and it defines basic regulation the road system including zoning and land use, and etc.

According to the analysis of future traffic demand in 2040 which is shown in Figure 10.1.4, the most critical radial road is Carretera a Masaya (more than 140,000 veh/day), Pan-America North (more than 86,000 veh/day) and Pan-American South (more than 84,000 veh/day). This situation is over the road capacity, therefore some road improvement and extension projects should be implemented. In addition to this, it is necessary to conduct the following measures 2)～5).

2) Strengthen the ring road network

Ring roads in Managua City occurs serius traffic congestions. Some section of ring road does not connect, and this situation becomes a cause of bottleneck.

The road improvement and extension projects should be implemented new bypass road projects which become alternative routes are needed for the Pista Juan Pablo II and Pista Suburbana.

In addition, truck traffic, which is passing through the Managua City, is not only produces congestion, but also increases traffic accidents and deterioration of road pavements. The damage of road pavements raises the road maintenance costs, and increasing of truck is affects the environmental conditions of the city.

Based on the traffic analysis and the future traffic flow, the following three heavy goods transport routes is needed to develop from / to Managua City and the outside area to avoid passing through the urban areas and to mitigate traffic congestion of Managua City.

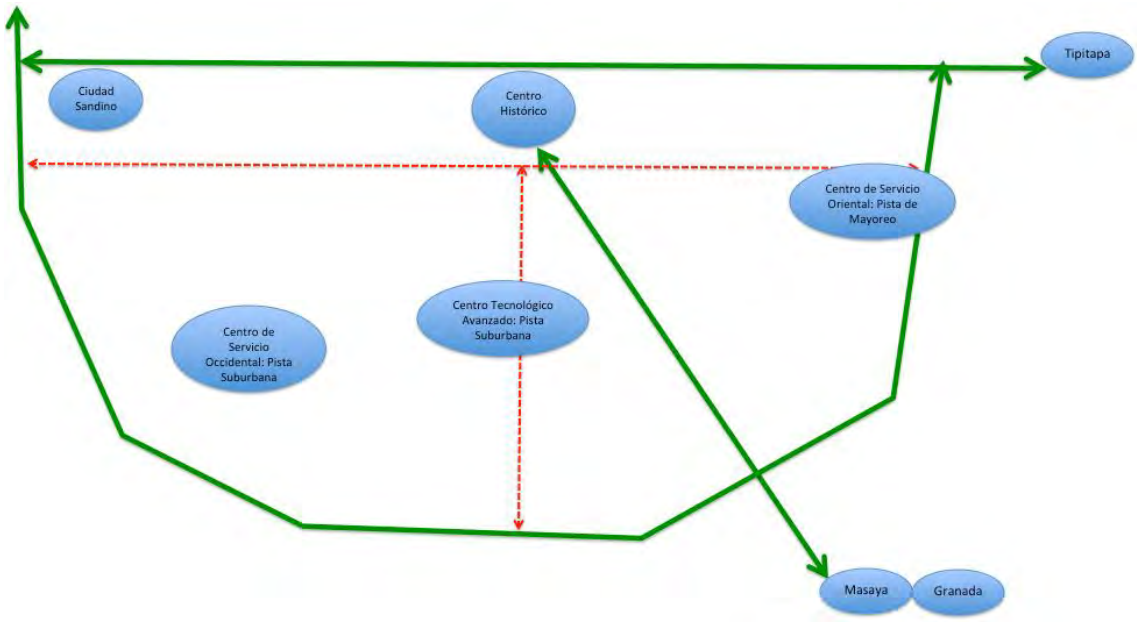
There are industrial development zones in Managua City located to the east and west side along the Pan-American North. These areas are utilized to store the products for logistic companies, manufacturers, etc. Logistic vehicle volume should be considered to manage the traffic control in the city. Logistics Zones outside the city or near the boundary of the city has effect of exclusion of through logistics traffic. There are two expected areas of logistics zones. One is the "Zona Franca" (Free Zone) located near the airport, and another is Ciudad Sandino. The commercial activity of Managua is very important. This is included in the 6 pillars as mentioned above.

a) Route East to West = Passing through Pan-American North

b) Route East to West =Passing through the outer ring road of new road construction.

c) Route Center to South = Passing throughCarretera a Masaya.

Considering the issues of the existing ring road network and the importance of the urban and national logistics, the outer ring road network should be reinforced.



Source: JICA Study Team

Figure 10.2.6 Conceptual Plan for Truck Diversion Routes

3) Strengthen the existing roads function in the urban area

According to the results of future traffic demand, the major traffic flows are concentrated in the main roads located in the urban area. In order to mitigate traffic congestion and maintain road function, these main roads should be reinforced. It should be determined to expand the capacity of some main distributor roads such as Pan-American North, Pista Suburban, Pista Mayoreo, and other alternative routes. In the case of the Pista Juan Pablo II, ALMA has initiated an extension of the entire route.

Regarding the lane expantion, many roads has enough space to expand the lane. Although some area have some restrictions, even if there is a need for resettlement, ALMA has a lot of experience of resettlement and can be done quickly. However, they need to consider a budget management for these relocations.

4) Prioritization of public transport

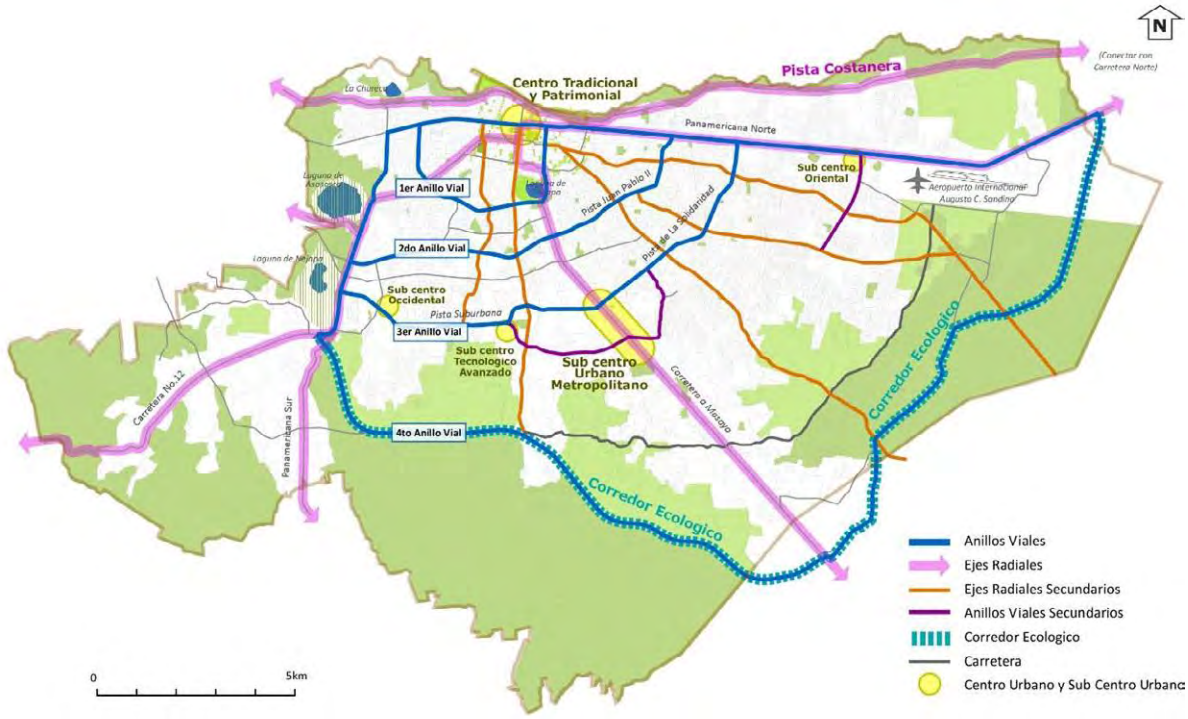
In order to avoid a concentration of traffic on the roads in urban area, it is important to give a priority to urban public transport. There are two important actions: (i) Integrate and harmonize the road network with the public transport corridors, and (ii) Relocation of urban and intercity bus terminals.

Three intercity bus terminals will be relocated along with Pan-American North, Pan-American South and Carretera a Masaya. Four integration terminals have also been considered in the most strategic points of passenger interchange: (i) Pan-American North (Centro), (ii) Pan-American North with Pista Juan Pablo II, (iii) Pista Juan Pablo II and Carretera a Masaya, (iv) Pista juan Pablo II with Carretera Sur.

5) Improvement of traffic management capacity

There are many weaknesses in traffic management field. Adequate traffic management can ensure the benefit to the traffic flow of the city. Proper countermeasures for improving traffic circulation is needed.

JICA Study Team analyzed that there is a limited capacity and almost all bottlenecks are generated on the main radial and ring roads, and JICA Study Team identified very critical sections in roads which have larger than regulatory widths as shown in Table 10.2.2 . Only 23% of listed them complies with the regulatory widths because of limitation of land acquisition or etc. It might be very difficult to implement lane extensions and to develop new routes in order to manage future traffic. Therefore, it is recommended to prioritize improvement of public transport and to consider some typical cross sections with dedicated lane for public transport as shown in Table 10.4.4.



Source: JICA Study Team

Figure 10.2.7 Future Road Network

Table 10.2.2 Width of Main Roads

No	Code	PROJECTS	No. of Lanes	Road width (m)			Qualify
				Hierarchy	Regulated	Existing	
1	A1	Paseo Naciones Unidas	4	DP	40 to 100 m	40 to 56 m	Yes
2	A2	5a Avenida SE	2	CP	27 to 39 m	10 to 18 m	No
3	A3	Pista Suburbana	4	DP	40 to 100 m	24 to 33 m	No
4	A4	Pista El Mayoreo	2	CP	27 to 39 m	24 to 27 m	Yes
5	A5	Suburbana (Centroamérica_Rotonda_LaVirgen)	2	CS	18 to 26 m	16 to 22 m	Yes
6	A6	Pista_Larreynaga_ CiudadBelén_GaritaTipitapa	2	DP	40 to 100 m	18 to 22 m	No
7	A7	Carretera Norte	6	DP	40 to 100 m	30 to 38 m	No
8	A8	Pista Jean Paul Genie	4	CS	18 to 26 m	24 to 30 m	Yes
9	A9	25 Calle Suroeste	4	CS	18 to 26 m	20 to 24 m	Yes
10	A10	Avenida Bolívar	4	CP	27 to 39 m	28 to 40 m	Yes
11	M1	Alterna Carretera Las Nubes	2	CS	18 to 26 m	narrow	No
12	M2	Av. Gabriel Cardenal	2	CS	18 to 26 m	14 to 16 m	No
13	M3	Carretera a Las Nubes	4	CS	18 to 26 m	14 to 24 m	Si
14	M4	Cuarto Anillo	4	CS	18 to 26 m	24 to 30 m	Si
15	M5	3a Avenida NE	4	DP	40 to 100 m	24 to 30 m	No
16	M6	35a Avenida So	4	DP	40 to 100 m	20 to 24 m	No
17	M7	3ra Avenida Sur Este	2	CP	27 to 39 m	12 to 18 m	No
18	M8	Carretera Norte	2	CP	27 to 39 m	12 to 14 m	No
19	M9	Av. Bolivar	4	DP	40 to 100 m	30 to 35 m	No

20	M10	Pista Sabana grande	4	DP	40 to 100 m	18 to 20 m	No
21	M11	Calle El Triunfo	2 to 4	DP	40 to 100 m	12 to 18 m	No
22	M12	Camino a San Isidro de Bolas	2	CP	27 to 39 m	12 to 16 m	No
23	M13	Pista Benjamín Zeledón	2	CP	27 to 39 m	16 to 18 m	No
24	M14	Pista Naciones Unidas	4	DP	40 to 100 m	26m	No
25	M15	Camino a San Isidro de la Cruz Verde	2	CP	27 to 39 m	16 to 36	Si
26	M16	Carretera Norte	6 to 8	DP	40 to 100 m	32, 40 to 45m	No
27	M17	Carretera Masaya	6	DP	40 to 100 m	32 to 40 m	No
28	M18	Santo Domingo / Roberto Huembés (2.4 km)	4	DP	40 to 100 m	24 to 30 m	No
29	N1	Circunvalación Oeste	2	DP	40 to 100 m	9 to 12 m	No
30	N2	Acceso Centro Servicios Oriental	2	CP	27 to 39 m	24 to 27 m	No
31	N3	Colectora	2	CP	27 to 39 m	24 to 27 m	No
32	N4	Colectora_CS	2	CP	27 to 39 m	24 to 27 m	No
33	N5	Centro de Conocimiento Avanzado	2	CS	18 to 26 m	24 to 27 m	Si
34	N6	Centro de Servicios Occidental	2	CP	27 to 39 m	13 to 18 m	No
35	N7	Conexión Sur	4	DP	40 to 100 m	25 to 30 m	No
36	N8	Prolongación Oeste de Jean P. Gennie	2	CS	18 to 26 m	24 to 27 m	Si
37	N9	Prolonagión Oeste de Juan Pablo II	2	DP	40 to 100 m	32 m	No
38	N10	Prolongación Oeste de Miguel Obando	4	CS	18 to 26 m	18 to 26 m	Si
39	N11	Antigua Vía Férrea (Sector Acahualinca)	2	CP	27 to 39 m	14 m	No

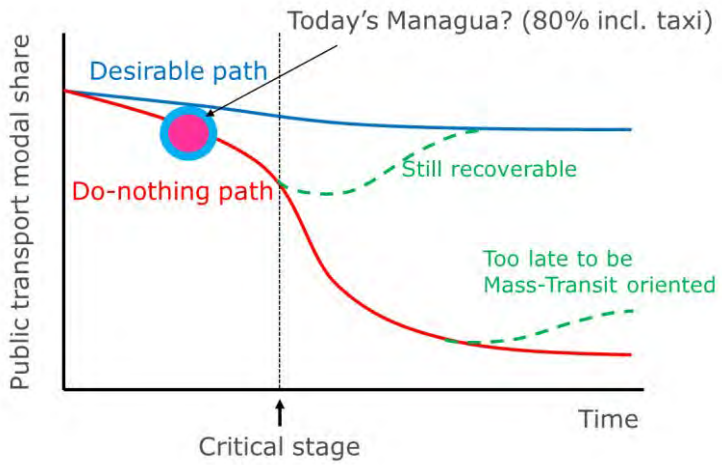
Source: JICA Study Team

10.2.3 Public Transport Plan

(1) Improvement of public transport service with mass-transit systems and the feeder buses

Public transport is currently the most dominant mode of transport in terms of modal share. As household interview survey disclosed, public bus handles 53% of trips and taxi 26%, which means around 80% of trips are being realized by public transport. According to passenger interview survey, two biggest reasons for citizens to use public bus are its cheap fee of ridership and non-availability of private transport mode. The same survey indicates also the dissatisfaction of the citizens on the current public bus service, where for instance 60% of citizens presented their preference to take more comfortable, modern and 5 minute faster public transport system even if they need to pay 8 times more than the existing service fee.

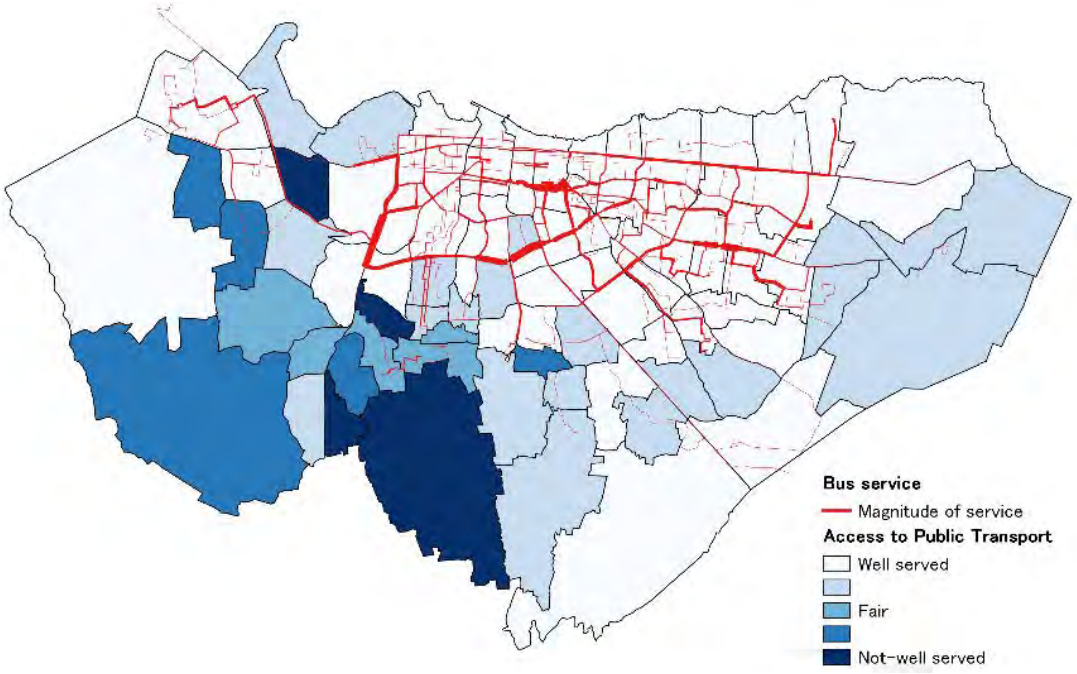
On the other hand, the economy of the nation and the capital has been and is supposed to keep growing steadily, and the vehicle registration of private vehicles including motorcycle and automobile are increasing progressively. If this tendency continues, it is highly expected that the modal share of public transport drops and that of private transport becomes dominant while causing more traffic congestions and accidents. Accordingly, it is important to improve the public transport service before the modal share of the public transport drops to the critical extent.



Source: Modified by JICA Study Team based on material by Institute for Transport Policy Studies of Japan Transport Research Institute

Figure 10.2.8 Conceptual paths of public transport modal share

Furthermore, one of the problems that prevents the adequate use of public transport by the citizens is the bus routes that haven't been radically modified since long time. After expansion of the city, the citizens, especially the ones with relatively lower incomes, are now living outer area, where the public transport is not well dispatched. As a result, these citizens in suburban areas are spending more money for the mobility by paying to intercity buses or taxies. Urban transport service should, as a public service, provide an appropriate accessibility with affordable price to these citizens.



Source: JICA Study Team

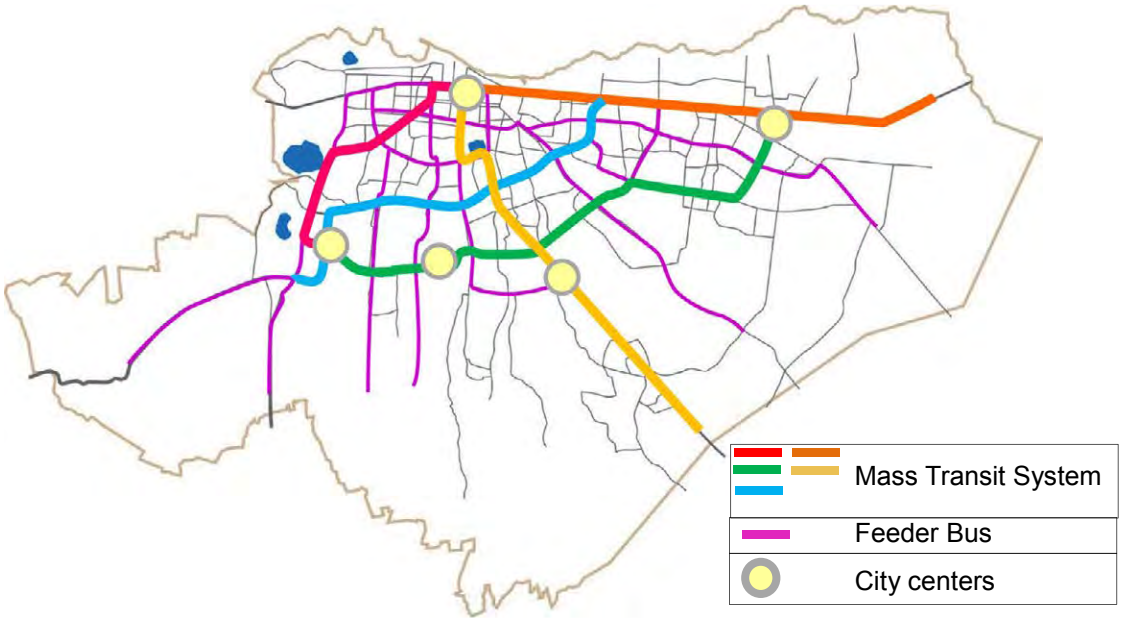
Figure 10.2.9 Public transport services and citizens' perception

These issues clarify the necessity to improve the public transport service. Considering the large volume of demand and large area to be covered, the combination of mass-transit systems as the main mode of

public transport and the feeder buses as the complementing system shall be proposed. The routes of mass-transit systems are designed with the following criterias;

- The routes should cover the frequented paths of maximum passengers
- The routes should be spreaded as much as possible in the city so that maximum citizens shall be in an acceptable distance
- The routes should connect the city centers

The proposed routes of mass-transit systems and their main feeder buses are presented in Figure 10.2.10.



Source: JICA Study Team

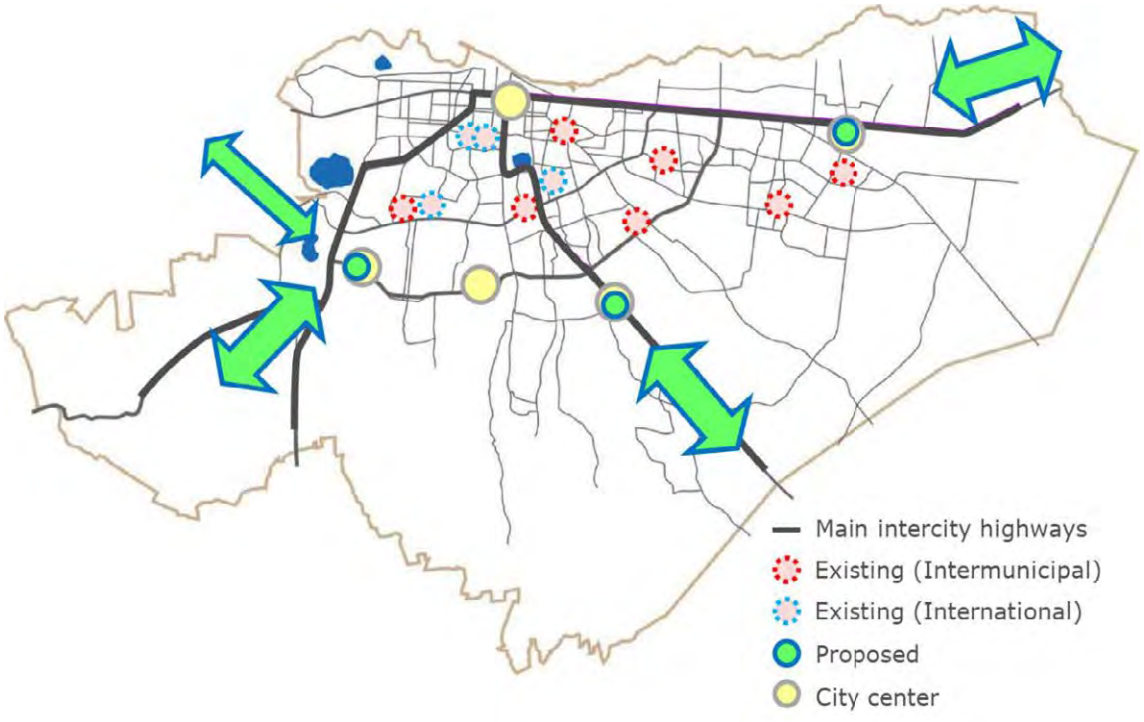
Figure 10.2.10 Proposed routes of mass-transit systems and their main feeder buses

(2) Relocation and improvement of bus terminals along intercity roads

Bus terminals are today located in the middle of the city, some in very clouded and non-secured neighbourhood, both for intercity and for international buses. In these limited areas, the connectivity with urban public buses is not well provided. Moreover, there are plenty of small shops without appropriate coordination inside or around the terminals and even in the maneuvering and parking areas of the buses, which are disturbing the operation of buses. Considering also the increasing traffic volume in the city, the effort to reduce the traffic inside the city could be on the controllable traffic such as public bus, so the relocation and the improvement of the terminals shall be a solution.

From practices around the world, there are two different strategies for location of bus terminal; one is to locate it inside or next to an important city center, where the buses enter the highly developed area interfering traffic but many of passengers don't need any further transit. The other is to locate it at fringe of the city with inner-city transport connectivity, where buses shall not interfere the traffic inside the city but most of the the passengers need to make a transit. Considering that there are some city centers proposed to be located near interurban highways and they're to be connected by mass-transit systems,

their inside or neighbour would be the most appropriate locations of new bus terminals by taking advantages of both strategies. This would at the same time give more efficiency to the inter-municipal servicess by reducing travel time.



Source: JICA Study Team

Figure 10.2.11 Proposed relocation of bus terminals

10.3 Proposal for Appropriate Transport Institution System

10.3.1 General

The institutional organization of urban transport in the Managua City has some gaps and overlaps, which lose efficient and effectiveness management in several aspects. JICA Study Team proposes to establish transportation planning and traffic management organization and to ensure efficient operation and services for urban traffic control. Transport planning usually is needed to get concensus with many sectors and many levels of government authorities. However, the transportat planning sector of ALMA has lost strength and presence. Therefore, the level of transport planning is not so high, and there is little coordination and limited scope. This situation is clearly seen with regard to the traffic management in the city. Tere are many institutions on municipal and national level, which share responsibilities and functions in Managua City. However, each functions of each organization are not sufficiently cleared.

In the public transport field, there is a series of functions and initiatives, but they have not have responsible. There are a lot of needs and decisions which have not been taken the action because of the lack of initiative and/or responsibility of public transport sector organizations.

10.3.2 Proposal for Institutional Organizations and Tasks

JICA Study Team proposes profound organizational and institutional transformation of transport sector with the function of decision and implementation of transport planning and projects. Strenghthening of organization for transport planning sector is needed for traffic management considering future traffinc demand of Managua City.

It is proposed here to modify the existing functions of organization. This proposal is focused on three functions, corresponding to transport planning, traffic management and public transport management. In addition, this is an executive function of public transport, which coordinated with other territorial authorities.

(1) Transport Planning

This is a main function as the creation of a body which concentrates all transport responsibilities with power and capacity at the municipal level. It is proposed to create “General Directorate of Transport Planning”, because it should be a regular function of ALMA with capability of dialogue with the other general directorates. It is assumed that this body has the following functions and responsibilities;

a) Management of overall urban transport

b) Transport planning in Managua City

c) Decisions of all activities of transport sector in Managua City

d) Coordination and integration of transport management in Managua City

e) Coordination with the transport regulators in other municipalities and with the ITN at national intermunicipal and international level.

In these responsibilities, the main role is the overall transport planning and traffic management, which includes at least the following three departments;

- Department of plans and programs:

This department is in charge of the preparation of plans and programs. It is responsible for preparing and proposing transportation planning. This department prepares strategic and development plan for short and midium tarm plans and they develops projects and actions based on the strategic plan. The monitoring, evaluation and control of proposed and developed strategies should also be undertaken.

- Department of studies and projects:

This department deals with the directly and/or commissioned transport studies, plans and projects according to the needs of the ALMA. It evaluates the studies and develops proper management for transportation in the city. It has the power of selection the consultants to conduct transportat studies.

- Department of technical standards:

This department is responsible for developing and proposing all technical standards related to transport operation (operating regime, service standards, etc.), vehicle norms (emission standards, fuel, sizes, technologies of vehicles, etc.), roads (design, materials, classification, etc.), emissions (vehicular emissions, pollution level, etc.), and the others.

(2) Traffic Management

With regard to traffic management functions, these should be organized as a technical office through the integration of the existing Traffic Control Center (TCC) with a broader range of functions and responsibilities. This TCC control all traffic signal and has broad responsibilities associated with the traffic movement in the city and traffic regulation.

Existing TCC is now under the Mayor's office, and it should continue to belong directly there. It should have close coordination and collaboration with the other transport-related departments of ALMA, the National Police, MTI, and other municipal agencies. The functions and responsibilities of the TCC focus on three specific field; traffic regulation; traffic control and management, road safety and accidents.

- Department of traffic regulation:

The activity of this department is to develop actions to order and make efficient traffic flow. This department is in charge of the management and operation of all the traffic signal in the city. This function includes the maintenance of the traffic signal network and its development (modernization, expansion, relocation of traffic signals, etc.). They develop and manage software tools for traffic management, and implement and maintain complementary equipment (cameras, loops, etc.) and the appropriate tools to use them. All of this should be allow it to be producing and updating online information regularly. It is possible to back up daily actions and all other actions. The staff for the Operations Control Room, whose operation, maintenance and development is the responsibility of this Department, is required.

- Department of traffic control

This department is collaborated with department of traffic regulation. Its function is to ensure compliance with traffic regulations for optimaization of traffic flow in the city. It manages and analyzes in real time the conditions of the traffic movement and everything which happens in the roads. They uses all the management tools by the department of traffic regulation and display its work supported by them. They control and monitor video cameras at intersections, adjust traffic singal cycleing based on the information of traffic counting and computer programs, and send variable text messages. It can visualize and identify all the incidents on the road and make coordination with the Traffic Police. This department is also located in the Operations Control Room. National Police also has a working space in that place to ensure an efficient and timely coordination.

- Department of road safety

The function of this department is the prevention of accidents, and the follow up and investigation of traffic accidents in conjunction with the police. They carry out necessary actions on-site when accient is happen, and they conduct studies and subsequent investigation of accidents. They also conduct preparation of the statistics related traffic safety, which are accident rates by population/by vehicles/by kilometers traveled, identification of black spots in the city, inspection and safety actions to improve the identified risk areas, promotion of road safety, traffic safety campaigns in conjunction with Traffic Police. Tehy conduct accident studies in order to explain its causes and to take necessary measures to prevent them. They also promote proper traffic rules with regulations, and evaluation of traffic movement.

(3) Management of Public Transport

This organization is responsible for ensuring the conditions for the operation of public transportat services within the municipal boundaries. Its functions are the regulation of mobility service to the Nicaraguan people.. The main functions of this organization are followings;

- The regulation of public transport, which essentially corresponds to the definition of the operating rules of the service including requirements to operate (forms of organization, type of vehicles, etc.), level of service required (routes, fleets, frequencies, etc.), forms of concession and tender procedures.
- The control of service by the permission process, in order that the totality of individual concessions can formulate a complete service network with appropriate operation timetable.
- The permission function. the responsibility for tenders and concession procedures, establishment of the bidding rules and selection of concessionaires based on the established rules, defining the contracts and taking care of the implementation of the concessions.
- The responsibility for all the equipment related to the operation of the transport such as bus stops, trasnfer stations and terminals by the different services.

10.3.3 Metropolitan Organization and Functions

There are some overlappings of the institutional service between bus oprating around the city and inter-citybus. These services cover the municipal territory, and they serve intramunicipal demand. On the other hand, its terminals are located inside the city, therefore their operation affect traffic flow in the city. In addition, this situation affects the expansion of the residents area of Managua City.

(1) The Metropolitan Transit Authority of Managua (MTAM)

For these reasons, Metropolitan Transit Authority should be considered. It should be in charge of ruling the operation of transit system at the metropolitan level. According to international experiences in this area, the best solution is to have a single urban transport management institution, in which all the territorial entities dealing with the activity, regardless of traditional authority and operational territory.

Under these conditions, the privileged actors of this organization should be the MTI and ALMA, because they are the main bodies that concentrate responsibilities and functions and because Managua City is the prime territory where the operation of these systems is taken place. In addition, the municipalities of Ciudad Sandino, Tipitapa, Mateare, Ticuantepe, El Crucero and Nindirí should be included in the Authority.

The Authority is in charge of coordinating all the actions that come from the joint decisions of the participating bodies, based on the initiatives and proposals of each of the partner municipalities or of the national power. For this reason, it will be responsible for the operation of public transport above each of the participating bodies, which will contribute to its decisions. Its authority is established on the contributions and powers added by each of the participants. The Authority rules and coordinates decisions regarding transportation routes, equipment (stops, dedicated lanes, payment systems, integration mechanisms, etc.).

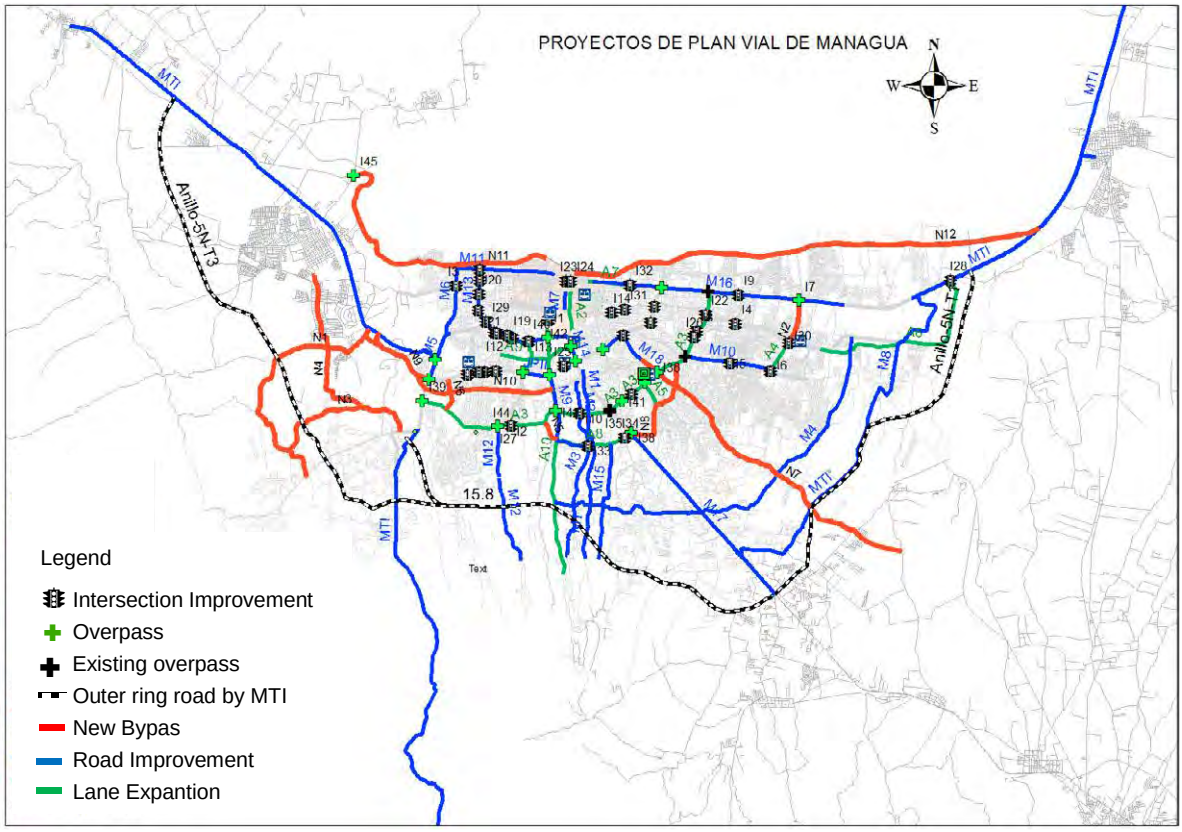
10.4 Proposed Projects for Transport Sector

10.4.1 Road Project

(1) Road project

The road network of Managua City has been increased without any forecast and control of the road capacities and it shows almost over the capacity and increase of bottlenecks. The road network consists in four project packages as shown in Figure 10.4.1:

- Improvement and Road Extensions Projects:
  - 18 Road improvements
  - 10 Road extensions
- 11 New Bypass Projects
- Outer Ring Road Project (4th. Ring Road, Section 1 and 3[1])
- Overpass and Intersections Projects
  - 19 Improvement projects for Traffic Signals (19)
  - 13 Intersection Improvement Projects
  - 16 Overpass Projects



Source: JICA Study Team

Figure 10.4.1 Components of the Road Plan

[1] Section 2 is Nejapa-Ticuantepe responsable for it is MTI it will be implemented in 2018.

These projects includes implement additional lanes, standardize the number of lanes, or redistribution of them for prioritizing the improvement of public transport, and the implementation periods is in the medium and long term as shown in Table 10.4.1.

Project has three groups;

- Project for Expansion and Improvement of Roads, which are mostly on existing roads and are some of the strategic plans that ALMA had contemplated.

- New Roads Project, which aim to connect and complement the existing network as well as connecting the new subcenters with the main road.
- Intersections and overpass project, which are improvements to existing ones and connecting new roads with the existing network. These are included the improvements and installation of traffic signal redesign of intersections, and construction of overpass on main roads which levels of service were already saturated.

Table 10.4.1 Proposed Road Projects Geometric Characteristics

Type of Projects		Number of lanes	Type of Road	Length (km)			
				Short	Medium	Long	Total
Improvement and Road Extension	Road Extension (10)	4,6 => 6	DP	0	1.58	0	1.58
		4 => 6	DP	1.265	12.833	0	14.098
		2 => 3	DP	0	6.76	0	6.76
		4 => 6	CP	0	8.6	0	8.6
		2 => 4	CP	2.98	0	0	2.98
		2 => 3	CP	0	1.305	0	1.305
		4 => 6	CS	0	5.71	0	5.71
		2 => 3	CS	2.65	0	0	2.65
	Road Improvement (18)	6,8 => 8	DP	8.5	0	0	8.5
		6	DP	0	7.5	0	7.5
		4	DP	15.06	5.62	0	20.68
		2,4	DP	0	3.379	0	3.379
		2,3	CP	9.891	9.15	0	19.041
		3	CS	0	1.2	0	1.2
		4	CS	0	6.8	0	6.8
		4	CS	0	18.73	0	18.73
New Bypass	Road (11)	6	DP	0		11.7	11.7
		4	DP	0	3.5	9	12.5
		4	CP	0	2.8	20.9	23.7
		4	CS	0	2.862	5.1	7.962
Outer Ring	4th. Ring (1)	3	DP	0	0	34.117	34.117
TOTAL				40.346	98.329	80.817	219.492

Source: JICA Study Team

Table 10.4.2 Proposed Road Projects Characteristics (Road Improvement and New Bypass)

Type of Projects		Type of Road	N	Cost ('000 NIO)			
				Short	Medium	Long	Total
Road Improvement	Road Extension	DP	4	18,075	350,809	0	368,884
		CP	3	29,389	115,680	0	145,069
		CS	3	30,125	64,298	0	94,423
		Total	10	77,589	530,788	0	608,377
	Road Improvements	DP	9	107,245	61,214	0	168,459
		CP	5	40,970	54,225	0	95,195
		CS	4	0	72,300	0	72,300
		Total	18	148,215	187,739	0	335,954
New Bypass	Roads	DP	3	0	60,250	216,900	277,150
		CP	5	0	42,175	239,795	281,970
		CS	3	0	45,790	72,300	118,090
		Total	11	0	148,215	528,995	677,210
Outer Ring Road Construction		DP	1	0	0	451,875	451,875
Total			40	225,804	866,742	980,870	2,073,416

Source: JICA Study Team

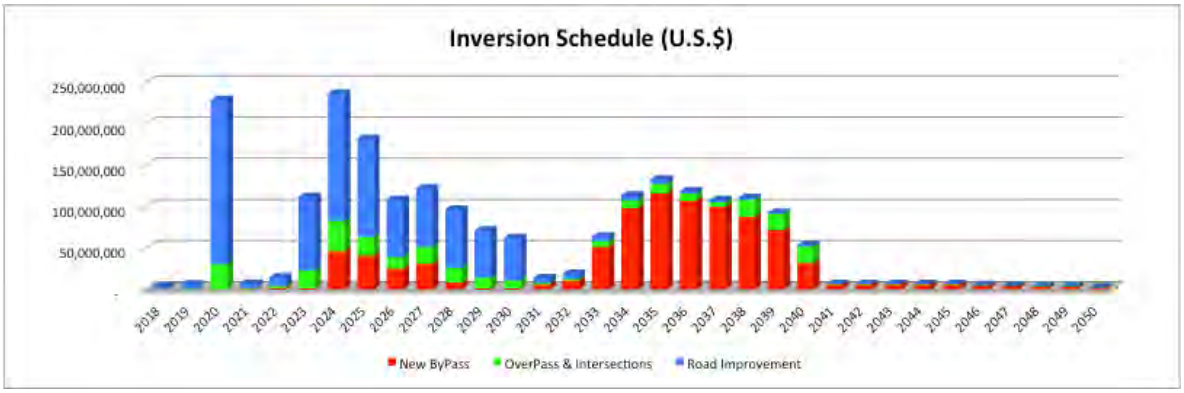
Table 10.4.3 Proposed Road Projects Characteristics (Overpass and Intersection)

Type of Projects	Type of Road	N	Cost ('000 NIO)			
			Short	Medium	Long	Total
Overpass and Intersection	Traffic Signals	17	10,242	0	0	10,242
		50	0	30,125	0	30,125
		50	0	0	30,125	30,125
	Intersections	6	25,171	0	0	25,171
		7	0	29,272	0	29,272
	Overpasses	12	0	107,245	0	107,245
		3	0	0	74,710	74,710
Total		45	35,413	166,642	104,835	306,891

Source: JICA Study Team

These projects will be implemented in the short, medium and long term, for which an implementation schedule was estimated based on estimated costs as shown inTable 10.4.5.

The investment schedule start from the first years of each period. Therefore, it is necessary to analyze the possibility of some projects with external and/or private financing.

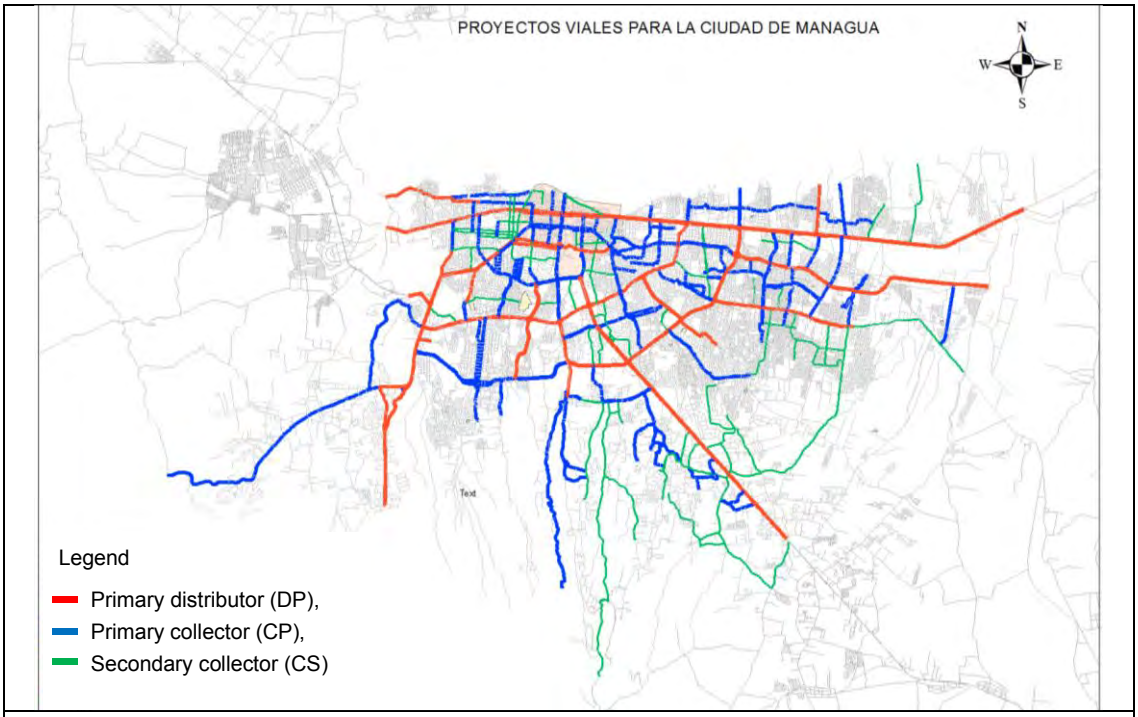


Source: JICA Study Team

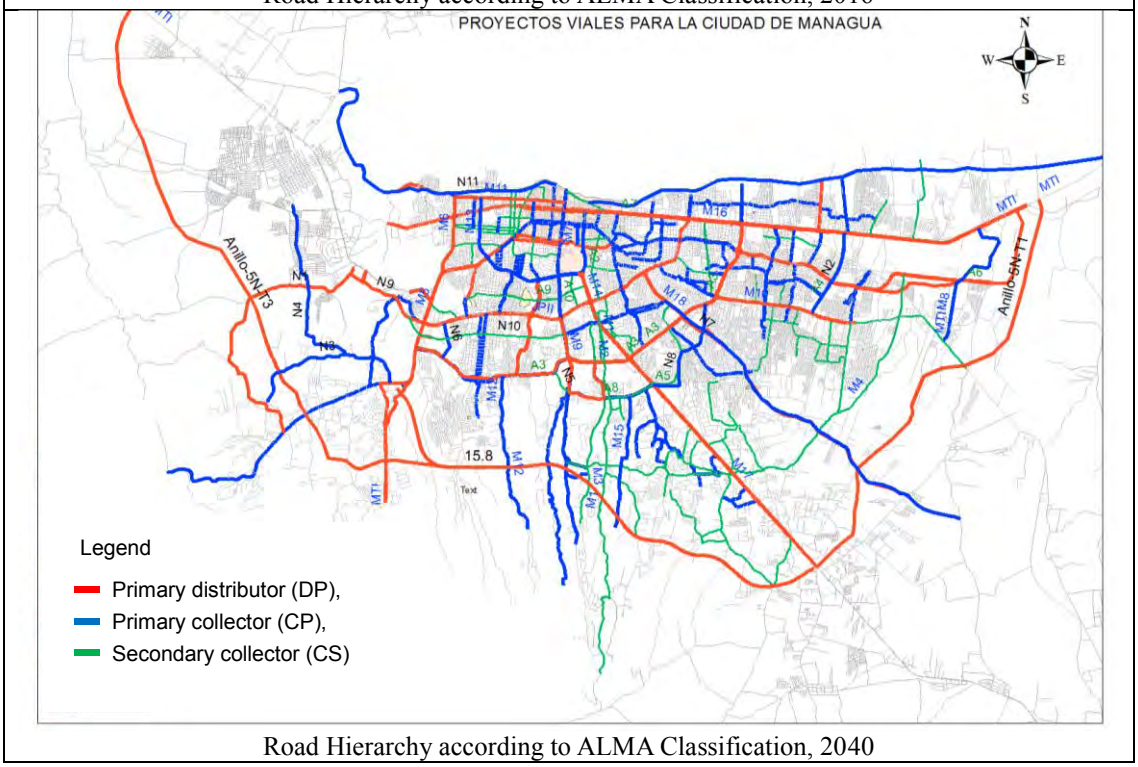
Figure 10.4.2 Investment Schedule of the Road Projects

Implementation of improvement of the proposed road projects optimizes and reduces traffic flows. However, the case 10, which has imtroduction of the massiv transportation system, is the optimum scenario for mitigating traffic congestion in 2040.

The following figures are the comparson of the current and projected road netwoek by road hierarchy, capacity (number of lanes) and implementation period.



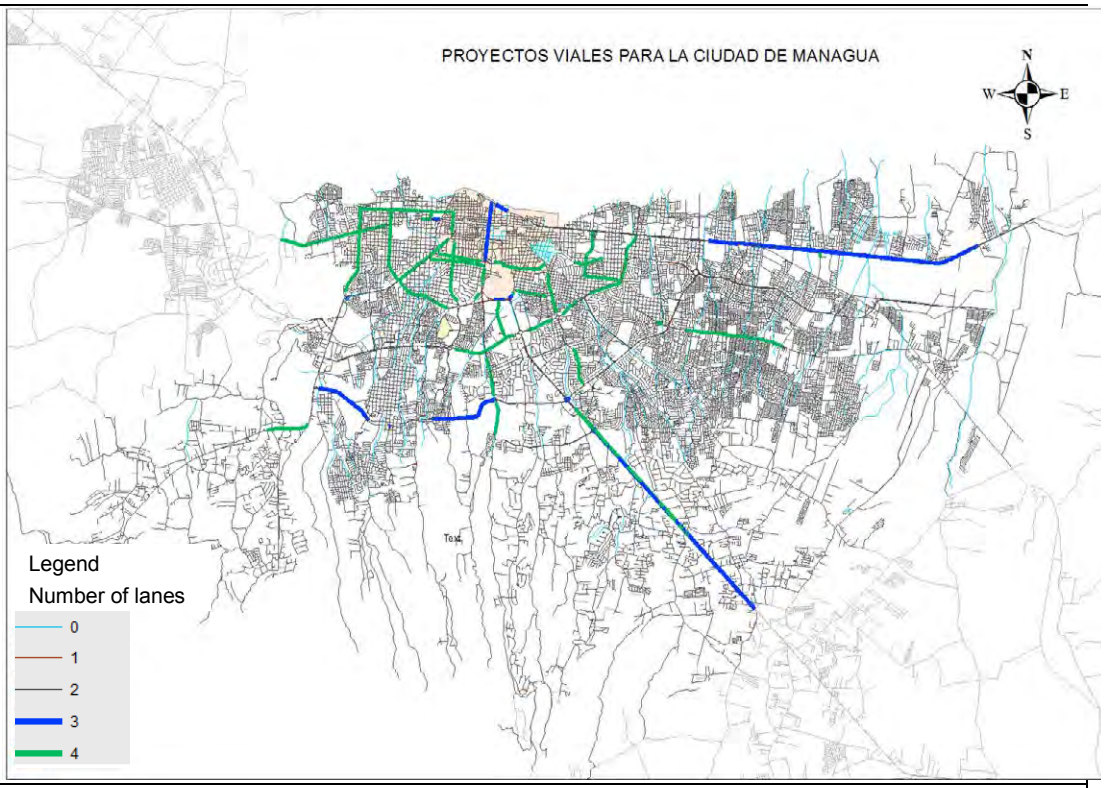
Road Hierarchy according to ALMA Classification, 2016



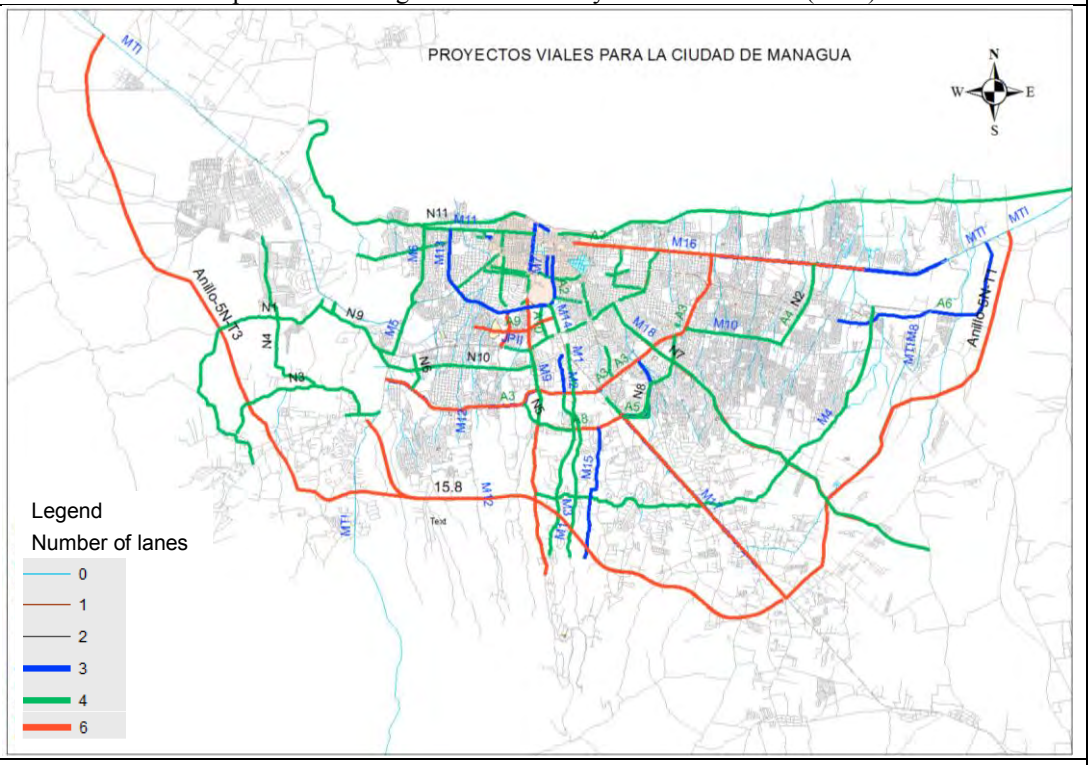
Road Hierarchy according to ALMA Classification, 2040

Source: JICA Study Team

Figure 10.4.3 Functional Hierarchy of the Master Plan of the Road Network



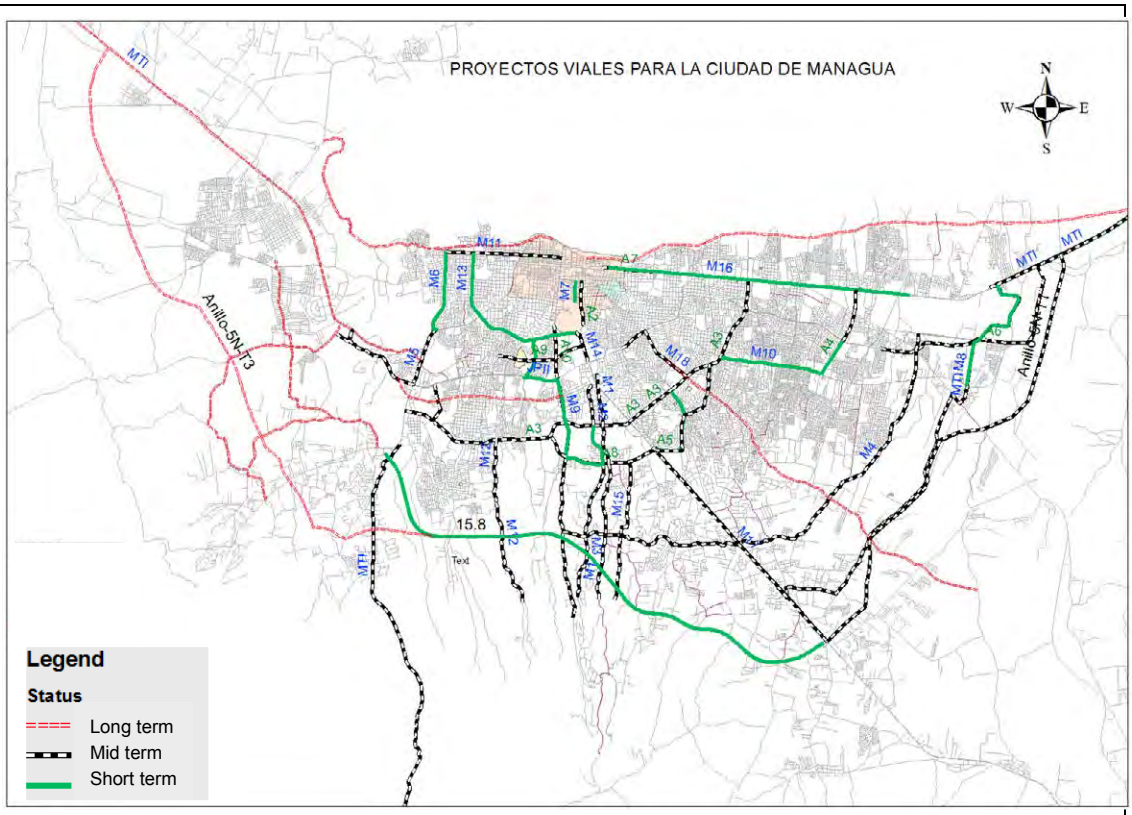
Map of the Existing Road Network by Number of Lanes (2016)



Map of the Existing Road Network by Number of Lanes (2040)

Source: JICA Study Team

Figure 10.4.4 Number of Lanes of the Master Plan of the Road Network



Short_Time (2020), Medium_Time (2030) and Large_Time (2040)

Source: JICA Study Team

Figure 10.4.5 Road Development Phases

The fourth ring road project will be done by MTI. However, this road is very effective for mitigating traffic congestion in Managua City. In addition to the increasing of road capacity, the large amounts of truck traffic do not need to pass through the Managua city. Therefore, the fourth ring road is very important project.

(2) Future Road Network to be adopted for the Study

The future road plan with target year 2040 was prepared, which focused on strengthening the road capacity. In addition to the inplementation of new bypass for reducing the effects of traffic congestion, taking a priority in the main axes for the introduction of massive transportation was considered. Table 10.4.4 shows a series of typical cross-sections based on the above was prepared. Some example has the segregated corridors for massive transport systems. The typical cross-section of future road plan considers the following road hierarchies according to the classification by the ALMA:

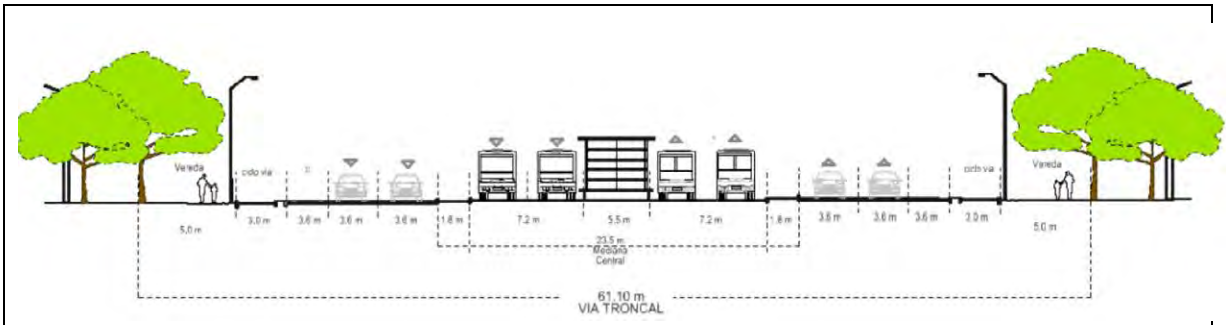
1) Primary distributor (DP),

2) Primary collector (CP),

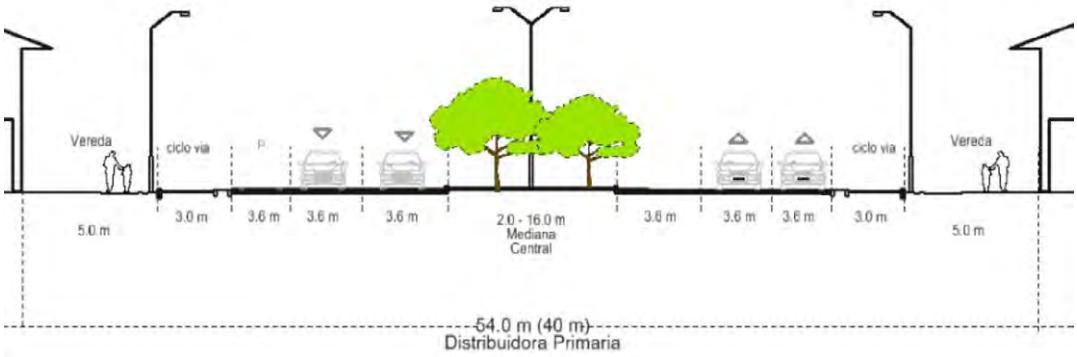
3) Secondary collector (CS), and

4) Local Road

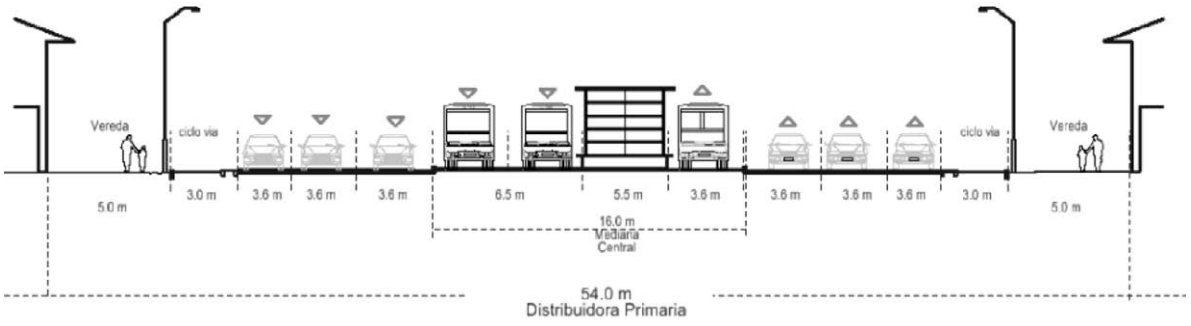
Table 10.4.4 Typical Cross-sections of the Road Network for the case of shared with massive public transport and capacity improvement of Local Roads



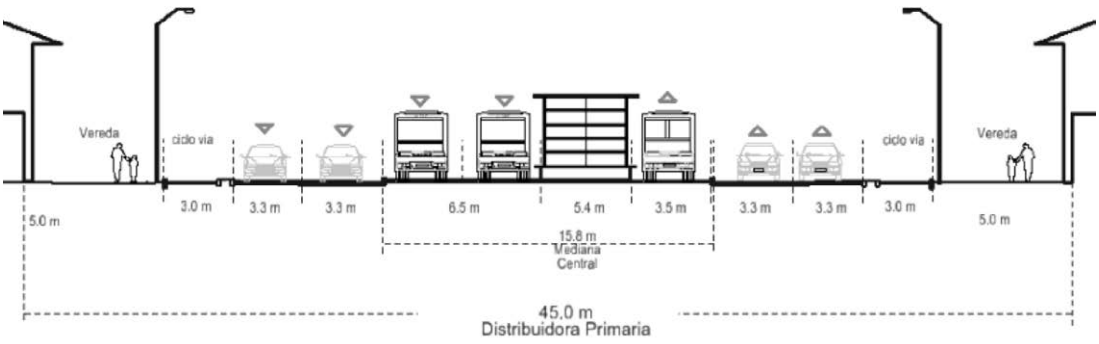
ST-01. Typical cross-section of primary distributor road with BRT system (capacity over 15,000 passengers / hour direction), 6 lanes for private including bike lanes.



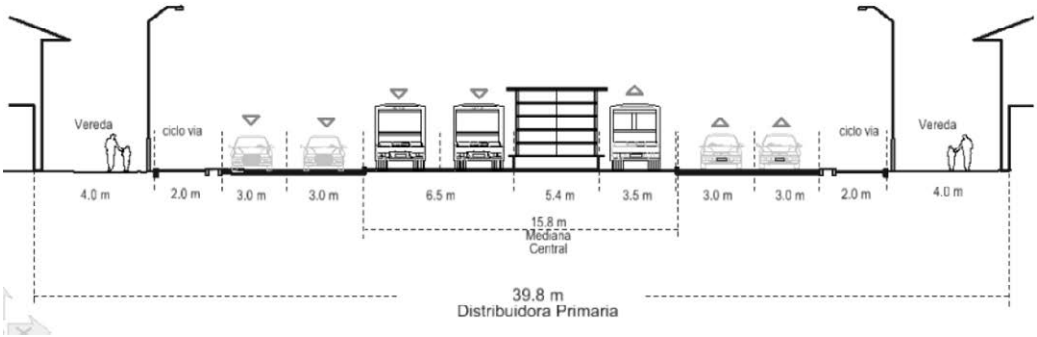
ST-02. Typical cross-section of primary distributor road, 6 lanes for private including bike lanes



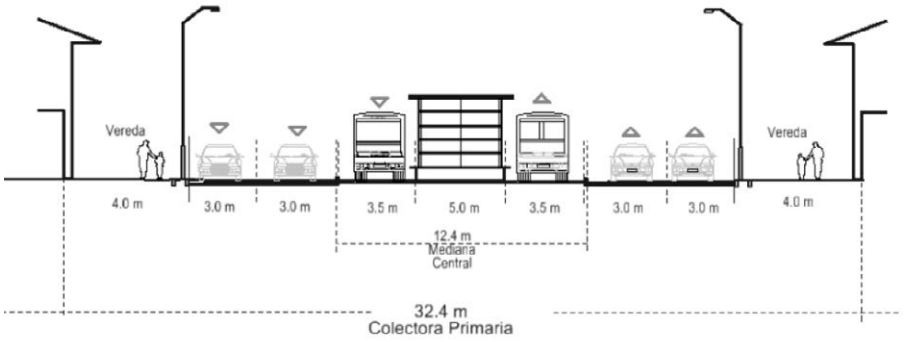
ST-03. Typical cross-sction of primary distributor road with BRT system (capacity over 13,000 passengers / hour direction), 6 lanes for private including bike lanes.



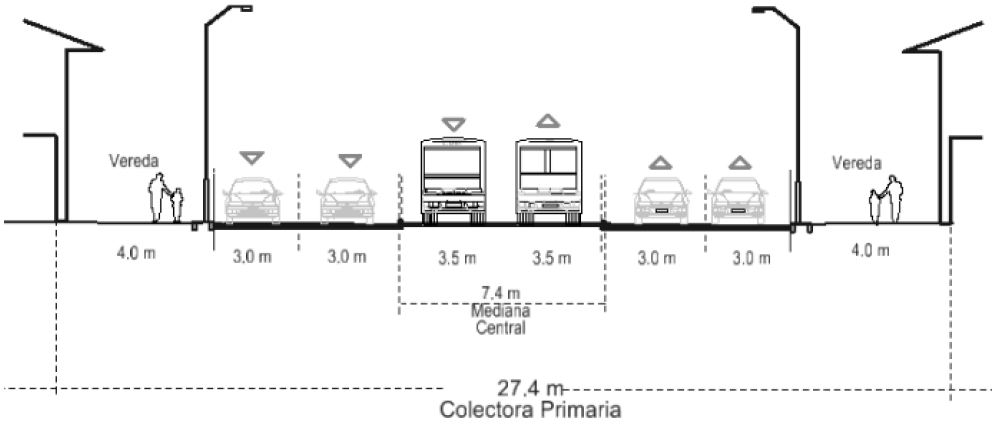
ST-04. Typical cross-section of primary distribution road with BRT system (capacity over 13,000 passengers / hour direction), 4 lanes for private including bike lanes.



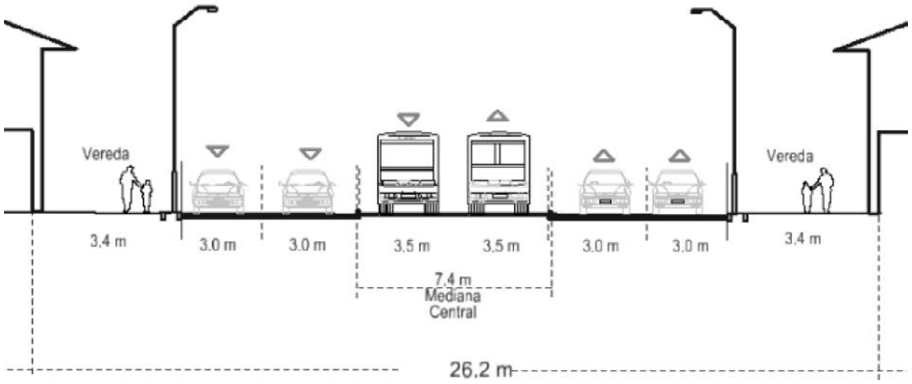
ST-05. Typical cross-section of minimum primary distribution road with BRT system (capacity over 13,000 passengers / hour direction), 4 lanes for private including bike Lanes.



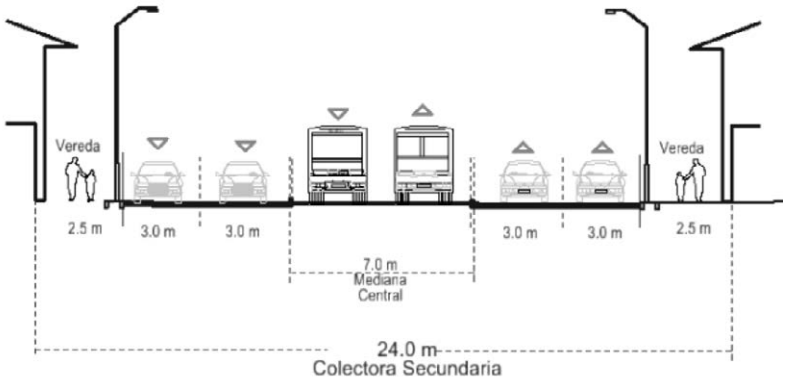
ST-06. Typical cross-section of the primarycollector road with BRT system (capacity up to 13,000 passengers / hour direction), 4 lanes for private. Passenger station zone.



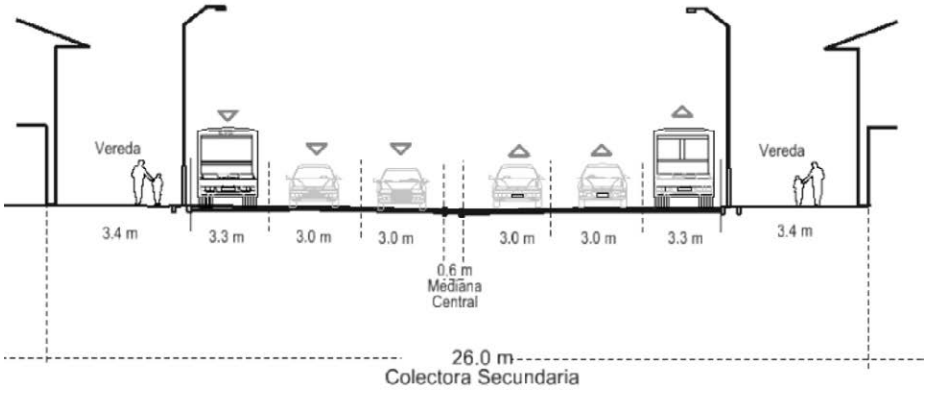
ST-07. Typical cross-section of primary collector road with BRT system (capacity up to 13,000 passengers / hour direction), 4 lanes for private. 1-lane central bus corridor.



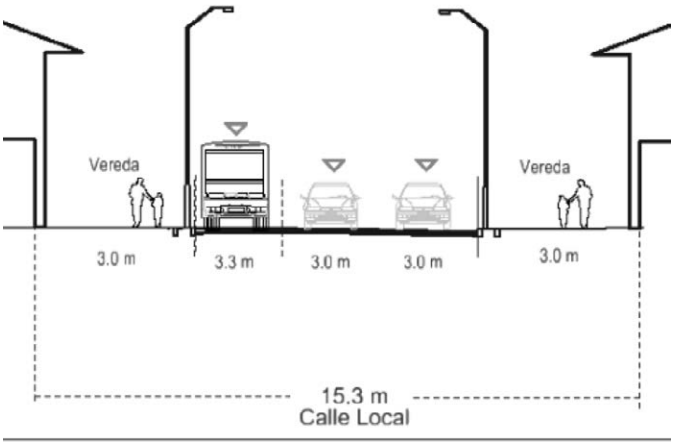
ST-08. Typical cross-section of secondary collector road with BRT system (capacity up to 13,000 passengers / hour direction), 4 lanes for private. 1-lane central bus corridor.



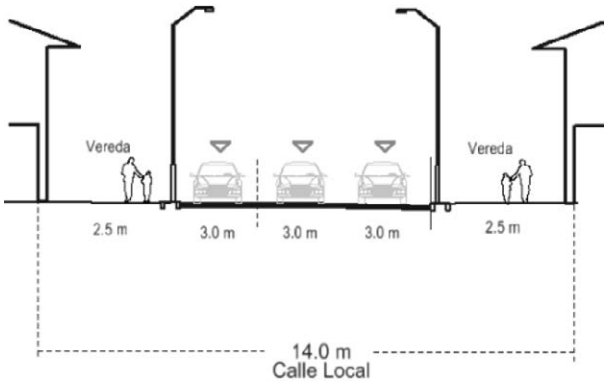
ST-09. Typical cross-section of minimum secondary collector road with BRT system (capacity up to 13,000 passengers / hour direction), 4 lanes for private. 1-lane central bus corridor.



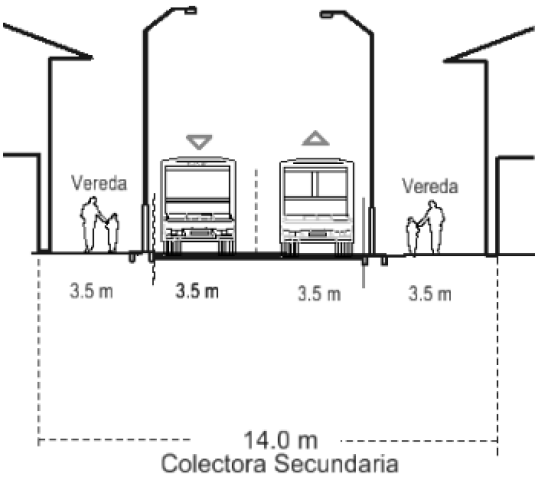
ST-10. Typical cross-section of secondary collector road with existing transportation system (capacity up to 5,000 passengers / hour direction), 4 lanes for private.



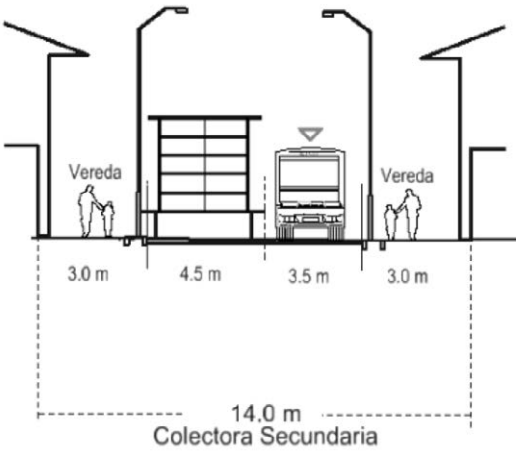
ST-11. Minimum typical cross-section of local road with existing transportation system (capacity up to 5,000 passengers / hour direction), 2 lanes for private in one direction.



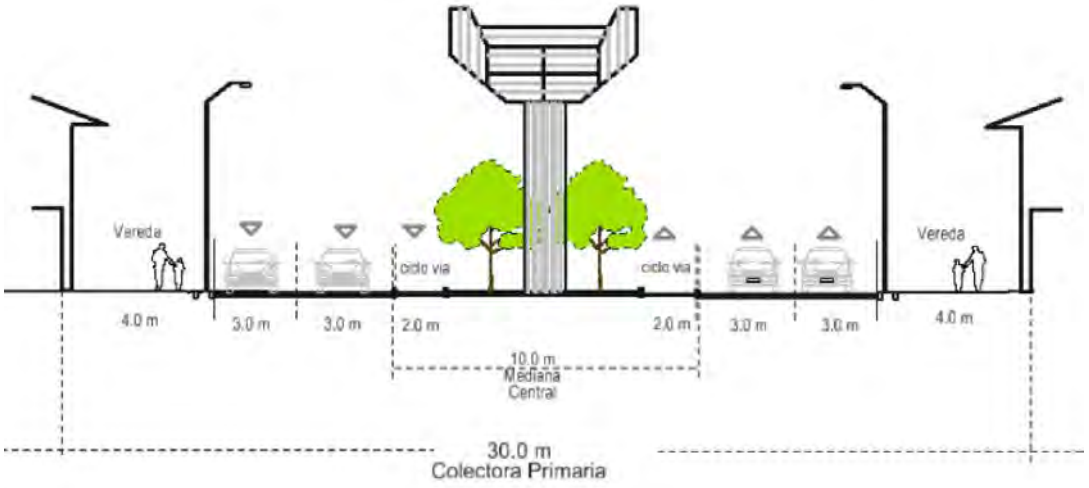
ST-12. Minimum typical cross-section local road with 3 lanes for private in one direction.



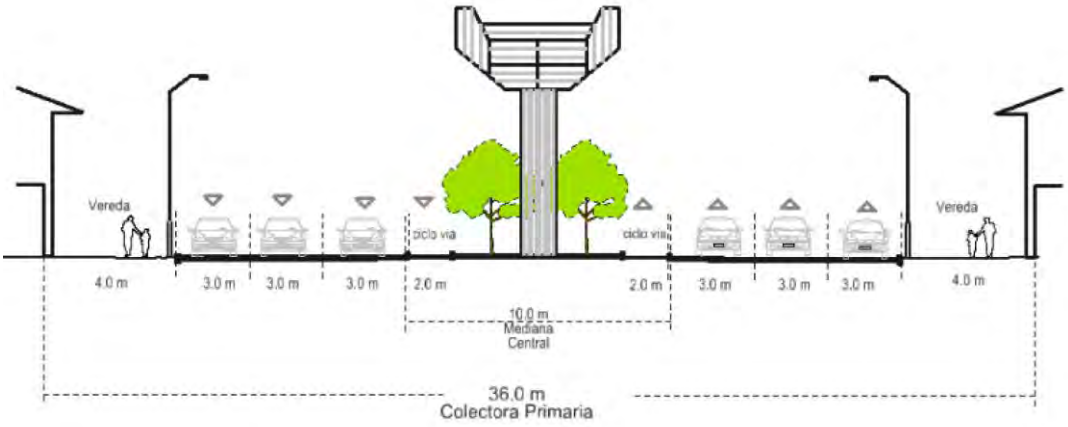
ST-13. Minimum typical cross-section of local road with exclusive BRT system (capacity up to 13,000 passengers / hour direction), 2 lanes in exclusive bus traffic.



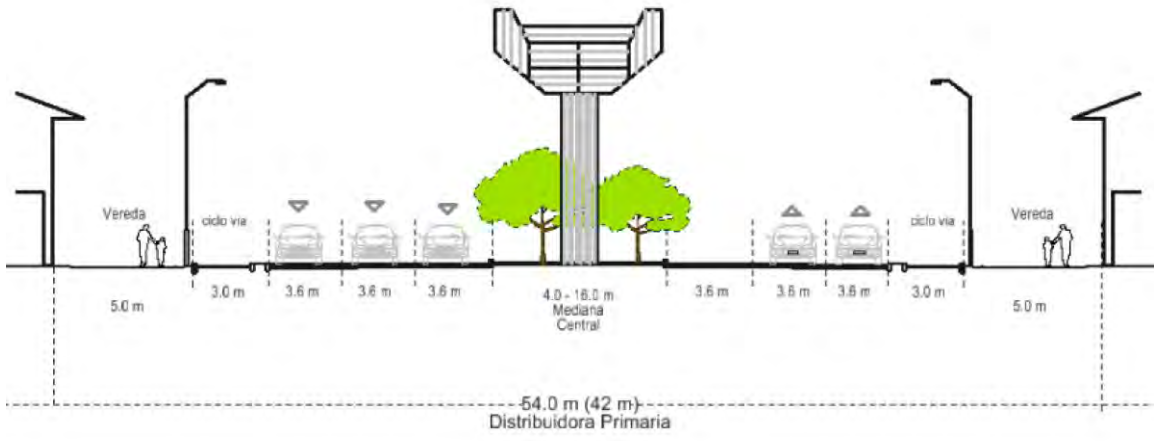
ST-14. Minimum typical cross-section local road with exclusive BRT system (capacity up to 13,000 passengers / hour direction), exclusive bus traffic, Station zone.



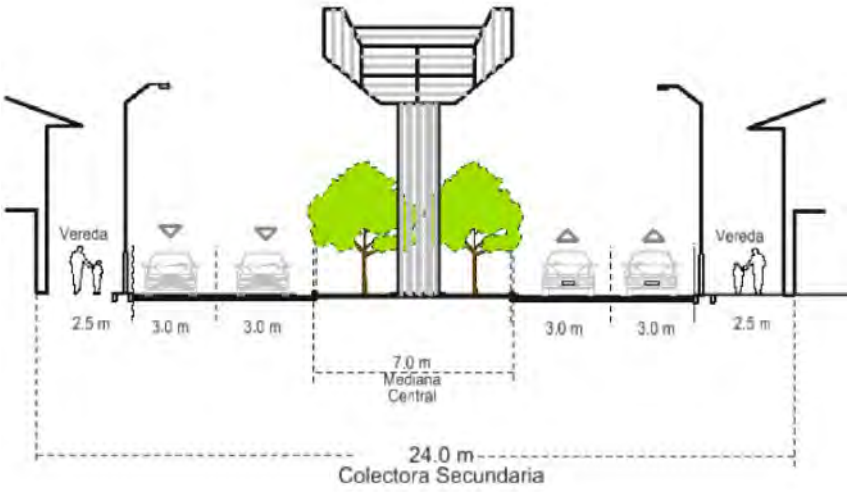
ST-15. Typical cross-section of primary collector road with AGT system (capacity up to 40,000 passengers / hour direction), 4 lanes for private including bike lanes.



ST-16. Typical cross-section of primary collector road with AGT system (capacity up to 40,000 passengers / hour direction), 6 lanes for private including bike lanes.



ST-17. Typical cross-section of primary collector road with BRT system (capacity up to 40,000 passengers / hour direction), 4 lanes for private including bike lanes.



ST-18. Critical typical cross-section of 24 m, corresponds to a secondary collector road. Typical primary collection road with AGT System (capacity up to 40,000 passengers / hour direction), 4 lanes for private, minimum paths.

Source: JICA Study Team

The projects were grouped by degree of intervention; road improvement and expansion, intersections and overpass, new roads, bus terminal projects and mass transportation. This timetable is not only to place the estimated budget per work, but also to establish the stages of the project from the pre-investment (profile, prefeasibility or feasibility study), execution (engineering studies, works and supervision) and maintenance of at least 10 years of operation.

Other timelines is shown in the summary graph of Figure 10.4.2

Table 10.4.5 Implementation Schedule of of the Road Plan Projects

CRONOGRAMA DE IMPLEMENTACIÓN DEL PLAN VIAL									Short			Medium										Long									
No	Code	Project/ Program	Type	Name of the Projects	U/M	Length	Condition	Cost buget of the project	1	2	3	1	2	3	4	5	6	7	8	9	0	1	2	3	4		19	20	21	22	23
1	A1	Road Improvement	Road Extension	2 Rotonda_ElPeriodísta_ ElGueguense	Km	1.265	Short term	15,000,000																							
2	A2			5a Avenida SE	Km	1.305	Med Term	16,000,000																							
3	A3*			Pista Suburbana	Km	12.833	Mid Term	205,328,000																							
4	A4*			Pista El Mayoreo	Km	2.98	Short term	24,390,000																							
5	A5*			5_Centroamérica_Rotonda_LaVirgen	Km	2.65	Short term	25,000,000																							
6	A6			9-10_Pista_Larreynaga_ CiudadBelén_GaritaTipitapa	Km	6.76	Med Term	70,000,000																							
7	A7			Carretera Norte	Km	1.58	Med Term	15,800,000																							
8	A8			Pista Jean Paul Genie	Km	2.77	Med Term	26,900,000																							
9	A9			25 Calle Suroeste	Km	2.94	Med Term	26,460,000																							
10	A10			Avenida Bolívar	Km	8.6	Med Term	80,000,000																							
11	I1	Over Pass and Intersections	Traffic Signal	Avenida Bolívar (Esc, De Manejo la Profesional)	c/u	1.0	Short Term	500,000																							
12	I2		Overpass	Memorial Sandino	c/u	1.0	Med Term	6,000,000																							
13	I3*		Intersection	Linda Vista (35 Avenida - Paseo Las Brisas	c/u	0.3	Short Term	2,500,000																							
14	I4		Intersection	Larreynaga -Pista Buenos Aires (San Jacinto)	c/u	0.3	Med Term	3,500,000																							
15	I5		Intersection	48 Rotonda Semáforos Iván Montenegro	c/u	0.3	Med Term	3,796,300																							
16	I6		Intersection	49 Rotonda Semáforos del Mercado Mayoreo	c/u	0.3	Short term	3,796,300																							
17	I7		Overpass	LA SUBASTA	c/u	1.0	Long Term	8,000,000																							
18	I8		Intersection	59 Rotonda intersección Barrio Santa Rosa	c/u	0.3	Short term	3,796,300																							
19	I9		Intersection	61 Rotonda Entrado barrio La Primavera	c/u	0.3	Short term	3,796,300																							
20	I11		Traffic Signal	Altagracia 1	c/u	1.0	Short term	500,000																							
21	I12		Traffic Signal	Altagracia 2 (RACACHACA)	c/u	1.0	Short term	500,000																							
22	I13		Traffic Signal	Altagracia 3	c/u	1.0	Short term	500,000																							
23	I14		Traffic Signal	Banco Popular	c/u	1.0	Short term	500,000																							
24	I15		Traffic Signal	Intersección Cementerio Central (La Ceibita)	c/u	1.0	Short term	500,000																							
25	I16		Traffic Signal	Intersección Centro_Comercial Altamira	c/u	1.0	Short term	500,000																							
26	I17		Traffic Signal	El Cortijo 2	c/u	1.0	Short term	500,000																							
27	I18		Traffic Signal	Calle El Triunfo -Benjamín Zeledón	c/u	1.0	Short term	500,000																							
28	I19		Traffic Signal	El Recreo	c/u	1.0	Short term	500,000																							
29	I20		Traffic Signal	Estatua Monseñor Lezcano	c/u	1.0	Short term	500,000																							
30	I21		Traffic Signal	La Ceibita (Benjamín Zeledón - Camino Viejo a León)	c/u	1.0	Short term	500,000																							
31	I22		Traffic Signal	Villa progreso (RUPAP)	c/u	0.3	Short term	500,000																							
32	I23		Traffic Signal	Intersección Poder_Judicial	c/u	1.0	Short term	500,000																							
33	I24		Traffic Signal	Intersección Poder_Judicial1	c/u	1.0	Short term	500,000																							

34	I25		Overpass	Villa fontana	c/u	1.0	Med term	7,000,000	
35	I26		Traffic Signal	Intersección Unión_Soviética	c/u	1.0	Short term	500,000	
36	I27		Traffic Signal	Intersección del Memorial Sandino	c/u	1.0	Short term	500,000	
37	I28		Intersection	Pista Larreynaga -Carretera Norte	c/u	0.3	Short term	3,500,000	
38	I29		Intersection	El Guanacaste (Carretera Sur - Pista Benjamín Zeledón)	c/u	0.3	Short term	3,500,000	
39	I30		Intersection	Pista Larreynaga -Mayoreo	c/u	0.3	Med Term	3.400.000	
40	I31		Intersection	La Tenderí (P, Larreynaga-Migración)	c/u	0.3	Med Term	2,500,000	
41	I32		Intersection	Intersección Antigua PEPSI	c/u	0.3	Med Term	3,800,000	
42	I33		Intersection	CLUB TERRAZA	c/u	0.3	Med Term	3,796,300	
43	I34		Intersection	Intersección Camino Viejo a Santo Domingo -Pista Jean Paul Genie	c/u	0.3	Med Term	3,500,000	
44	I35		Overpass	Rotonda Centroamérica	c/u	1.0	Long Term	6,000,000	
45	I36		Overpass	Intersección Hospital del Niño	c/u	1.0	Med Term	6,000,000	
46	I37		Overpass	Mercado Roberto Huembes	c/u	1.0	Med Term	6,000,000	
47	I38		Overpass	Rotonda Jean Paul Genie	c/u	1.0	Med Term	8,000,000	
48	I39		Overpass	Suburbana-Carretera Sur (BANCENTRO)	c/u	1.0	Med Term	6,000,000	
49	I40		Overpass	Hospital Militar (Jonathan González - PETRONIC)	c/u	1.0	Med Term	6,000,000	
50	I41		Overpass	LOZELSA (HOSP. CENTRAL)	c/u	1.0	Med Term	6,000,000	
51	I42		Overpass	Naciones Unidas	c/u	1.0	Long Term	3,000,000	
52	I43		Overpass	UNIVERSITARIA	c/u	1.0	Med Term	6,000,000	
53	I44		Overpass	Camino de Bolas (Entrada Parque de Ferias	c/u	1	Med Term	6,000,000	
54	I45		Overpass	Puente 46 Ciudad Sandino	c/u	1,00	Med Term	6,000,000	
55	*		Overpass	Pasos a Desnivel a Mediano Plazo	c/u	2	Med Term	20,000,000	
56			Overpass	Pasos a Desnivel a Largo Plazo		3	Long Term	45,000,000	
57			Traffic Signal	Paquete de Mejoramiento de Intersecciones Existentes	c/u	50	Med Term	25,000,000	
58			Traffic Signal	Paquete de Mejoramiento de Intersecciones Existentes	c/u	50	Long Term	25,000,000	
59	M1	Road Improvement	Road Improvement	Alterna Carretera Las Nubes	Km	6.8	Med Term	14,000,000	
60	M2			Av. Gabriel Cardenal	Km	1.2	Med Term	3,000,000	
61	M3			Carretera a Las Nubes	Km	4.1	Med Term	8,000,000	
62	M4			Cuarto Anillo	Km	14.63	Med Term	35,000,000	
63	M5			3a Avenida NE	Km	1.8	Med Term	3,600,000	
64	M6*			35a Avenida So	Km	2.95	Short Term	30,000,000	
65	M7			3ra Avenida Sur Este	Km	0.65	Short Term	6,000,000	
66	M8			Ciudad Belén / Carretera Norte (3.6 km)	Km	4.2	Short Term	8,000,000	
67	M9			Enel Central - Rigoberto López	Km	4.7	Short Term	9,000,000	
68	M10*			Pista Sabana grande	Km	7.41	Short Term	30,000,000	
69	M11			Calle El Triunfo	Km	3.379	Med Term	15,000,000	
70	M12			Camino a San Isidro de Bolas	Km	4.9	Med Term	22,500,000	

71	M13			Pista Benjamín Zeledón	Km	5.041	Short term	20,000,000	
72	M14			Pista Naciones Unidas	Km	1.17	Med Term	11,700,000	
73	M15			Camino a San Isidro de la Cruz Verde	Km	4.25	Med Term	22,500,000	
74	M16			Carretera Norte	Km	8.5	Short term	20,000,000	
75	M17			Carretera Masaya	Km	7.5	Med Term	15,000,000	
76	M18			Santo Domingo / Roberto Huembés (2.4 km)	Km	2.65	Med Term	5,500,000	
77	N1	New Bypass	Route	Circunvalación Oeste	Km	9	Largo Plazo	80,000,000	
78	N2			Acceso Centro Servicios Oriental	Km	1.6	Mediano Plazo	20,000,000	
79	N3			Colectora	Km	5.2	Largo Plazo	52,000,000	
80	N4			Colectora_CS	Km	5.7	Largo Plazo	57,000,000	
81	N5			Centro de Conocimiento Avanzado	Km	0.762	Mediano Plazo	8,000,000	
82	N6			Centro de Servicios Occidental	Km	1.2	Mediano Plazo	15,000,000	
83	N7			Conexión Sur	Km	11.76	Largo Plazo	100,000,000	
84	N8			Prolongación Jean P. Genie	Km	3.72	Mediano Plazo	46,500,000	
85	N9			Prolongación Oeste de Juan Pablo II	Km	3.5	Mediano Plazo	50,000,000	
86	N10			Prolongación Oeste de Pedro Obando	Km	5.1	Largo Plazo	60,000,000	
87	N11			Antigua Vía Férrea (Sector Acahualinca)	Km	10	Largo Plazo	90,000,000	
88	N12			Costanera Norte	Km	16.46	Largo Plazo	160,000,000	
					Km	331.715		1,773,459,500	

*: existing project which has planned by ALMA

Legend:

	Short	Medium	Large
Preinversión			
Estudios de Ingeniería			
Construcción y Supervisión de Obras			

Source: JICA Study Team

10.4.2 Public Transport Project

(1) Mass-transit systems

1) General functions

As already presented, mass-transit systems are proposed to keep moving the future Managua City. The systems need to have the following features in general;

- Adequate capacity

  As the reinforced traffic axes of Managua city, the routes should cover the frequented routes of maximum passengers, connecting the urban centers. Accordingly, the capacity of the system must be adequate to transport the large volume of passengers.

- Wide coverage complemented by feeder buses

  It is important that maximum citizens can access to the service, so the routes should be spreaded as much as possible in the city. And the feeder buses should complement the main routes of mass-transit systems.

- Punctual operation

  Punctual operation is an important characteristic of the future mass-transit system, as the passenger interview survey showed the preference of citizens. The routes should accordingly have their dedicated lanes, and the intersection control should be prioritized for the mass-transit system in case of ground-level operation. There should also be a control center which monitors the real-time condition and regulate the operation.

- Comfortable and secured service

  Comfortability and security are also the important concerns for the citizens. According to the passenger interview survey, the biggest two reasons to use the private car are the comfortability and the security. Concerning this issue, here is a popular quote from a former mayor of Bogota, Columbia, saying "a developed country is not a place where the poor have cars. It is where the rich use public transportation." The public transport should be comfortable and secured, to be a reasonable alternative for everyone.

- Easy transit

  Transit between different mass-transit systems with other modes of public transport such as feeder buses, intercity buses, taxi and mototaxies should be well designed to facilitate the mobility of public transport users.

- Park & Ride

  Park & Ride facility should also be integrated in the system, in order to provide the private vehicle users with the alternative mode of transport.

Source: Railway Technology (http://www.railway-technology.com)

Figure 10.4.6 Example of Park & Ride facility (Nante, France)

- Information provision

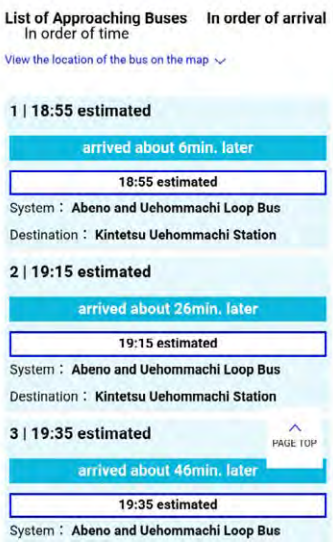
Information of operation including regular timetable and real-time operation situation should be conveyed towered the users in multiple ways such as by display at the stations and by the applications / internet.

- Integrated pricing system

The pricing system should be integrated among various transport modes, especially among the mass-transit systems and the feeder buses. Some intercity buses could also be integrated. The price charging for mass-transit systems should be done at the stations and not on-board in order to minimize the station dwell time.

- Accessibility

All the stations and fleets should be accessible for all the passengers, including for example people with disabilities and non-Spanish speakers. The hardware and software should accordingly equipped based on the universal design.



Source: Screenshot from Kintetsu Bus web service

Figure 10.4.7 Example of Bus location info provision (Osaka, Japan)

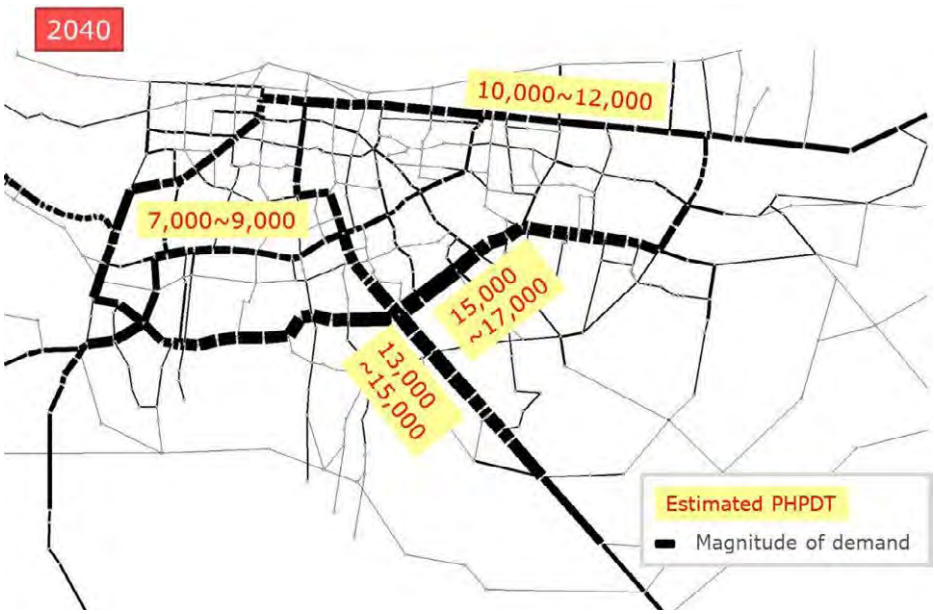
Source: ALMA by Training in Japan

Figure 10.4.8 Example of accessible design of public transport facilities (Toyama, Japan)

2) Estimated demand and implementation timing

Considering the technical and finantial capacity, projects of the mass-transit systems cannot be initiated all in one time, but it should be started with one or two lines then should be completed in the later stage for all the lines.

The forecasted peak hour peak direction trips (PHPDT) is the main indicator of demand for public transport, which is shown below for the year 2040, assuming the installation of all four lines of mass-transit systems by the moments. The estimated PHPDT indicates that the higher demand is observed on Suburbana road and Masaya highway.



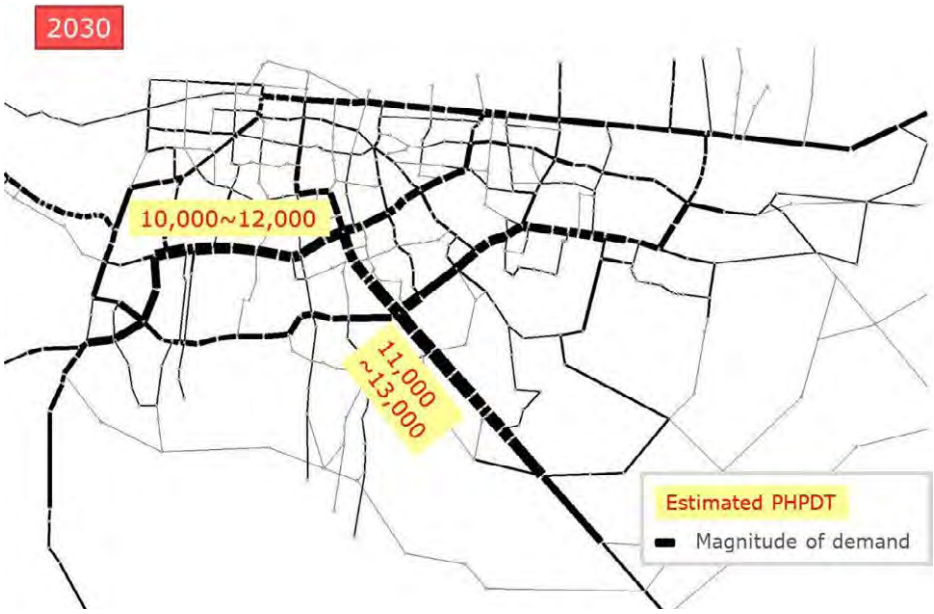
Source: JICA Study Team

Figure 10.4.9 Peak hour peak direction trips (PHPDT) on public transport network in 2040

Looking at the large volume of demand and the important function to connect the two principle urban centers of the city, the line on Masaya road is one to be developed in the earlier phase.

As for another line for the earlier phase, there is a project of widening of Juan Pablo II road that is already at the point of initiation as of May 2017. The project includes the arrangement of exclusive lanes for buses, and ALMA is planning to introduce BRT system. Although Juan Pablo II is not a line with the highest demand, it could be the first line to be developed, considering this existing project that shall support the viability as well as its route going in the middle of the city that shall have less risk to foster unexpected urban sprawl. Also, its relatively small volume of passenger demand could be handled by a lighter mass-transit system that requires relatively less investment than other systems, which should be an important aspect as the first mass-transit system in the country.

Figure 10.4.10 presents the PHPDT on public transport network in 2030 with only Juan Pablo line and Masaya line completed.



Source: JICA Study Team

Figure 10.4.10 Peak hour peak direction trips (PHPDT) on public transport network in 2030

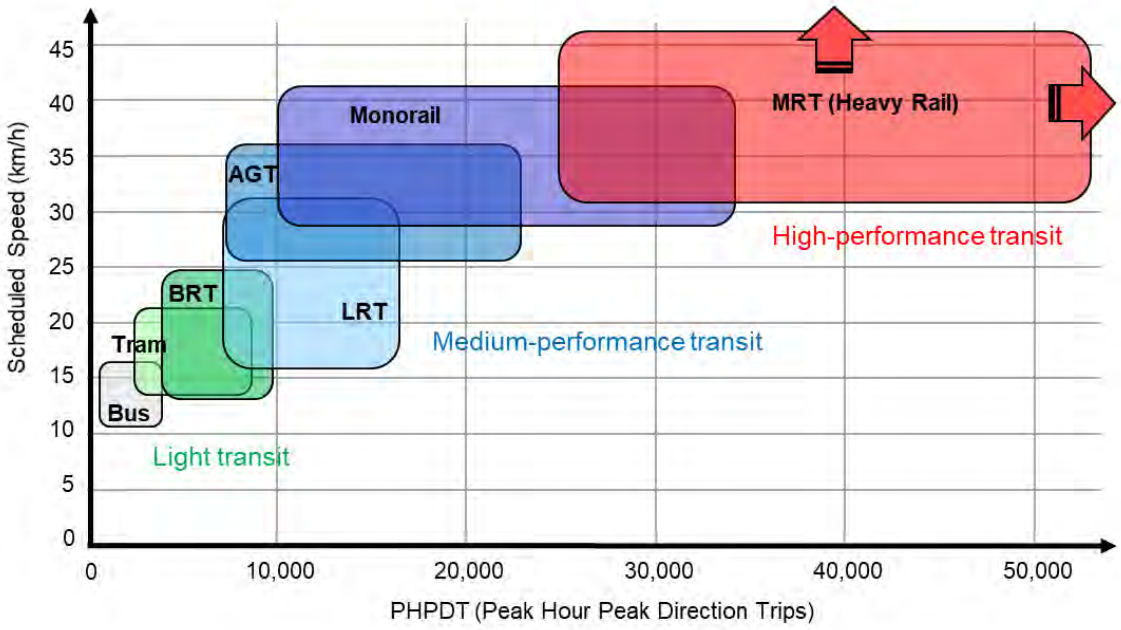
The system to be installed in each route was studied based mainly on the volume of peak demand (PHPDT), land availability and characteristics of the route. The comparison of the main characteristics of different mass-transit systems is presented in Table 10.4.6.

Concerning the PHPDT capacity of each system, there are many theories and practices that define the capacity differently. In particular, the capacity of Bus Rapid Transit (BRT) is sometimes defined over 40,000 PHPDT, stating the practice of Bogota and others. However, it must be noted that most of the world practices of BRT serve up to around 10,000 PHPDT, which should be a sort of standard value. In any definition, the demand in Managua City would require medium capacity transit systems.

Table 10.4.6 Comparison of medium capacity mass-transit systems

	BRT	LRT	AGT	Monorail
Capacity	Small-Medium	Small-Meduim	Medium	Medium
Speed	Slow	Slow-middle	Middle	Middle
Required land space	Large	Large	Small	Small
Landscape	Normal	Good	Normal	Good
Construction Cost	Small-Medium	Medium-Large	Medium-Large	Large

Source: JICA Study Team



Source: JICA Study Team

Figure 10.4.11 Scheduled speed and PHPDT capacity of mass-transit systems

As a conclusion of the analysis on different systems and features of each line, the recommended systems were selected as below;

- Bus Rapid Transit (BRT) for Juan Pablo II Line (planned project)
- Light Rail Transit (LRT) for Panamerican Line
- Automated Guideway Transit (AGT) for Masaya Line and Suburbana Line

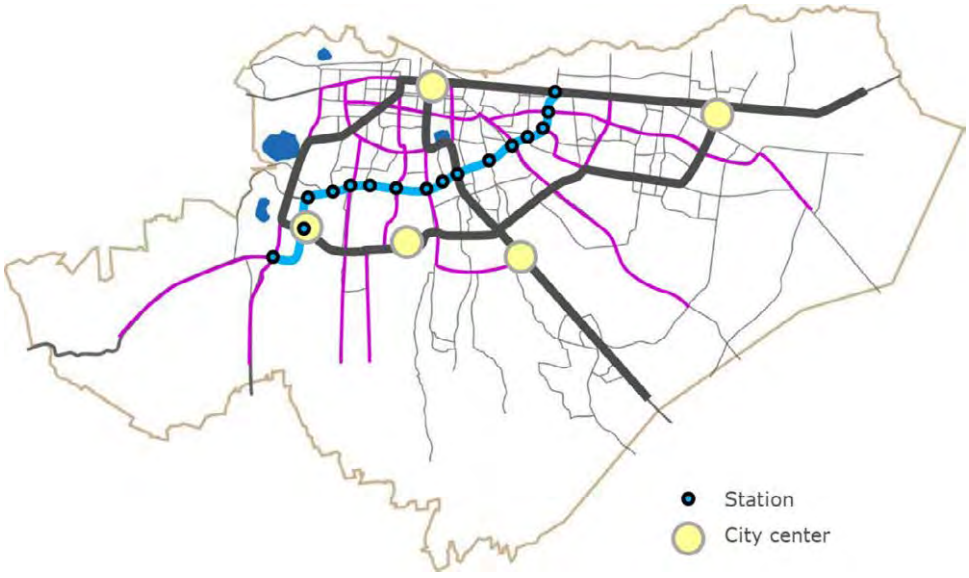
3) Features of each route

Juan Pablo II Line

Juan Pablo II Line with longitude of 11.6km shall connect Juan Pablo II road and Nejapa area. The route shall provide a good accessibility to the population in the inner area of the city and in Nejapa area, and to the intercity passengers from southwest alighting at the bus terminal integrated with West city center. This route shall serve as a west-east axe of the city.

The demand is estimated to be around around 11,000 PHPDT and 250,000 daily passengers in 2030, and 8,000 PHPDT and 250,000 daily passengers in 2040. This volume could be handled by BRT, which is the recommended system for this route. The implementation is expected to be in the short term considering the widening project of Juan Pablo II road that is already at the point of initiation.

The peak demand can be fulfilled by bi-articulated bus (3 modules) with full-loaded capacity of 300 passengers that runs with headway of 1.6 minutes, or by articulated bus (2 modules) with full capacity of 200 passengers running with 1.1 minute's headway. Stations should have 2 or 3 stopping bays by direction as well as additional passing lane for express buses. Expected number of stations would be 16 with the average interval of 770m.



Source: JICA Study Team

Figure 10.4.12 Proposed route of Juan Pablo II Line

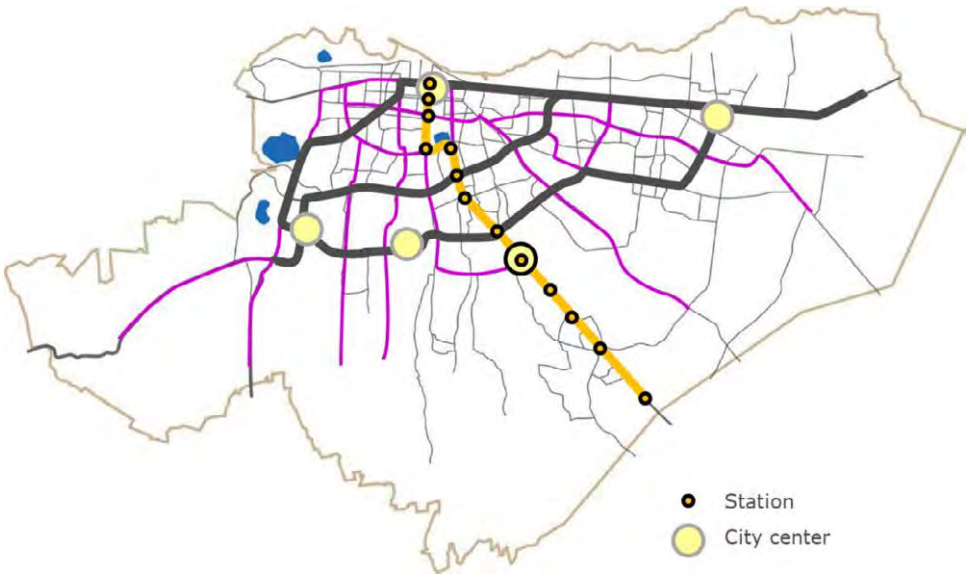
Masaya Line

One of the most demanded route shall be Masaya Line with longitude of 11.9km. This route shall be designed to connect Traditional and heritage center and around Esquipulas via Masaya city center, while providing a good accessibility to the population in southeast area of the city. This line shall also provide a good connectivity to the intercity bus passengers alighting at the bus terminal integrated in Masaya city center. For the connectivity, Masaya line should be at the median and operate by right-hand basis so that the interurban bus passengers coming from outside can smoothly change to Masaya line northward transport, and same for the passengers going outward.

Considering the demand to be around 12,000 PHPDT and 250,000 daily passengers in 2030 and around 14,000 PHPDT and 300,000 daily passengers in 2040 at the highest demanded section, and also the function that this would connect the most important city centers of Managua City, the detailed study of this project should start in the short term to be inaugurated as soon as possible.

The recommended system for this line is Automated Guideway Transit (AGT) with rubber tires and on elevated lanes, because it has an adequate capacity for the demand. It is also a considerable advantage of AGT for this route that it requires less land space while leaving larger road capacity for the ground-level vehicles, because this route goes on a highly demanded Masaya road and passes a narrow section around Tiscapa Lake. Relatively higher resilience against disaster is also a positive factor for Managua city to choose AGT instead of Monorail.

For the transport of passengers during the peak hour in 2040, the system should have vehicles with full-load capacity of 600 passengers (6 modules of 100 passengers) that run with headway of 2.6 minutes, which is fairly realizable by the automated system. The stations should be located at major activity points as well as at transfers with other lines, which shall count 13 stations with the average distance of 990m in between.



Source: JICA Study Team

Figure 10.4.13 Proposed route of Masaya Line

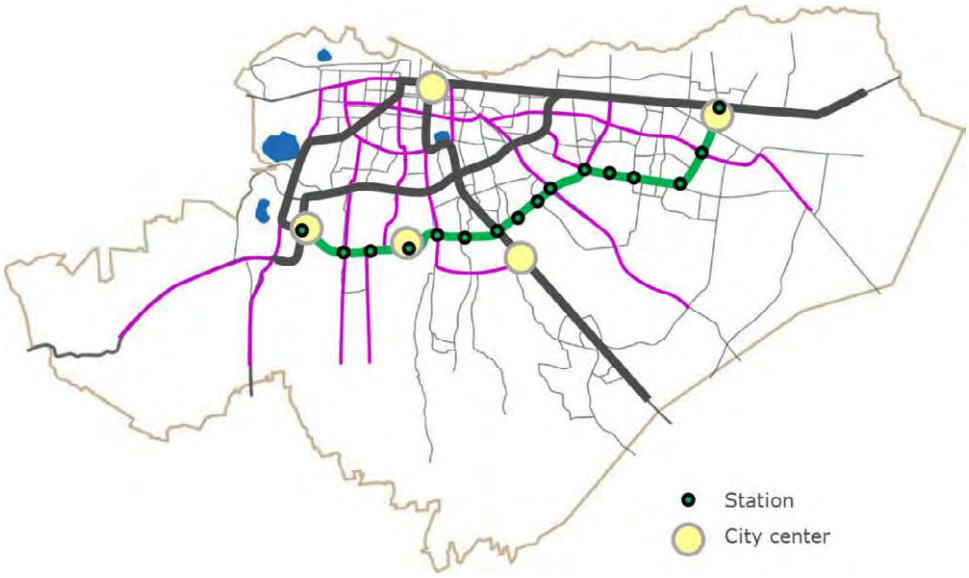
Suburbana Line

Suburbana Line with longitude of 15.0km is the most demanded route. This route shall connect East city center and Centroamerica roundabout via Sabana Highway and Suburbana Highway, and then West city center via Knowledge center. The route shall provide a good accessibility to the population in east and south area of the city, and shall provide a good accessibility also to the intercity passengers from east and north alighting at the bus terminal integrated with East city center and to the passengers from west alighting at the bus terminal in West city center.

The demand is estimated to be around 16,000 PHPDT and 450,000 daily passengers in 2040, which is the largest demand among the network. Considering also that this route connect three city centers to be developed, the detailed analysis of this project is expected to be started as soon as possible.

The recommended system for this line is AGT that is elevated likewise Masaya Line, as the line shall have a medium volume of passenger demand and pass highly demanded sections of Solidaridad road and narrow sections around Villa Roma and Mayoreo.

The system should have vehicles with full-load capacity of 600 passengers (6 modules of 100 passengers) that run with headway of 2.3 minutes, which is fairly realizable by the automated system. Expected number of stations would be 16 with the average interval of 1.0km.



Source: JICA Study Team

Figure 10.4.14 Proposed route of Suburbana Line

Panamerican Line

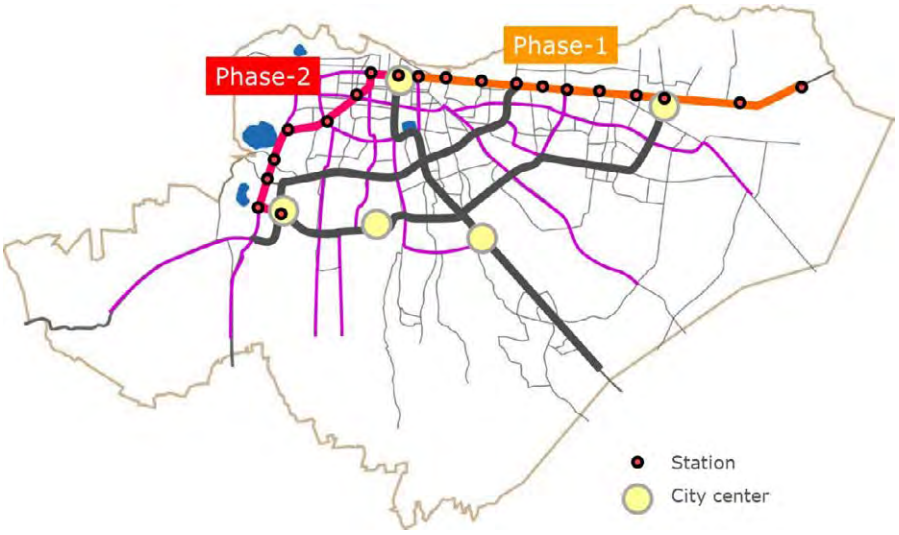
Panamerican Line with longitude of 20.8km shall also be devided into two phases; the first phase (12.8km) shall connect Zona Franca, Airport, East city center and Traditional and heritage center, and second phase (8.0km) connects Traditional and heritage center and West city center. The route shall provide a good accessibility to the population in the lakeside area and west area of the city, and also to the intercity passengers from west alighting at the west bus terminal and to the passengers from west alighting at the bus terminal in West city center. This route shall also serve for airport users and the commuters for Zona Franca.

The demand is estimated to be around 11,000 PHPDT and 360,000 daily passengers in 2040. This volume could be handled by BRT, however, considering this route will be a part of international gateway, the system should have an additional space and shouled give a good impression of the city. In addition, the route shall pass along the Managua lake, so the system had better be a ground-level one for the landscape from the other part of the city.

The recommended system for this route is accordingly Light Rail Transit (LRT). The project phase-1 should be started right after the projects of Masaya Line and Suburban Line which have larger demand.

The phase-2 should follow the precedent phase, however the timing could be late since this section is expected to have a relatively small volume of demand, comparing with the others.

The system should have vehicles with full-load capacity of 500 passengers (5 modules of 100 passengers) that run with headway of 2.7 minutes. Expected number of stations would be 20 with the average interval of 1.1km.



Source: JICA Study Team

Figure 10.4.15 Proposed route of Panamerican Line

4) Summary of recommended mass-transit systems

Table 10.4.7 presents the summary of mass-transit lines.

Table 10.4.7 Summary of Mass-Transit Lines

	Juan Pablo II	Masaya	Suburbana	Panamerican
Main feature(s)	• Diagonal axe of the city • Road improvement project exist	• Connection of 2 principle city centers	• Connection of 3 urban centers • Largest demand volume	• International gateway
Longitude (km)	11.6km	11.9km	15.0km	20.8km
PHPDT (2040)	11,000*	14,000	16,000	11,000
Daily ridership (2040)	250,000	300,000	450,000	360,000
No. of connected urban centers	1	2 (main)	3	3
Land availability	Good**	Bad	Bad	Fair
Direction	West-East	South-North	West-East	West-East
Suggested system	BRT	AGT	AGT	LRT
Investment cost (million USD)***	116	417.5	525	520

Note*: Value of year 2030 for Juan Pablo II Line
Note**: Assumption of project implementation of widening project
Note***: Unit cost/km was assumed as 10 million USD for BRT, 35 million USD for AGT and 25 million USD for LRT
Source: JICA Study Team

The suitable mass-transit mode should be decided based on the pre-feasibility study for introduction of the mass transport, which conducts detail analysis including operation system, infrastructure of station/terminal, economic/financial analysis and etc, because some analyses is including preliminary level.

(2) Urban public bus reorganization (feeder buses)

Existing urban public bus should be reorganized to provide the access to the non-served citizens. It is obvious that the suburban areas, especially the Nejapa area, are not covered by the existing service. At the same time it must be considered the current services are already heavily used by the citizens, which means the simple rerouting shall only change the non-served group of citizens to another. Accordingly, the reorganization should include an increase of total fleets of urban public bus service.

The bus services should be well coordinated with the mass-transit systems to be developed, to function as the feeder buses when completed the mass-transit systems. The steps of reorganization are presented below;

1. Increase the total number of bus fleets

   Today IRTRAMMA is planning to increase 500 buses, which means 60% increase from the present situation. And this would decrease the IPK from 6.0 to 3.5, which is still high value as conventional bus service but much better than the present situation. Also it should be taken into account that the increase of bus fleets must be accompanied by the increase of their drivers, whose driving manner will definitely affect much the raffic flow and road safety as well as reliability and confortability of public transport. Accordingly training of the drivers must be well provided, and an increase of 500 bus units is a sort of maximum and reasonable step.

2. Allocate the new fleets and the under-used fleets of existing routes to the non-served areas and to the routes of coming mass-transit systems

   The development should be accompanied by basic transport infrastructure such as busbays, garages and workshops as well as the connection with intercity buses. The areas being missed by current route system are indicated in Figure 10.2.9. The network should be modified taking into account also the areas to be protected with its natural resources. Likewise today's practice, the connections with Ciudad Sandino should be realized by various routes of urban public bus services, which needs to be enforced.

3. Once the mass-transit systems installed, the bus services change the routes to serve as the feeder buses

   Each route of the feeder buses should be connected to at least one line of mass-transit systems, while covering as much area of the city as possible by its route. One of the main

roles of the is the complement, accordingly the routes should have no or minimum overlapping with the mass-transit systems.

(3) Bus terminal relocation

There are 5 major radial roads connecting Managua city with the others. Among them, route No. 28 is serving mainly as the connection with Ciudad Sandino that is in a commuting distance; less than 10km to the Traditional and heritage center. Accordingly, as discussed above, the connection with Ciudad Sandino should be treated as a part of urban public transport, and not as an intercity transport.

Also, 2 of the other 4 radial roads meet at Nejapa area in southwest part of the city. Accordingly, the main entrances to the developed area of Managua city can be summarized as three roads;

- Route No.1 (Panamerican North) – Tipitapa and other east and north parts of the country
- Carretera a Masaya – Masaya and other east and southeast parts of the country
- Route No.1 (Panamerican South) – South and west parts of the country

And for each one of three roads, there is a proposed CBD (Masaya CBD) or a city center (East city center and West city center) nearby at relatively outer area of the city. Accordingly, it is proposed to construct three bus terminals as the replacement of the existing ones.

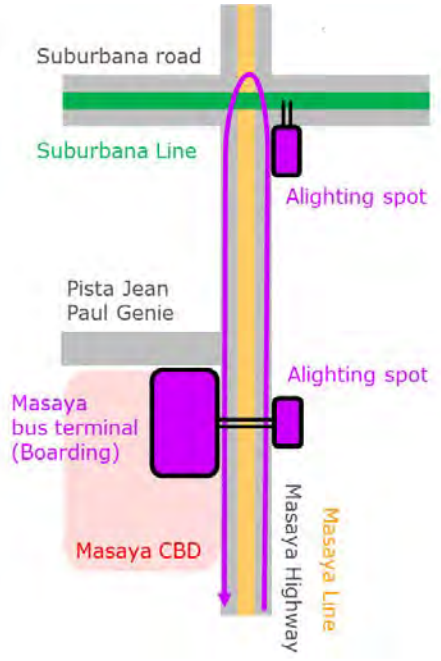
Each of them shall be associated with and integrated in city center to be developed, and be well connected with the other modes of public transport including mass-transit systems, feeder buses, taxies and mototaxies for the passengers traveling from/to other part of the city. In order that these vehicles don't occur congestion in the surrounding area, the design of the terminals should carefully consider the location, width and setback of the entrance/exit as well as the traffic control around the area. It is important that the operation areas of these terminals are well separated from commercial activities, in order to keep the fuction of the facility to provide the safe and orderly mobility and to maintain the priority of use of space. Furthermore, they shall also have Park & Ride facility, whose fee shall be payable by a common smart card of transport. The operation and maintenance of the new terminals could be carried out by private concessioners as it is today.

The features of each bus terminal are presented below;

1) Masaya bus terminal

Masaya bus terminal shall serve mainly for intercity passengers from east and southeast parts of the country. The terminal shall be integrated in Masaya CBD, which would have an important traffic demand by itself. The bus terminal shall also provide an intermodal connectivity with Masaya Line operated by mass-transit system as well as other modes of transport.

For the arriving intercity buses from outside, in order to simplify the transit of passengers to take Suburbana Line, the buses shall be able to reach up to the Centroamerica Roundabout. Before it, the buses shall pass the Masaya CBD, where there should be several alighting berths connected with Masaya CBD, Masaya Line and other modes of connecting transport. The boarding berths for the intercity buses toward southeast shall accordingly be at the opposite side of the alighting berths across Masaya highway. (Figure 10.4.16)



Source: JICA Study Team

Figure 10.4.16 Intercity bus arrangement around Masaya bus terminal

It is estimated that Masaya bus terminal accommodates around 70,000 intercity passengers per day in 2040. During the evening peak hour, around 3,500 passengers would get on board the intercity buses at the terminal, and it would require about 9 berths for large buses and 8 berths for micro buses, with assumption of common use of berths by 10 minutes cycle for large buses and 5 minutes for micro buses.

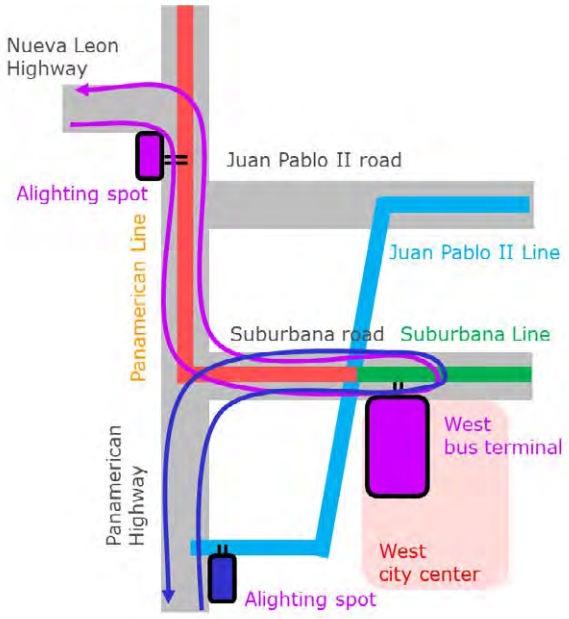
2) East bus terminal

East bus terminal shall serve mainly for intercity passengers from north and east part of the country. The access with East city center shall be facilitated, which would have an important traffic demand by itself. The bus terminal shall also provide an intermodal connectivity with Suburbana Line and Panamerican Line operated by mass-transit system and other modes of transport. Considering the location along Panamerican highway and near the international airport, this terminal shall also accommodate international buses.

The estimated volume of passengers is 50,000 per day in 2040, and the peak hour's demand is by 2,500 passengers who're getting on board. It would need about 7 berths for large buses and 6 berths for micro buses, with same assumption of common use of berths as Masaya bus terminal.

3) Western bus terminal

West bus terminal shall serve mainly for intercity passengers from south and west part of the country. The access with West city center shall be facilitated, which would have an important traffic demand by itself. The bus terminal shall also provide an intermodal connectivity with Suburbana Line, Panamerican Line and Juan Pablo II Line operated by mass-transit system and other modes of transport.



Source: JICA Study Team

Figure 10.4.17 Intercity bus arrangement around West bus terminal

The intercity buses coming through Nejapa area shall make a short stop at the area for alighting of passengers connecting to Juan Pablo II Line, and then continue to Western bus terminal. The intercity buses coming through Nueva Leon highway shall make a short stop when they come to the Panamerican highway for alighting of passengers connecting to Panamerican Line, and then continue to West bus terminal. These shall ease the operation stress during peak hours at the bus terminal Figure 10.4.17).

The estimated volume of passengers is 69,000 per day in 2040, and the peak hour's demand is by 4,700 passengers who're getting on board. It would need about 12 berths for large buses and 11 berths for micro buses, with same assumption of common use of berths as Masaya bus terminal.

10.4.3 Traffic Management Project

(1) Short Term

Proposed project in short term is to organize the definitive and modern Traffic Control Center (TCC). These projects are renewal and update TCC itself and to provide resources to undertake its task in a new and modern equipment. The proposals are mainly concentrated in two fields: the development of the Traffic Control Center and traffic management measures.

1) The development of Traffic Control Center

The first measure is related to the organization and aims to the unification under a single command in the TCC, which tasks related to traffic management and traffic singnal in the Managua City. To this purpose, the integration of unique traffic control and traffic management

office is promoted as renewal TCC. All traffic signals should be under its responsibility, and a place and function should be in one office.

Consequently, all traditional traffic signals under TCC should change to intelligent traffic signals. There are 92 old traffic singals, which should be incorporated into the modern network, with all the necessary devices (cameras, loops for counts, etc.).

The new office of the TCC must be furnished with all the resources that are in accordance with the equipment and responsibilities. Therefore, it should be installed some equipments for collecting information (from cameras), for real-time traffic management system, and for controlling traffic signal cycling with real-time traffic flow.

2) Traffic Operation Measures

In order to make traffic flow more efficient, some measures are proposed for improving traffic condition on some roads.

A first measure is to ensure proper balance in the direction of movement in the city such as lane management. However, a traffic study should be carried out to determine the distribution of flows according to the direction of the roads. The principle of promoting road pairs in opposite directions should be proposed which guarantee equivalent capacities in both directions. These roads should have enough road width and design to ensure stable and adequate urban speed.

A second measure is a parking plan. The current regulations have not been considered adequately about the parking lots in a city, despite of increasing traffic volume and on-road parking. Therefore, there are some problems which affects the traffic condition such as badly parked vehicles and drivers those who are looking for a parking space by low speed. For this reason, it is necessary to assure capacity for the vehicle parking and to facilitate their access. Parking measure should be considered as a part of traffic management policy. As first measure, it is importatnt to strengthen the penalty of parking violation for decreasing it and inducing proper use of parking space. In parallel to this measure, development of parking lot should be planned. The location should not be in congested area to avoid further congestion, however, parking space should be also have a convenience to access destination. Therefore, two criteria are proposed for the implementation of parking lots which should be studied and evaluated during short term. One is the parking space in the periphery of the city, where connected to public transport with parking spaces for prolonged parking by affordable prices such as Park & Ride. It gives an incentive to not-enter the center area and reduce congestion in the city. Another type of parking is located inside bus terminal at city center. These locations have good connectivity and fares for long and short parking for motorists who access the urban area. Four candidate parking locations including cases of integration with bus terminal (masaya bus terminal, east bus terminal, west bus terminal, historical and heritage center) are assumed, but it is necessary to decide the parking location and space based on the inflow of traffic volume.

The development of new capacities in the TCC should promote renewal with more modern and efficient function for traffic management and planning. Traffic information provision is one of the projects of this for traffic management. By using data which produced regularly from traffic flows and traffic condition, it is possible to contribute to prepare useful road planning and proper investments based on traffic studies.

One of the major issues is the traffic management plans around the markets. There are two problems which should be solved. One is the truck traffic around the markets as trip generation (movement of goods and customers, and the other is that most of markets are a place of intermunicipal buses terminals. For these reasons, comprehensive plans for traffic control, parking, and trucks. One measure is to set unloading zones around markets in the city. The plan for freight transport should be considered carefuly because these activeties relates economic activity. This plan will consist of setting the definition and rule for cargo vehicles. Their schedules will be defined for the movement of trucks within the city. Truck terminal for changing load from tractor to smal truck will be established at the periphery of the city.

In the framework of traffic studies and in coordination with the development of mass transport systems, dedicated lane for public transport will be developed in major roads. These lanes ensure the punctuality of public transport, and it should not allow to enter the other vehicles. To do so, it is necessary to identify the axes for mass transit, and then public transport priority signal should be introduced.

3) Other Measures

An important issue is to produce resources and financing. As of now, car owners have to pay a car permission tax which is using for traffic management, investment and maintenance of infrastructure and signal control, but it is not so high rate. For this reason, increasing of the car permission tax by gradiation (finally, 500%) is one solution. As the current value is very low (only USD 3 per any vehicle), its multiplication by 5 is not significant economic impact on households. The income generated by this is estimated at USD 3 million per year, which will finance some of the initiatives of the transport sector.

(2) The Mid Term

As of 2021, it is assumed that considerable measures might be acquired in the traffic management fields. The tasks to be developed for this term are an extension or enlargement or refinement of short term project.

1) Measures

A first measure is the expansion of the traffic signal network. This is an additional 15 new intersections with traffic signals annually for introducing in this period, which total number is 150 new intelligent traffic signals. 294 traffic signals wll be install in the city in 2030.

A second important measure is the construction of the two parking lots (one in the peripheraly of the city, another is in the center) which was evaluated in the previous term. Type of its implementation could be executed by PPP.

During this term, traffic management should be strengthened by the installation of variable message sign, which will guide and provide traffic situation information to drivers. It is proposed to install 30 variable message sign in the main roads in the city.

2) Studies and Reports

The preparation of data and the study of the traffic management is very important to have information to take measures in the future. For this reason, function of the TCC can utilize for these study and analysis. Two main tasks is pointed out below.

One is a evaluation of traffic condition such as studies or research on traffic conditions at some critical points in the city. These result can be understand the situation for municipal staff and to utilize education for citizens. a semi-annual study or investigation should also be carried out for analyzing and drawing lessons from significant accident case in the city, which will be distributed for public in a bulletin.

Two is annual traffic and management report, which is published as Annual Report of the TCC. It is shown the statistics of automotive fleet, roads, traffic flows, traffic signal network and statistics of traffic accident.

3) Traffic Operation

The aim here is to promote a series of measures and initiatives for maintaining and improving traffic conditions. The city is threatened by the traffic growth which is produced by economic activities, and by the growth of the urban area.

Even if necessary measures could be taken to improve traffic flow, above mentioned will be expected. The growth of motorization will be faster than investments in road infrastructure. Therefore, it is assumed that road traffic restriction plan will be needed, which will prohibit the daily traffic muvement of 20% of the city's total fleet of automobiles.

In the public transport management, priority road or dedicated roads for mass transport will be constructed. These will consist of the priority crossings which allows an efficient operation of mass transportation systems.

The zone 30 should be promote for avoiding traffic accident risk and ensure confortable environment. It is necessary selection of some roads and area in the pericentral zone including some central roads in special area or patrimonial area. This measure is to set maximum speed limit under 30 km/h in these roads and area. This will promote road sharing between motorists, cyclists and pedestrians. The promoting "soft transporation modes" such as walking and cycling is necessary. Therefore, another step is to introduce cycling roads.

Another important measure is to put names and numbers to all the streets and buildings of the city, so that there is a clear and easy reference for drivers to arrive at their destinations. Road signs should be installed with the name of the streets and avenues, and will be located in every corner of roads, indicating the name of the street and the corresponding numbering in each block.

4) Other Measures

The second increase of car permission tax will be implemented. It will be increased by 200% in this period. With the new tax value and the growth of the fleet of vehicles, it will be possible to raise an additional USD 9 million in municipal revenue annually.

(3) The Long Term

General measures are proposed between 2031 and 2040. It should not be forgotten the measures taken in previous periods. They are still in force and positively affect. For this reason, the proposals in long term are to continue the previous measure with little innovation.

1) Investment

The increasing the number of traffic signals in the city should be continued. It should be promoted the expansion of the traffic signal network. Additional traffic signals will be installed in ten different crossing each year, that is, 100 new traffic singals will be installed in this period. The total number of traffic signals is almost 400 intersections by 2040.

In the perspective of the rationalization of the use of roads and more efficient ways of using them, High Occupancy Vehicles (HOV) lanes will be introduced in this period. It is allow to use the dedicated lane on specified roads to cars which carry at least three passengers.

2) Other Measures

It is maintained here the policy of continuing to increase car permission tax. The third increase of the car permission tax will be 50% of the previous value. It will be possible to collect annually an approximate amount of an additional USD 22.5 million for municipal revenue.

10.4.4 Assessment of Future Traffic Flow with Proposed Project

(1) Evaluatino cases for future project

Traffic demand forcast with project case was carried out by the following cases which is shown in the Table 10.4.8.

Table 10.4.8 Traffic Demand Forecast Case

		Densification		Traffic Management	Road		Mass Transportation
		Do Nothing	Optimization		Planned	Proposed	
Case 0 (Existing Case)	2016	-	-	-	-	-	-
Case 1	2020	☑	-		☑	-	-
Case 2		-	☑	☑	☑	☑	-
Case 3		-	☑	☑	☑	☑	
Case 4	2030	☑	-	-	☑	-	-
Case 5		-	☑	☑	☑	-	-
Case 6		-	☑	☑	☑	☑	-
Case 7		-	☑	☑	☑	☑	☑
Case 8	2040	☑	-	-	☑	-	-
Case 9		-	☑	☑	☑	-	-
Case 10		-	☑	☑	☑	☑	-
Case 11		-	☑	☑	☑	☑	☑
Case 12 (Do-Nothing Case)		☑	-	-	-	-	-

Source: JICA Study Team

This analysis was considered about with/without urban densification and with/without road, mass transportation, and traffic management project.The case of traffic demand forecast was devided into “with traffic management project”, “with traffic management and road project”, and “with all transport project” for understanding effect of implementation.

Traffic management project is included traffic control optimization by installation of intelligent traffic signal. This project is easy to implement compared with road and mass trasnsportation project. Therefore, the order of evaluation of road traffic project was set as firstly traffic management project, secondly traffic management and road project, finally all road traffic project including mass transportation project. Regarding the effect of traffic management, the capacity of road which is connected with intelligent traffic signal intersection was evaluated by increasing 10%. Road project was evaluated by adding each proposed project to traffic demand forecast. Regarding mass transport project, passenger traffic demand was evaluated by result of ratio of modal shift which was obtained by passenger interview survey. For the judgement of implementation of each projects, the goal was set that to keep the same level of traffic conditions of the current situation in 2040. It means VCR keep approximately 0.55 in 2040. However, it is necessary to adjust the project implementation timing by the construction period and budget for each projects. Therefore, considering the shift of implementation timing of some projects to the next term, the goal of VCR was set under 0.8 in the short term and medium term.

(2) Result of evaluation of future transportation project

The summarized results of each cases are shown in Table 10.4.9. With and without project figures of short, mid, and long term as representative example are shown in Figure 10.4.18, Figure 10.4.19, and Figure 10.4.20. The figures of remaining cases are shown in Appendix 3.

Table 10.4.9 Result of Traffic Demand Forecast by Each Case

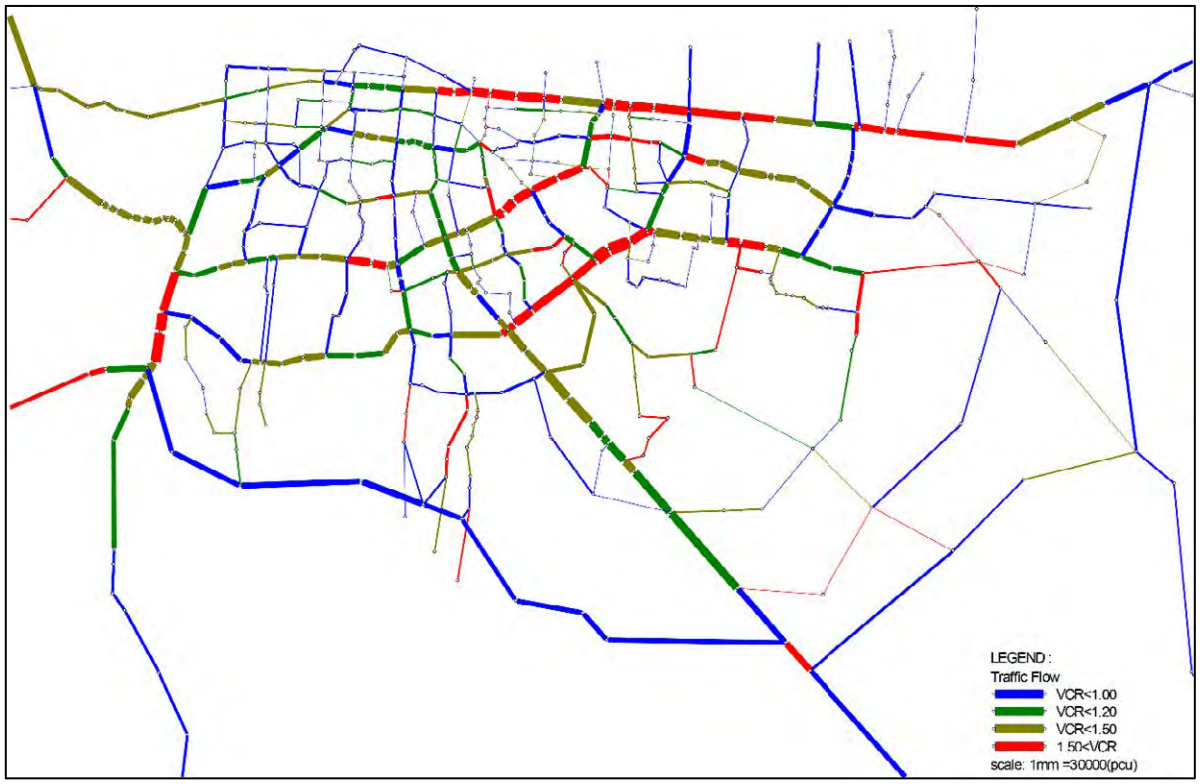
Case	Project Period	Year of Traffic Demad	Year of Road Network	Vehicle-km Total (PCU-km) ('000)	Vehicle-hours Total (PCU-Hour)	Ave. VCR*
Existing	-	2016	2016	6,071	121,479	0.55
Do-Nothing	-	2040	2016	13,444	643,507	1.44
Case 1	Short (-2020)	2020		9,457	214,944	0.84
Case 2		2020		9,073	199,713	0.8
Case 3		2020		9,072	199,683	0.8
Case 4	Mid (2021-2030)	2030		11,677	293,308	0.99
Case 5		2030		10,486	236,509	0.87
Case 6		2030		10,482	219,470	0.81
Case 7		2030		9,166	186,002	0.74
Case 8	Long (2031-2040)	2040		14,297	370,557	1.01
Case 9		2040		12,120	262,014	0.83
Case 10		2040		11,715	229,550	0.68
Case 11		2040		9,257	172,855	0.55

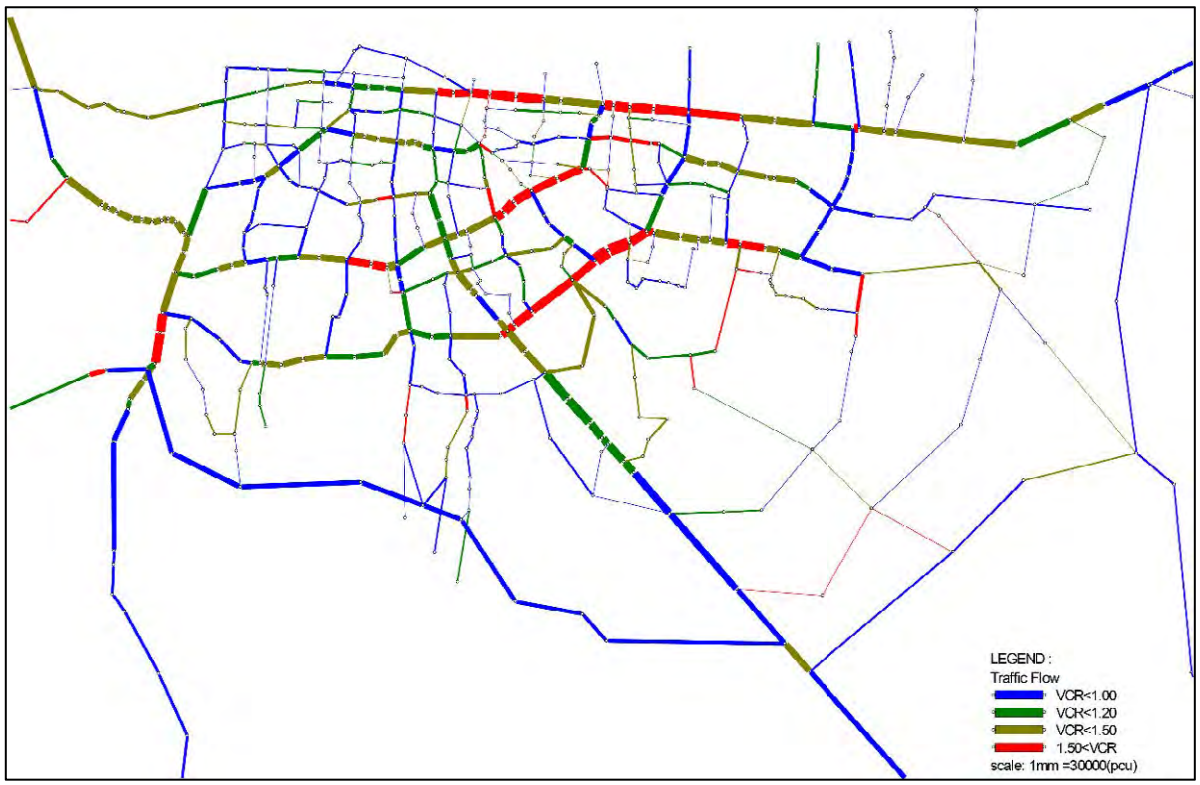
*: Vehicle Capacity Ratio
Source: JICA Study Team

In the short term, effect of traffic management in short term is high. One of the reason is that there is available road capacity in Managua City by 2020 for managing traffic movement if traffic control management could be implemented. Road project in short term is not high bevause component of road project is road improvement project mostly, which cannot expect to increase road capacity drastically.

In the mid term, effect of traffic management is still high, but its effect decrease compared with short term project. It is assumed that traffic demand cannot be control and manage only traffic management project. effect of road project is high, but it is assumed that traffic condition is worsen that short term. Vehicle capacity ration of some road section of major road is over 1.00. It means this section cannot control traffic by over capacity. Some area will be occurred serius congestion in mid term. Mass transport ptoject show high effect, therefore, introduction of mass transportation is effective. However, it is necessary to consider mass transportation mode based on the expected passenger demand. Detail explanation of mass transportation mode is shown in 10.4.2.

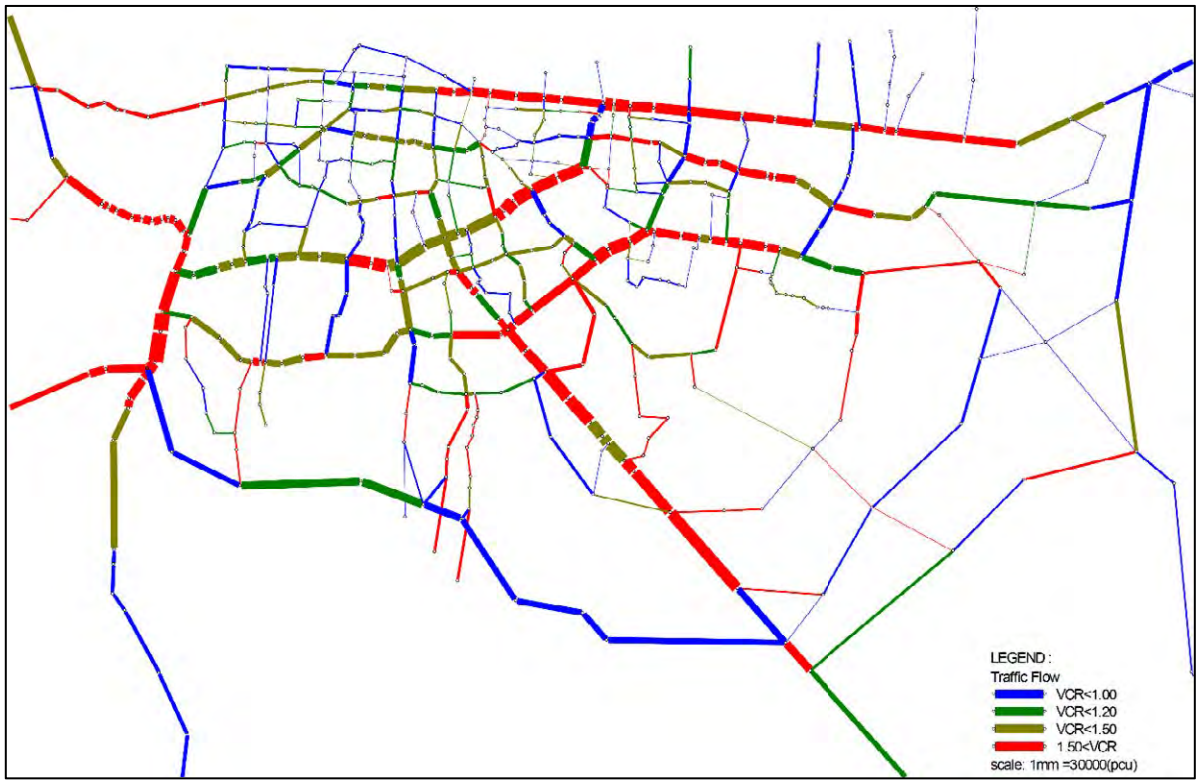
In the Long term, traffic demand is increased more, and implementation of several project will be needed. If road project and mass transport project was implemented, traffic condition become serius. It is also necessary to consider mass trasnsportation mode and route based on the passenger demand. Coastal road show high effect because it can become bypass route of Pan-American North. However, construction of this road might be needed high technical capability. It is desirable to consider implementation of coastal road based on the traffic situation at that point.

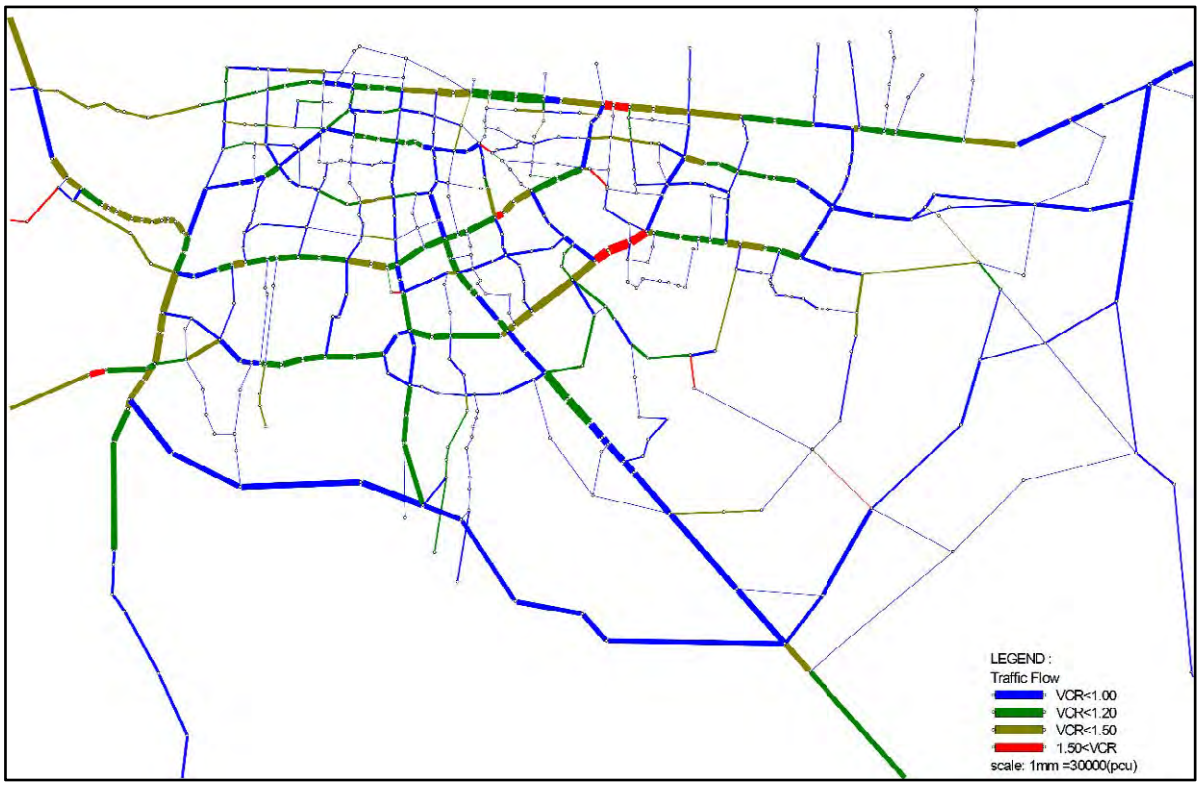




Source: JICA Study Team

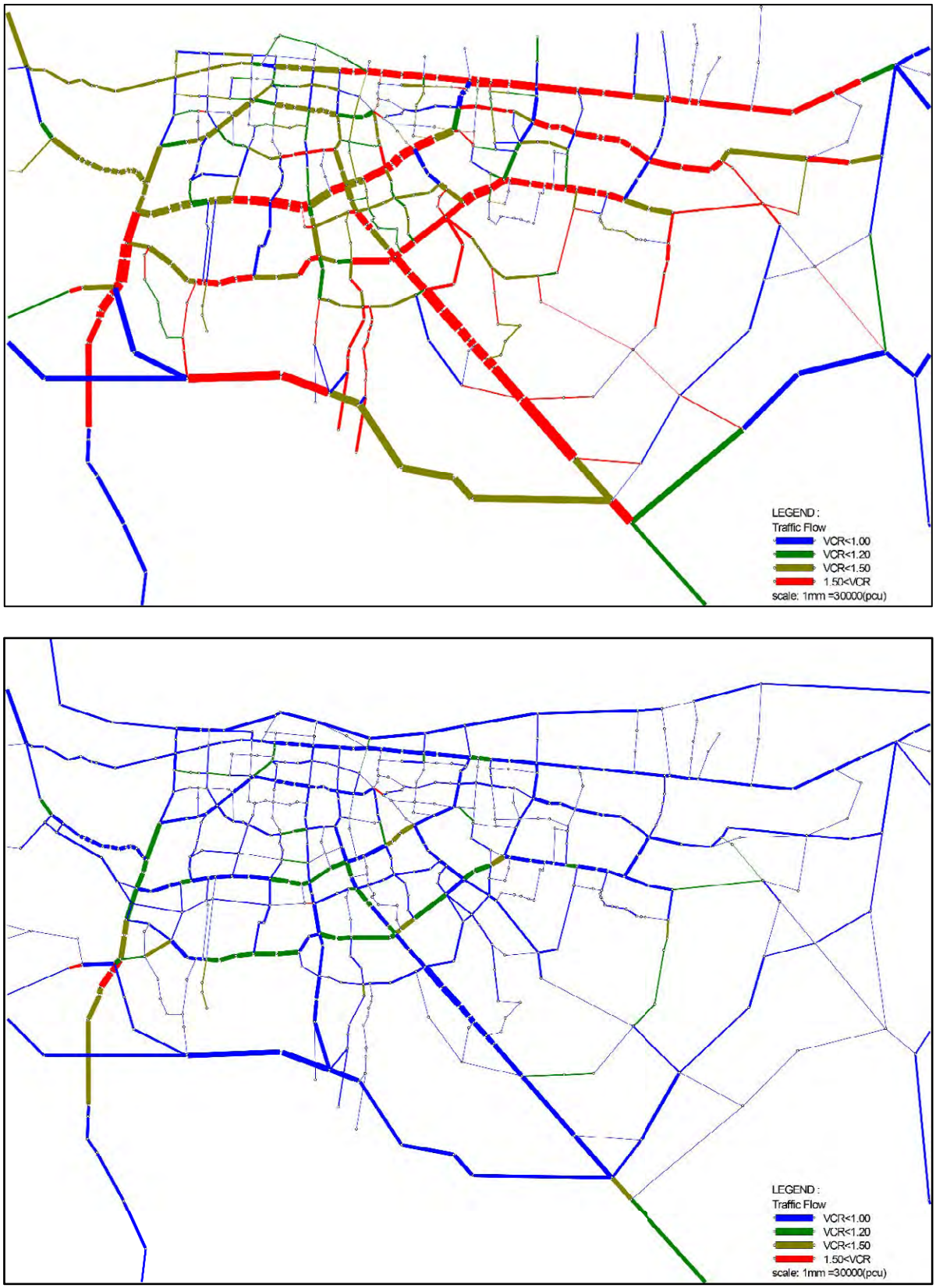
Figure 10.4.18 Future Traffic Flow in 2020 without Project (Up) with Project (Below)





Source: JICA Study Team

Figure 10.4.19 Future Traffic Flow in 2030 without Project (Up) and with Project (Below)

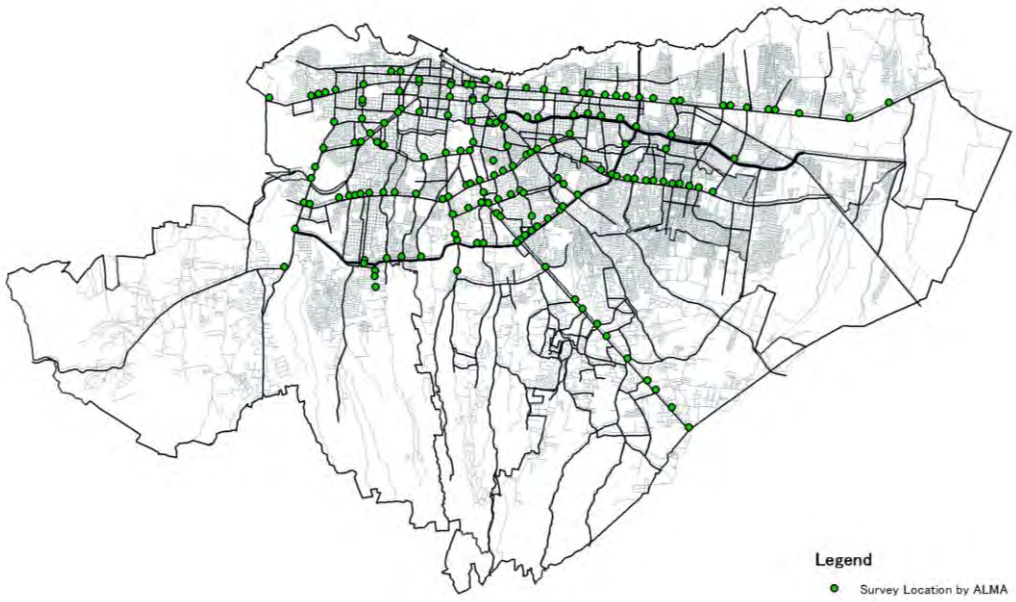


Source: JICA Study Team

Figure 10.4.20 Future Traffic Flow in 2040 without Project (Up) and with Project (Below)

10.4.5 Database of Traffic Survey

Currently, ALMA has surveyed traffic volume at around 170 intersections every year by direction and by type of vehicle. Survey locations are shown in below. ALMA counts traffic volumes of 12 hours by five types of vehicles. ALMA utilize the survey result to identify traffic situation in the Managua city.



Source: JICA Study Team

Figure 10.4.21 Survey Locations for Intersection Counting

Direction

NOMBRE DE LA PISTA: LARREYNAGA
INTERSECCIÓN: ROTONDA BELLO HORIZONTE — MIERCOLE

TIEMPO	ENTRADA																				
	NORTE - 2					TOTAL	OESTE - 4					TOTAL	SUR - 6					TOTAL	EST		
INICIO - FIN	BI	M	A	B	C	NORTE	BI	M	A	B	C	OESTE	BI	M	A	B	C	SUR	BI	M	
7:00 am - 8:00 am	0	61	221	0	2	284	0	176	917	37	15	1,145								247	1,2
7:15 am - 8:15 am	0	60	238	0	2	300	0	188	997	38	17	1,240								250	1,3
7:30 am - 8:30 am	0	56	244	0	1	301	0	191	1,008	39	17	1,255								248	1,2
7:45 am - 8:45 am	0	44	233	0	1	278	0	221	1,002	40	18	1,281	0	96	437	16	7	556	0	224	1,2
8:00 am - 9:00 a	0	46	213	0	0	259	0	197	978	42	17	1,234	0	84	398	14	10	506	0	192	8
8:15 am - 9:15 am	0	52	207	1	3	263	0	196	921	43	17	1,177	0	83	363	16	8	470	0	190	8
8:30 am - 9:30 am	0	51	195	1	5	252	0	197	932	46	15	1,190	0	82	345	18	7	452	0	179	7
8:45 am - 9:45 a	0	62	190	1	6	259	0	139	935	44	15	1,133	0	80	338	19	6	443	0	175	7
9:00 am - 10:00 a	0	57	186	1	8	252	0	120	932	43	16	1,111	0	84	332	18	5	439	0	170	9
9:15 am - 10:15 a	0	50	183	0	6	239	0	123	908	43	19	1,093	0	90	320	17	4	431	0	144	1,0
9:30 am - 10:30 a			94	0	5	248	0	129	879	39	19	1,066	0	97	321	16	5	439	0	138	1,0
9:45 am - 10:45 a			02	0	4	255	0	170	868	35	18	1,091	0	110	320	14	8	452	0	135	1,0
10:00 am - 11:00			00	0	2	256	0	195	881	34	22	1,132	0	122	330	14	8	474	0	143	9
10:15 am - 11:00	0	61	190	0	3	254	0	205	901	32	21	1,159	0	135	348	14	8	505	0	150	9

Hour

Five type of vehicle

Source: JICA Study Team

Figure 10.4.22 Survey Result for Intersection Counting

On the other hand, there is no other traffic survey done by ALMA constantly. To make a road plan or decide a road specification, several types of surveys are required ideally.

One of important point is related to updating PDUM. It can be said updating traffic survey data is important including traffic surveys conducted in PDUM periodically. Master Plan is needed to be

updated and monitored on some regular basis. Accordingly, JICA study team suggests to conduct several kinds of traffic surveys every five years.

Second point is identifying daily or monthly or seasonal variation of traffic volume. ALMA currently is taking a variation factor by counting traffic volume only on the specific location that needs road redevelopment or new road nearby. Accumulation of database is basic way of thinking for traffic survey including variation factor. Therefore, JICA study team recommends to accumulate traffic volume data. Identifying variation factor needs vast human resources and cost, if counting is relied on manual methodology. Using automatic count device is recommended in terms of budget management.

Considering above two ideas, Table 10.4.10 indicates example of survey schedule. ALMA consider to develop the traffic control center to monitor the traffic volume. The schedule regard the development as realization, It can be utilized for update the database. “Periodic Survey” shows traffic surveys required for updating traffic master plan. These surveys are ideal plan, accordingly it should be considered with budget problem carefully. The survey can be conducted by ALMA road department or IRTRAMMA or Planification division. Ideally, person trip survey conducted the same period with national census since saple size should be decided based on the statsistic data.

Other organization also collect valuable data for understanding traffic situation. MTI conduct traffic counding nationwide including Managua city. MPESO collects urban bus users’ information. To consider the future traffic surveys, other organization’s data also should be taken in consideration.

Table 10.4.10 Proposal of Future Traffic Survey

●Annual Survey

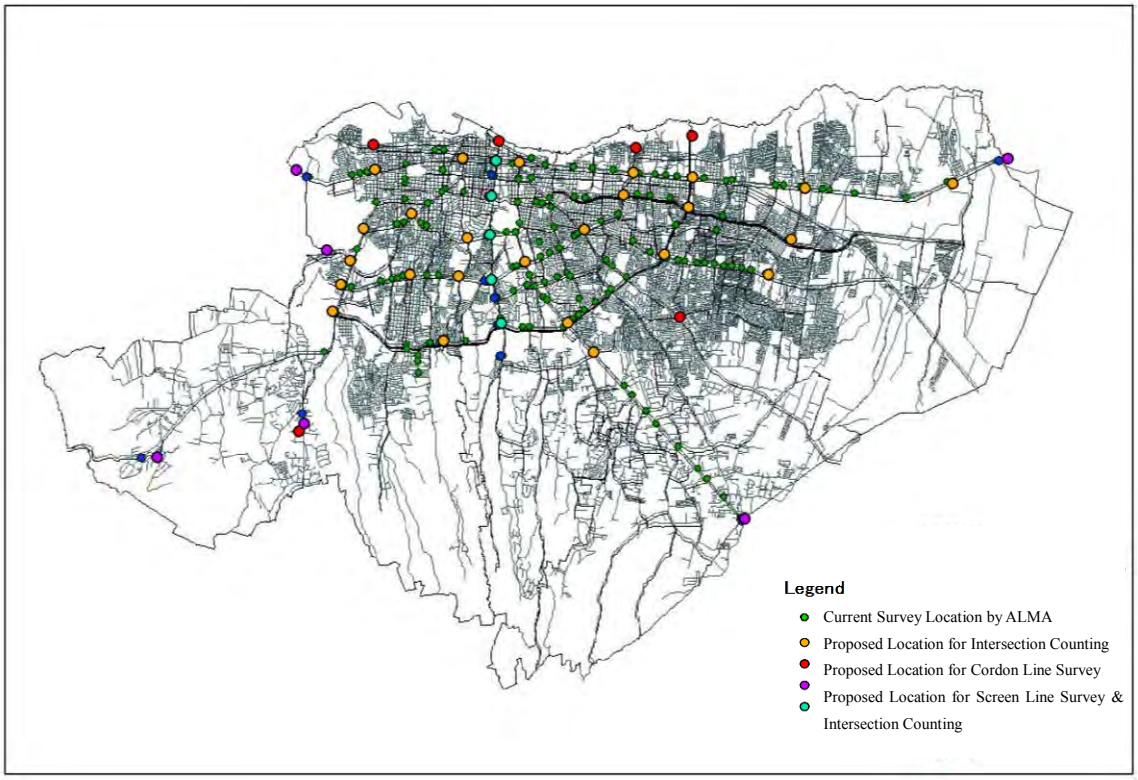
Period	Component
2017~until automatic traffic count device was installed	IC(Intersection Counting 1d,12h, 25LC, Main 24h 5LC)
	ATC(Automatic Traffic Count 12m, 7d, 24h, 5LC)
	Traffic Count by control center

●Periodic Survey

Period	Component
2018	ATC(Automatic Traffic Count 12m, 7d/m, 24h, 5LC)
2020	CL& SL(1d, 24h)+TS
2025	IC(1d, 12h, Manual, 50LC)+TS
2030	PDUM survey + IC(1d, 12h, Manual, 50LC) + Road inventory
2035	IC(1d, 12h, Manual, 50LC) + TS
2040	PDUM survey + IC(1d, 12h, Manual, 50LC) + Road inventory

*PDUM survey…..CL(Cordon Line Survey), SL(Screen Line Survey), HIS(Household Interview Survey), TM(Truck Movement Survey), TS(Travel Speed Survey)

Source: JICA Study Team



Source: JICA Study Team

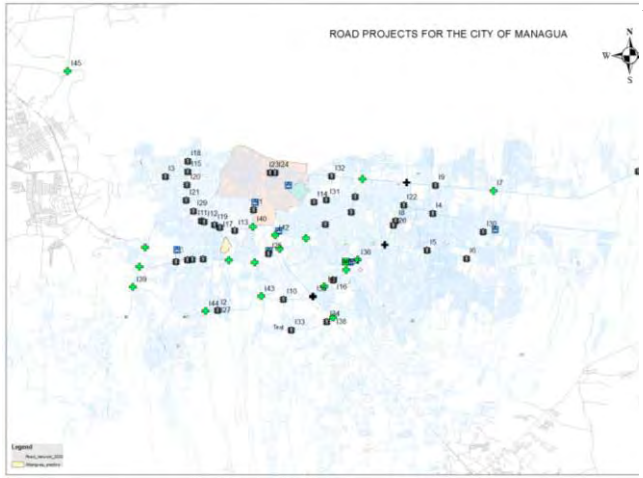
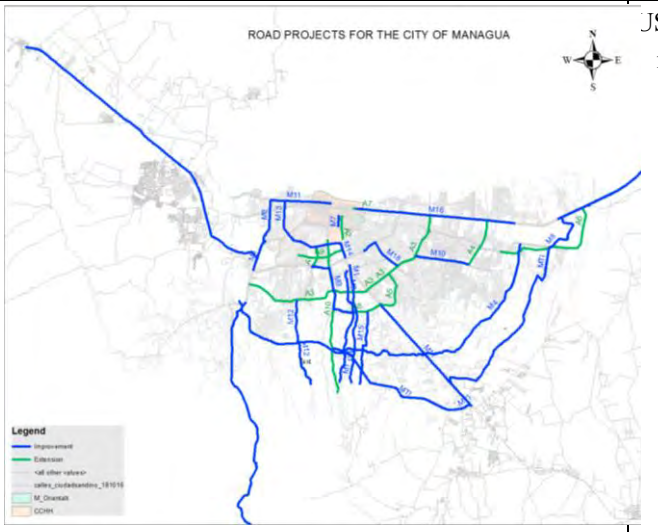
Figure 10.4.23 Proposed Traffic Survey Locations

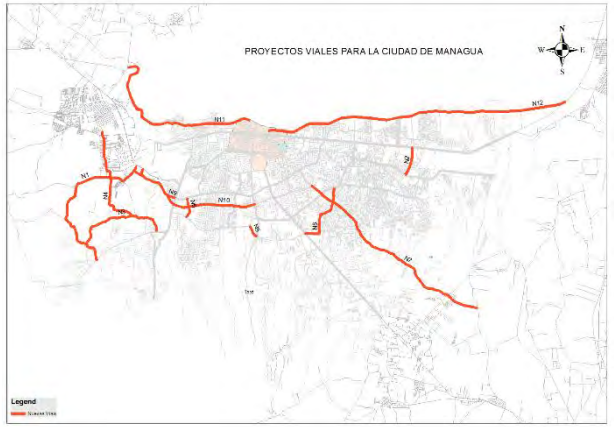
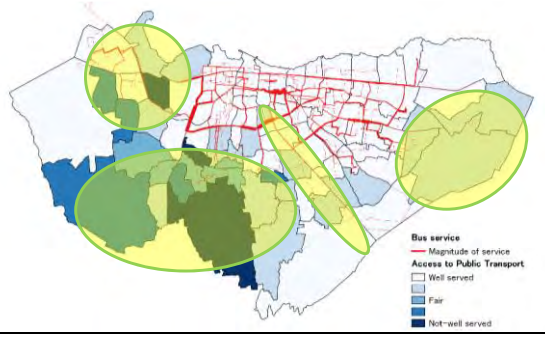
10.4.6 Proposed Projects from Transport Planning

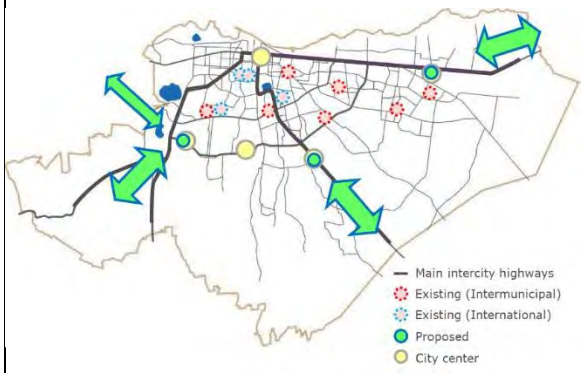
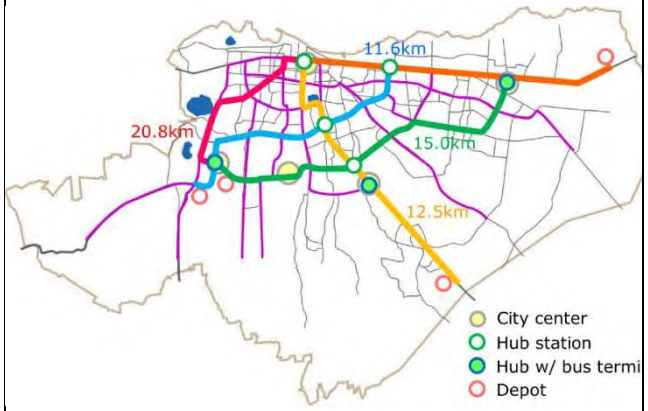
In order to implement the master plan explained above, the necessary projects for transport planning are identified as listed in below. This list shows projects by categolizing the project type and its objective for easy understanding.

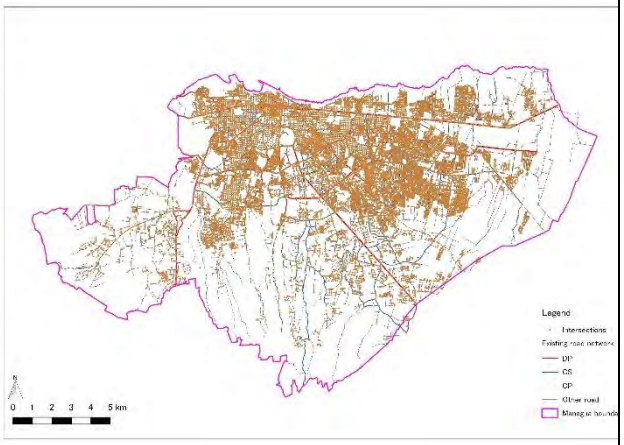
Table 10.4.11 List of Proposed Projects for Transport Planning

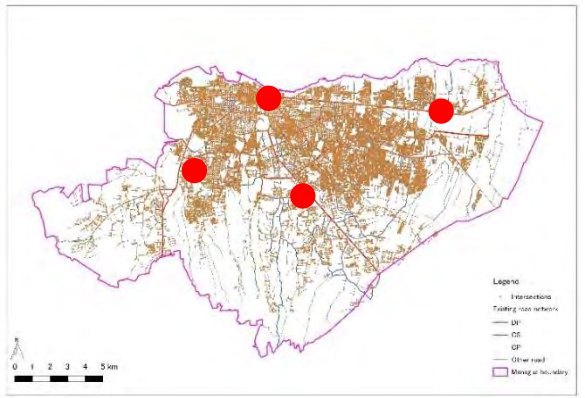
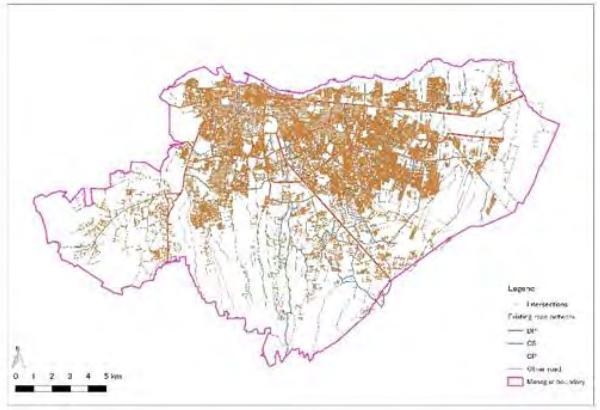
Project Name	Objective	Implementation organization	Project overview	Location	Cost
Capacity Development [CD-1]	- The capacity of traffic and transportation departments and organizations are enhanced	ALMA IRTRA MMA	(1) General support for the own activities of ALMA, in parallel with urban planning (1-1) Reorganization of conventional urban public buses (future feeder buses) (1-2) Traffic management (traffic signal, traffic demand management, and parking) (1-3) Capacity development for traffic analysis (1-4) Institutional reorganization (2) Feasibility study for mass-transit system (implementation preparation for specific project)		US $ 2 million

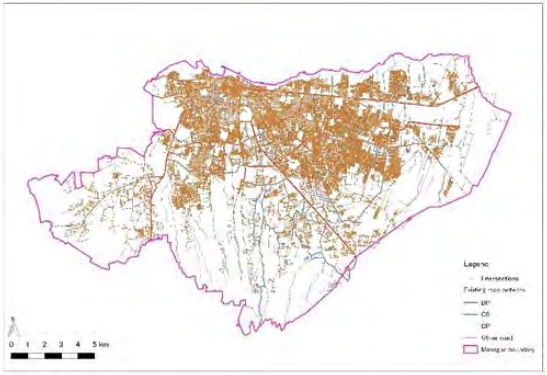
Overpass and Intersections Project [RD-1]	- To improve intersections with redesign, new signage and intelligent traffic signals - To evaluate and implement overpass - To givie a priority to mass transport systems	ALMA, National Police	(1) Preinvestment Study (1-1) Pre-investment study at the Profile, Prefeasibility and Feasibility level when applicable according to the level of investment (2) Definitive Engineering Studies (2-1) Overpass Program (2-2) Intersection Program (3) Implementation of Programs (3-1) Construction and Supervision of Overpass Works (3-2) Construction and Supervision of Intersection Works		US $ 307 million
Road Improvement and Road Extension Project [RD-2]	- To Improve and expand the existing road network considering to connection with each districts and other cities	ALMA: MTI:	1) Preinvestment Study (1-1) Pre-investment study at the Profile, Prefeasibility and Feasibility level when applicable according to the level of investment (2) Definitive Engineering Studies (2-1) Road Improvement Program (2-2) Extension Program (3) Implementation of Programs (3-1) Construction and Supervision of Road Improvement Works (3-2) Construction and Supervision of Extension Works		US $ 944.3 million

New Bypass Project [RD-3]	- To design and build new bypasses in the metropolitan area	ALMA and MTI	1) Preinvestment Study (1-1) Pre-investment study at the Profile, Prefeasibility and Feasibility level when applicable according to the level of investment (2) Definitive Engineering Studies (2-1) New Bypass Program (3) Implementation of Programs (3-1) Construction and Supervision of New Bypass Works		US $ 677.2 million
Urban public bus reorganizatio n project [PT-1]	- To serve the populated area inside the city with urban public buses - To improve the quality of service of urban public buses All above to reduce the total volume of traffic in the city	ALMA/ IRTRA MMA	(i) Reorganization of urban public bus network (ii) Increase (500) and improvement (835) of fleets		US$ 41.2 million

Intercity bus terminal project [PT-2]	- To relocate the bus terminals to city center near the fringe of the development area. - To direct the intercity buses to the fringe of the development area All above to reduce the total volume of traffic in the city.	MTI with ALMA	(i) Relocation of bus terminals (ii) Restriction of intercity bus routes		US$ 51.3 million
Urban mass transit project [PT-3～PT-6]	- To connect the sections with high traffic demand (especially new city centers/sub-centers) by mass transit - To absorb the intercity traffic demand at the fringe of the city and let them transfer to urban mass transit All above to reduce the total volume of traffic in the city.	ALMA	(i) Construction of infrastructures; 1. Runways 2. Stations 3. Hub stations and Depot 4. Administrative office including control center (ii) System integration with traffic signals and existing line (iii) Transformation of existing bus services to feeder services		US$ 2,391 million

Increase in value of car permission tax [TM-1]	- To increase in car permission tax for contributing to finance for transport projects in Managua City	ALMA	(i) dictate of a regulation establishing an increase in value of car permission tax, which must be paid every year (ii) At the beginning of every year car users should pay this permit		zero
Panels with street names [TM-2]	- To install road sign for providing names of the streets in order to save time and find destinations easily	ALMA	Installation of panels with name of each street in all crossings of the city. It is estimated that there will be 19.000 crossings to be furnished with panels		US$ 19 Million

Studies for the Parking sites [TM-3～4]	- To improve traffic flow in the city by shifting to public transport system - To reduce the use of illegal parking places - To evaluate the feasibility of construction	ALMA	One parking lot at bus terminal, consisting of 3 levels, with 24.000 m2, (90x90 m each level) with capacity for 960 cars One along Carretera a Masaya with 2 levels, 36.000 m2 (1.000 x 18m each level) with capacity for 1.440 cars.		US$ 30.2 Million
Studies on traffic and parking [TM-5]	- To study for changing direction of traffic flows in some roads - To plan the road infrastructure with solid information - To prepare the traffic control plans for markets and freight traa¥nsport - To propose zone 30 (max speed 30 km/h) - To propose HOV lanes	ALMA	A study gathering information on traffic and parking in the city, analysing it and proposing measures to fulfil objectives		US$ 0,2 Million

Traffic Management [TM-6]	- Modernization of all traffic signals - Concentration of the entire traffic responsibility in only one organization	ALMA	1) Construction of a building to concentrate all the traffic management functions. 2) Equipment (screens, command control, Video walls, cables, etc.) of the building 3) Traffic light modernization, including Renewal of 92 ancient traffic signals into modern ones (2018 – 2020) Installation of new additional traffic signals signals in 150 intersections (2021 – 2030) Installation of new additional traffic signals in 100 intersections (2031 – 2040) Installation of new additional 30 traffic information panels (2021 – 2014)		US$ 30,3 Million

Source: JICA study team