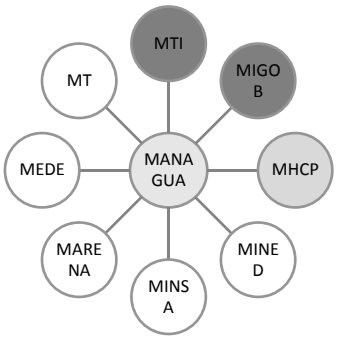
CHAPTER 4 TRANSPORT PLANNING

4.1 Traffic Administration, Institution, and Legislation

4.1.1 National Organizations and Institutions

(1) General Conditions

At the national level, many institutions are related to the urban transport field in Managua. The Ministry of Transport and Infrastructure (*Ministerio de Transporte e Infraestructura* : MTI) and the National Police are major nationwide institutions linked to transport at the national level. Eight ministries have an impact on urban transport, directly or indirectly, as shown in Figure 4.1.1 below.



Source: Ley de Organización, Competencia y Procedimientos del Poder Ejecutivo N° 290

Figure 4.1.1 Ministries Involved in Transport in Managua City

(2) National Transport Organizations and Institutions

The national transportation system is managed by MTI, under the central government. MTI is responsible for transport and roads nationwide and intercity public transport, and it is also responsible for issuing rules and regulations that apply generally in the country.

The National Police performs functions of traffic control and management, road safety and accidents throughout the country (application of the Traffic Act). The road maintenance fund (*Fondo de Mantenimiento Vial*: FOMAV) provides financial resources for maintenance of national road infrastructure.

1) MTI

The MTI is in charge of regulation of public service of ground transportation nationwide and intercity public transport, and is responsible for the following:

- Improve, maintain and develop the road network infrastructure in Nicaragua, ensuring the accessibility and mobility in a comprehensive manner, efficient, safe and economic conditions
- Grant and permit licensing of public transport for international and inter-municipal transport, tourist transport and cargo transport and/or specialized freight (Law 524, General Land Transport, Articles 40 and 41);

- Monitor and implement the General Law of Land Transport (LGTT);
- Coordinate planning for traffic, transportation and transport infrastructure, along with the Ministry of Interior and the municipalities (Law 290/1998);
- Develop the National Transport Plan (Decree No.42-2005) that rules licensing of public passenger transport service (Law No. 524/2005);
- Regulate the public service fares for passenger of land transportation in the entire country (Law No. 524/2005) excluding intra-city services;
- Grant the certificate of operation for public passengers transport service (Decree No.42-2005);
- Monitor, inspect, and control vehicles in circulation (Law No. 524/2005); and
- Issue and supervise the Certificate of Control of Pollutant Gas Emissions and authorize certification-issuing centers (Act No. 524/2005) in coordination with the Ministry of Environment and Natural Resources (Law No. 431/2003).

2) National Police

The National Police is directed, organized, coordinated, and supervised by the Ministry of the Interior Affairs (*Ministerio de Gobernación* : MIGOB). The roles of the National Police in terms of urban transport are listed below.

- Regulate traffic at the national and urban level through the Traffic Police;
- Plan and develop traffic safety plans, traffic education programs, and traffic signaling phase in coordination with ALMA and MTI (Law No. 431/2003);
- Issue licenses to drivers of public land transport vehicles (Law No. 524/2005 and Law No. 431/2003); and
- Be responsible for the Public Registry of Vehicular Property and the National Road Safety and Education Fund for safety and education projects and road signaling in coordination with the local governments, the National Road Safety Council, and the MTI.

3) Other national institutions related to transport

- The Ministry of Finance and Public Credit (*Ministerio de Hacienda y Crédito Público* : MHCP) extends the special permits, for the purposes of processing the legalization of imported used vehicles, through the General Direction of Customs (*Dirección General de Servicios Aduaneros* : DGA);
- The Ministry of Education, Culture and Sports (*Ministerio de Educatión* : MINED) implements road safety education under academic programs in coordination with the National Police;
- The Ministry of Health (*Ministerio de Salud* : MINSA) certifies the first aid course for drivers (Law No 524/2005);
- The Ministry of Environment and Natural Resources (*Ministerio del Ambiente y los*

Recursos Naturales : MARENA) administers the environmental assessment system and is responsible for the National Register of Environmental Assessment to control any polluting activities;

- MARENA also coordinates with the Ministry of Development, Industry and Trade (*Ministerio de Fomento Industria y Comercio* : MIFIC) regarding the policies for sustainable use of hydrocarbons (Law No. 290/1998); and
- FOMAV is an organization with technical and administrative autonomy under Law No. 290, and responsible for the conservation of Maintainable Road Network nationally (Law No. 355/2000 and No. 706/2009). They are funded by the special tax applied to fuels (diesel and gasoline), which is used for routine and periodic maintenance of the national road network (Law No. 706/2009). Twenty percent of the revenue is transferred to the municipalities for maintenance of the municipal road network (Decree No. 13/2006). FOMAV also establishes the policies for road maintenance and projects the maintainable road network, in coordination with MTI for the national network and INIFOM for the municipal network services (Law No. 355/2000).

There are several cross-sectoral national agencies directly and indirectly related to urban transport, as listed below.

- MTI chairs the National Council of Land Transport (CNTT) (Law No. 524/2005), whose functions are to propose policies, plans, and strategies, and to promote the development of transport activity. It can 1) propose the creation of laws and regulations to modernize the activity, 2) review the national plans for granting new concessions to be tendered, and 3) set tariffs. It serves as a forum for dialogue in case of conflicts; an instance of appeal in case of penalties and cancellation of concessions. The municipal level holds the vice presidency of the Municipal Transport Councils (CMT). CNTT includes the Association of Municipalities of Nicaragua (AMUNIC), the Chief of Traffic of the National Police, the General Director of Land Transportation of MTI, a representative of the organizations of civil society, representative of users, and four delegates of transport operators, representing each mode. The National Council for Road Safety and Education (Law No. 431/2003) is an advisory organization, of public-private composition. It proposes and promotes public policies on road safety and education (Law No 431/2003). It is composed of MIGOB, the National Police, MTI, MINED, a representative of private enterprise, a representative of associations of transport carriers (buses, taxis and cargo), the AMUNIC and a representative of insurance private companies. The Permanent Commission of the National Fund for Road Safety and Education approves the budget for the operation of the National Fund for Road Safety and Education (Law No. 431/2003). It is composed of the National Chief of Traffic Police, AMUNIC, the General Comptroller of the Republic, the Ministry of Finance and Public Credit, the National Road Safety Council, a representative of associations of operators, and a representative of the private insurance companies

4.1.2 Transport Organizations and Institutions of ALMA

The municipality is the basic unit of political and administrative division of the country. It is organized based on citizen participation. The essential elements of municipality are territory, population, and government (Law 40).

At the municipal level, Law No. 40 defines the functions of municipalities, some of which stand in relation to urban transport, as follows:

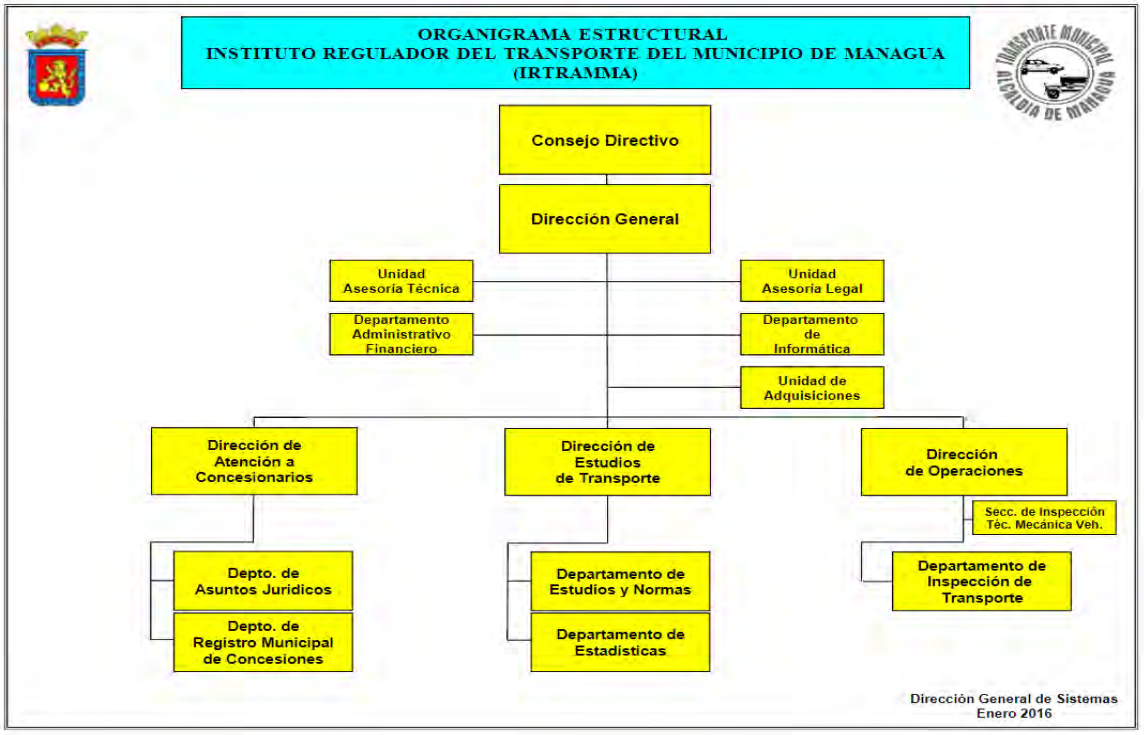
- Planning, regulation, and control of land use; and urban, suburban, and rural development;
- Construction and maintenance of streets, sidewalks, parks, and squares;
- Development, conservation, and control of rational use of environment and natural resources as a basis for sustainable development of the municipality and the country;
- Participation in the assessment of environmental impact studies, works, or projects developed in the municipality, prior to the granting of an environmental permit by MARENA;
- Development of transport and communication routes (including roads, highways, streets, tracks, corridors, and rails);
- Building and maintaining bridges, and local and inner city roads;
- Promoting, regulating, and controlling the urban, rural, and intercity public transport services;
- Managing land transport terminals, in coordination with the relevant national authority;
- Defining inner city public transport fares;
- Managing river and lake ports, in coordination with the appropriate national body; and
- Designing and planning traffic signal phasing in urban and rural roads.

To fulfil this function, the municipality can establish companies for the provision of municipal services based on the law (Law No. 40, 2013), strictly related to the exercise of their competences.

It is important to state that municipal governments can contract with the established company about executive power. Executive power is related to the delegation of duties concerning central administration, if they are accompanied by the transfer of resources necessary for the execution of the works or services. Established companies can also join voluntarily through municipal associations to promote and represent their interests and provide cooperation for the effective performance of their activities.

Article 35 of Law 40 states that the municipality can create complementary administrative entities in order to strengthen the participation of the population, improve the service delivery, and improve the municipal management. Under this principle, the Regulating Institute of Transport of the Managua City (*Instituto Regulador de Transporte de Municipio de Managua* : IRTRAMMA) (Municipal Resolution 14-99) was created in 1999. This entity is in charge of regulation and control of public transport services in Managua City. The management and administration of IRTRAMMA are entrusted to a council, which

is composed of the Mayor (President), 3 councilors appointed by the City Council, a member of the Regional Chamber of Transport, the Secretary General of Managua City, the Secretary of Municipal Council of Managua, and IRTRAMMA legal advisor (Secretary of the Executive Council). Executive management is headed by a General Director, who is named by the council from a list proposed by the Mayor of Managua.



Source: Resolución Municipal No. 14-99

Figure 4.1.2 Organizational Chart of IRTRAMMA

Its powers are delegated by the municipality based on Law No. 40 and No. 524 as follows:

- To develop public transport and roads;
- To promote, regulate, and control land and water public transport service in urban and rural;
- To plan and design the traffic signals of urban and rural roads in coordination with relevant national authorities;
- To manage the bus terminals in coordination with Managua City and national authorities involved;
- To implement strategies and undertake related studies to propose alternatives in order to decongest the roads;
- To propose location of city bus terminals and their access roads, as well as the location of small ports and berths in lakes, ponds, and rivers;
- To encourage the private sector to build public transport terminals;
- To develop plans for location of stops of urban public transport;
- To plan, organize, direct, and coordinate the standards regarding safety, health, and comfort of

public transport vehicles, ports, terminals, and related infrastructure;

- To formulate and establish pricing policies for services;
- To permit routes, licenses, and operations for public transport; and
- To manage intercity road transport terminals and berths and ports in rivers, lakes, and lagoons.

As part of its role in inner city transport services, IRTRAMMA can:

- Permit, modify, or cancel licensing and operating permits for public transport services at the inner city level;
- Set the number of units per route or mode of passenger transport taking into account the recommendations of the last National Transport Plan and the municipal councils (Law No. 524/2005);
- Authorize stops for passengers of public transport (Decree No. 42-2005);
- Set fares of municipal land public passenger transport (Act No. 524/2005);
- Establish technical standards for passenger transport, cargo, tourism, and especially the type of vehicle, capacity, service life of vehicles, and other characteristics (Law No. 524/2005);
- Monitor travel time or route (Decree No. 42-2005) and tariff (Act No. 524/2005);
- Authorize the terminals of origin and destination of inner city public transport (Law No. 524/2005);
- Control through semi-annual reviews the technical and mechanical condition of the vehicles of inner city public transport, and ensure safety and comfort for users;
- Establish mandatory supervision and control mechanisms for the various vehicles used in the inner city public transport;
- Develop and/or review studies and analysis to determine the conditions for the establishment, authorization, and/or modification of transport routes;
- To promote, authorize, and supervise the construction of bays and booths at stops of urban public transport;
- To promote public safety in urban public transport; and
- Manage intercity transport terminals.

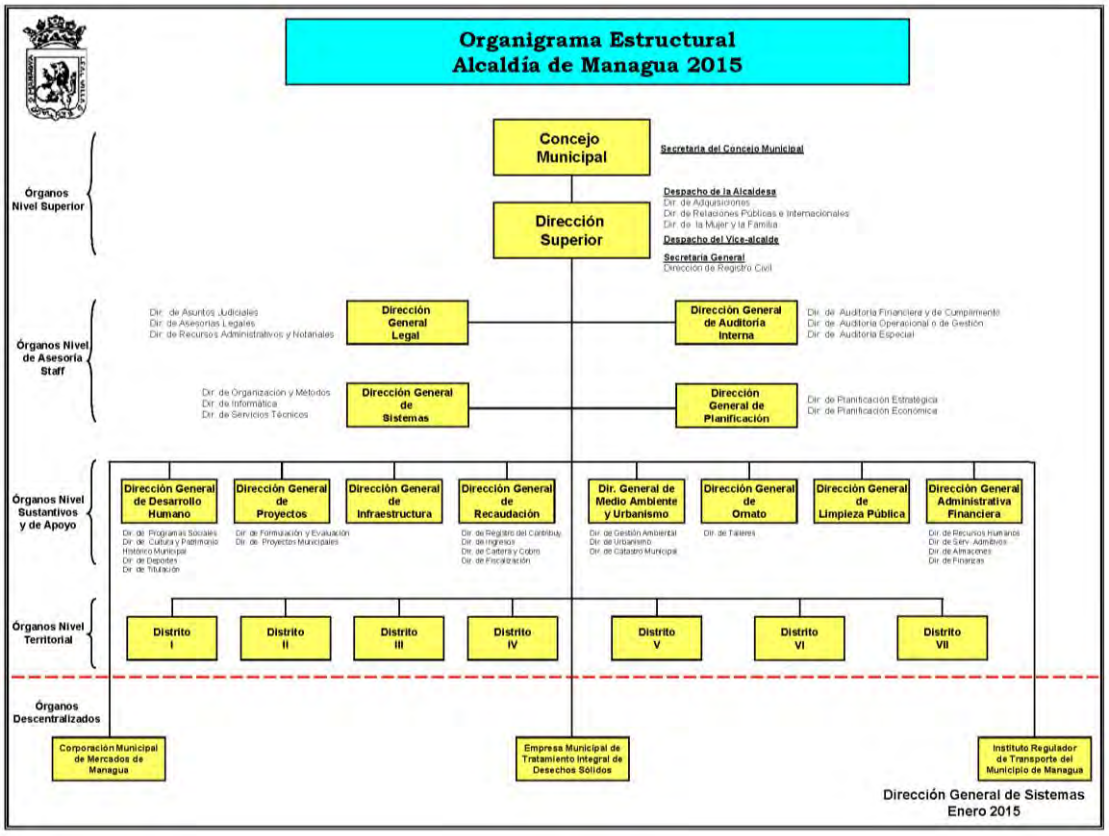
At the municipal level, several divisions (called "*direcciones*") are linked to transport directly or indirectly.

The General Directorate of Planning is responsible for establishing policies, strategies, physical and financial management plans, programs and projects for Managua City. It also participates in the development of the strategic plan for local urban improvement, which contains major and minor works.

The General Directorate of Projects, which manages investment projects, executes the plan of major and minor works such as construction of roads, bridges, and improving intersections. Under its

administration, the Department of Design and Evaluation proposes urban infrastructure projects, roads, and environment and pre-investment studies; the Project Control Directorate develops and oversees projects.

The General Direction of Infrastructure and Municipal Services, executes the plans and programs of development and maintenance of the infrastructure and equipment of the city.



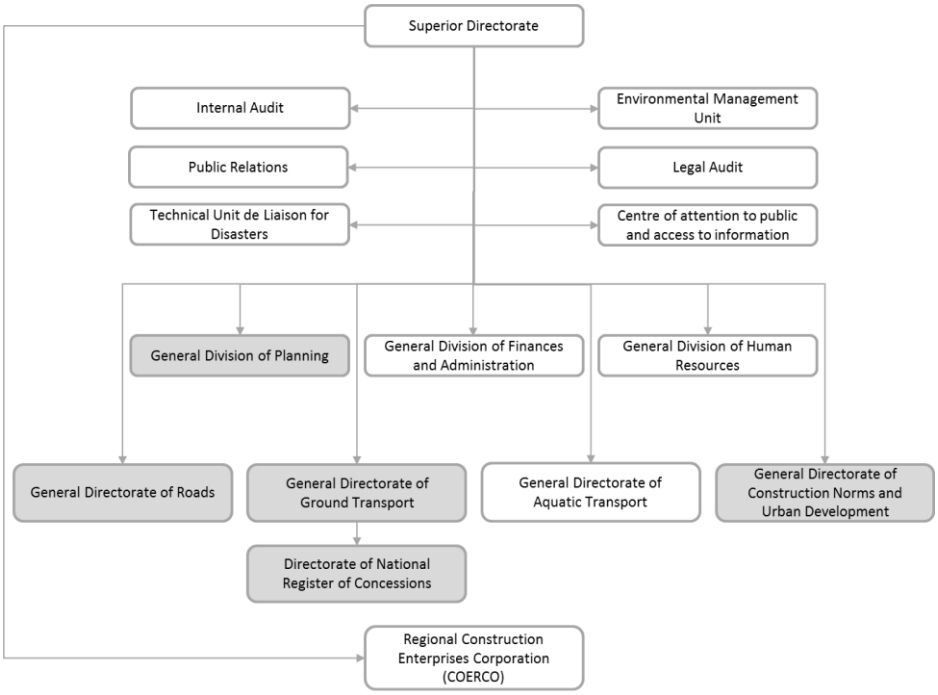
Source: ALMA 2016

Figure 4.1.3 Organizational Chart of ALMA

4.1.3 Transport Organizations and Institutions of MTI

The law establishes the general functions of the MTI to label and mark the country's roads, in coordination with the National Police. It also defines the points where traffic and directional lights and pedestrian bridges should be installed, also in coordination with local governments and the Traffic Police. It also establishes tariff regulations of land public passenger transport, which is valid for the entire national territory (except for inner city area) and controls its compliance. Regarding concessions, it establishes the geographical location of terminals, through coordination with the municipalities and the National Police, and authorizes the design and projects of passenger terminals.

Similarly, it authorizes stops of public passenger transport and special stops for intercity services, and establishes the infrastructure of these stops. Finally, in the area of supervision and control, MTI is responsible for public transport routes and issues the Certificate of Emission Control of gaseous pollutants in public transportation services, and authorizes the certification centers.



Source: MTI Home Page (http://www.mti.gob.ni/)

Figure 4.1.4 Organizational Chart of MTI

There are one division and three general directorates in charge of functions regarding land transport, namely: the General Planning Division, the General Directorate of Roads, the General Directorate of Land Transport, and the General Directorate of Construction Standards and Urban Development.

The General Planning Division formulates the National Transport Plan (Decree No. 42-2005) governing the concessions of public passenger transport service (Law No. 524/2005).

The General Directorate of Roads grants the certificate of weights and measures (Department of Weights and Dimensions), keeps the control books of special cargo which is complementary to the National Registry, and grants special permits for indivisible freight transportation whose weight and/or dimensions exceed the values indicated in the regulations (Decree No. 42-2005).

The General Direction of Land Transportation (*Dirección General de Transporte Terrestre* : DGTT) coordinates with the municipalities for the implementation of Law No. 524/2005 and regulations (Decree No. 42-2005) and grants the concessions and operating licenses for service of public passenger transport at the intercity level (Law No. 524/2005 and Decree No. 42-2005), as follows:

- Establishes routes, frequencies, intervals, and travel times in the concession contracts (Decree No. 42-2005).
- Issues Route Certificates for different modes of intercity transport (Decree No. 65-2007).
- Authorizes change of schedules for departures and arrivals or for start and end of daily activities of intercity transportation (Decree No. 42-2005).
- Authorizes the provision of emergency service units or parts, at peak times or greater crowding of passengers (Decree No. 42-2005).

- Establishes the technical stops for express services with routes over 150 kilometers, for refueling and feeding passengers (Decree No. 42-2005).

In the area of control and supervision, the DGTT appoints the department's delegates for control and regulation in intercity terminals in checkpoints at the entrance or exit of major cities and towns, as well as at any other point of highways or roads. They appoint also land transport inspectors (Decree No. 42-2005). They are also in charge of a series of records such as driver's licenses, route permissions for concessions, and operation of every vehicle providing public transport under concession (Directorate of National Registry of Concessions - Decree No. 65-2007) and also certificates authorizing weights and dimensions (Decree No. 42-2005).

Finally, DGTT fixes intercity technical standards for control of drivers and support staff of land transport. It establishes the requirements on physical and mechanical conditions, type, capacity, and performance of vehicles for intercity service for passengers, cargo, and tourism. It controls and supervises the specialized companies that carry out technical inspections and control of vehicles providing land public transport service.

4.1.4 Organizations and Institutions of Round Table (MTI / IRTRAMMA)

The round tables (mesa de diálogo) have operated in cases of conflicts between operators and authority (IRTRAMMA or MTI). There have been no conflicts between the operators and the authority.

Moreover, the CMT is composed of the Mayor of Managua, who chairs, the representative of MTI in the municipality, who is the vice president, the Head of the Traffic Safety Managua, IRTRAMMA, a representative of civil society organizations, and a representative of users. A delegate of the transport union organizations legally constituted at the municipal level can intervene anytime.

4.1.5 Legislations Regarding Transport

(1) General Law of Transport and Land Transport

According to Article 1, this law aims to "standardize, direct, and regulate the public service of land transportation concerning people and goods in the national territory, and establish requirements and administrative procedures for obtaining, renewing, and cancelling operation concessions or licenses of land transport."

It establishes that land public transport service is classified into domestic and international transport, and that the provision must be made by the concession holder with vehicles of his property or emerging units duly authorized.

This public service is classified into passenger (it is provided regularly to move people from one place to another, subject to frequency and routes), transportation of livestock, freight transport, mixed transport (which mobilizes simultaneously people and cargo, and works only in rural areas), transport for tourism and special transportation (moving people on specific routes and itineraries, on their own

routes and stops, and not available to the general public), such as school transport and personnel transport.

The law states that public passenger transport services are classified into intercity (between different municipalities) and inner city (within the same municipality). They can be:

- Urban (Colectivo Urbano): system of routes that structure a network, which can be operated with conventional services within the authorized area confined to the boundaries of the urbanized center of the city,
- Suburban: between urban centers and adjacent populations of the same municipality, and
- Rural: it is done between villages, valleys, and counties within the same municipality.

Table 4.1.1 Quality of Service and Type of Vehicles

Collective For a number of persons with routes and schedules previously defined.		Selective (taxis) For a number of persons without routes or schedules previously defined.	
Conventional or ordinary	Moves people in collective dimension regularly, in routes and schedules previously defined and authorized to allow the boarding and alighting passengers along the route.	Local or "ruleteros"	Individualized public transport service vehicle, which is confined in the limits of each municipality. It does not have fixed route nor schedules. They are regulated according to the periods of operation and roads to circulate. They do not have specific places for passengers getting on or off.
Express	Move passengers from one place to another in previously defined routes and schedules, without stopping before arriving to destination. They have a superior condition with respect to conventional services, better vehicles, faster, direct, and more comfortable. It is an additional service, simultaneous and alternative to ordinary service.	Interlocal	Express service linking two cities or localities. Trips are done in a direct way, from terminal to terminal, according to demand.
Executive or luxury	Moves passengers to their destination. It has a superior quality with respect to express service and uses modern vehicles with special specifications that offer additional comfort.	With stops established	Exclusive service having pre-established stops in hotels, markets, airports, and others defined by the user.

Source: Article 12 of Law No. 524

Article 40 states that MTI is the regulator of public service of land transportation nationwide and it is the administrative entity responsible for granting concessions and permissions to international, intercity (including taxis and school buses), tourism, and heavy and/or specialized freight transport services.

Article 42 states that it is the responsibility of municipalities to grant concessions and permits to inner city public transport (urban, suburban, rural, *ruleteros* taxis, taxis with stop and others), light and commercial freight, and special transport (school and any other long distance).

Article 47 states that the operation of the concessions of public transport services is a right granted by the state through MTI or municipalities to a natural or legal person, to work on an exclusive route in a particular time and schedule.

There are other laws related to the transportation field, and these are shown in the appendix.

(2) Decrees

Decree No. 65-2007 / Modification of Regulation of the General Law of Ground Transport

It creates the Directorate of National Register of Concessions. It is attached to the General Directorate of Land Transportation, which is responsible for the National Register of any official document issued by MTI relating to land transport of passengers and freight. It modifies the competence of MTI concerning the geographical location of passenger's terminals for intercity routes, to be established through coordination between MTI, municipalities, and the National Police.

Decree No. 13-2006 / Regulations of the Law of Reform to the Law Creating the Road Maintenance Fund

It states about the case of the municipal maintainable road network, and FOMAV must issue a special regulation and standards for the application of norms.

Decree No. 42-2005 / Regulation for General Land Transport Act

Its goal is to establish the administrative and technical provisions for better understanding and application of the General Law of Land Transport (LGTT).

Decree No. 10-91 / Tax Plan of Managua City

It aims to establish the fundamental sources of income for Managua City. It states that every owner of motor vehicle or any kind of vehicle must pay an annual road tax to be determined by the Mayor of Managua by Municipal Agreement.

(3) Regulations

Nicaraguan Technical Norm, Architectural Design, NTN12 Vocabulary 001-11.

It notes that the right of way is defined as the area between two defined property lines. It is dedicated for public use, and it includes avenues, streets, roads, highways, or other public service passage. These rights of way are the property of each municipal government; in the case of road right of way, it is administered by the MTI.

Nicaraguan Technical Standards

Dimensioning Minimum Standards for Development Housing, NTON 11 013-04, is a guide for the design of urban housing projects for social purposes, for which it standardizes and regulates the dimensions of the different areas that create the projects for the use of single-family or multifamily housing.

Regarding road, it establishes that continuity should be given to the existing urban network in the surrounding areas considering the orientation and location of streets and avenues so as to facilitate the layout of housing blocks and their accessibility. The entire road system of a complex or a part of it must have both horizontal and vertical road signs. For this purpose, it establishes the size of ways, depending on whether it is a pedestrian road, a vehicular alley, or local service street.

Finally, it states that the circulation area should range from 13% at minimum to 22% at maximum of the gross area of the project.

4.2 Person Trip Characteristics

4.2.1 Outline of Traffic Surveys

(1) Survey Component

The objective of the the traffic survey is to update the result of the previous surveys in 1998 for PITRAVI and evaluate variation of traffic movements thereafter. This traffic survey was used for the traffic forecast in 2040.

The JICA Study Team conducted various traffic surveys for obtaining the characteristics of the existing traffic and transport situation. The components of the traffic survey are listed in Table 4.2.1. Household interview survey is the main component of this survey.

Other survey components are cordon line survey and screen line survey, which are used for calibration of the OD matrix. Passenger interview survey, travel speed survey, and truck movement survey are used for the supplementary study to grasp traffic problems and to calibrate traffic simulation. The details of the traffic surveys are described in Appendix-1.

Table 4.2.1 Survey Components of Traffic Surveys

No.	Survey Component	Objective	Coverage	Methodology
1	Household Interview Survey	Socio-economic profile and trip information of residents	-10,000 households in Managua City and Ciudad Sandino	-Direct interview of all members of selected households
2	Cordon Line Survey	Traffic volume and information on non – resident trips	-5 stations at boundaries of Managua City	-Trafic count for 24 hours -Roadside interview with drivers
3	Airport Cordon Line Survey	Traffic information on non – resident trips	August C. Sandino International Airport	Interview with departing and arriving passengers for domestic and international flight
4	Screen Line Survey	Traffic volume and vehicle occupancy	-8 stations along Avenida Simon Bolivar	-Traffic count for 24 hours and 14 hours -Observation of vehicle occupancy for 14 hours
5	Passenger Interview Survey	Stated preference with regard to selected mode	-1,000 samples along the planned BRT routes including Pan-American Highway and Carretera a Masaya and Avenida Simon Bolivar	-Direct interview with bus passengers.
6	Travel Speed Survey	Travel speed on major roads	-Observation in peak hour on 16 major roads	-Collect floating car data for three round trips in peak hour by route
7	Truck Movement Survey	Goods and freight flow characteristics	-5 locations same as cordon line survey and oriental market and August C. Sandino International Airport. -Interviews with 50 major transportation companies.	-Truck volume count for 24 hours -Direct interview with truck drivers. -Interview survey for selected logistic companies

Source: JICA Study Team

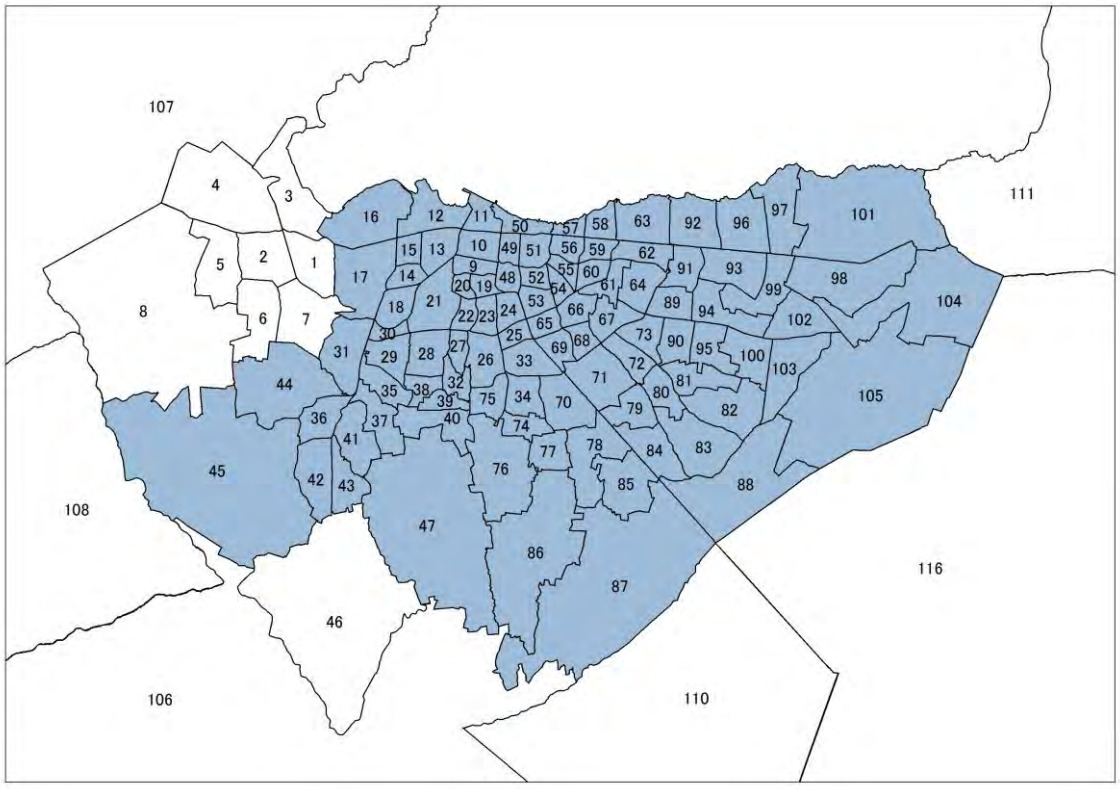
(2) Survey Zone

The study area is divided into 104 traffic zones inside and 17 traffic zones outside for a total of 121 traffic zones. To compare with PITRAVI in 1998, the traffic zone was created based on PITRAVI. However, El Crucero City and Ciudad Sandino were independent from Managua City in 2000. In addition, the administrative boundary of Managua City was changed. Therefore, the JICA Study Team modified the traffic zone to adapt to the current situation. To decide the zoning system, the JICA Study Team used geographical database called "SISCAT". SISCAT is a database owned by ALMA. The categories of administrative boundaries are district, UTB, barrio (neighborhood), manzana (block), and predio. District is the biggest administrative boundary while predio is the smallest.

Table 4.2.2 Zone Code

	Planning Zone	Traffic Zone	Survey Zone
Managua City	27	96	165
Ciudad Sandino	3	8	19
Other area	8	17	26
Total	38	121	210

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.1 Traffic Zoning inside Managua City

(3) Database Building

Traffic survey data was used to assume person trip behavior in the Managua city. The present OD matrix consists of residents' trip and visitors' trip. From Household Interview Survey, JICA study team assume OD matrix of residents. After preparting, amplification to total population in the Managua city was conducted. OD matrix of visitors were predicted by Cordon Line Survey. Finally created OD matrix shall be adjusted by the result of Screen Line Survey.

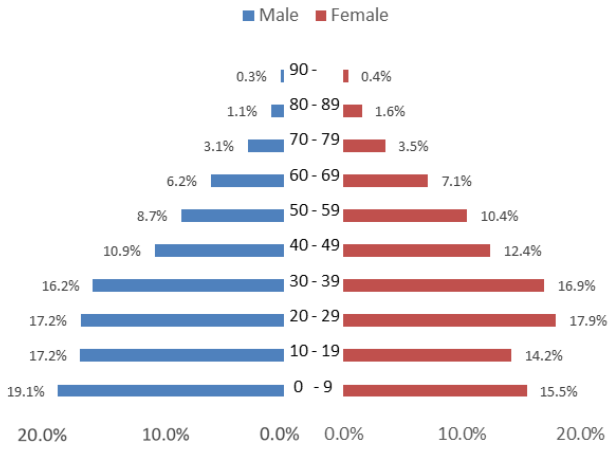
Traffic survey data was handed over to ALMA. The survey form and survey result were summarized and they are expected to be updated in the future by ALMA.

4.2.2 Urban Transport Characteristics

(1) Socioeconomic Characteristic

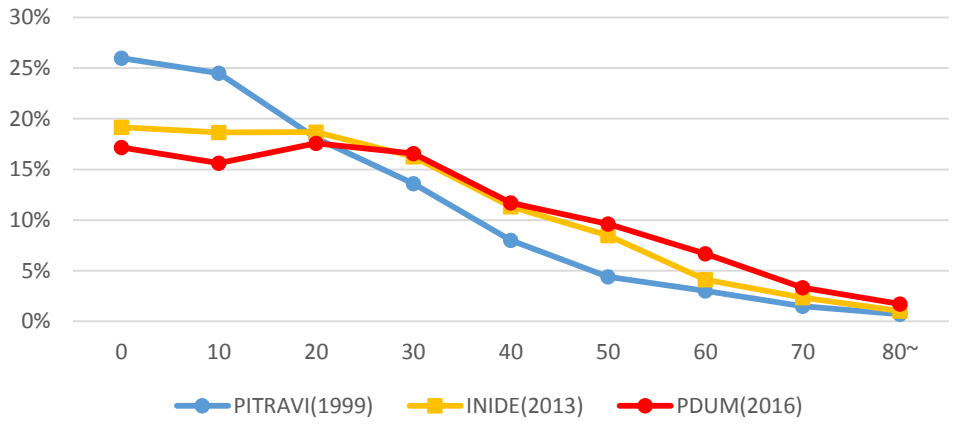
The average number of household members is 4.11 people. Around 28% of the households consist of four people. The households include not only family members that have blood relationship but also household helpers who share the household expenses and budget. In terms of gender, ratio of male is 46% and the remaining percentage is female. In terms of age, people under 30 years old occupied over 50% of both gender. The tendency is close to national statistic data taken by INIDE.

Compared demographic data in 1999 and 2013, ratio of younger people was decreased from 1999.



Source: JICA Study Team

Figure 4.2.2 Demographic Pyramid for Surveyed People



Note: Geographical boundary are differed by statistics;
PITRAVI - Managua City and El crucero City and Ciudad Sandino,
INIDE – Urban area of Managua department, PDUM – Managua City and Ciudad Sandino
Source: JICA study team

Figure 4.2.3 Demographoc Pyramid 1999 and 2016

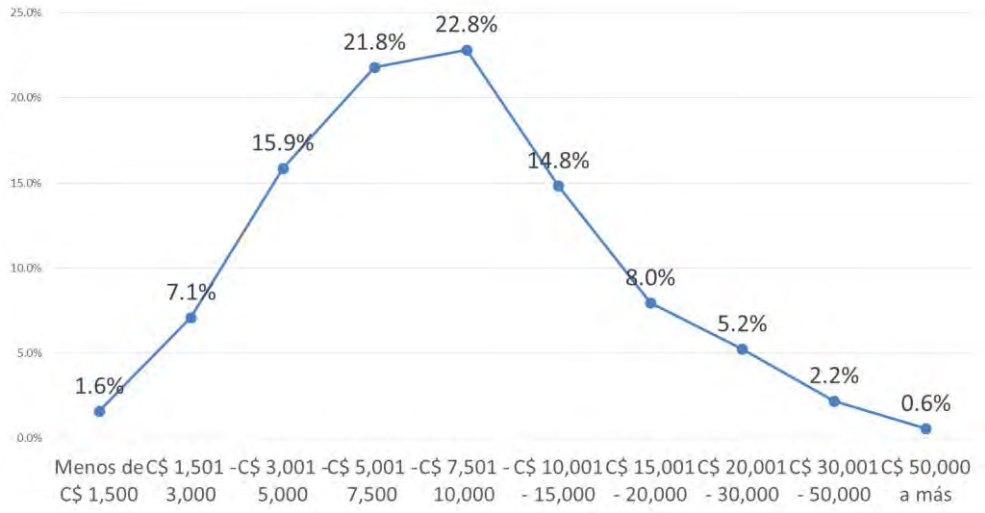
Occupation data is shown in the following Table 4.2.3. Worker is 44.6% and housewife is 22.6%. In general, occupation composition has relationship with trip number. Trip number of housewife and jobless/retired is known to be low.

Table 4.2.3 Occupation Composition

Occupation	Number of People	Ratio
Worker	14,453	44.6%
Jobless/Retired	5,416	16.7%
Housewife	7,325	22.6%
Students	4,210	13.0%
Others	1,007	3.1%
Total	32,411	100.0%

Source: JICA Study Team

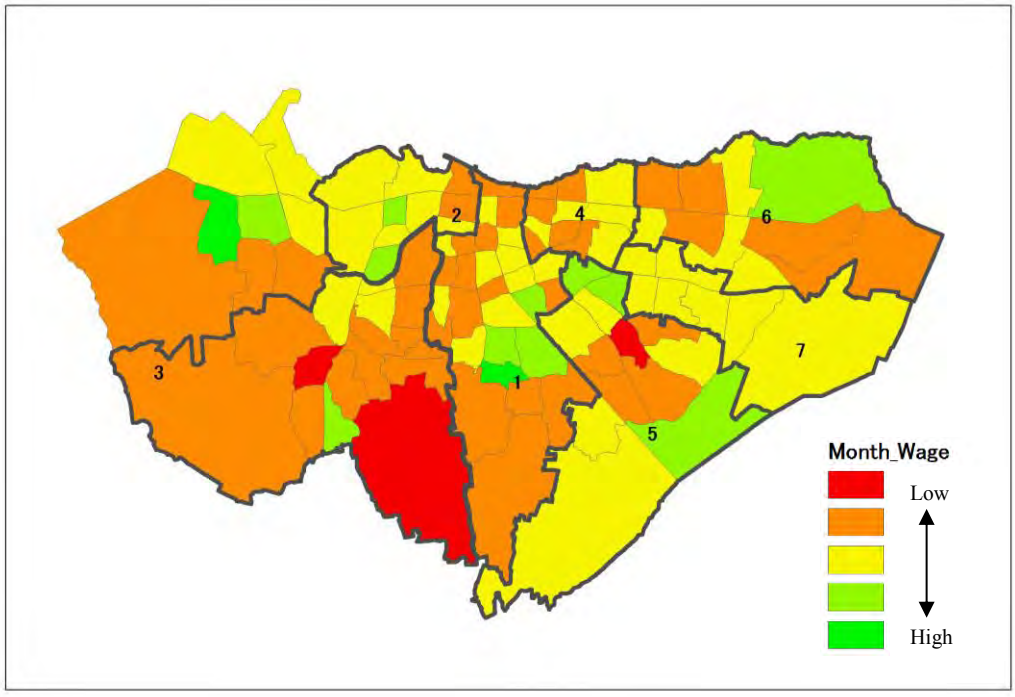
Household income level was surveyed in the household interview survey. Eighty-one percent of the households answered the question about income level. The chart in Figure 4.2.4 shows the income distribution from valid data. The peak is in the income group of NIO 7,501 – 10,000. The person trip survey in 1999 indicates an average income of NIO 2,470. It means the average income level has grown over three times. Note that this data set is biased because it is known that higher income people are not willing to give information about their income.



Source: JICA Study Team

Figure 4.2.4 Household Income Level

Monthly income by traffic zone is shown in the following Figure 4.2.5. High income level appeared along Carretera a Masaya and areas in Ciudad Sandino along Pan-American Highway and areas north of the airport. Residential area is recently developed in the outer area of Managua City. Therefore, it can be considered that high economic households gather there. It is difficult to collect household information in some areas in District 5 and District 1 due to the existence of gated community. In fact, part of the gated communities rejected the interview totally. These areas seemed to have higher economic level. District 3 and part of Ciudad Sandino appeared to have lower income. ALMA classifies residential area by type of house. The result is similar with the zoning map.



Source: JICA Study Team

Figure 4.2.5 Household Income Level by Traffic Zone

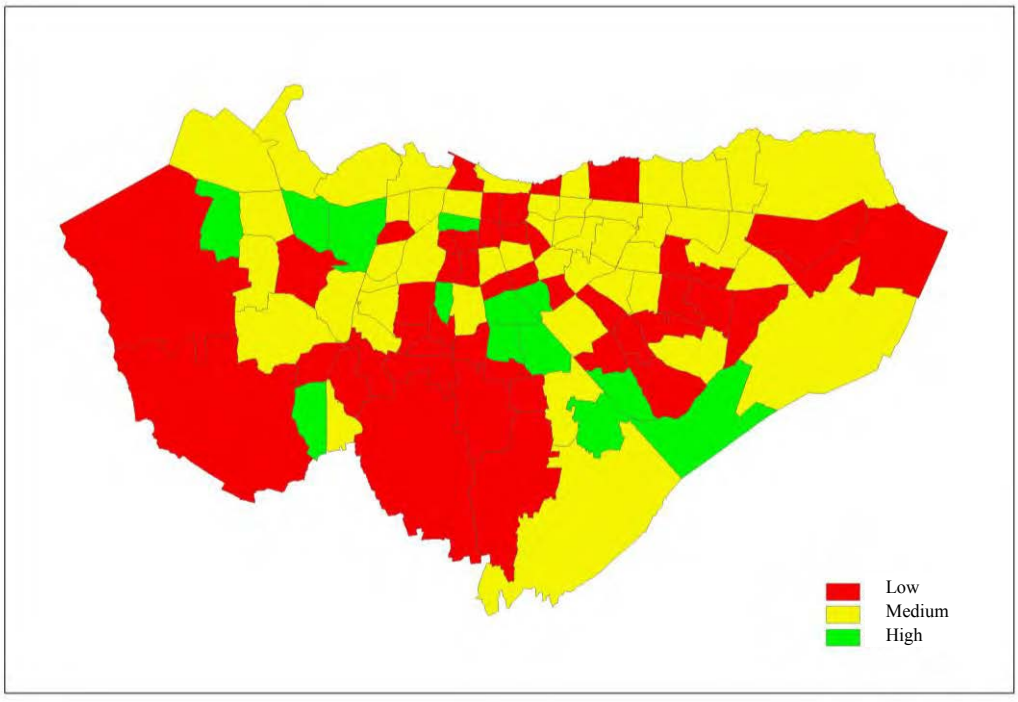
Ratio of vehicle ownership is shown in Table 4.2.4. It describes the ratio of possession by type of vehicle. About 17.7% of households own at least one passenger car. Without considering bicycle, 34% of the households own a vehicle. The person trip survey in 1990 revealed that the car ownership ratio is 19.9%. With regard to vehicle ownership by location, the ratio is found to be higher especially in the area along Carretera a Masaya. Outer District 3 and District 1 show lower ratio. It is known that wage and vehicle ownership have relationship. The distribution is similar with the map of monthly wage. Furthermore, vehicle ownership and monthly wage also have strong relationship in general.

Table 4.2.4 Ratio of Vehicle Possession

	Bicycle	Motorcycle	Private Car	Van	Minibus
Yes	6.4%	14.7%	17.7%	4.0%	0.4%
No	93.6%	85.3%	82.3%	96.0%	99.6%
Total sample	9996	9996	9996	9995	9995

	Bus	Truck	Trailer	Other
Yes	0.1%	0.3%	0.0%	0.4%
No	99.9%	99.7%	100.0%	99.6%
Total sample	9995	9995	9995	9995

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.6 Vehicle Ownership by Traffic Zone

Regarding driving license, 19% of the people have their driving license. In terms of generation, the highest ratio was observed for 30-49 years old. Twenty-four percent of the people in this generation have their driving license. Through analysis of license and trip number, license holders have two times

more trip than non-license holders. It shows that the ratio of license holders has a relationship with trip number.

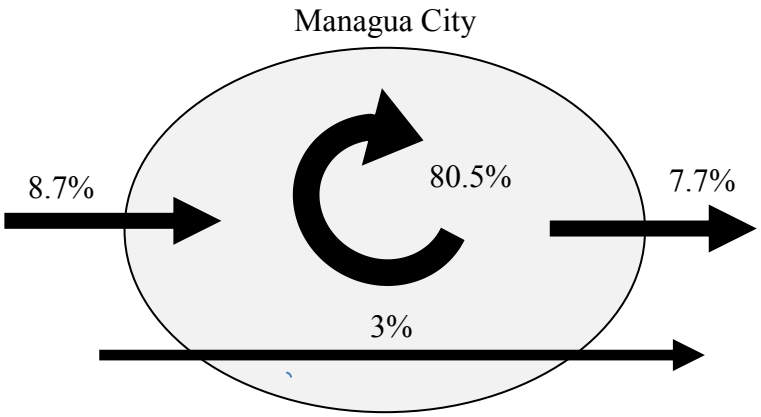
Table 4.2.5 Ratio of Driving License Holders

10 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99
5%	15%	24%	24%	22%	19%	12%	6%	3%

Soource: JICA Study Team

(2) Overall Travels Demand

Trip distribution can be described in the following figure. The trip distribution contains trip behaviour of both residents and non-residents in Managua City. Incoming trips exceed the ratio of outgoing trips. Some trips just pass the city and have neither origin nor destination.

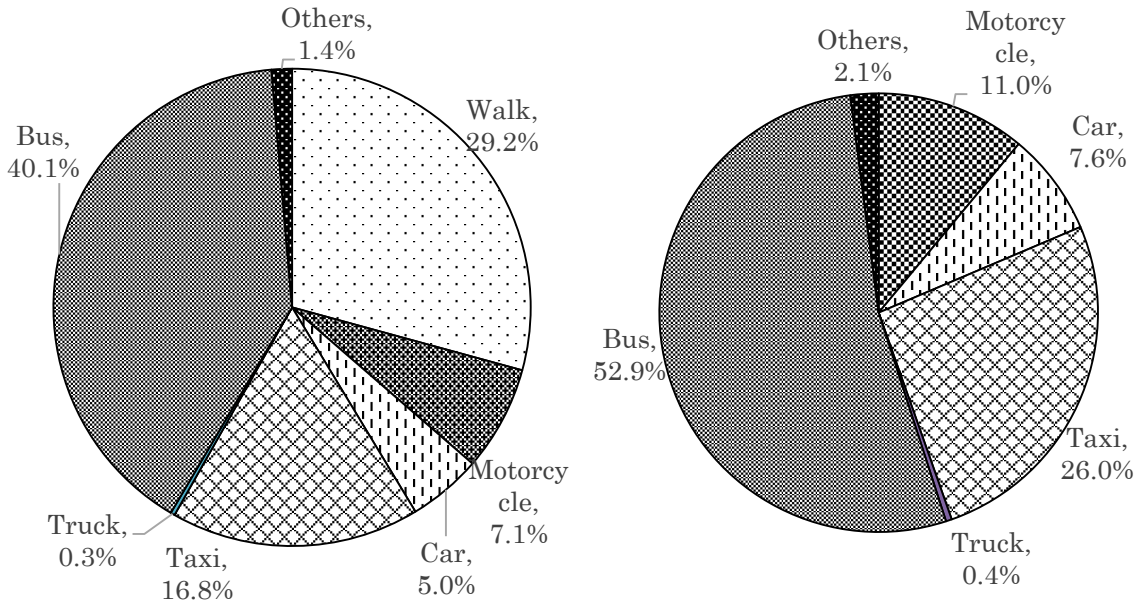


Source: JICA Study Team

Figure 4.2.7 Person Trip Distribution in Managua City

Regarding average trip number by car ownership, people who own car make more trips than people who do not own car. People who own only motorcycle has lower trip number than car-owning people. As mentioned above, car ownership is 34% in Managua City and Ciudad Sandino.

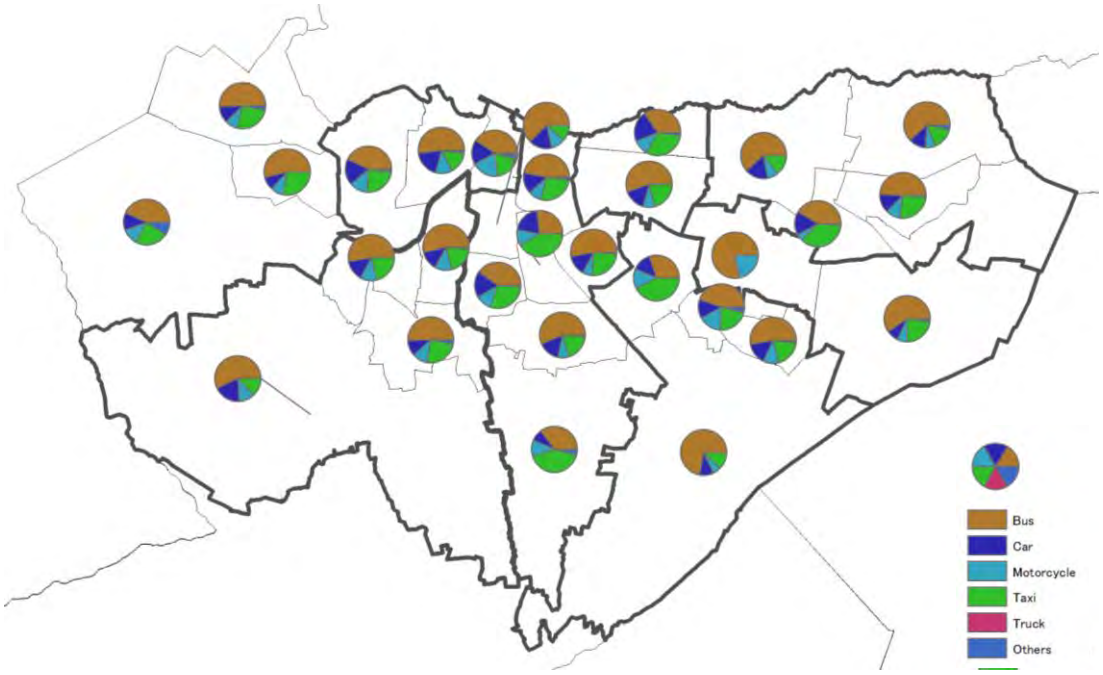
Figure 4.2.8 shows the modal share. Generally speaking, one trip includes several modes. Accordingly, the principal modes were asked to the interviewees and answers were compiled as representative modes in the data set. The left chart shows modal share excluding walking trip while the right one shows the modal share including walking trips. As seen in the left figure, over half of trips are accounted by walking trips and bus. Taxi accounts for 16.8%. Looking taxi in detail, many people used especially mototaxi. On the other hand, passenger car accounts for small portion. One of the reasons is that car ownership ratio is 33% in the target area. Ratio of motorcycle exceeds the ratio of passenger car.



Source: JICA Study Team

Figure 4.2.8 Modal Share (Left: With Walk Trip, Right: Without Walk Trip)

Modal share by planning zone is shown in Figure 4.2.9. Bus dominates higher ratio in most of areas. Ratio of vehicles except bus become higher in center area rather than outer area of Managua city. There are some areas lacked with urban bus network in outer area of Managua city, people tend to use mototaxi or bicycle taxi to get close bus stop.

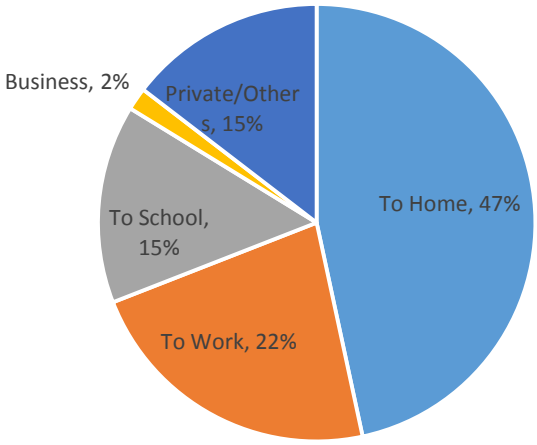


Source: JICA Study Team

Figure 4.2.9 Modal Share by Planning Zone

The household interview collects 46,428 trips in total. Table **4.2.6** shows the modal share by purpose of the collected trip information. As for trip purpose, “To Home” accounts for 47% in total. In terms of modal share, walking trips have higher ratio especially for “To School”. This is considered natural

because many younger people commute to their neghborhood school by foot. Passenger car accounts for 22.5% of "Business". "Business" does not include commuting to the office, but it includes trips for meeting or negotiation outside the office. They use company or own car or motorcycle in the business trip. As seen in "Private", walk ratio exceeds other walk trip but for different purpose. In "Private", visiting friend's house and shopping and taking dishes are included. It can be considered that "Private" purpose trip is a relatively short distance trip.



Source: JICA study team

Figure 4.2.10 Composition of Trip Purpose

Table 4.2.6 **Composition of Trip Mode by Purpose**

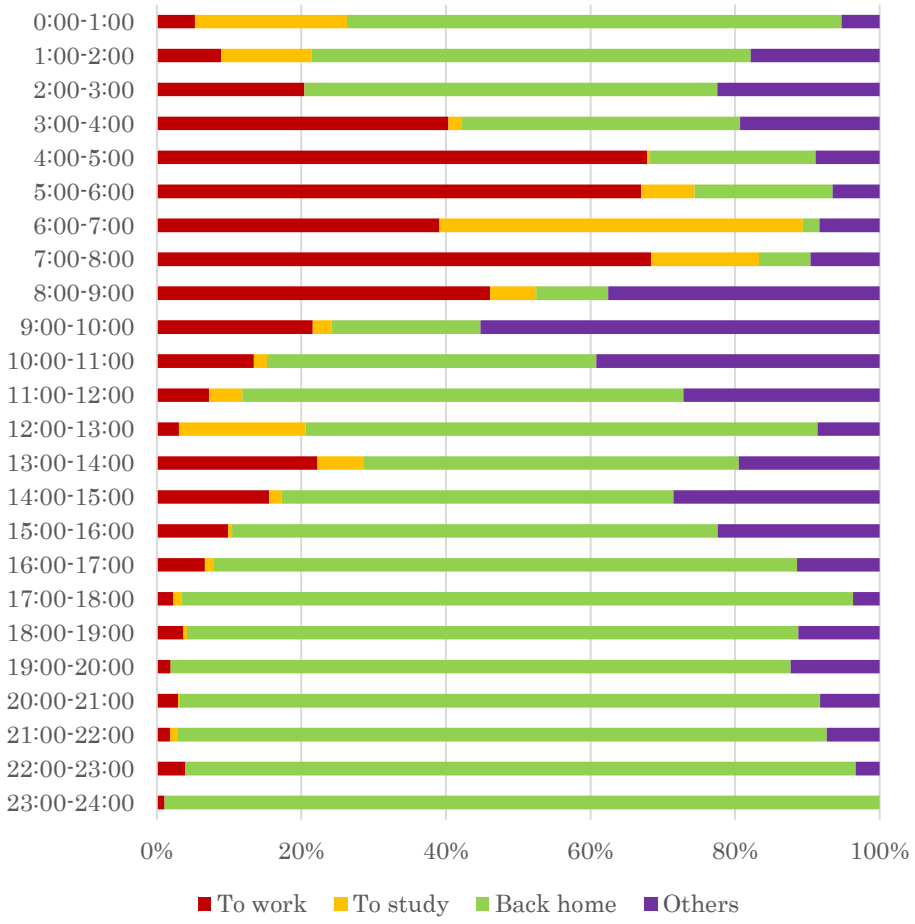
	To Home	To Work	To School	Business	Private/Others
Walk	33.5%	26.6%	58.5%	14.9%	35.1%
Motorcycle	6.9%	11.5%	1.6%	7.2%	6.4%
Car	5.2%	3.7%	0.9%	22.5%	7.5%
Taxi	15.1%	20.5%	9.3%	22.0%	23.0%
Truck	0.2%	0.4%	0.1%	2.8%	0.2%
Bus	37.7%	35.2%	29.2%	29.2%	26.3%
Others	1.3%	2.0%	0.4%	1.3%	1.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: JICA Study Team

Figure 4.2.11 show the hourly variation of trip generation and attraction by trip purpose. "To work" and "To study" have their peak in the morning. "Others" has its peak hour during 9:00-10:00. "Others" contains shopping, eating, health treatment, leisure and so on. As for composition of "Others", many people answered shopping, which accounts for 65% of the total answers for "Others" between 9:00 and 10:00. Composition of trip purpose is change by hour. It change means trip mode is also changed hourly since trip mode is different by purpose as mentioned above. Figure 4.2.12 describes the hourly variation of trip generation and attraction. Difference between trip generation and attraction is not found. Peak

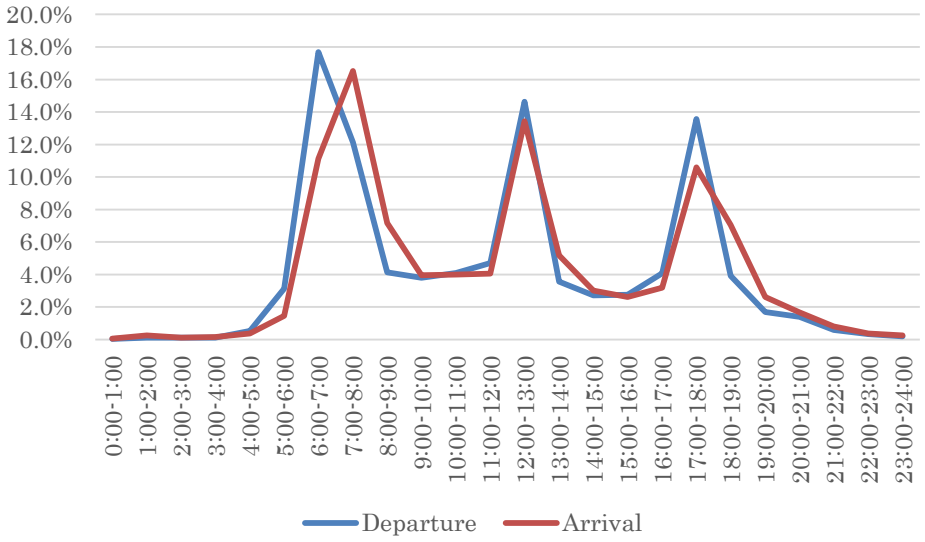
hours of trip generation and trip attraction are concentrated at 6:00-8:00 and 12:00-13:00 and 17:00-18:00.

In Managua city, public school adopt two time shift in a day. Primary schools start its lesson from early morning until noon, subsequently second shift start around noon to evening. Therefore students trip concentrate in three times; morning, noon and evening. That tradition appeared in trip peak hour in the noon.



Source: JICA Study Team

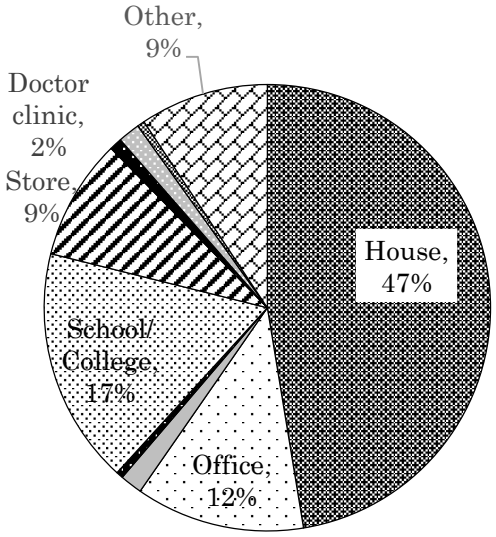
Figure 4.2.11 Hourly Variation of Trip Generation by Trip Purpose



Source: JICA Study Team

Figure 4.2.12 Hourly Variation of Trip Generation and Attraction

As for type of location, around 50% of the trip started from the house. Office accounts for 12% and school accounts for 17% in both origin and destination. Since most of the people did two trips in a day, half of the trips start or end at their house. Accordingly, the composition ratio is similar betwen origin and destination. Under "Other" trips, places such as church, park or family's house can be considered.



Source: JICA Study Team

Figure 4.2.13 Type of Destination

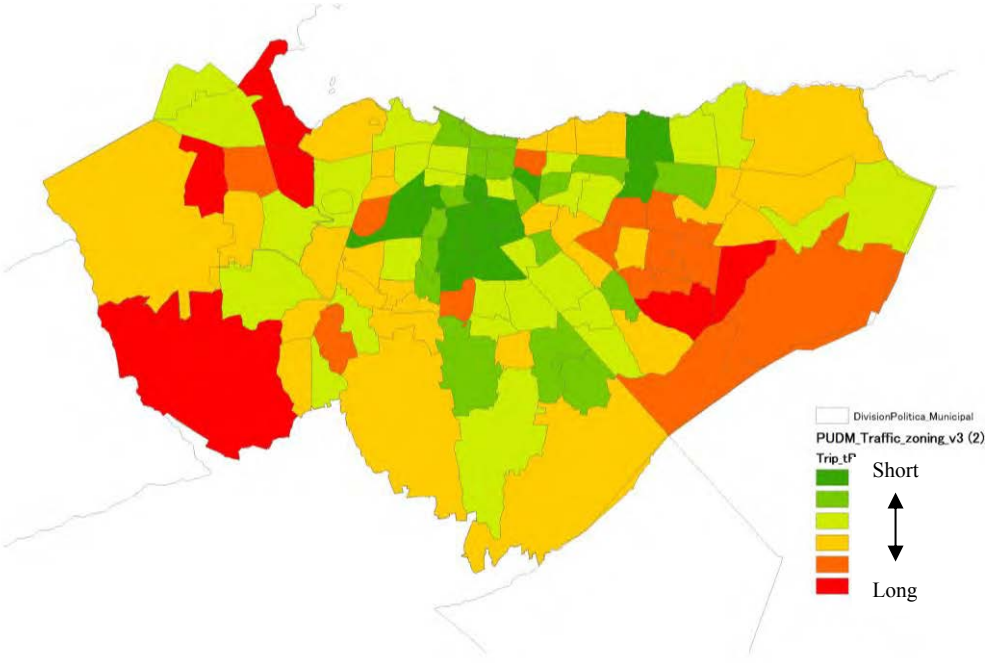
Average trip time by principal trip mode is shown in Table 4.2.7. Average trip time is 22.63 minutes. By trip mode, average travel time is around 30 minutes for passenger car and travel time of bus is much longer than that of car. The longest trip time is truck due to the existence of logistic movement to outside Managua City and Ciudad Sandino. Compared with the traffic survey in 1998, trip time became short except for walk and truck. Most of the modes shorten their average trip time by 2 minutes to 8 minutes.

Development of road infrastructure can be considered as a reason. Figure 4.2.14 shows average trip time generated from each traffic zone. As traffic zone located farther from the center, average trip time become longer.

Table 4.2.7 Average Trip Time by Mode

	2016 (Minutes)
Walk	22.7
Car	27.8
Truck	50.3
Bus	42.9
Motorcycle	26.3
Taxi	24.3
Average	22.63

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.14 Trip time by traffic zone

Results shows in following table. 53% of the passengers have origin or destination inside the Managua city and Ciudad Sandino. Most of international passengers answered their purpose is “Personal”. It includes sightseeing while domestic passengers answered “To Work”

Table 4.2.8 Purpose of Trip to Arrival Passengers

	To House	To Work	The college / university/ school	Personal	Business
International	23%	10%	0%	59%	8%
Domestic	3%	66%	0%	24%	7%

Source: JICA Study Team

4.3 Road Facility and Traffic Characteristics

4.3.1 Conditions of the Roads

(1) Road Administration

Managua City and Ciudad Sandino form the metropolitan area, which interconnects with ten areas around its boundaries. One of the most important cities is Leon (89.3 km) in the western part of Managua City, and then Masaya (31.6 km) and Granada (38.9 km) in the southeastern part. Other cities that interconnect are Tipitapa (22.8 km) in the eastern part, and Crucero and Jinotepe (48.8 km) in the southern part. There are two roads to access León. The main road has much traffic volume, i.e., Masaya Road (79.016 veh/day, Rotonda Jean Paul Genie), Carretera Norte (66.901 veh/day, Portezuelo), and Carretera Sur (43.606 veh/day, 10.5 km a Nejapa)[1].

Source: JICA Study Team

Figure 4.3.1 Interconnection Map of the Metropolitan Area of Managua to the Main Cities

The Regulatory Plan of Managua City is the unique legal instrument that contemplates a model of physical order for the municipality. This is reference for other basic ruling documents. In the case of the road sector, there is a subsequent document, namely, Rules of the Road System for the Metropolitan Area of Managua, and it is a complementary part of the Regulatory Plan.

In the General Plan of Development for the Municipality of Managua, the following correlate the problems presented and objectives in the 2001-2010 period:

- "Ranked Road System (Complete, Efficient and Functional): a ranked road system to facilitate the

[1] Source: Traffic Survey 2015, MTI- Planning Division - Road Management Division

traffic flow and security for vehicles and pedestrians."

- "Secure and Modern Transport System: a municipality for an efficient transport system (speedy, modern, and quality) respecting the pedestrian mobility by discouraging the use of individual cars and making shift to bus as the main transport media".

The ALMA is responsible to plan, build, improve, and maintain the road network including national roads under its jurisdiction. The local and smallest roads are under the responsibility of each municipality.

(2) Road Classification

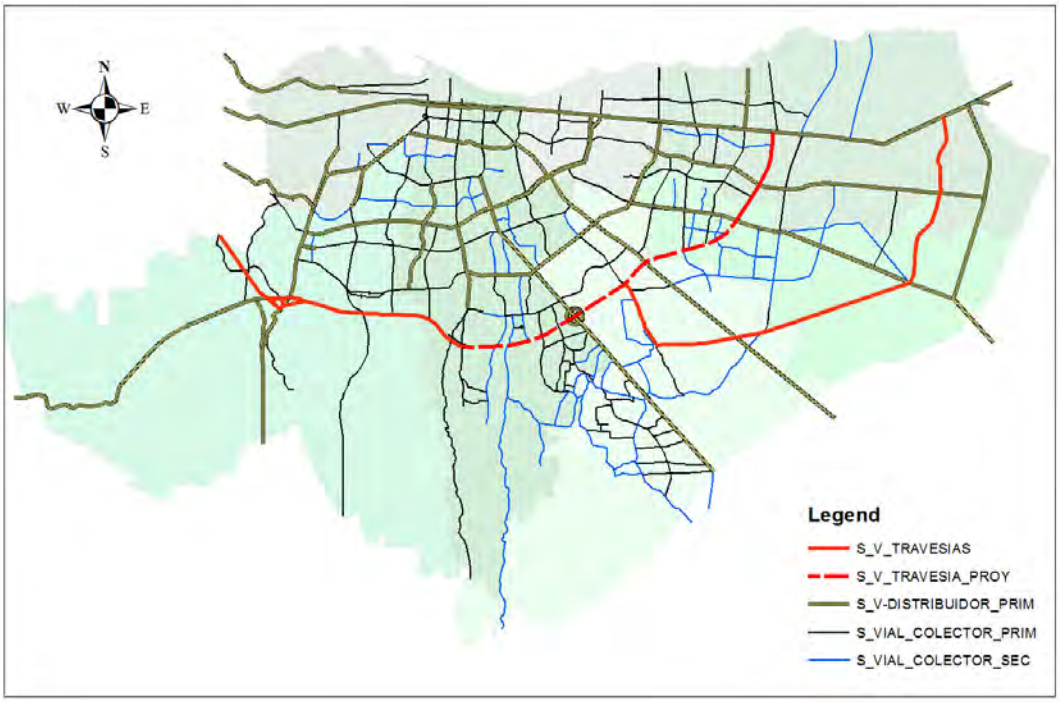
1) Classification by Administrative Jurisdiction

The road system is classified according to administrative jurisdictions. The national roads are administered by the central government; while other roads are administered by municipal and district government.

2) Classification by Functions

In the Regulatory Plan, the roads has been classified as follows:

- Expressway, Primary Distributor (arterial road), Primary and Secondary Collector (collector road), Street and Alley and Recreational route.



Source: Direction Urban Planning, according to Regulatory Plan

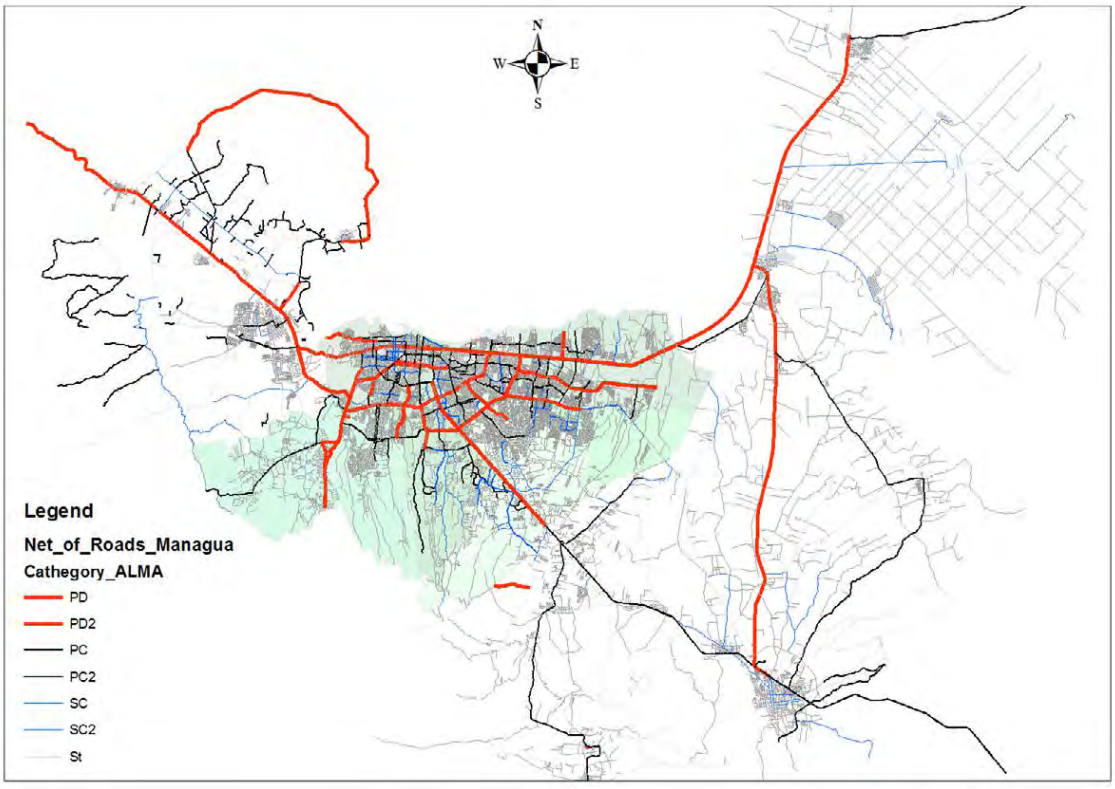
Figure 4.3.2 Map of the Managua Metropolitan Road System

- Expressways (E): There is no this type of road in Managua City so far. This type of roads is an access road which is totally controlled with multiple lanes separated by a median, and it has a lot of interurban traffic volume and its speed is relatively high.
- Primary Distributor (PD): This type of road is two-way road with service road. These roads have

large traffic volumes, and their travel distances in the urban area is long and their speed is relatively high.

- Primary Collector (PC): This type of road is two-way road with direct access to the adjacent houses. Public passenger transport circulates on these routes.
- Secondary Collector (SC): This type of road is one-way road with direct access to the adjacent houses or to the street.
- Street (St): This type of road is the local road or streets whose main function is to allow access to adjacent urban properties.
- Alley: This type of road allows access to the adjacent properties such as minimum parking and vehicular circulation for parking maneuvers and service delivery. According to land use, it may exist in areas of trade and housing.
- Recreational route: Primary function of this road is for recreational and tourist, with special bays for lookouts, and it is designed for moderate traffic flow rates with frequent intersections.

However, at present, the metropolitan roads of Managua City consist of only four categories as shown in Figure 4.3.3, i.e.: Primary Distributor (red line), Primary Collector (black line), Secondary Collector (thin blue line), and Street (thin gray line).



Source: Direction Urban Planning, according to the Regulatory Plan

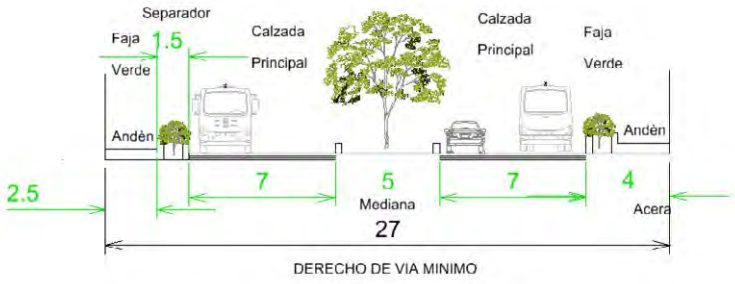
Figure 4.3.3 Map of Managua, Tipitapa and Ciudad Sandino Metropolitan Road System

The Managua metropolitan road system has cross section structures that determine the minimum width for the Primary Distributor to be 40 m for right of way. The service road in this section is

called Marginal Street, but there is only one direction under the regulations. The following figure has drawn the minimum section recommended under the regulations.

Full Cross Section Structure
Primary Distributor Road

Incomplete Minimum Cross Section Structure
Primary Distributor Road



Minimum Cross Section Structure
Primary Collector Road

Minimum Cross Section Structure
Secondary Collector Road

Minimum Cross Section Structure
Local Roadt

Source: Urban Traffic Regulation, Regulatory Plan

Figure 4.3.4 Transversal Section Types in the Metropolitan Road Network

Reviewing the existing road system, which has been updated, it is observed that it needs to be re-categorized because urban sprawl has spread beyond expectation. In some cases, there is lack of continuity of the road network and invasion of the right of way. It has a lack of continuity of the road network, narrow streets, and poor accessibility.

The classification allows to establish criteria for road width, direction of movement, regulation of vehicles, length of travel, speed of operation, travel demand, access to private property, continuity of road network, on-street parking, retreats, and space. These parameters are shown in Table 4.3.2.

(3) Existing Arterial Roads

The existing network of arterial roads (Primary Distributor) is semi-circular including Ciudad Sandino. It discontinues and tries to maintain a system of radial roads starting from the central area of the Managua City where the administration was focused before the earthquake of 1972. Currently, there is only the National Assembly left in that area. In addition, it connects to ring roads (although they do not form a complete road network).

1) Radial Road Networks

Network of radial roads: There are ten routes which fulfill the function of Arterial Radial roads with the following main roads: the Pan-American North, Pan-American South, Carretera a Masaya, antigua Carretera a León, Route 28 to Ciudad Sandino (1, 5, 8, 8-2, 9, and 10), and then there are Secondary Radial roads (2, 3, 4, 6, and 7) which will eventually become Arterial. The details of the radial roads are shown in Table 4.3.1:

Table 4.3.1 Main Radial Roads

Radial Road*	Avenues that confirm it**
Radial 1	Pan-American North, from the center to the Airport
Radial 2	Formed by the Pista Larreynaga, to the Oriental Market
Radial 3	20ª Street SE, Pista La Sabana, Highway to Sabana Grande
Radial 4	Incomplete, only section of Próceres del Primero de Mayo Ave., accounting for the channel, but is invaded by families in precarious houses. Camino a las Jagüitas
Radial 5	The road to Masaya, which is made up of the Paseo Naciones Unidas Avenue and the Union Europea Avenue and from the Via Suburban, is the Masaya Highway.
Radial 6	Bolívar Avenue, from the roundabout of the 1ª Avenue to Pista Benjamín, Casimira Sotelo Ave., Pista de la Unan to the Pista Jean Paul Genie
Radial 7	11 Southwest Avenue, Paseo Naciones Unidas
Radial 8	Pan-American South
Radial 8-2	La Batahola Avenue (It is partially invaded)
Radial 9	Route No 12, Antigua Carretera a León
Radial 10	Radial of La Cuesta de los Mártires (Del Plomo, Route No. 28 to City)

(*) Road Network of Regulatory Plan, (**) Existing roads that make up the radial axes.

Source: JICA Study Team

Table 4.3.2 Functional Classification of Urban Road System

Criteria	System					
	Primary Distributor	Primary Collector	Secondary Collector	Streets	Alleys	Recreational
Right of way	40-100 m	27-39 m	18-26 m	14-17 m	12-13 m	Variable
Typical elements considered in the right of way	Carriageway	Carriageway	Carriageway	Carriageway	Carriageway	Carriageway
	Ditch	Ditch	Ditch	Ditch	Ditch	Ditch
	Curbs	Curbs	---	---	---	Atmosphere Element
	Sidewalks	Sidewalks	Sidewalks	Sidewalks	Sidewalks	Sidewalks
	Platforms	Platforms	Platforms	Platforms	Platforms	Platforms
	Tree boxes	Tree boxes	Tree boxes	Tree boxes	---	Green areas
	Lanes for buses	Bus stops	Green lane	Green lane	Green Lane	Bay
	Median	---	---	---	---	Parking lanes
	Lateral spacers	---	---	---	---	Lookouts
Direction of movement	Two way	Two way	Two way	Two way	Two way	Two way
Regulation on certain vehicles	Allows movement of public transport with high frequency of operation, service vehicles	Allows movement of public transport with high frequency of operation, service vehicles	Allows movement of public transport with low operating frequency, municipal service vehicles	Allows movement of public transport with low operating frequency, municipal service vehicles	Does not allow movement of public transport, only vehicles of municipal services	Does not allow traffic of trucks and buses for urban public transport.
Trip distance	5-10 km	2-5 km	1-2 km	100-500 m	100 m	---
Operating speed	50 - 65 km/h	50 - 65 km/h	40 -50 km/h	20 - 30 km/h	Maximum 20 km/h	30 km/h
Trip demand	20,000-40,000 veh/day	5,000-20,000 veh/day	3,000-8,000 veh/day	1,000-3,000 veh/day	200 veh/day	3,000-8,000 veh/day
Access to private property	Controlled by marginal streets and / or regulations stipulated in the Vehicle Parking Regulations	Controlled by standards set in the Vehicle Parking Regulations	Direct	Direct	Direct	Controlled by standards set in the Vehicle Parking Regulations
Continuity of system	Yes	Yes	Yes	Yes	No	Yes
On-street Parking	Not allowed	Not allowed	Not allowed	A parking lane controlled under minimum regulation	Parking spaces in both directions	Only specially designed bays
Retreat	According to the Zoning Regulations and Land Use Area for Managua City					
Spacing	1.5 km	Under 1.5 km	500-750 m	100-200 m	100 m	Undefined

Source: Regulatory Plan of Managua, Municipal Agreement No. 14, Municipality of Managua (September 13th 1991).

2) Ring Road Network

Because there is a blank space at the center, the municipality is building new public spaces to generate new attractions at the center, unlike the historic area of other cities with little use. The Regulatory Plan in the Metropolitan Highway System (Managua City) considered four ring roads including a ring road at the center of Managua City. However, it has only been possible to implement until the third ring road, which is made up of existing roads.

Table 4.3.3 Ring Roads

Ring*	Avenues that confirm it**
Ring 1	2a Calle SE1 - Calle Colon – Monumental Avenue
Ring 2	Pista Juan Pablo II (Carretera Norte – Carretera Sur)
Ring 3	Pista Solidaridad – Pista Suburbana
Ring 4***	Incomplete, Pista del Mayoreo (Carretera Norte – Pista Sabana Grande)

(*) Regulatory Road Network Plan, (**) Existing roads that make up the radial axes, (***) Proposed rings
Source: JICA Study Team

3) Network of Expressways

In the case of the Directorate of Urban Planning through its Regulatory Plan, there are two expressways (approximately 37.5 km) forming the outer rings according to its classification corresponding to the crossings system. However, only part of the original proposal, 2.7 km, i.e., the section between the Pan-American North and the Pista Sabana Grande, has been done.

(4) Regulatory Design Standards

In Nicaragua, there are regulatory design standards for national roads governing Central American countries. The contents of NIC2000 Manual of General Specifications for Road Construction, Streets and Bridges are: Division I. Legal Requirements, Administrative and Environmental; Division II - Technical Specifications (construction details) and Environmental Basic Standards.

The Central American Manual for Pavement Design of the United States Agency for International Development - Secretariat of Central American Economic Integration – is used in this country. This manual includes the functional classification of regional roads, traffic volumes, number of lanes and road surface type, but it has not been applied to urban roads.

For the design of urban roads, the Regulation of Road System for the area of Managua City, which is one of the components of the Regulatory Plan of Managua and which was approved by La Gaceta Diario Oficial N° 085 and 086 in May 2nd and 3rd, 1984 accordingly, and incorporated to municipal urban legislation of Managua trough the Municipal Agreement No.14 of Managua City (September 13th 1991), is also used. This regulation establishes the minimum standards which must apply to each road classification. Table 4.3.4 shows the standards made by Managua City.

Table 4.3.4 Minimum Standards of Geometric Design of Roads (Road Design Standards)

TTYPES OF ROADS	DESIGN VEHICLE (Distance of the axes, cm.)	VOLUME (veh/day)	SPEED DESIGN	MINIMUM WIDTH OF GREEN STRIP	MINIMUM WIDTH OF PARKING LANE	PARKING LANE	MINIMUM WIDTH OF SIDEWALKS	MINMUM WIDTH OF PLATFORM	MINIMUM WIDTH OF MIDDLE RAIL	SIDE SEPARATOR	MAXIMUM SLOPE	MINIMUM SLOPE	MINIMUM RIGHT OF WAY	MINIMUM BENDING RADIUS	MINIMUM DISTANCE OF STOP SPEED
Primary Distributor	1200	20,000-40,000 veh/day	50 - 65 kph	1.50 m	3.5 m	2.4 m	6.0 m	3.0 - 4.5 m	5.0 m	3.0 m	6%	0.5%	40 m	162 m	50 m
Primary Collector	860	5,000-20,000 veh/day	50 - 65 kph	1.50 m	3.5 m	2.4 m	4.0 m	2.0 - 2.5 m	5.0 m	---	6%	0.5%	27 m	162 m	50 m
Secondary Collector	860	3,000-8,000 veh/day	40 - 50 kph	1.50 m	3.3 m	2.4 m	3.0 m	1.5 - 2.15 m	---	---	8%	0.5%	18 m	86 m	40 m
Streets	335	1,000-3,000 veh/day	20 - 30 kph	1.50 m	3.0 m	2.4 m	2.8 m	1.5 - 1.75 m	---	---	12%	0.5%	14 m	40 m	30 m
Alleys	240	200 veh/day	20 kph Max	1.50 m	3.0 m	2.0 m	2.5 m	1.25 - 1.5 m	---	---	12%	0.5%	12 m	20 m	20 m

Source: Rule of the Road System, Municipal Agreement No.14 of Managua City (September 13th 1991)

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(5) Road Length and Road Width

1) Road Length

The length of the metropolitan road network of Managua City planned in the Regulatory Plan in 1984 is approximately 457.72 km. Around 37.6 km of these correspond to expressways; primary distributor is 151.092 km, and collector is 269.07 km. In the case of local roads, they have been built gradually according to urban sprawl. The official uncompleted road network distributed in all districts of the city is shown in Table 4.3.5. Roads in District 1, which account for 28%, will be constructed preferentially, and then those in District 6 and District 2 will also be done.

Table 4.3.5 Length of the Existing Road Network by Type and District (km)

District	PD	PD*	PC	PC*	SC	SC*	Streets	Total
Dist.1	33.518		25.652	16.585	16.964	12.915	328.523	434.157
Dist.2	19.534	2.389	11.999	5.700	13.225	1.931	181.981	236.760
Dist.3	11.385	0.387	18.701	9.848	1.849	1.832	380.598	424.600
Dist.4	15.457		11.470	10.412	3.684		166.175	207.198
Dist.5	7.267	1.567	5.676	2.433	10.156	16.955	414.031	458.085
Dist.6	21.911	1.527	8.815	9.486	3.941	3.244	341.390	390.315
Dist.7	6.071		6.045	4.807	9.588	6.467	318.571	351.549
No Inf.					0.490	1.583	7.201	9.274
Total	115.143	5.870	88.358	59.271	59.897	44.928	2,138.470	2,511.938

(*) Existing road similar function and approximate line

Source: JICA Study Team based on the GIS Data of Road Inventory

Authorized roads can increase the number of lanes depending on the need. Expressways and primary distributor are usually four lanes. Primary collectors are three lanes and secondary collectors are two lanes. Usually, most local roads, which account for more than 82% of the road network, are one or two lanes.

18.4% of the planned road network has still missing information, because there is a growth of the city where the road network was not defined, and there is a group of roads that complies with the function set in the regulation, but they are found in the magnified area.

Table 4.3.6 Summary of the Planned and Existing Road Network

Items		System				
		Expressways	Primary Distributor	Primary Collector	Secondary Collector	Streets
Managua	Existing**	--	121.013	147.629	104.825	2,138.470
	Planned*	37.559	151.092	173.129	95.938	0.000
Construction Radius %)		0.0%	80.1%	85.3%	109.3%	--

Source: (*) Directorate of Urbanism (SVM-1984), (**) GIS Inventory of the Road Network (18.10.2016)

An update has been made on the urban areas that are adjacent to Managua City, such as Ciudad Sandino, Tipitapa and Masaya. In Ciudad Sandino, there are other municipalities like Mateare and Villa El Carmen. This road network has almost the same length (2,396 km). However, the quality is not the same. These municipalities have a classification of national network level as established in the MTI.

Table 4.3.7 Equivalent Classification of the Regional and Urban Road Network

Functional Classification	Secondary Trunk	Primary Collector	Secondary Collector	Vecinal Road
MTI's Classification	Primary National	Secondary	Tertiary	Municipal
Vehicle Volume	500 veh/day	250 veh/day	250 veh/day	50 veh/day
Road Width	50 m	50 m	30 m	30 m
Route	Interdepartamental	Intermunicipal	Vecinal	Property Access

Source: Standards for Geometric Design of Regional Roads SIECA-2004, Road Network 2015 - General Planning Division – MTI

2) Width of the Roads

The width of the road is shown in Table 4.3.2. The Primary Distributors (PD) and Primary Collectors (PC) should have three or four lanes, but the Secondary Collectors (SC) should have a minimum of two lanes.

(6) Road Structure

There are no expressways in Managua City, but there are multilane highways interconnected with Masaya (Carretera a Masaya) or Tipitapa (Pan-American Highway).

Arterial roads are level road structures and the road section is formed in the central area with four lanes of high speed in both directions; there are four service roads on the outside in both directions. The lanes of high speed are separated from the auxiliary ways by external divisions. There are sidewalks on both sides of the roads and are its width is about 5 meters. There are no parking spaces in the auxiliary roads and parking in commercial areas is outside the right of way. In residential areas, parking is prohibited on roads and each home has its own parking.

Table 4.3.8 Existing Road Network of Managua City, According to the Number of Lanes and Directions on the Road (km)

DISTRICT	WAY			NUMBER OF LANES					
	ONE	DOUBLE	TOTAL	4	3	2	1	No/Inf.	TOTAL
I	59.713	374.444	434.157	11.093	8.300	402.479	5.799	6.485	434.157
II	26.518	210.242	236.760	15.678	1.573	215.772	2.184	1.553	236.760
III	26.496	398.104	424.600	2.925	1.509	417.801	1.344	1.021	424.600
IV	22.185	185.014	207.198	6.589		195.474	3.804	1.332	207.198
V	12.519	445.566	458.085	0.035	0.090	454.315	2.107	1.538	458.085
VI	25.271	365.044	390.315		7.090	374.279	3.942	5.003	390.315
VII	12.889	338.660	351.549	2.863		346.127	1.097	1.461	351.549
NO INF.	0.244	9.030	9.274			8.947	0.327		9.274
TOTAL	185.833	2,326.104	2,511.938	39.183	18.562	2,415.194	20.605	18.393	2,511,937

Source: GIS Inventory of the Road Network

As a survey of road infrastructure, information of current situation and data of the road network have been collected, and it is important to take into account investments of this year 2016, because based on the summary of the Annual Investment Plan of 2016, 80% is used in infrastructure projects. This budget is used equally in each of the districts.

Table 4.3.9 Annual Investment Plan (PIA) – 2016 (USD) *

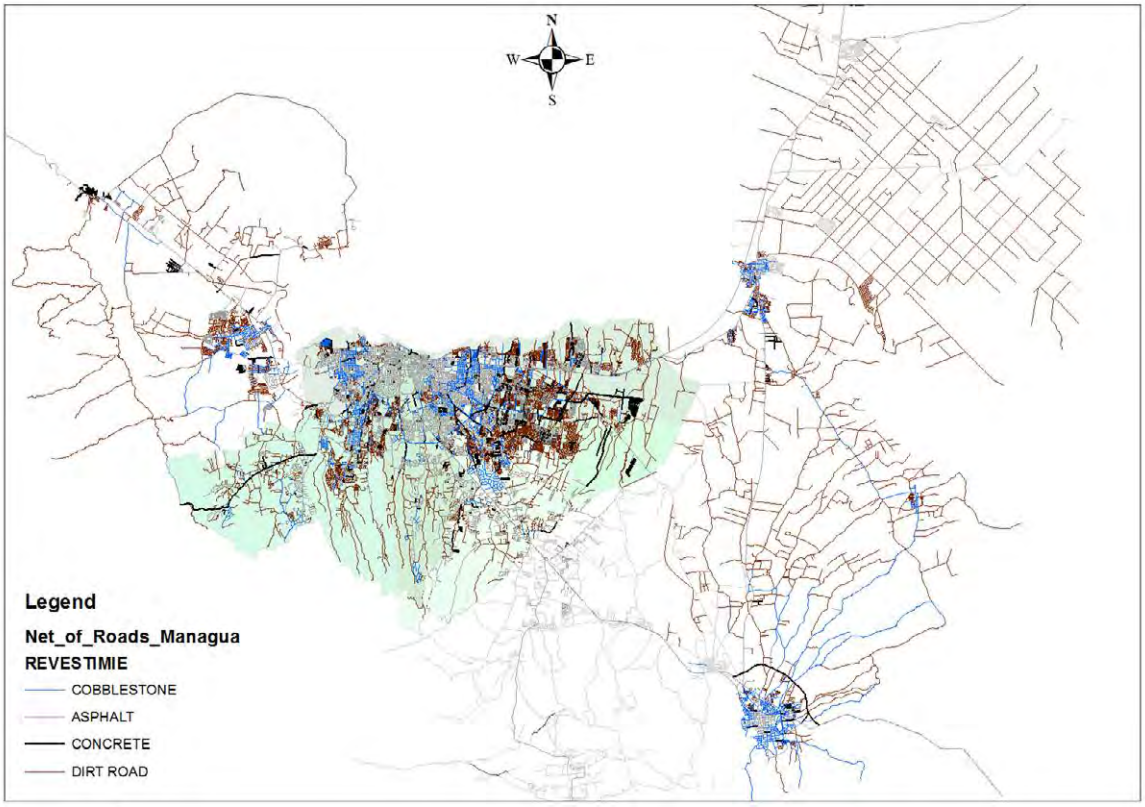
Concept	District I	District II	District III	District IV	District V	District VI	District VII	TOTAL
Own Resources	**10,904,842**	**10,965,518**	**10,849,535**	**8,478,271**	**12,683,776**	**9,659,333**	**8,896,927**	**72,438,201**
Infrastructure Projects	**8,945,134**	**9,712,922**	**9,440,181**	**7,190,031**	**10,575,926**	**7,813,569**	**6,899,202**	**60,576,965**
General Directorate of Projects	5,374,157	7,448,481	7,448,481	4,917,102	5,690,579	4,460,048	4,460,048	39,798,896
Infrastructure Directorate	921,893	957,315	623,048	913,066	3,455,169	1,963,774	978,111	9,812,377
General Directorate of Environment	222,500	94,173	120,542	94,173	94,173	94,173	94,173	813,909
Directorate of Ornaments	2,426,584	1,212,952	1,248,110	1,265,689	1,336,005	1,295,574	1,366,869	10,151,784
Investment for Human Development	**1,059,311**	**498,326**	**477,666**	**478,199**	**662,854**	**518,196**	**648,711**	**4,343,264**
General Directorate of Human Development	1,050,270	489,286	468,625	469,159	653,813	509,156	639,670	4,279,979
Directorate of Culture and Historical Heritage	*70,090*	*101,908*	*56,027*	*41,964*	*41,964*	*41,964*	*41,964*	*395,879*
Directorate of Social Programs	*808,052*	*215,249*	*240,470*	*255,067*	*439,721*	*295,064*	*425,579*	*2,679,202*
Directorate of Sports	*172,128*	*172,128*	*172,128*	*172,128*	*172,128*	*172,128*	*172,128*	*1,204,898*
Directorate of Women and Family	9,041	0	9,041	9,041	9,041	9,041	9,041	63,284
District Projects	900,397	0	931,688	0	1,444,995	1,327,567	1,349,014	7,517,973
External Management Project	0	0	0	0	0	0	0	3,392,571
Foreign Resources	0	0	0	0	0	0	0	2,951,733
National Funds	0	0	0	0	0	0	0	440,838
TOTAL	10,904,842	10,965,518	10,849,535	8,478,271	12,683,776	9,65,333	8,896,927	75,830,772

(*) EUR (16.05.2016) = NIO 2.884 (USD 01)
Source: General Directorate of Projects (May 2016)

(7) Conditions of Pavement and Drainage Facilities

1) Pavement Conditions

Many local roads and collector roads in the periphery are not paved excluding in the central area. The central area has a lot of paved roads including district roads. In the local district roads, pavement is mostly concrete. Mainly, arterial roads are paved with asphalt, but some parts are concrete pavement. There are no deterioration of asphalt due to rain so far. Therefore, pavement conditions are comparatively good, but there is deterioration due to lack of resources for maintenance in some areas.



Source: JICA Study Team

Figure 4.3.5 Map of Road Network by Pavement Type

Table 4.3.10 Existing Road Network of Managua – October 2016

Type of Pavement	Good		Regular		Bad		Total	
	Length (km)	%	Length (km)	%	Length (km)	%	Length (km)	%
Cobblestone	4.982	0.20%	298.385	11.88%	0.151	0.01%	303.518	12.08%
Asphalt	1,040.898	41.44%	44.037	1.75%	4.514	0.18%	1,089.449	43.37%
Concrete	165.291	6.58%	8.550	0.34%	0	0.00%	173.841	6.92%
Dirt	12.261	0.49%	931.628	37.09%	1.241	0.05%	945.129	37.63%
Total	1,223.432	48.70%	1,282.600	51.06%	5.906	0.24%	2,511.938	100.00%

Source: General Directorate of Infrastructure, GIS Network Vial Inventory of the JICA Study Team

Only 43% of the network is asphalt and more than 90% of them is in good condition. While 38% are dirt roads and their condition are in regular. Only 7% are hydraulic concrete roads that are in good condition. Another important pavement is the cobbled block which ratio is 12%, and their condition is mostly in regular.

2) Drainage Facilities

Climate in Managua City is hot, and rainy season is from May to October (1,200 mm per year). The details of the stormwater and drainage facilities are shown in Chapter 5.3. However, there are many watercrouses across the city and they have built pedestrian bridges to maintain connectivity between homes and roads in some section. There is also a network of watercourses, which show lack of cleaning.

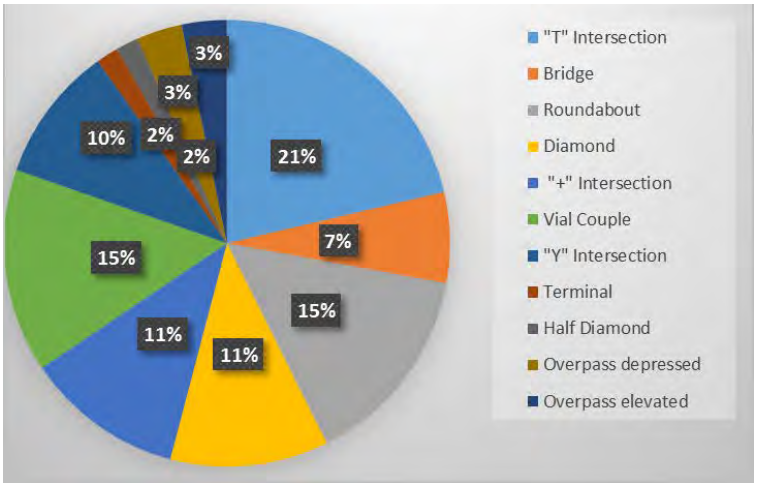
(8) Intersections

1) Intersection Facilities

Intersection between primary distributor roads and collector roads are almost crossing at grade, and most of them are "T" type intersections (21%) because there are many roundabouts in Managua City. There are four overpasses (two elevated and two underpass) between Ave. Suburbana and Carretera a Masaya, and Pan-American North (Panamericana) and Primary Collector Rubenia.

Intersection between both primary and secondary collector roads are mostly at-grade intersections, and four-way or more intersections are roundabouts.

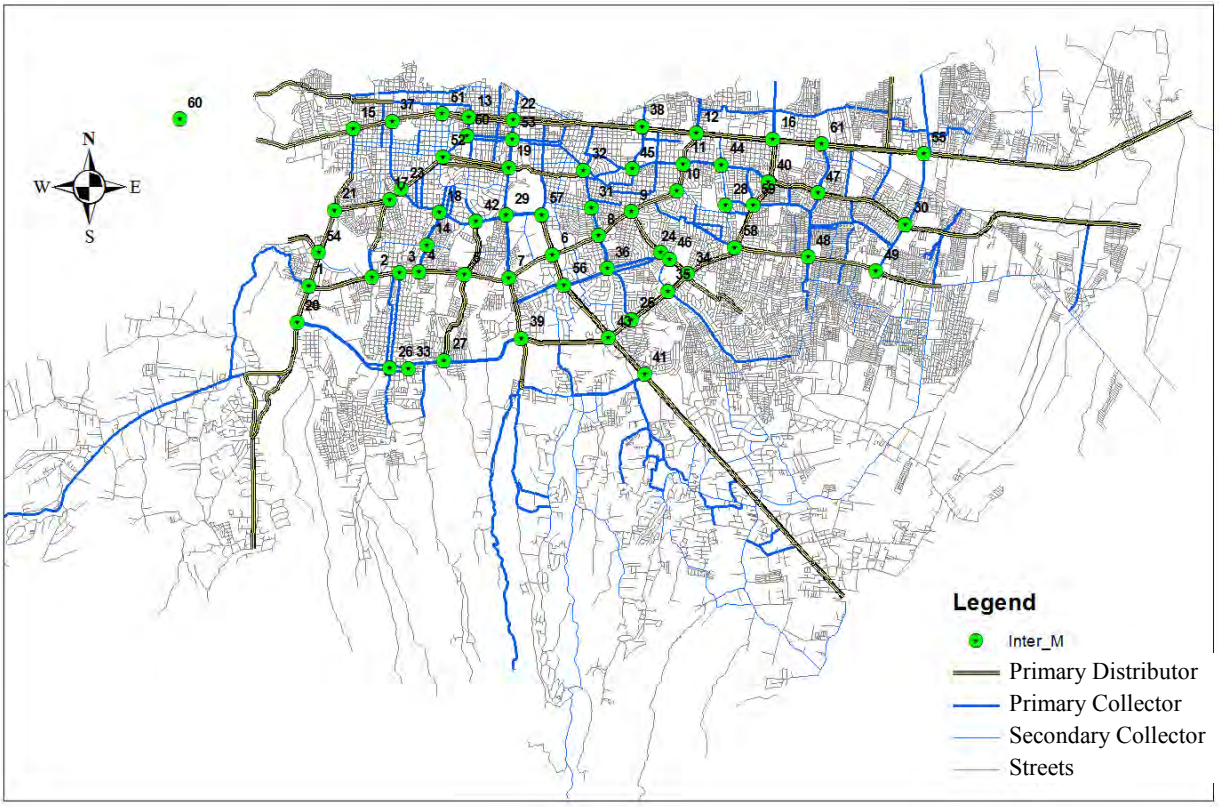
There are 61 major intersections identified for connectivity with the metropolitan road network, which requires implementation in the near future. Some overpasses have already been built. The ratio of intersection type is shown in Figure 4.3.6.



Source: Prepared by the JICA Study Team

Figure 4.3.6 Ratio of Intersection Type in Managua City

For the proper development of these intersections in the future, it is necessary to check the movements of traffic flow to determine the type of intersection for more convenient, and start reserving areas for extensions.



Source: JICA Study Team

Figure 4.3.7 Location of Major Intersection

These intersections have been selected for the degree of continuity. However, according to the database of traffic accidents, a large number of accidents have occurred in more than 100 critical points (more than 100 accidents) in the last ten years. Detail information is shown in Chapter 4.4.3.

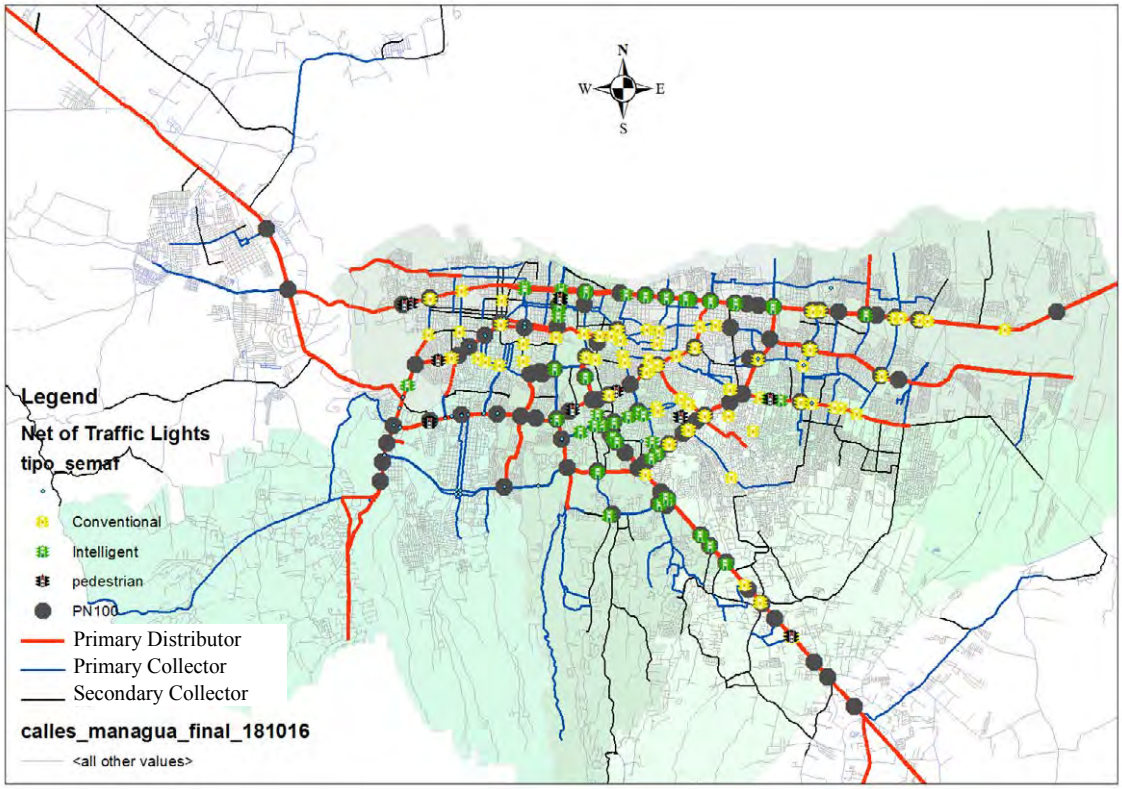
Table 4.3.11 Example of Major Intersections in Managua City

		
Diamond of Pista Unan	Roundabout Santo Domingo, Roundabout Cristo Rey	Roundabout Centro América
Intersection of Pista de la Resistencia with Pista Unan, in front of the Universidad Nacional Autónoma de Nicaragua	Intersection Radial Santo Domingo with Pista de la Resistencia	Interchange Vial Roundabout with the overpass Naciones Unidas, located between the Pista Suburbana and the. Naciones Unidas Avenue (Highway to Masaya), in front of the La Colonia Supermarket.
		
Roundabout Hugo Chávez	Overpass Portezuelo	Roundabout Bello Horizonte
Intersection between Bolívar Avenue with Calle Colón	Carretera Panamericana con la 55ª Avenue SE	Boulevard Rubén Darío with Pista Larreynaga
		
Intersección El Guanacaste	Paso a Desnivel de Tiscapa	Intercambio Rubenia
Intersection of Pan American south with Pista Benjamin Zeledón in front of the building Waltmart	Intersection between Pista Benjamín Zeledón and Carretera Masaya, and Paseo Tiscapa y Paseo Rubén Darío. paso a desnivel in front of a Laguna de Tiscapa, and Carretera a Masaya	Viaduct (elevated way) on the Pista Suburbana, and Nivel Roundabout, Intersection with La Pista Sabana Grande. Near the School Mi Redentor

Source: JICA Study Team

2) Facilities for Traffic Signal

Most of the intersections between main roads are installed traffic signal, The number of signalized intersections are 144. However, a lot of them are still under the old system, and only 52 intersections have "intelligent traffic signal" system. The traffic signals are mostly installed for vehicles,. Traffic signals for pedestrians are very few. This update of the traffic signal has been done with a renewal of vertical and horizontal signage.



Source: JICA Study Team

Figure 4.3.8 Location of Main Signalized Intersection

There are several black spots with intersections on the Carretera a Masaya, the accidents have increased in the last years in Km 11 and 13. Also, Pista Juan Pablo II has several black spots because this road is a high-speed route and it is not an urban highway for mass transit, which can greatly reduce its capacity and reduce the number of accidents.

Two separate entities of the municipality manages the traffic signals, road signs, and pavement maintenance on roads. The General Directorate of Infrastructure does maintenance and the General Secretariat of ALMA manages the new traffic signal network including the traffic control center. They are also in charge of regulation and traffic control.

Although deficient signage information in streets and avenues, there are preventive and regulatory signs in almost all districts.

Horizontal and vertical preventive signaling and regulatory information exist in most avenues; traffic signals and street corners missing information signs**.** Source: JICA Study Team

Figure 4.3.9 Traffic Signal and Sign in Managua City

The municipality through the Traffic Signal Department has been implemented and maintained traffic signal with its own resources, but the allocated budget is insufficient. An installation of traffic signal must be initiated on the main road network, i.e., primary distributor roads and collector roads firstly, then the districts should work it on the local roads.

The next projects will be the horizontal and vertical signposting of the following roads: Pista Sabana Grande, Pista Larreynaga, Tramo Belen-La Garita in Pan-american North, Pista Xolotlán (vertical only), as well as Xolotlán- Los Brasiles.

There is a modernization project of 12 intersections with ITS. The approximate cost of the project is USD 3.8 million. The Traffic Signal Department will invest NIO 1 million for synchronization of seven new intersections and the modernization of the old signal system.

(9) Conditions of Sidewalks, Parking Spaces

1) Sidewalks

Primary distributor roads have sidewalks on both sides regulated with minimum widths of 6 m. However, in some places, there are no sidewalks or the large space is occupied by obstacles or by bus stop. The width of the sidewalks in the collector roads varies between 3.0 m and 4.0 m according to road regulations. On local roads, width of sidewalks are 1.5 m or not-exist despite the regulation defined it 2.8 m. In some neighbourhoods, there are no sidewalks. Therefore, there are a lack of facilities for pedestrians in these places.

There are few slopes to reduce the difference between the sidewalk and the road, which provides facilities for disabilities person. The transport system is not adapted for the disabled. The bus network is conventional and bus stops are spacious.

In La Resistencia and Pista Juan Pablo II s, there are footbridges. There are footbridges also in Pan-American North from the Zona Franca to Dupla Norte, and some bridges for access to houses due to the presence of the channels.


On local streets, sidewalks are narrow and have obstacles and in some avenues, they are very generous, e.g., Avenida Bolivar
Source: JICA Study Team

Figure 4.3.10 Sidewalk Conditions

2) Parking Space

Parking space is not in the primary distributor roads and collector roads. According to the rules indicated by functionality, it should have a minimum width of 2.4 m. It has been observed that commercial premises adjacent to these roads build parking space for their customers. In the case of local roads, one lane for parking is allowed under minimum regulation control. The parking lane width is 2.4 m at the minimum. For alleys, parking spaces are allowed for two-way roads. Minimum width is 2.0 m. In recreational areas, parking space is allowed in specially designed areas for this use.


Parking on arterial and collector roads is restricted; however, on local roads, vehicles park in the driveway.
Source: JICA Study Team

Figure 4.3.11 Vehicle Parking Restrictions

In Managua City, the number of vehicles increases everyday, and there are no parking spaces. Therefore, if drivers park in unauthorized spaces, ALMA and the police will apply the traffic law by putting on locks on vehicles that are badly parked. In addition, businesses do not adequately define the parking areas and resort to sanction.

3) Turning Facilities

Some arterial roads, which have 4 to 6 lanes on both directions, are divided by a central separator. Intersections on arterial roads are well spaced and it is not allowed to turn left at some points in the intersections between two arterial roads. In order to control left turns, Pan-American South, such as from Pista Suburbana to Roundabout El Periodista, has four lanes in each direction with

a divider in the narrow median that does not allow a left turning lane. In some cases, there are additional lanes on auxiliary roads to facilitate right turn, and then two lanes are reduced by the lack of continuity of the auxiliary roads. There is no facility for left turn, but it is wide enough in some sectors to expand bays for buses and right turns.

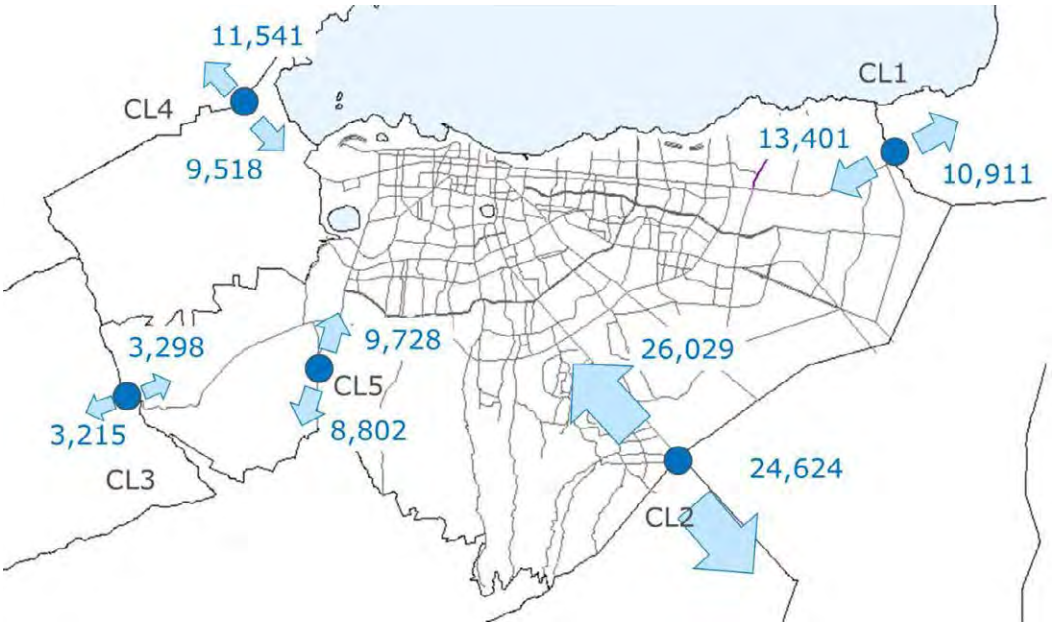
In Suburbana Ave., an at-grade intersection, has been built for facilitating the passage of vehicles on the left with the splice Pan-American South, followed by three lanes in each direction, and then continues only with two lanes in each direction with a restricted return. At the intersection with William Romero Ave., axes for left turn in both directions have been incorporated and from there, it continues again with three lanes in each direction.

In the Carretera a Masaya, access have been introduced in the central separator to allow left turn. This design is one of the causes of traffic congestion. Almost all the road has two lanes in each direction, but from the underpass, there are four lanes in each direction.

4.3.2 Current Features Road Traffic

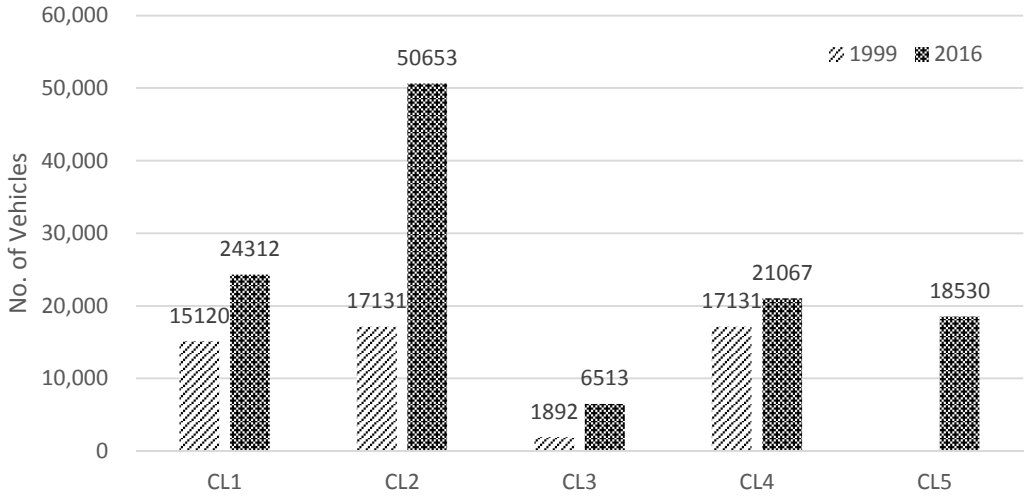
(1) Traffic Characteristics at Cordon Line

The current origin-destination matrices were prepared as one of important data for transport planning. One of traffic count survey's objective is to provide information to calibrate the current origin-destination matrices. Figure 4.3.12 shows the traffic volume at the five survey locations. Heavy traffic volume was observed in CL2 along Carretera a Masaya. The total traffic volume is 59,101 vehicles for outbound traffic and 61,974 vehicles for inbound traffic. Traffic volume heading inside Managua City and Ciudad Sandino exceeds that of outbound. Figure 4.3.12 shows the traffic volume from the cordonline survey in 2016. The figures are total inbound and outbound traffic volume. As can be seen in the figure, the traffic volume increased in all locations. Increase ratio is especially high in CL2 – Carretera a Masaya. It increased 2.9 times from 1998. Total traffic volume of the five locations increased by around two times from 1998.



Source: JICA Study Team

Figure 4.3.12 Traffic Volume from Cordon Line Survey in 2016

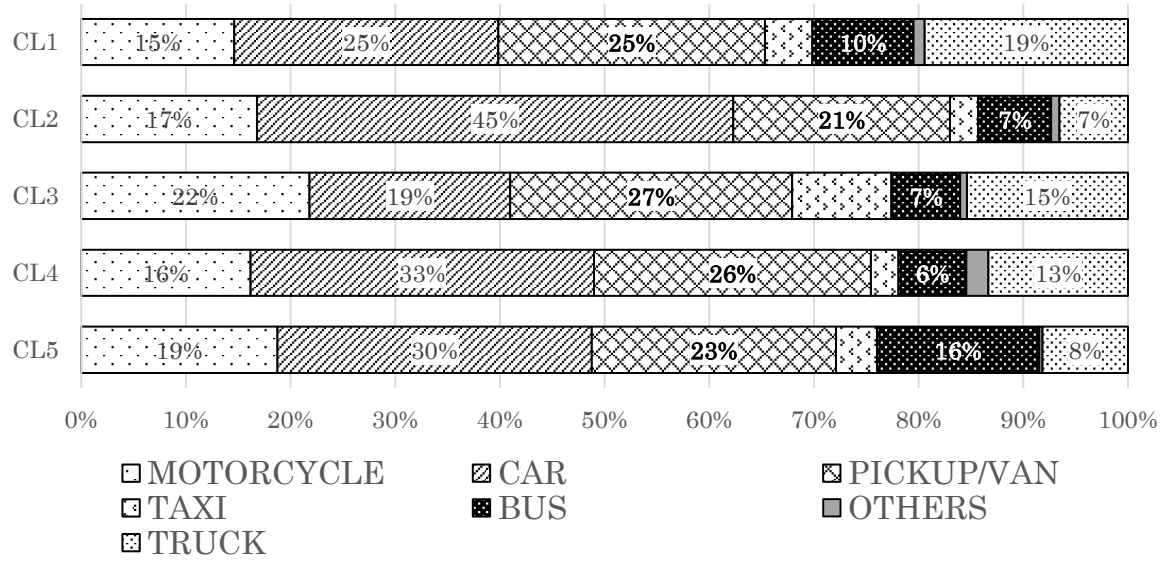


Source: JICA Study Team

Figure 4.3.13 Traffic Volume in 1999 and 2016

As for composition of vehicle type, ratio of truck is relatively high in CL1 – Pan-American Highway since industrial zone and airport are located near the CL1 and Pan-American Highway is the main industrial road. SL4 is also located on Pan-American Highway; thus, truck ratio is high. Passenger cars account for 45% in CL2, while ratio of truck is lower than in other locations. According to the household interview survey, vehicle ownership is higher in the area along Masaya Highway. This likely affects the composition of vehicle type. In CL3, there are few passenger cars, but the ratio of taxi and motorcycle is high. In CL5, ratio of bus is higher than in other areas. OD interview revealed that CL5 is used mainly for short trips within the surrounding neighborhood communities. In comparison with 1998, composition was changed drastically. Firstly, percentage of motorcycle increased by around four times.

Secondly, percentages of bus and truck decreased. It is likely that the spread of passenger cars and motorcycle contributes to the results. In addition, traffic volume was highest in CL2-Carretera a Masaya. Since the composition of location has influence on the total composition, truck ratio seems to be lower.



Source: JICA Study Team

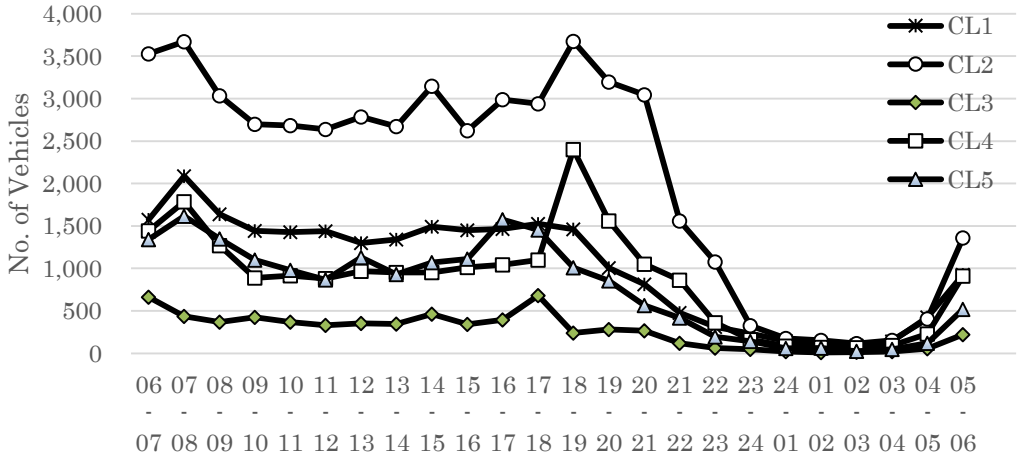
Figure 4.3.14 Composition of Type of Vehicle in Cordon Line

Table 4.3.12 Vehicle Composition

	Car	Bus	Truck	Motorcycle	Others
Total (2016)	62.4%	8.7%	11.0%	16.8%	1.0%
Total (1999)	65.0%	12.3%	16.1%	4.1%	2.5%

Source: JICA Study Team

Hourly variation of inbound and outbound traffic is listed below. Inbound traffic has its peak hour from 6:00 to 8:00 in the morning. Outbound traffic has its peak hour from 18:00 to 19:00. These results indicate that people come from outside Managua City and Ciudad Sandino in the morning, then go back to their home in the evening.



Source: JICA Study Team

Figure 4.3.15 Hourly Traffic Variation for Total Traffic Volume

In terms of peak hour ratio, the peak time period is shifted as shown in Table 4.3.13. Evidently, most of the locations shifted their peak time period. Locations 2, 3, and 4 have their peak hour in the evening time and Locations 1 and 5 have their peak hour in the morning. In Locations 3 and 4, peak hour ratio increased.

Table 4.3.13 Ratio of Peak-Hour Traffic, 1999 and 2016

Station		1999		2016	
		Peak Hour Ratio (%)	Peak Time Period	Peak Hour Ratio (%)	Peak Time Period
Cordon Line	1	8.7	17-18	8.6	7-8
	2	9.0	7-8	7.3	18-19
	3	8.0	17-18	10.4	17-18
	4	8.1	13-14	11.4	18-19
	5	-	-	8.7	7-8

Source: JICA Study Team

Household interview survey collects trip behaviour of residents in the city. Residents living outside the target area are out of the scope of the household interview survey. It is important to analyze the trip behaviour of those people since it affects the traffic situation in the target area. To understand the incoming people and outgoing people' trip behavior, traffic count survey and OD interview survey in the cordon line were conducted. Number of passengers that passed the cordon line is shown in following Table 4.5.14. Total incoming people is at 233,400 while outgoing people is calculated at 189,837 in total. Comparing ratio of traffic modes, bus passenger has the highest ratio for inbound and car, pickup, and taxi have the highest number for outbound.

Table 4.3.14 Number of Estimated Passengers Who Passed the Cordon Line

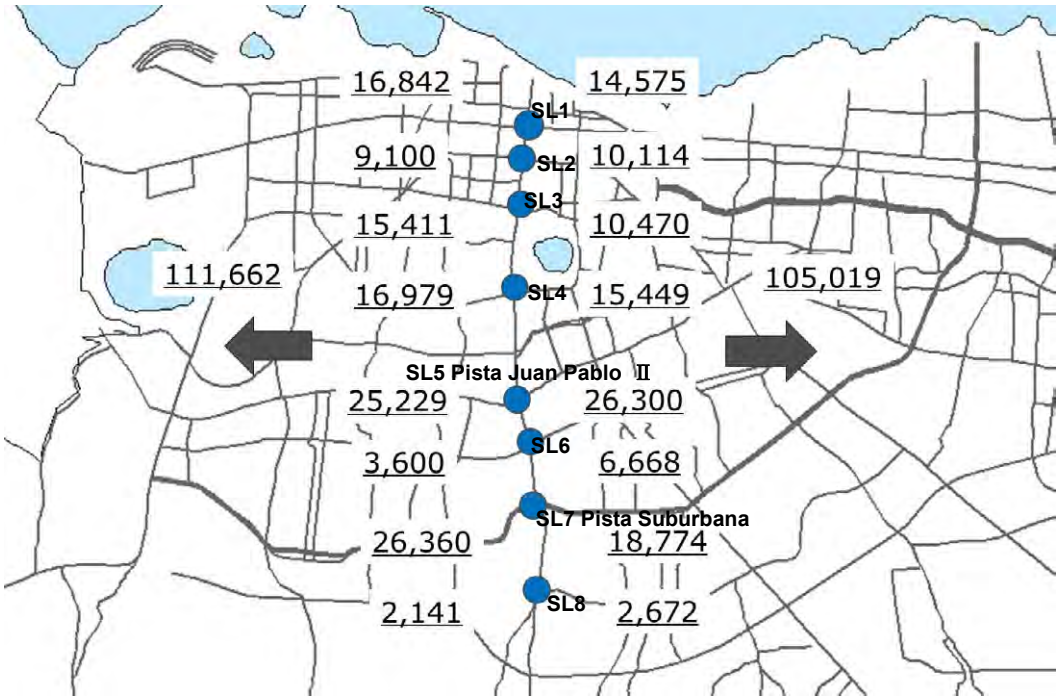
	Bicycle, Motorcycle	Car,Pickup, Taxi	Van,Minibus	Bus	Truck,Trailer	Mototaxi, Caponier	Total
Inbound	13,331	73,177	27,665	102,303	15,401	1,522	233,400
Outbound	13,804	73,344	24,820	63,996	12,846	1,027	189,837

Source: JICA Study Team

Origin and destination interview is implemented at five cordon line locations. People from outside tend to have a trip to Oriental Market, Mayoreo Market, UCA, Israel Lewites Market, Huembus Market, and Centro Comercial Managua. This reveals that the market generates lots of trips.

(2) Traffic Characteristics at Screen Line

Traffic volume is shown in the following Figure 4.5.19. The number is the traffic volume in 24 hours. High traffic volume was observed in SL5- Pista Juan Pablo II and SL7- Pista Suburbana.



Source: JICA Study Team

Figure 4.3.16 Traffic Volume from Screen Line Survey in 2016

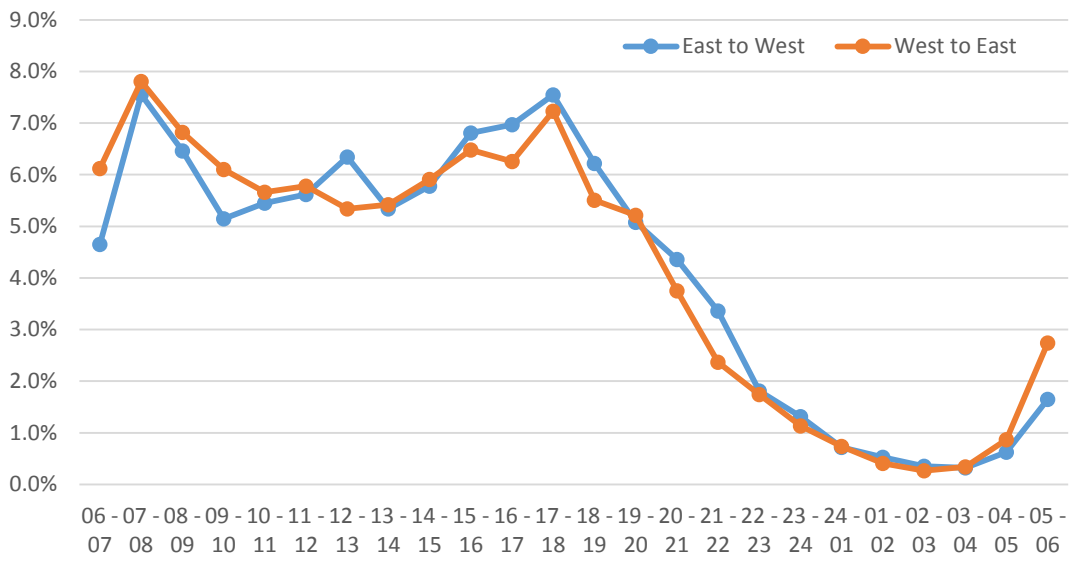
Table 4.3.15 Traffic Volume and Ratio of Screen Line Survey in 2016

No.	Station Name	Vehicles	Peak Ratio	Public Transport Ratio	Truck Ratio
		(000)	(%)	(%)	(%)
1	Xolotan Promenade - Pan-American Highway	4,754	8.8%	34.8%	1.1%
2	North Highway Intersection	31,414	9.5%	18.9%	11.2%
3	Traffic light intersection "Asamblea Nacional"	19,214	9.5%	25.3%	3.9%
4	Hugo Chavez Roundabout	33,315	7.2%	32.3%	2.3%
5	Traffic light intersection "Hospital Militar"	32,655	6.8%	23.7%	1.1%
6	Traffic light intersection "ENEL"	51,529	8.1%	33.7%	3.7%
7	Rigoberto Lopez Perez Intersection	10,129	8.3%	26.8%	3.8%
8	Universitaria Roundabout	41,134	8.3%	13.3%	7.5%

Source: JICA Study Team

In the screen line survey, ratio of truck was observed high in SL1-Pan-American Highway because the road functions as industrial road to carry logistics. Passenger car has the highest portion in most of the locations. In SL8-Universitaria Roundabout, the road is mainly used as access road to neighborhood barrio and not mainly used as arterial road. High bus ratio was caused by such road characteristics.

Regarding hourly variation of traffic volume along Bolivar Avenue by direction, there is no difference observed by direction. There are two peak hours, namely, 7:00-8:00 in the morning and 17:00-18:00 in the evening. Figure 4.3.17 shows the hourly variation of total traffic volume from east to west along Bolivar Avenue in 2016. The tendency is the same in all directions.

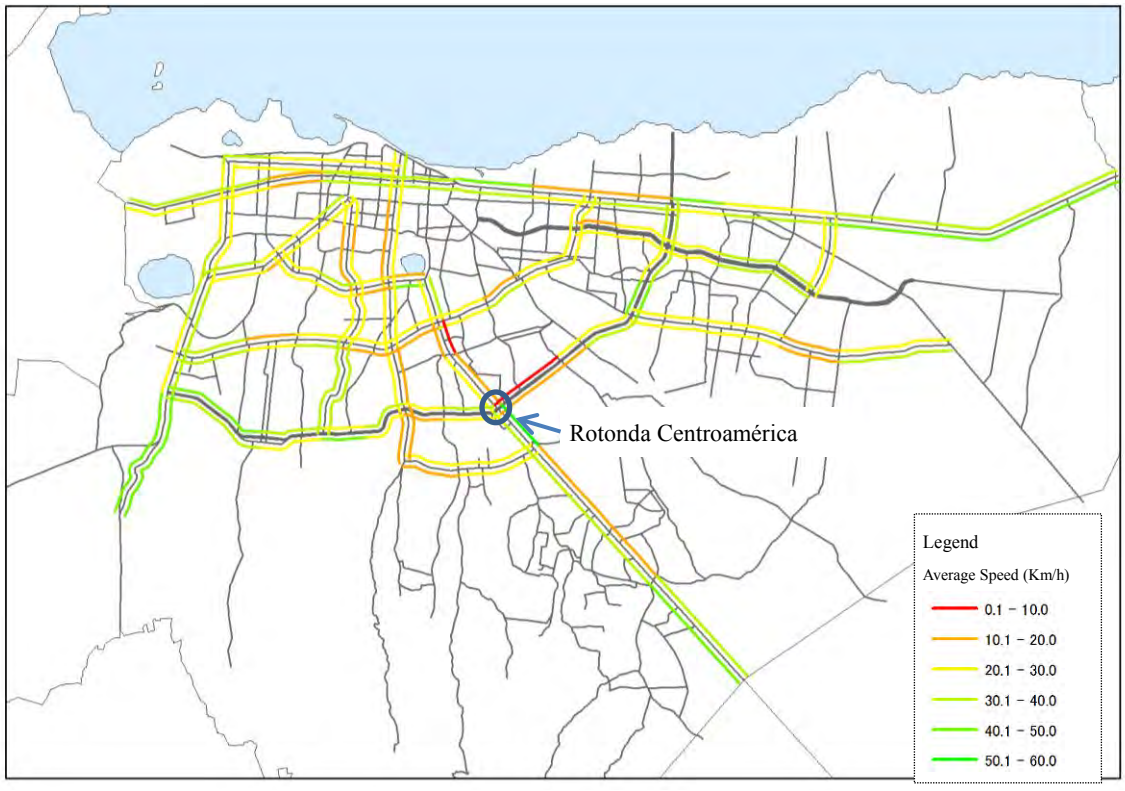


Source: JICA Study Team

Figure 4.3.17 Hourly Traffic Variation by Direction

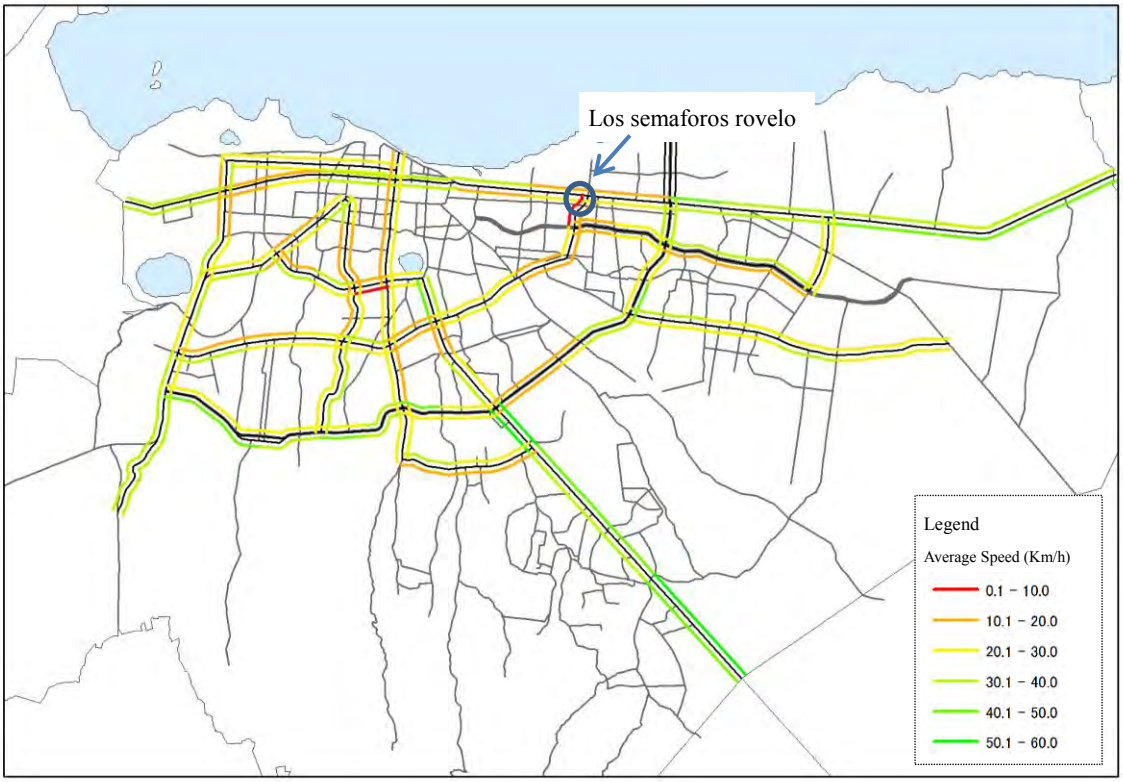
(3) Travel Speed Survey

The congested section is Rotonda Centroamérica (Roberto Terán) during the morning peak hour and evening peak hour. Los Semafores Rovelo is also indicated as a congested section during the off-peak and evening peak hour.



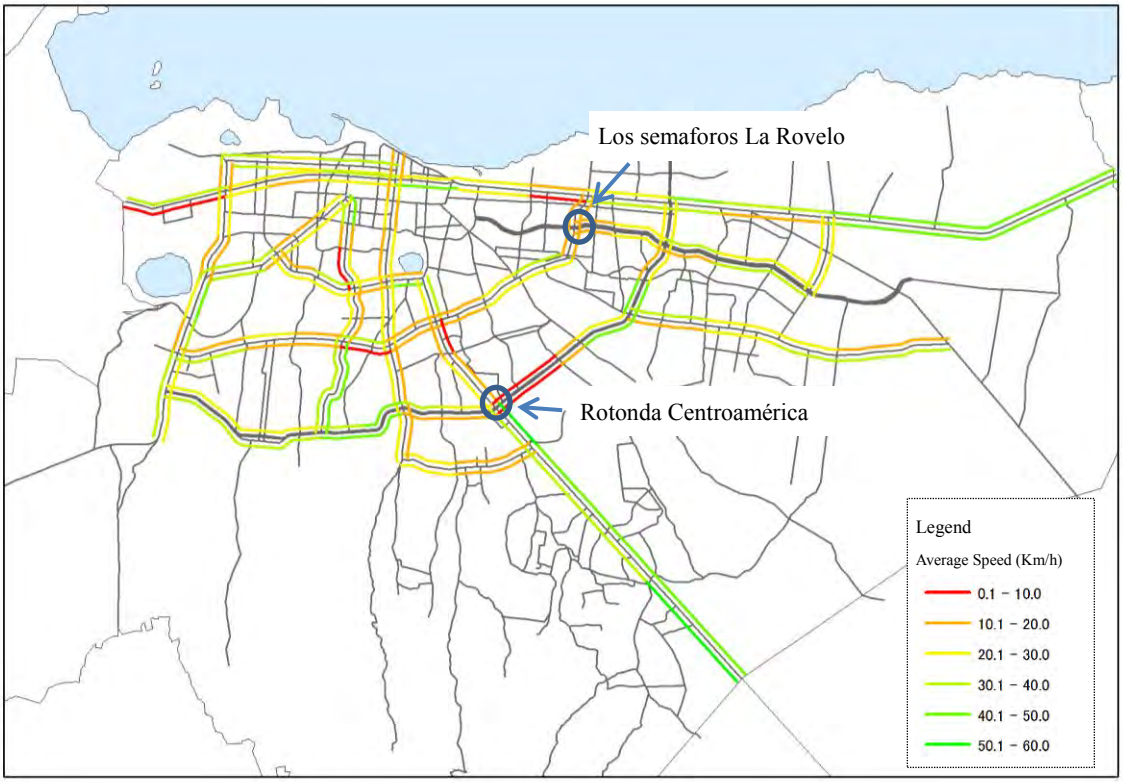
Source: JICA Study Team

Figure 4.3.18 Result of Travel Speed Survey (Morning, 7:00 – 10:00)



Source: JICA Study Team

Figure 4.3.19 Result of Travel Speed Survey (Off-peak, 11:00 – 14:00)



Source: JICA Study Team

Figure 4.3.20 Result of Travel Speed Survey (Evening, 16:00 – 19:00)

4.3.3 Cargo Transport

Results are shown in Table 4.3.16. Seventy-five percent of the trucks came from outside the city, while trucks plan to go outside the city after leaving the oriental market. Main origins and destinations are Matagalpa, Masaya, and Leon. As for their carried commodity, 77% of the trucks carried food and 12% carried manufacturing goods such as appliances.

Table 4.3.16 Origin and Destination of Trucks which Stayed in the Oriental Market

	Inside Managua		Outside Managua		Total	
	Sample Size (veh)	Ratio	Sample Size (veh)	Ratio	Sample Size (veh)	Ratio
Origin before arrive to oriental market	81	25%	240	75%	321	100%
Destination after leaving oriental market	71	22%	250	78%	321	100%

Source: JICA Study Team

Result of OD interview in the cordon line survey indicates 23% of the trucks came to Managua City and go outside Managua City. It means 23% of the trucks are through traffic. Main destinations are Masaya, Leon, Chinandega, Tipitapa, and Corinto. Corinto has a port; therefore, many trucks have Corinto as destination.

(1) Outline of the Demand for Cargo Handling

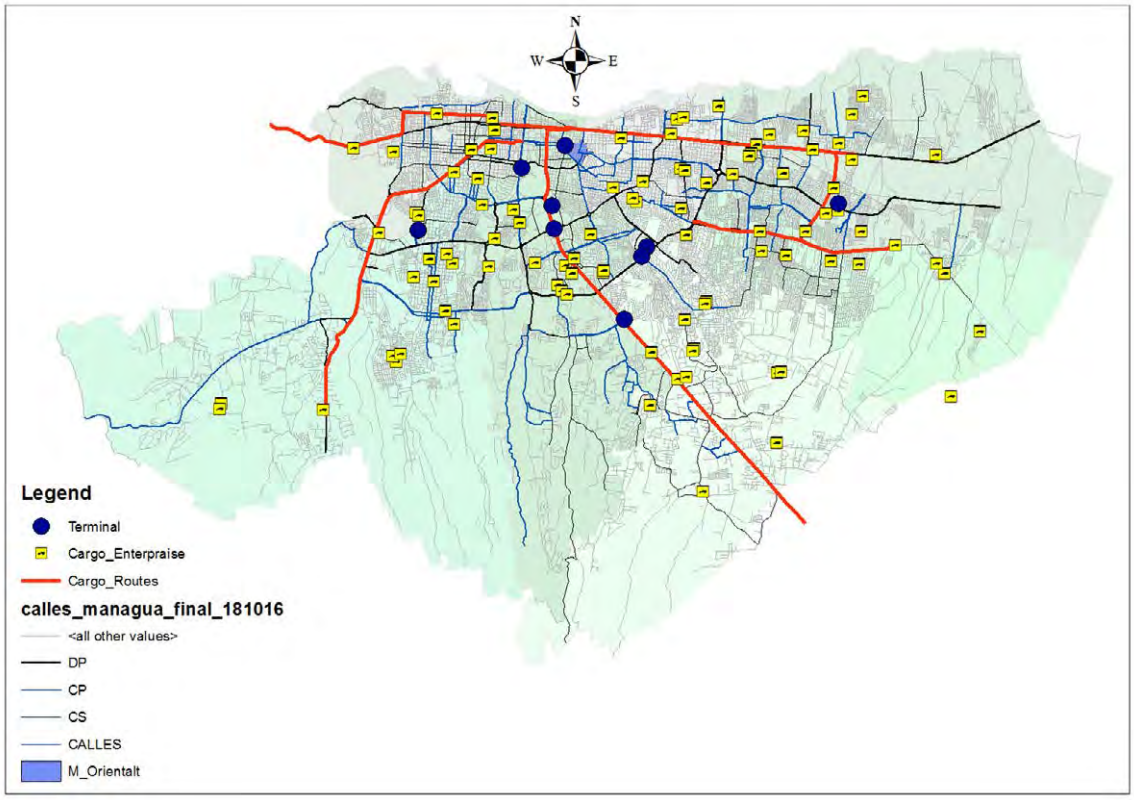
Freight transportation influences circulation and congestion, and large cargo movement is also generated by the markets in the city. One of the largest markets is Mercado Oriental, which is 120 hectares and has more than 9,000 merchants and varied goods. It generates trade all day and night for supply of vegetables and fruits. Another interesting market is Huembes that has an intercity bus terminal, and whose products are varied and include Nicaraguan crafts.

Source: JICA Study Team

Figure 4.3.21 Markets in Managua City and Cargo Transportation

Urban logistics is very important and intense in the city and it interferes with traffic. As shown on the map, the main roads where freight trucks circulate have been identified (especially, Pan-American North, Pista del Mayoreo, Pista La Sabana, and Pan-American South). However, some alternate routes are also used.

Likewise, the location of the companies that provide the service has been identified. They are found dispersed throughout the city together with new interchange projects in the main markets where there would be a greater concentration of trips. The majority are located in the center.



Source: JICA Study Team

Figure 4.3.22 Location of Main Freight Transport Companies and the Most Used Road Network

4.3.4 Existing Road Plans

Currently in Managua City, there are short- and medium-term development plans which have defined a series of projects for both the road network and the solution of intersections. These plans are the following:

Comprehensive Transportation Plan in the Municipality of Managua in the Republic of Nicaragua (PITRAVI, 1999), which has not completed its projects, namely: 23 road project packages, 12 transportation projects, 17 project management packages. It should be noted that some have been partially built, but already require an extension or improvement. Another interesting project is the implementation of the Travesias with private toll resources, now that there is a new legislation for the promotion of private investment that can be applied both to this project and to mass transportation (BRT or metro).

The **National Transportation Plan** (PNT) with an investment of USD 8,826.00 million, especially for land transport (roads: 7,488 km, 43 bridges), acquisition of bus fleet (1,124 units), a store of bus inspections, 17 bus terminals and 7 stations on the way, and 5 logistics parks.

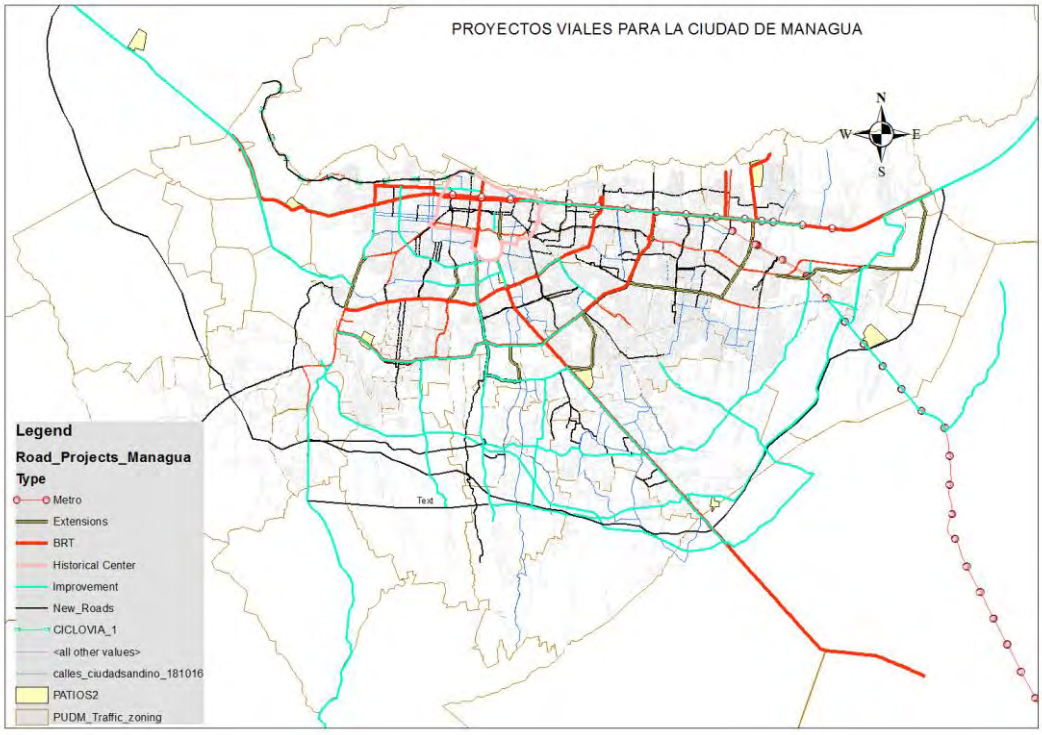
The **Road Infrastructure Plan 2017 - 2022** has planned ten extensions of roads or new slopes, ten overpasses, and eight roundabouts, but these proposals have been updated due to the new adjustments in mobility behavior and the increase of the automotive parquet from the city.

An update of the Metropolitan Road System must be taken into account, which has not only been outdated by the extension of the city, but also by its disarticulated growth and the failure to maintain the necessary road sections for expresway, primary distributors, and collectors.

The Directorate General of Projects has been consolidated various proposals, However, it should prioritize different aspects such as urban mobility, road safety for the mitigation of accidents and congestion. In that sense, they have been divided into four groups of projects according to their typology of road infrastructure and management, as follows:

(1) Road Network Extension Projects

As for road infrastructure projects, they are financed by the state through the MTI and with municipal resources and some projects are financed by donors. Among these projects, there are urban mobility projects such as urban and suburban metro and high capacity buses which routes has dedicated lane as well as cycle paths that seek to promote transport sustainability, reduce pollution, and improve the environmental and living quality of the users.



Source: JICA Team Study

Figure 4.3.23 Transportation Infrastructure Projects

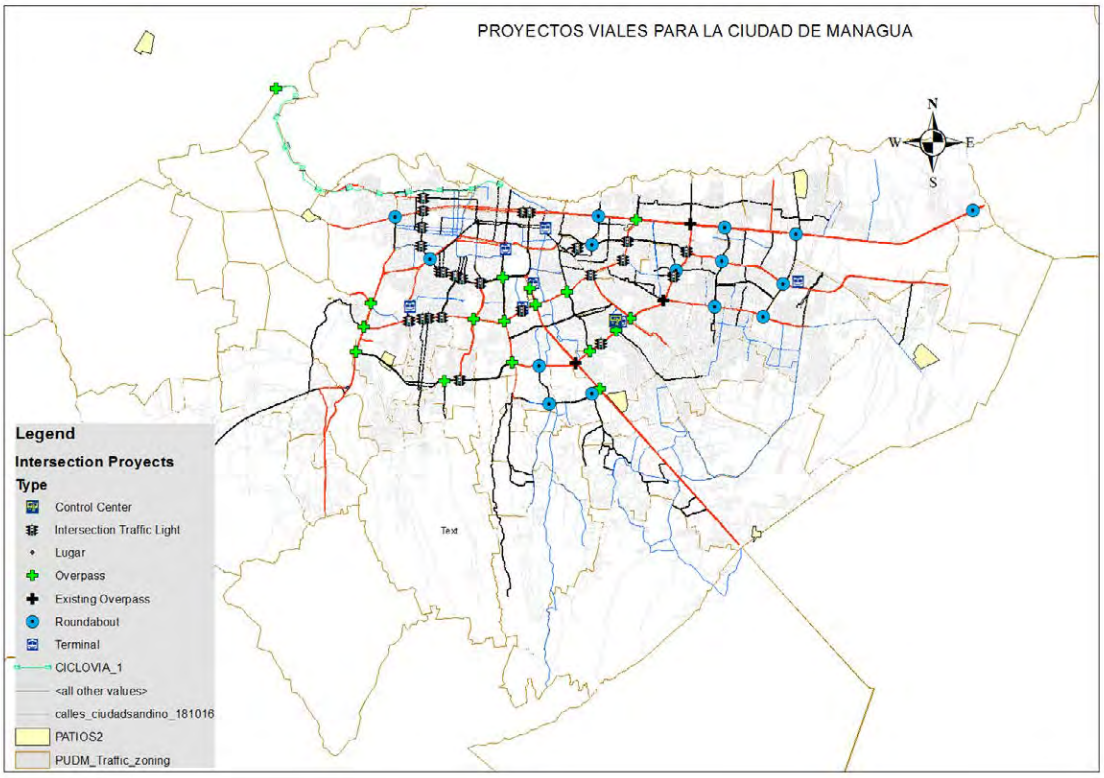
As for highway infrastructure projects, there are four highway expansions, three BRT corridors projects, a global project such as the Recovery of the Historic Center of Managua City, which financed by IDB, 12 improvements of routes, an urban metro project, and proposal of five new roads.

The details of these projects which indicates the length and term of implementation and the list of the road projects is shown in the appendix.

(2) Road Intersection Projects

In the proposals of investment in the main road intersections, different actions have been defined, namely: 24 synchronized intersections for short term, one control center for bus operation, 17 steps to elevation, 15 roundabout, and 7 transport terminals.

The development of these intersections should be analyzed in an integral way with the proposals of extensions of the road or the intervention of a new system of mass transit since these changes must be considered in the designs. The list of the road projects is shown in the appendix.



Source: JICA Study Team

Figure 4.3.24 Intersection Development Projects

(3) Ring Road Projects

There are many proposals for peripheral routes and external rings in Managua City. Several documents have been analyzed such as regulations and plans for road development and planning.

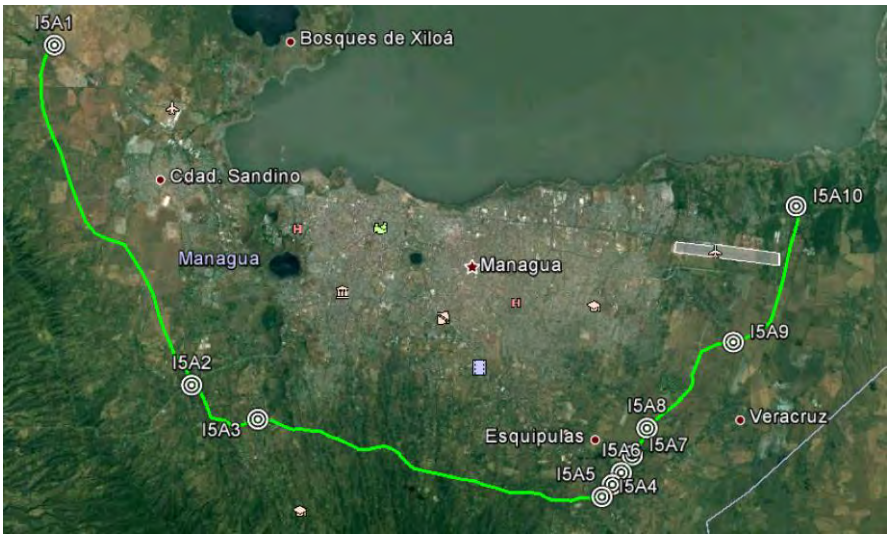
Managua City has been growing without taking into account the lines proposed in the different plans, not only in the route but also in the road reservation of the required section.

According to the Regulation of the Road System of the Regulatory Plan, the type of road according to classification and function must comply with the road section of the crossing system. This road crosses the populated center and serves as axes of entry and exit of the city and connecting the center. It is formed by roads separated by traffic circulation, with a right of way that ranges between 40 m and 100 m, and with controlled access to properties adjacent to the road through marginal lateral streets.

There is a proposal for the road R_PR1 Chiquilistagua (NIC-12) - San Benito (NIC-1) Road as a main urban highway with four lanes, a length of 32.6 km, and an investment amount of USD 183.1 million.

To realize a new ring road in the urban area is very expensive because it is necessary to realize expropriations in consolidated urban areas. In addition, at least 50 m requires rearrangement work and improvement of facades. It is very expensive because the costs of expropriations and other additional works for recovery of public spaces and urbanism must be added to the cost of construction of the road.

However, analyzing the proposal for the peripheral route and the new construction of the roads on the east side near the airport, the extension of the airport for a road length of 3,100 m, and the conurbation between Ciudad Sandino and Managua City, the proposal of the peripheral road is interesting but it is not only designed to connect to the NIC-12ª Road, but will also extend and take areas that will still allow to maintain a road section of 100 m preferably which will allow the inclusion of a mass transport system and interconnection of the main radials to be determined in the city in the future.



Source: JICA Study Team

Figure 4.3.25 Proposed Route and Main Intersections with the Managua Radial Network

The terrains are fully equipped but not built as can be seen in the proposed route. In addition to connecting to the Pan-American Highway in the east and west, this route is bypass or peripheral route across several districts. The length of the road is 45.4 km.

It will take interdepartmental and international traffic of passengers and freight. It will also have to take into account points of logistics zones and transport terminals that do not mix within the urban traffic.

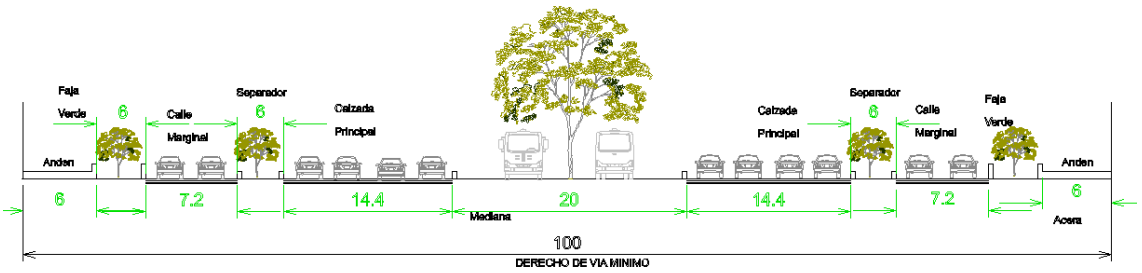
Proposed typicall cross-section is shown in the following Table and Figure. The 6 m wide sidewalks, 6 m berms, two-lane auxiliary driveway (7.2 m), 6 m spacers, central driveway for mixed traffic with four

lanes (14.4 m) and a central medium that allows different actions from a reversible lane to a mass transportation system.

Table 4.3.17 Widths of the Elements of the Proposed Way Type Section

Elements	Ideal	Normal	Mínimun
Sidewalk	6.0	4.5	2.5
Shoulder Right	6.0	2.5	0.6
Auxiliary Carriageway	7.2	7.2	6.0
Shoulder Left	6.0	6.0	4.0
Central Carriageway	14.4	14.4	14.4
Median*	20.0	10.0	6.0
Central Carriageway	14.4	14.4	14.4
Shoulder Left	6.0	6.0	4.0
Auxiliary Carriageway	7.2	7.2	6.0
Shoulder Right	6.0	2.5	0.6
Sidewalk	6.0	4.5	2.5
Total Length (m)	99.2	79.2	61.0
(*) Reserved for Mass Transportation Rail			

Source: JICA Study Team

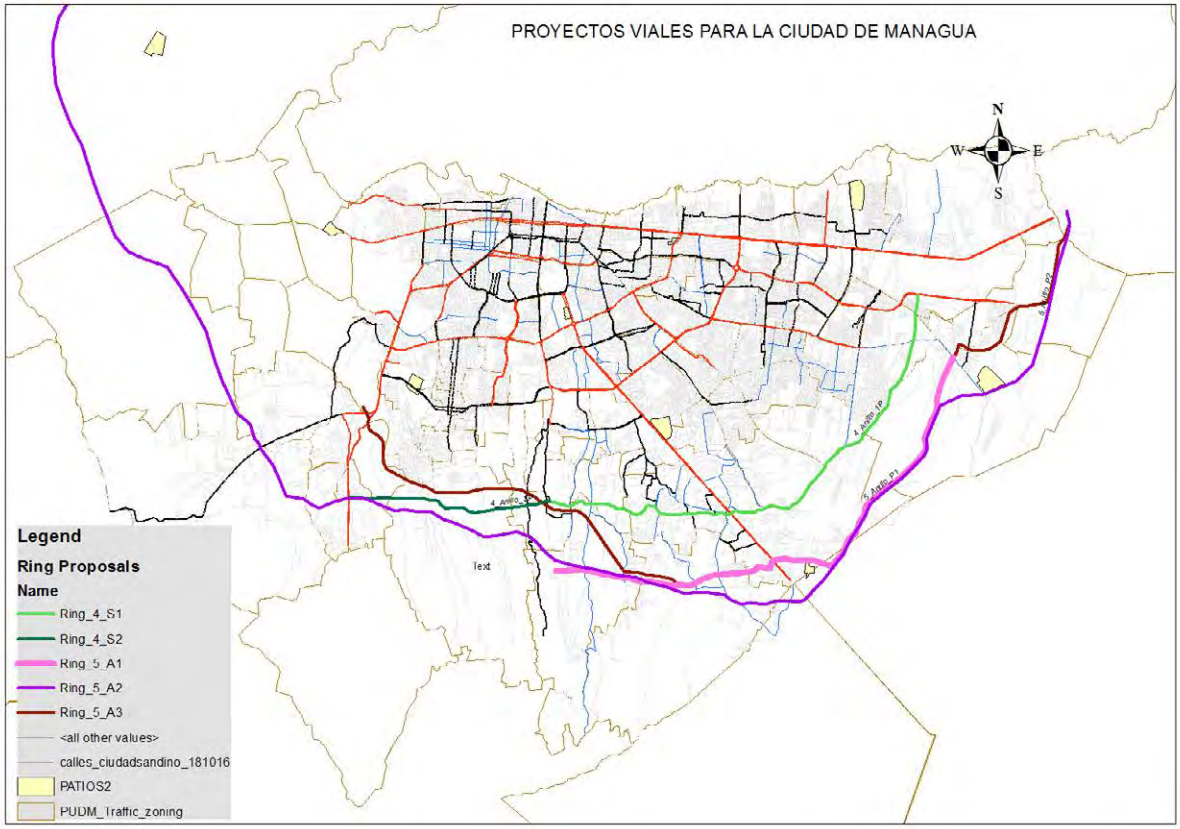


Source: JICA Study Team

Figure 4.3.26 Cross Section of Trunk Roads

The proposed section allows sufficient space for deceleration and acceleration, bridging and overpass structures, ramps, elevated trains or catenary systems, and stations.

In the case of the Fourth Ring, two sections has been proposed, starting from the Larreynaga Track and heading west to intersect Bolivar Av. The first section measures 14,625 km and the second 5,745 m. This section starts from the intersection with Bolivar Av. until the intersection with the South Road, with minimum road section of 50 m.



Source: JICA Study Team

Figure 4.3.27 Proposed Fourth and Fifth Ring

4.4 Public Transport Conditions

4.4.1 Overview

Managua City has four types of public transport service, namely: urban public bus, intercity bus, taxi and mototaxi. Public transport is administered by the Institute of Transport of Managua City (IRTRAMMA) except intercity bus that is administered by the Ministry Transport and Infrastructure (MTI), while the bus terminals are administrated by ALMA and the Municipal Corporation of Managua Markets (COMMEMA). Urban public bus, intercity bus, taxi, as well as bus terminals are operated by concessionaires, while mototaxi is operated by private companies and drivers authorized by IRTRAMMA.

Table 4.4.1 Existing Public Transport Services

Service	Role	Administrator	Operator
Urban public bus	Circulation within city	IRTRAMMA	Concessionaires
Intercity bus	Intercity transport including several stops within city	MTI	Concessionaires
Taxi	Free circulation within city	IRTRAMMA	Concessionaires
Mototaxi	Short access up to other transport system	IRTRAMMA	Private companies and drivers

Source: JICA Study Team

4.4.2 Urban Public Bus

(1) Administration

1) Organization

Bus service called "*Transporte Urbano Colectivo*" (TUC) represents the urban public bus service circulating within Managua City along 35 fixed routes.

The responsible institute is IRTRAMMA which is the municipal institution that regulates and controls the provision of public transport services such as urban public bus, school bus, taxi and mototaxi within Managua City. The urban public bus service is carried out by 28 concessionaires (26 cooperatives and 2 companies; only major difference is about tax), whose communication with IRTRAMMA is facilitated by a union of concessionaires.

The concessionaires are mandated to provide the service on their assigned route(s) defined by the concession contract and to report the number of passengers to IRTRAMMA. The data are checked and certified, and then delivered to the central government who subsidizes the urban public bus service.

2) Monetary Flow

The central government subsidizes the urban public bus service in several manners listed below, including allowance based on the reported number of passengers via IRTRAMMA:

- Passenger-based allowance: NIO 0.60 per transported passenger

- Fuel subsidy: more than half of market price (driver can always buy the fuel at NIO 40.50 per gallon)
- Vehicle subsidy for cooperatives: tax exemption (15%) for transport equipment, new tires, supplies and spare parts

The concessionaires who adopt the TUC Card system, which is the fare collection system by contactless smart card, receive each day the total amount of fare from the system provider MPESO based on the number of passengers of the previous day. MPESO subtracts NIO 0.16 per passenger from the total amount for the concessionaires as its service fee.

(2) Facility

1) Fleet

As of 2016, there are 834 buses authorized for the service, and 789 of them are being mobilized for regular service. The buses are of only four models; KAvZ 4238 is the most possessed model followed by DINA Pickers, KAvZ 4235, and Mercedes-Benz. The registration status and their capacities are summarized in Table 4.4.2.

Table 4.4.2 Registration Status and Capacities of Urban Public Bus Fleet

Model	Number of Authorized Cars	Number of Cars on Service	Number of Seats	Total Capacity
KAvZ 4238	389	367	39	70
KAvZ 4235	91	68	25	56
DINA Pickers	350	350	40	80
Mercedes-Benz	4	4	N/A	N/A

Source: IRTRAMMA (2016)

A bus in service must be registered within ten years after fabrication; however, there is no regulation about its maximum duration in service. The registered bus can be in service as long as it clears the technical inspection that is carried out twice a year by IRTRAMMA.

2) Electronic Payment System

The fare of urban public bus is fixed at NIO 2.50 by the government but the concessionaires are allowed to collect the fare in their own manner. Accordingly, all the concessionaires adopted the TUC Card system, which is a fare collection system using contactless smart card provided by a Nicaraguan private company named MPESO that also provides several other services for electronic payment or money transfer. The card is purchasable and rechargeable in ordinary grocery stores in Managua City.

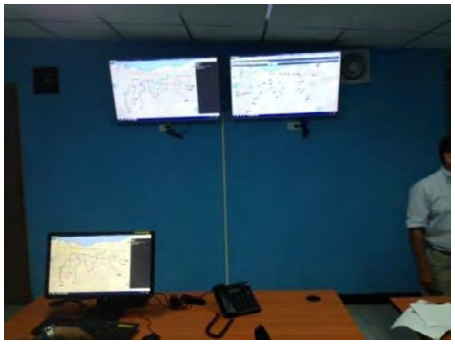
Source: JICA Study Team

Figure 4.4.1 TUC Card by MPESO

The TUC Card service started in 2013 and now all the buses are equipped with the system. About 40% of total fleets accept fare payment both by cash and by TUC Card, and the remaining 60% only accept TUC Card. According to IRTRAMMA, it is estimated that only 13-15% of passengers pay by cash. The details of the system are shown in Chapter 4.5.7.

3) GPS System

IRTRAMMA started a pilot project of fleet control of urban public buses by global positioning system (GPS) in April 2016, as a part of *Promoción de Transporte Ambientalmente Sostenible para Managua Metropolitana* financed by the Global Environment Facility (GEF). In this project, GPS equipment with mobile communication system was installed in 120 buses on five routes, and their location data are transmitted in real time to the control center in the building of IRTRAMMA who monitors the operation and accumulates the operation data for service assessment and future improvement of the service. The details of the system are shown in Chapter 4.4.



Source: JICA Study Team

Figure 4.4.2 Control Center for Urban Public Bus in IRTRAMMA

The pilot project has been planned to last until September 2016, and then all the urban public buses are expected to adapt the same system.

4) Bus Stop

There are in average 44 bus stops for each route, and the average distance between stops is 440 m. Many bus stops have roof and chairs for waiting passengers but some of them do not. Some larger stops frequented by numerous bus routes have a display board indicating the routes as presented in Figure 4.4.3. There are also a certain number of unofficial stops without any infrastructure but recognized and used by drivers and passengers. There is no bus terminal serving urban public buses.

Mini stands of snacks or groceries gather around any type of bus stops. Some of them occupy a certain space under the roof as presented in Figure 4.4.4, which is not prohibited.

Carriageway is widened for some bus stops for safer stop and less disturbance of traffic. However, many bus stops including those on main corridors do not have such bus bay.

Source: JICA Study Team

Figure 4.4.3 Bus Stop with Display Board of Passing Routes

Source: JICA Study Team

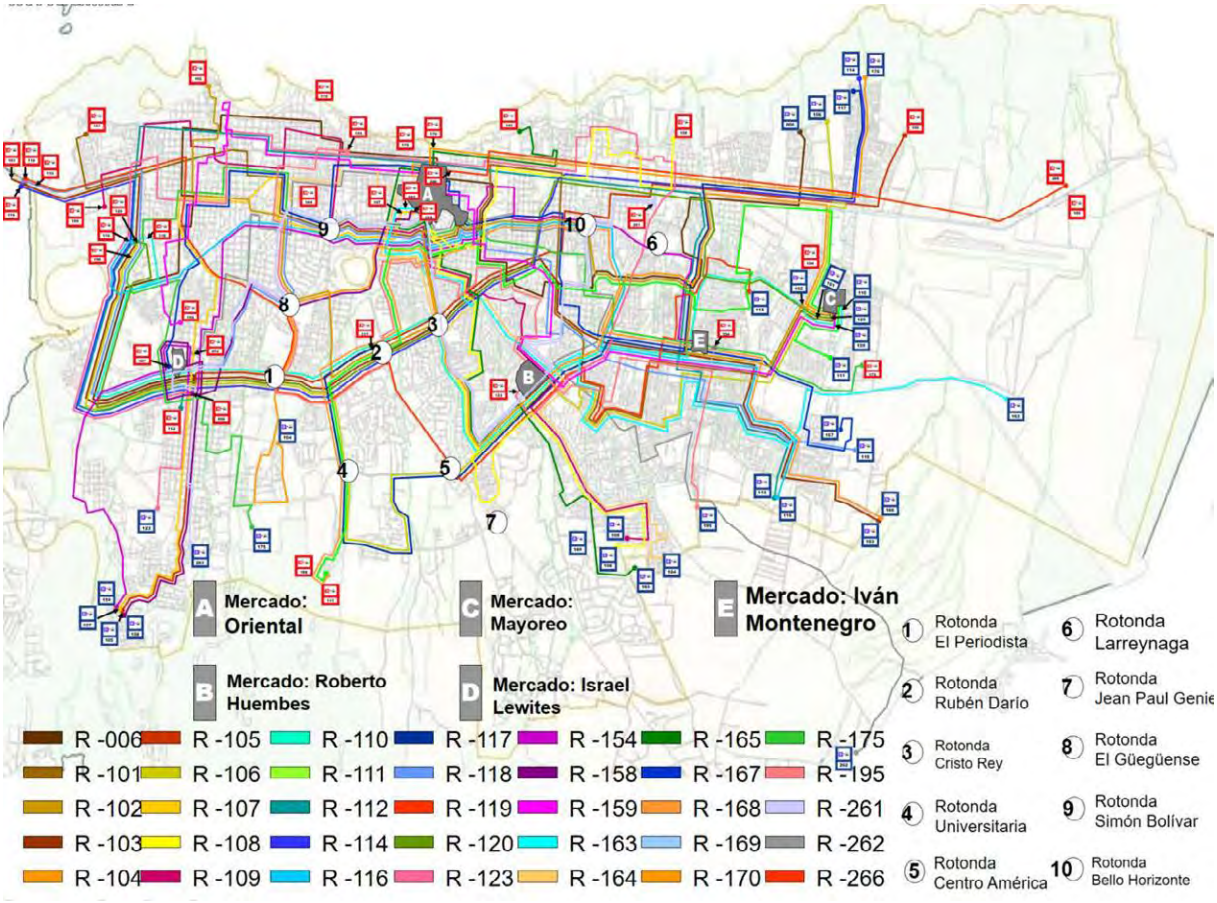
Figure 4.4.4 Occupation of Bus Stop Space by Mini Stand

(3) Service

1) Routes

There are 35 routes of urban public bus including three routes serving suburban areas as presented in Figure 4.4.5. The average distance of the routes is 19.4 km for one direction. These routes have not been radically changed since the 1980s, except extension of several routes due to urban expansion.

As observed in the figure, there are some areas which are served by many bus routes, typically on the Pista Juan Pablo II and Pista La Sabana. On the other hand, the area along Carretera a Masaya, west part of Pista Suburbana and also Nejapa area that is even out (southeast) of the route map are scarcely served by public urban bus in spite of the high traffic demand. According to IRTRAMMA and MTI, the residents without own vehicle in these areas need to look for other modes of transport such as taxi and intercity bus, due to the lack of service of urban public bus.



Source: IRTRAMMA

Figure 4.4.5 Routes of Urban Public Bus

2) Operation Frequency

The average number of operations of each route in 2014 was 89 times per weekday and 83 times including weekend. The ordinary operation hours are 16 hours from 5:00 a.m. to 9:00 p.m. Accordingly, there are five buses per hour, and one bus every 12 minutes on average. However, the timetables of bus operation are not formally open to the public.

The most served route is Route #266 connecting Frente al Ceibo Mercado Oriental and Zona Franca via Panamericana Norte, which is served 152 times per weekday and 141 times including weekend on average.

3) Fare

The fare is fixed at NIO 2.50 per passenger, regardless of riding distance, age, physical condition such as disability, or mode of payment such as TUC card.

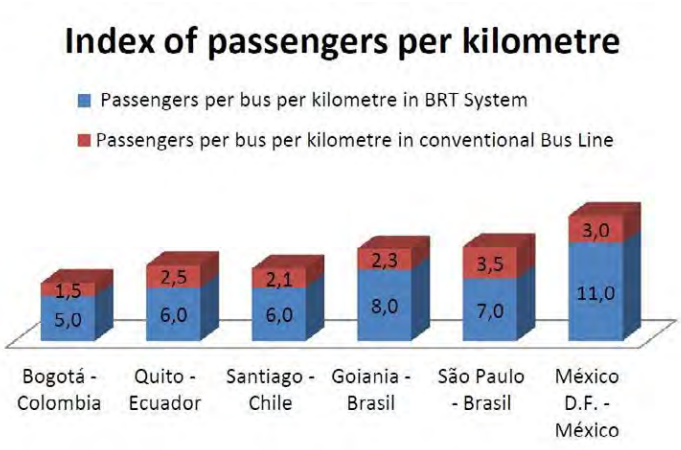
(4) Passengers

1) Number of Passengers

Annual average daily passengers in 2014 for whole Managua City was 696,089 passengers on weekday and 645,390 passengers including weekend, meaning 19,888 passengers and 18,440

passengers, respectively, for each route. The most used route is Route #112 connecting Villa Libertad and Col. Independencia via Panamericana Norte, which transports 37,278 passengers on weekday and 34,643 passengers including weekend on average.

Passenger Kilometre Index quantifies the number of passengers transported by bus per kilometre runned by bus. It should be noted that the index of whole urban public buses of Managua City counts 6.0 as of 2014, which is a considerably high value as service realized by conventional buses.

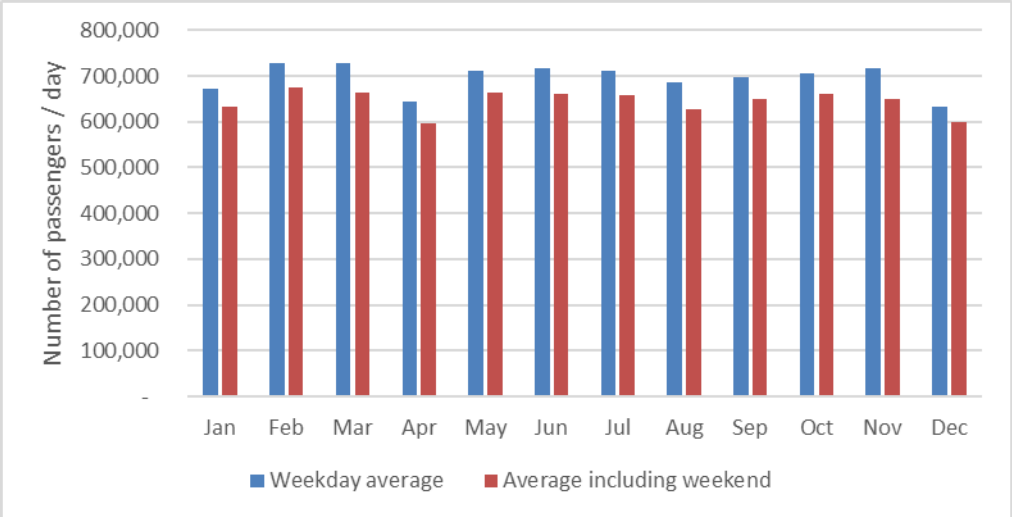


Source: International Association of Public Transport (UITP)

Figure 4.4.6 Index of Passengers per Kilometre

2) Monthly Fluctuation

Number of passengers varies by month. Relatively less passengers ride the urban public bus in January, April, and December.

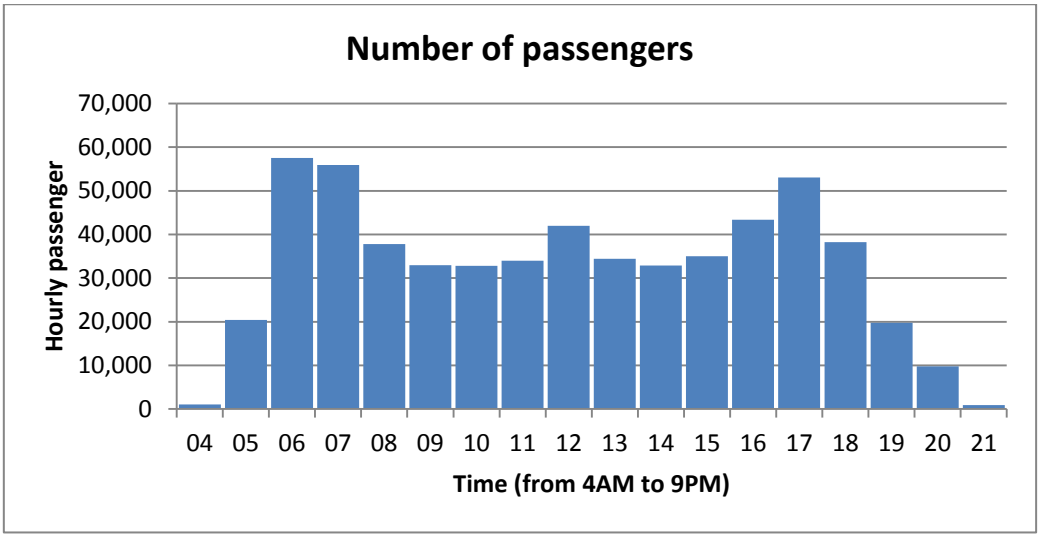


Source: IRTRAMMA (2014)

Figure 4.4.7 Average Daily Passengers of All Urban Public Buses by Month in 2014

3) Hourly Fluctuation

Figure 4.4.8 shows the hourly passenger number of all the routes. The morning peak is around 6:00 a.m.-7:00 a.m., followed by lunchtime peak around 12:00 p.m., and the evening peak is around 5:00 p.m. It is indicated that the morning peak is longer and more intense than the other time period of the day.



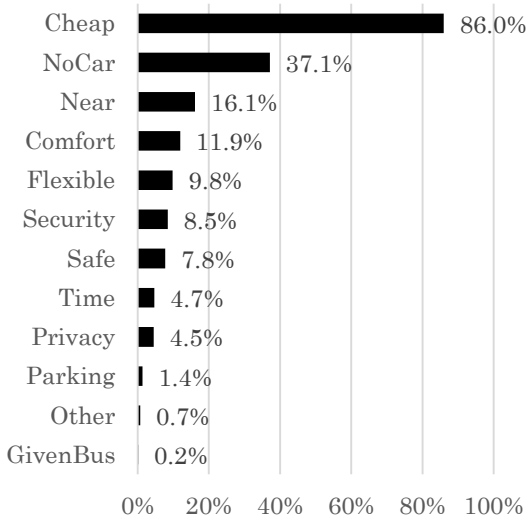
Note: Example of one weekday in October 2016
Source: MPESO (2016)

Figure 4.4.8 Number of Passengers of All Routes by Hour

4) Perception by citizens (result of passenger interview survey)

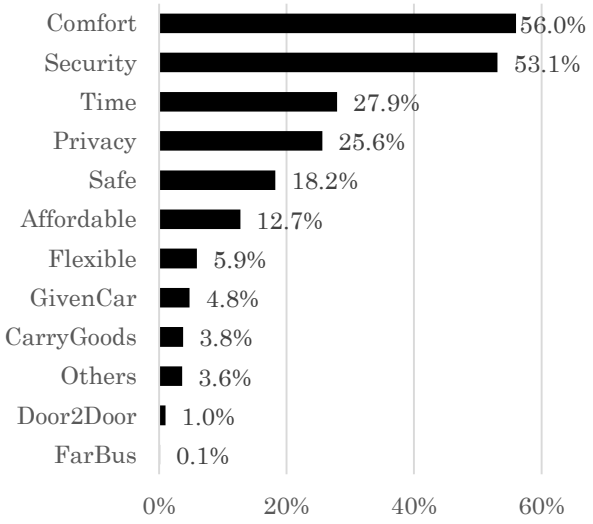
Passenger interview survey conducted with cooperation by 579 bus users revealed that the most important reason of using urban public bus is its “cheap price”, which was stated by 86% of the interviewees. The second biggest reason is the non-availability of other alternative modes of transport, which counts 37%. After these two major reasons which are not really related to the service usability, there come some positive evaluations of the services such as the easy-access to the bus stations and confortability, which counts 16% and 12% respectively.

Meanwhile, the survey to another 691 interviewees who use private vehicles revealed that the two major reasons to use their private vehicle are comfortability and security. Time-saving is the third reason, however the importance is not as big as the first two.



Source: JICA Study Team

Figure 4.4.9 Reason for Choosing Bus



Source: JICA Study Team

Figure 4.4.10 Reason for Choosing Car

JICA study team also surveyed the stated preference of the same interviewees, comparing existing urban public bus service or private vehicle and modern massive transport service. Since such modern service is not present today in Managua City, the interview was carried out by showing some images and explaining some general advantages of mass-transit system such as the punctuality and comfortability. The interviewees were asked to choose one of two modes, meaning the modern massive transport or the other, under some hypothetical situations.

As the result, it became clear that more than half of the interviewees of both groups choose the modern massive transport service. It is remarkable that 61% of bus users are willing to pay NIO 20, which is 8 times more than the fare of existing service, in order to take more comfortable, modern and minutes faster service of public transport. Similary, 63% of private car users are willing to take the modern massive transport service even though it would take more time and would save cost by only NIO 2. Naturally, the more the superiority of time and fare become large, the more interviewees answered to choose the modern massive transport service.

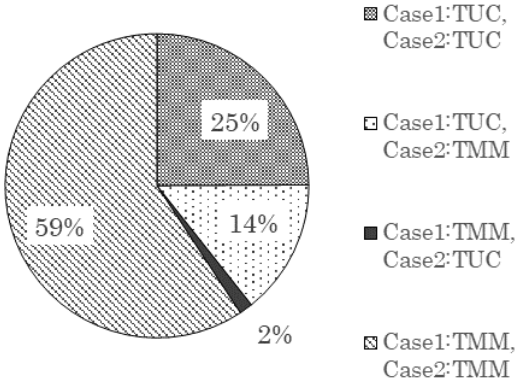
[Question for TUC users]

Case 1: for the same destination, TUC takes 15 min and costs NIO 2.5, meanwhile a modern massive transport system takes 10 min and costs NIO 20. Which do you choos?

Case 2: for the same destination, TUC takes 45 min and costs NIO 2.5, meanwhile a modern massive transport system takes 30 min and costs NIO 20. Which do you choos?

[TMM: Modern Massive Transport]

[Result]



Source: JICA Study Team

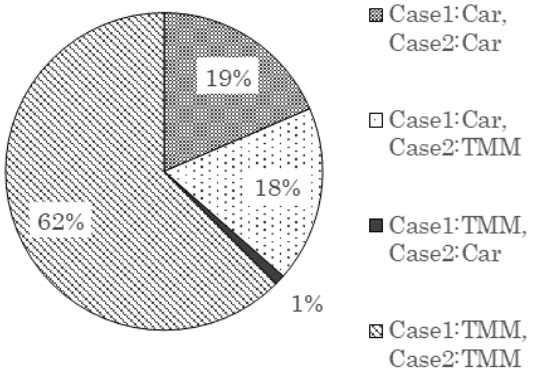
Figure 4.4.11 Choice Tendency for TUC Users

[Question]

Case 1: for the same destination, car takes 15 min and costs NIO 22, meanwhile a modern massive transport system takes 23 min including walking time and costs NIO 20. Which do you choos?

Case 2: for the same destination, car takes 30 min and costs NIO 42, meanwhile a modern massive transport system takes 40 min including walking time and costs NIO 20. Which do you choos?

[Result]



Source: JICA Study Team

Figure 4.4.12 Choice Tendency for Car Users

These results indicate as the whole that the citizens are not satisfied with the service quality of the existing urban public bus, on the other hand they are willing to take a modern and comfortable alternative if provided, even though it costs them much more or it doesn't shorten the travel time.

4.4.3 Intercity Bus

(1) Administration

MTI is responsible for the intercity buses that link cities in Nicaragua, including Managua City. Meanwhile, the bus terminals in Managua City are administrated by ALMA and the Municipal Corporation of Managua Markets (COMMEMA). The bus service is carried out by concession, whose duration is 20 years.

(2) Facility

1) Fleet

More or less 3,500 buses on 565 routes are operating intercity service, among which 1,584 buses on 130 routes enter Managua City every day. Vehicle license is given to larger bus with 25 or more seats for five years, and to smaller bus for a year. All the buses need to be qualified by technical inspection conducted twice a year. There are some intercity buses equipped with GPS device.

2) Bus Terminal

There are 11 bus terminals in Managua City, including six terminals around Mercado Oriental. The terminals Israel Lewites, UCA, Casimiro Sotel and Iván Montenegro are operated by COMMEMA, which is a municipal entity that organizes the markets in Managua City, for the reason that these bus terminals are located inside or next to markets. Terminal Rigoberto

Cabezas is leased to a cooperative called Cotlantico, and the others are the private terminals. Their locations and main destinations are presented in Figure 4.4.13. In short, Terminal Rigoberto Cabezas is used for destinations in the north and east of Nicaragua, Terminal Iván Montenegro for the east, Terminal Casimiro Sotelo for the south, Terminal UCA for all main destinations, Terminal Israel Lewistes for the west, and the other terminals around Mercado Oriental for all main destinations.

Source: JICA Study Team

Figure 4.4.13 Locations of Intercity Bus Terminals

The six terminals around Mercado Oriental do not have any infrastructure unlike the other five terminals. The minimum composition of infrastructure is bus bays with destination boards, passengers' waiting space with roof, and car pool. The other component differs by terminal, such as car repair station and gas station. Numerous small shops are installed in and around the terminals.

No urban public bus enters the terminals. Meanwhile, taxies are allowed to enter and wait for the passengers.

Source: JICA Study Team

Figure 4.4.14 Terminal Israel Lewites

Source: JICA Study Team

Figure 4.4.15 Terminal Casimiro Sotelo

(3) Service

1) Service Types

There are four types of intercity bus, namely: Ordinaria (ordinary bus), Expreso (express bus), Interlocal (inter-local bus), and Rural (rural bus) depending on the size, destination/origin, and stop regulation. Their differences are summarized in Table 4.4.3.

Under Law 431, intercity buses are allowed to stop and drop off passengers but not allowed to pick up passengers, except at the terminal. However, intercity buses pick up passengers in reality and is complementing the urban bus service.

Table 4.4.3 Types of Intercity Bus

Type	Size	Destination/Origin	Stop Regulation
Ordinaria	Large bus (25 seats or more)	Other city	Several stops before destination city
Expreso	Large bus (25 seats or more)	Other city	Non-stop until destination
Interlocal	Micro bus (less than 25 seats)	Other city	Non-stop until destination
Rural	Large bus (25 seats or more)	Rural area out of Managua	Several stops before destination city

Source: JICA Study Team

2) Frequency and Fare

Frequency and fare depend on the destination, service type, and operating concessionaire. For example, the Ordinario connecting Managua City and León City leaves Terminal Israel Lewites every 25 minutes and its fare is NIO 30; meanwhile, Expreso to Guasaule leaves the same terminal only three times a day and costs NIO 80.

(4) Passengers

There are about 158,000 passengers using the bus terminals in Managua City every day. Terminal Casimiro Sotelo is the most frequented by about 55,600 passengers, followed by Terminal UCA with 28,600 passengers,

Based on the survey conducted by inspectors of MTI in March 2016 at the traditional stops in Managua City, there are about 15,140 passengers who use intercity buses for mobility inside Managua City. The numbers of such passengers by road are presented in Table 4.4.4. The value indicates the traffic demand that should in principle be served by urban public bus.

Table 4.4.4 Use of Intercity Bus for Mobility Inside Managua City

Road	Number of Buses Passing on the Road	Number of Passengers for Mobility Inside Managua City
Carretera Sur	532	1,726
Las Piedrecitas	773	3,610
Carretera a Masaya	1,253	4,478
Carretera Norte	1,032	4,227
Carretera Norte until Roberto Huembes	374	1,099
Total	3,964	15,140

Source: MTI

4.4.4 Taxi

(1) Administration

The responsible institute for taxi service in Managua City is IRTRAMMA, and the service is carried out under concession. There are 158 cooperatives and 13 unions of cooperatives, but there are also taxi drivers working individually.

There is no subsidy from the central government; however, there was a subsidy for gasoline for five years until 2015 because the oil price was significantly expensive during the period.

(2) Facility

1) Fleet

Taxi vehicles belong not to cooperative but to individual drivers or employers of drivers. There are 11,680 taxis registered in the list by IRTRAMMA, including 9,688 taxis with valid authorization. Estimated number of taxis in operation is about 12,000, including vehicles with expired authorization and illegal taxis that have no authorization from the beginning.

All the registered taxis are marked with stripe on their vehicle body. Each vehicle has one of two different types of stripe, white or yellow, for service hours' control.

2) Taxi Stand

There is no designated taxi stand in Managua City; accordingly, taxis seek clients by driving throughout the city or waiting at wider spaces such as in intercity bus terminal.

Unions of taxi cooperatives have a technical committee who is now planning a designated taxi stand at some frequented locations in the city, such as in market place or at UCA.

(3) Service

1) Area of Service

Taxis registered by IRTRAMMA are allowed to operate only within the area of Managua City. If a taxi goes beyond the city border, the taxi is obliged to pay NIO 150 as a circulation permission and is prohibited to take new passenger until it goes back inside the border.

2) Service Hours

In order to control the traffic volume, service hours of taxi are separated into three shifts, namely: morning shift from 6:00 a.m. to 2:00 p.m., afternoon shift from 2:00 p.m. to 10:00 p.m. and night shift from 10:00 p.m. to 6:00 a.m. A group with white or yellow stripes on their body operates during morning shift, the other group with the other color operates during afternoon shift, and all the taxis are allowed to operate during night shift. The groups rotate the shifts weekly.

3) Fare

The fare is decided by negotiation between driver and client. The minimum fare is about NIO 25-30 regardless of trip distance, and it increases depending on the travel demand.

Some taxi cooperatives are considering the introduction of taximeter for automatic fare calculation, in order to regulate the calculation and to avoid any trouble with client.

4) Pick-up Service

Two cooperatives are operating taxi service called "radio taxi", where clients can call the central offices to ask for pick-up at specified place. The fare becomes double that of normal floating taxi.

(4) Passenger

There is no proper record regarding passenger. A report by IRTRAMMA in 2006 says that average number of passengers per taxi is 24.0 persons or 3.23 persons per hour for morning shift and 29.4 persons or 4.29 persons per hour for afternoon shift.

4.4.5 Mototaxi

(1) Administration

The responsible institute for mototaxi service in Managua City is IRTRAMMA. Unlike other modes, the service is not carried out under consession, but on permission basis. There are one union of 54 cooperatives and one syndicate of individual mototaxi drivers.

(2) Facility

1) Fleet

The vehicles belong to individual drivers or employers of drivers. There are approximately 1,400 mototaxis in Managua City. Capacity of a mototaxi vehicle is three persons including a driver.

2) Mototaxi Spot

There are 89 authorized mototaxi spots in Managua City, where mototaxis of the area gather while waiting for passengers. The spots are located mainly at entrance of local communities but do not have any infrastructure nor additional space for parking; accordingly, the waiting vehicles occasionally block the circulation from and to the community.

Number of mototaxi spots increased rapidly these years, which caused several problems of congestion.

(3) Service

1) Area of Service

The main role of mototaxi service is to provide local communities with access. Accordingly, mototaxis are allowed to operate only within fixed small area for each group of mototaxis and are not allowed to run on or cross main corridors. When they arrived at a main corridor, passenger continues the trip by other type of transport such as bus or taxi. Normally, the distance of the trip service goes from 1 km to 2 km.

2) Fare

The fare is decided by negotiation between driver and client. In general, the fare is from NIO 5 to NIO 20, depending on the travel demand.

(4) Passenger

According to the union and syndicate, the daily average number of passenger per mototaxi vehicle is about 200 persons, and 90% of the passengers are residents of the area.

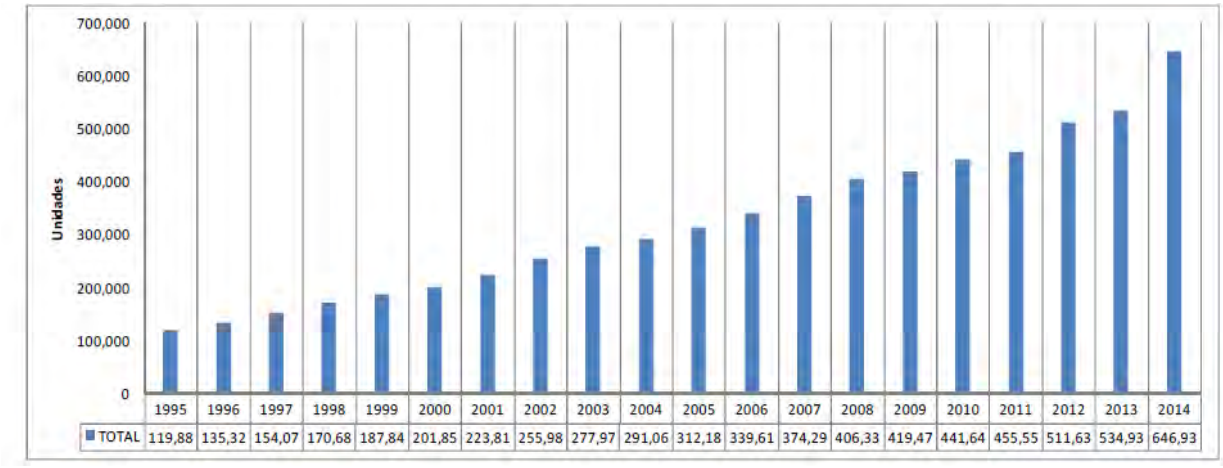
4.5 Traffic Control and Management Conditions

Traffic control and management is one of the major challenges in Managua City. In the context of increased motorization and congestion, the traffic circulation depends largely on traffic management and the current conditions present difficulties in technological and institutional aspects.

The main causes of the congestion are lack of continuity in the roads, irregularities in layout and functionality such as changing road widths, irregular pavement quality, and defective road edges and turns. Lack of a good road infrastructure forces the drivers to circulate in the few principal roads with better conditions.

The growth rates of car ownership also contribute to worsening the congestion and problems in traffic management, including management of traffic signals and traffic police. Managua City has half of the national vehicle fleet, which increased by 17.31% in 2014.

Figure 4.5.1 shows the annual growth rate of the vehicle fleet at the country level. It increased over five times in the last 20 years and over two times during the last ten years.



Source: Traffic Yearbook 2014, MTI

Figure 4.5.1 Growth of Car Fleet in Nicaragua, 1995 - 2014

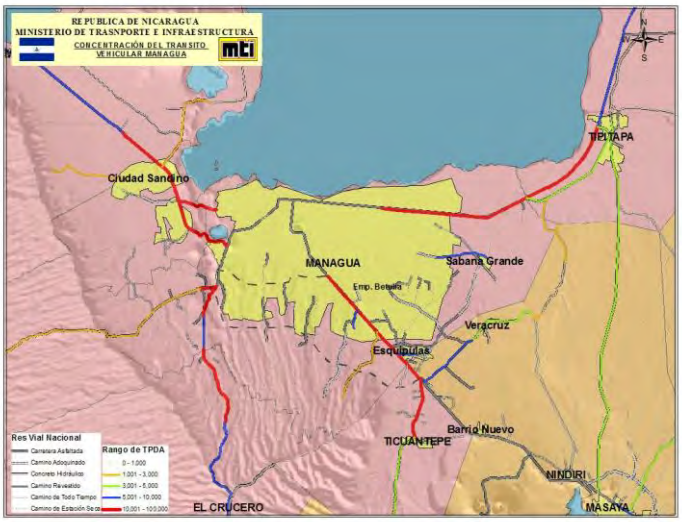
In the last five years, the traffic flows have increased at a range of around 5% annually nationwide according to the traffic counting carried out by MTI. On the main access roads to the city, the growth rates are slightly lower than the national average as shown in the following Table 4.5.1.

Table 4.5.1 Rate of Growth of Traffic in Permanent Counting Stations

Station / Section	2010	2011	2012	2013	2014
Zona Franca-La Garita	2.08%	0.70%	1.90%	2.31%	2.42%
Entrada al INCAE El Crucero	2.52%	4.14%	4.30%	4.07%	4.54%
San Marcos-Masatepe	5.36%	5.49%	7.55%	6.49%	6.90%
Average for the year (11 stations)	3.36%	4.71%	5.33%	5.09%	5.14%

Source: TrafficYearbook 2014, MTI

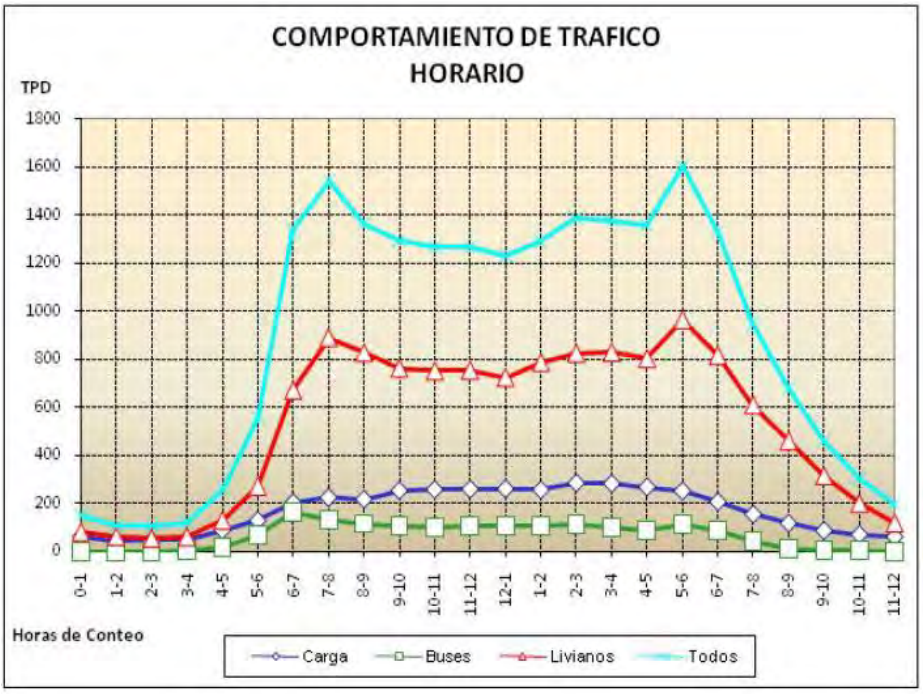
Figure 4.5.2 identifies the routes of highest traffic flow in the country. The access roads to Managua City show high traffic volume.



Source: Traffic Yearbook 2014, MTI

Figure 4.5.2 Traffic Concentration Around Managua City

Vehicle movements are significantly higher in peak hours. The road becomes almost full capacity during those peak hours and the traffic congestion is increasing. Traffic flow at peak time in urban area also has higher traffic flows and it affects occupation of road capacity and increasing congestion. Figure 4.5.3 shows this condition at La Garita - Zona Franca, where located in the Pan-American North of Managua City.



Source: TrafficYearbook2014, MTI. Counting location is La Garita – Zona Franca.

Figure 4.5.3 Example of Hourly Traffic

4.5.1 Condition of Traffic Signal Control

The traffic signals and signs in the Managua City are not installed properly. It can be explained by the urban structure which has developed horizontally. The population density is relatively low, on the other hand, the traffic flow has grown rapidly due to increase of vehicle fleet.

The traffic signal network in Managua City is insufficient and it is one of the priority needs for traffic management. The traffic signals network of Managua City is limited in comparison with other 25 Latin American major cities. Managua City is ranked the fourth worst in the comparison of the road network length per number of traffic signals and the second worst in the comparison of population per traffic signal ratio.

Table 4.5.2 Traffic Signals, Roads and Population in Selected Cities of Latin America

Metropolitan Area (Year)	Road Network (km)	Traffic Signals in Intersections	Population	Roads/ Traffic Signals	Population/ Traffic Signals
Belo Horizonte (2007)	11,370	1,173	4,803,198	9.69	4,094.80
Bogotá (2007)	7,749	1,123	7,823,957	6.90	6,967.01
Brasília (2007)	4,982	791	2,455,903	6.30	3,104.81
Buenos Aires (2007)	44,994	7,200	13,126,760	6.25	1,823.16
Caracas (2007)	2,758	496	3,140,076	5.56	6,330.80
Ciudad de México (2007)	63,726	3,056	19,239,910	20.85	6,295.78
Curitiba (2007)	6,677	1,116	2,872,486	5.98	2,573.91
Guadalajara (2007)	11,045	1,300	4,374.721	8.50	3,365.17
León (2007)	2,647	442	1,360,310	5.99	3,077.62
Lima (2007)	12,355	996	8,482,619	12.40	8,516.69
Porto Alegre (2007)	9,903	1,301	3,410,676	7.61	2,621.58
Recife (2007)	7,557	716	3,658,318	10.55	5,109.38
Rio de Janeiro (2007)	15,371	3,683	10,689,406	4.17	2,902.36
Salvador (2007)	4,256	494	3,445,499	8.62	6,974.69
San José (2007)	4,437	415	1,286,877	10.69	3,100.91
Santiago (2007)	11,396	2,200	6,038,971	5.18	2,744.99
São Paulo (2007)	37,728	7,562	18,783,649	4.99	2,483.95
Rosario (2008)	4,479	361	1,320,718	12.41	3,658.50
Montevideo (2009)	3,699	737	1,835,641	5.02	2,490.69
Pereira (2009)	998	177	673,015	5.64	3,802.34
Quito (2009)	3,919	715	2,231,706	5.48	3,121.27
Florianopolis (2010)	3,162	145	877,116	21.81	6,049.08
Manaus (2010)	4,214	624	2,106,322	6.75	3,375.52
Panamá (2010)	2,100	176	1,577,959	11.93	8,965.68
Santa Cruz de la Sierra (2011)	3,955	136	1,697,630	29.08	12,482.57
Managua*	2,512	144	1,495,385	17.44	10,384.6

*Managua: Several sources

Source: Urban Mobility Observatory CAF

(1) Facilities

Traffic signal is a shared responsibility between the National Police and municipal authorities, the General Directorate of Infrastructure (DGI). Traffic lights, pedestrian bridges, and traffic signals are installed following the national guidelines from MTI by these two organizations. The funding comes primarily from the a part of annual vehicle tax paid by the vehicle's owners in Managua City. DGI is responsible for managing these resources.

According to information from the DGI, they have painted annually between 160 to 200 km of continuous and discontinuous road marks, and between 10,000 to 20,000 m^2 of horizontal road signs. The number of existing road signs (informative, regulatory, preventive and destination) is unknown because the DGI installs annually about 2,000 signs, but these road signs disappear after installation by theft, destroy and etc. As of 2010, there are 5,000 traffic signals in the Managua City.

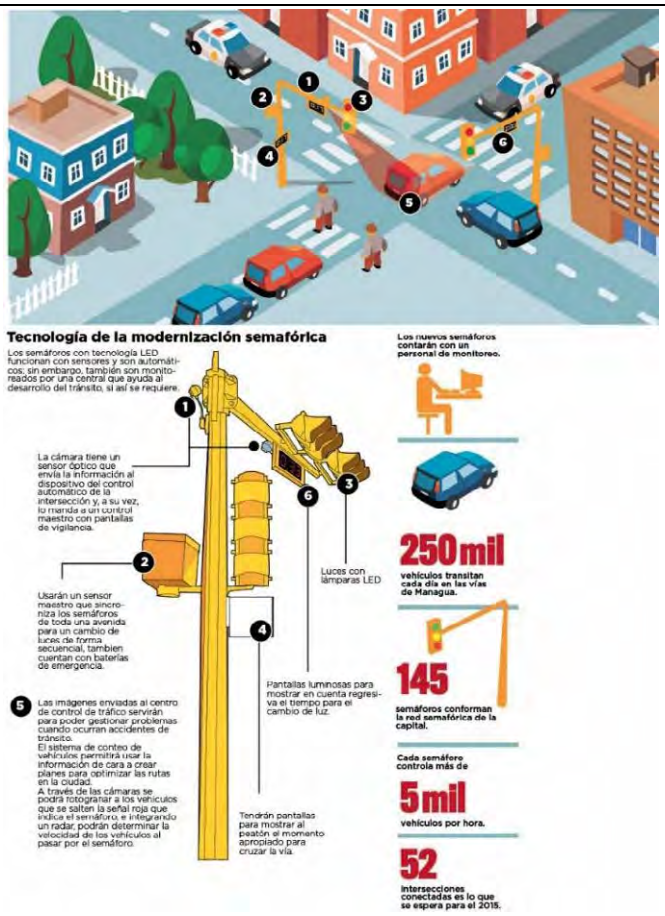
(2) Signal Phasing System

A number of traffic signals in Managua City is poor. Most of them are old technology, and their use is not efficient. There are over 3,000 intersections in the main road network and 144 out of the 375 critical intersections are signalized.

Traffic singals are divided into two different networks. Old network is installed at 64% of the signalized intersections. This network is administered by DGI of ALMA. Thirty-six percent of the traffic signals are new intelligent traffic signals which is installed at 52 major intersections along with most active road axes in the city, namely: Pan-American North (25 intersections), Carretera a Masaya (14), Avda. Simon Bolivar (4), and other main roads (9). This network is administered by the General Secretary of ALMA and it is planned to be expanded in the future.

<New Intelligent Traffic Signals>

- ✓ The renovation project of the network began in August 2015. It aims to improve traffic flow, reduce waiting and travel times, and remove bottlenecks at major intersections.
- ✓ This modern system can allocates proper signal cycles depending on the real time traffic volume.
- ✓ The system includes a timer to show the remaining time of the cycle, signals for pedestrians and seven digital information boards to provide the information of the roads.
- ✓ There are up to six cameras per intersection, some of which are fixed and the others are movable.
- ✓ Devices (sensors and cameras) can record the number of vehicles and the information is sent to the traffic control center, which is monitoring what happens on the roads and has the capacity to control with traffic signals.
- ✓ Traffic control center monitors 280 cameras, which is operated automatically at signalized intersection and record for 24 hours/day. It allows the accumulation of traffic flow information (counts at each intersection) and also record any incident occuring at the intersection and its surroundings.
- ✓ Currently, most of the abovementioned available tools are not used because the system is incomplete and because there is no technical capacity to handle them. One of the inconvenient situation is that the National Police controls traffic by hand manual at an intersection, where modern traffic signals are already installed, for mitigation of traffic congestion.



Source: elnuevodiario.com.ni, 6 de enero 2015

Figure 4.5.4 Technology of New Traffic Signals

(3) Bottlenecks at Signalized Intersections and Roundabouts

Managua City is facing some traffic problems due to the increased traffic volume and the limited road capacity, in despite of the car ownership is not significantly high (122 cars per 1,000 inhabitants) even by Latin American standards. In 2015, 335,899 motor vehicles were registered, and 107,097 of them is motorcycles and 183,454 of them are automobiles, trucks, and jeeps.

The design of the main road network of the city has not changed since it was projected in the 1960s and 1970s when the motorization in the city was extremely low and the urban area was noticeably reduced. Since then, the improvement of connectivity of additional roads has not been done very effectively. Therefore, vehicles must continue using mostly the same main arterials, which are saturated at peak times. There are also design problems at junctions, intersections, and spaces for pedestrians.

Table 4.5.3 show clearly that the traffic volumes are high.

Table 4.5.3 Daily Traffic in Access Roads to Managua Department in 2015

Name of the Sector	Department	Funtion	TPDA
Portezuelo - El Dancing	Managua	Troncal Principal	66,901
El Dancing - La Subasta	Managua	Troncal Principal	58,904
La Subasta - Aeropuerto	Managua	Troncal Principal	43,767
Aeropuerto - Zona Franca	Managua	Troncal Principal	29,000
Zona Franca - La Garita	Managua	Troncal Principal	22,685
La Garita - Empalme Los Pollos*	Tipitapa	Troncal Principal	14,208
Empalme Los Pollos - Punta de Plancha*	Tipitapa	Troncal Principal	10,642
Punta de Plancha - Empalme San Benito*	Tipitapa	Troncal Principal	10,523
Semáforo 7 Sur - EmpalmeNejapa*	Managua	Troncal Principal	43,606
Km. 10 1/2 Carretera Sur - EmpalmeNejapa (Regreso)*	Managua	Troncal Principal	8,740
Km. 10 1/2 Carretera Sur - Entrada al INCAE*	Managua	Troncal Principal	19,828
Entrada al INCAE - El Crucero	Managua	Troncal Principal	8,685
Rotonda Centroamérica - Rotonda Jean P. Genie*	Managua	Troncal Principal	59,609
Rotonda Jean P. Genie - 1ra. Entrada Las Colinas*	Managua	Troncal Principal	79,016
1ra. Entrada Las Colinas - Entrada a la UNICA*	Managua	Troncal Principal	48,785
Entrada a la UNICA - Entrada a Esquipulas*	Managua	Troncal Principal	42,673
Entrada a Esquipulas - EmpalmeTicuantepe*	Managua	Troncal Principal	41,454
EmpalmeNejapa - Semáforos Auto Hotel Nejapa*	Managua	Troncal Principal	23,641
Las Piedrecitas - Cuesta Héroes y Mártires	Managua	Troncal Principal	26,568
Cuesta Héroes y Mártires - Entrada a Ciudad Sandino	Managua	Troncal Principal	28,537
Entrada a Ciudad Sandino - Los Brasiles	Managua	Troncal Principal	15,345
Los Brasiles – Nagarote	Managua	Troncal Principal	7,834
Nagarote - La Paz Centro	Managua	Troncal Principal	6,083

* Projected traffic

TPDA: Average daily annual traffic

Source: MTI

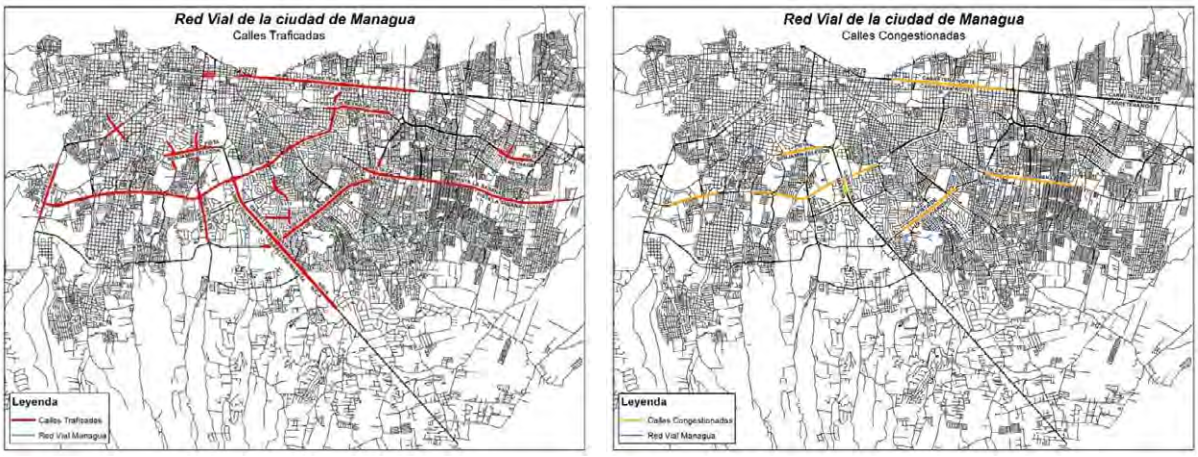
MTI's data shows not only high occupancy of roads but also proves that there are a sequence of "dormitory towns" around Managua City that generate daily trips to the city. According to the data from DGI of ALMA, these figures fit well with the data trend of the municipality.

Table 4.5.4 Traffic in Main Axes of the City

Route	Volume (veh/day)
Pista Pedro J. Chamorro (Carretera Norte)	50,000
Pista Juan Pablo II	45,000
Carretera a Masaya	40,000
Pista Suburbana	30,000

Source: General Directorate of Infrastructure, ALMA

The intensive use of the roads makes it poor condition, and affect traffic movement. Figure 4.5.5 shows the congestion roads in Managua City. The right side of this figure shows more congested corridors and sections in the city.



Source: General Directorate of Infrastructure, ALMA

Figure 4.5.5 Roads and Sections with Greater Flows in the City

4.5.2 Traffic Regulations

According to the Law 431 of 2003 ("Act Regime for Vehicular Circulation and Traffic Violations"), the authority responsible for the additional administrative rules for the implementation of the law and regulations of traffic in the country is the National Police, through the national Traffic Safety Expertise (from now on Traffic Police).

The National Police, through the Traffic Police, 1) regulates the traffic at the national and urban level, 2) plans and prepares safety plans and traffic education and urban signage in coordination with ALMA and MTI (Law No. 431/2003) , 3) issues driver's licenses to drivers of public transportation and road vehicles (Law No. 524/2005 and Law No. 431/2003), 4) is responsible for the public registry of vehicular of the Property and the Road Safety and Education National Fund for safety, education and road signs projects, and 5) is responsible for road safety itself and traffic accident investigation.

(1) One-Way Traffic Regulation

Law 431 establishes the list of control functions of the police concerning transit and traffic regulations. It includes the drivers behaviours which must observe in terms of the relationships between drivers, the signs on roads and their location, and vehicle conditions which must comply with including the approval of permissions and inspections (mechanical and gas emission).

The regulation also includes the following stipulations:

- ✓ It classifies violations and set the corresponding fines;
- ✓ It establishes maximum speeds and the conditions for large vehicles or with considerable freight; and

- ✓ It also classifies the roads according to their conditions, establishing that one-lane streets will be one-way streets, and that avenues and streets having at least two or more lanes will have double way of circulation.

(2) Regulation for Parking

Parking is allowed only along streets and alleys with width between 12 m and 17 m. Parking is prohibited on high hierarchy roads.

(3) Speed Limit Regulation

The maximum speed is defined in the Traffic Act is 45 km/h in urban areas, 60 km/h in suburban roads, and 100 km/h on expressways.

(4) Truck Ban Regulation

The law entitles the police to regulate the circulation of heavy vehicles, but there is no restrictions in practice by time or zone.

4.5.3 Traffic Safety Conditions

Around 49.6% of the motorized vehicles are concentrated in Managua City and one third of them are motorcycles. According to the statement by the police, security conditions have deteriorated by the high concentration of vehicles in the city and the growth of the vehicle.

One of the main problems of accidents are 1) congestion, 2) increasing number of motorcycles, 3) the rapid increase of new drivers (at least as fast as the growth of the parking space), and 4) insufficient traffic safety education of drivers and pedestrians.

For improving these conditions, the Traffic Police carried out important preventive and reactive actions, which include mandatory road safety education in all schools in the country, training of officers, agents, and drivers for speed controls, prevention of nocturnal illegal races on the roads around Managua City, and control program and high penalties for alcohol consumption by drivers.

4.5.4 Traffic Accidents

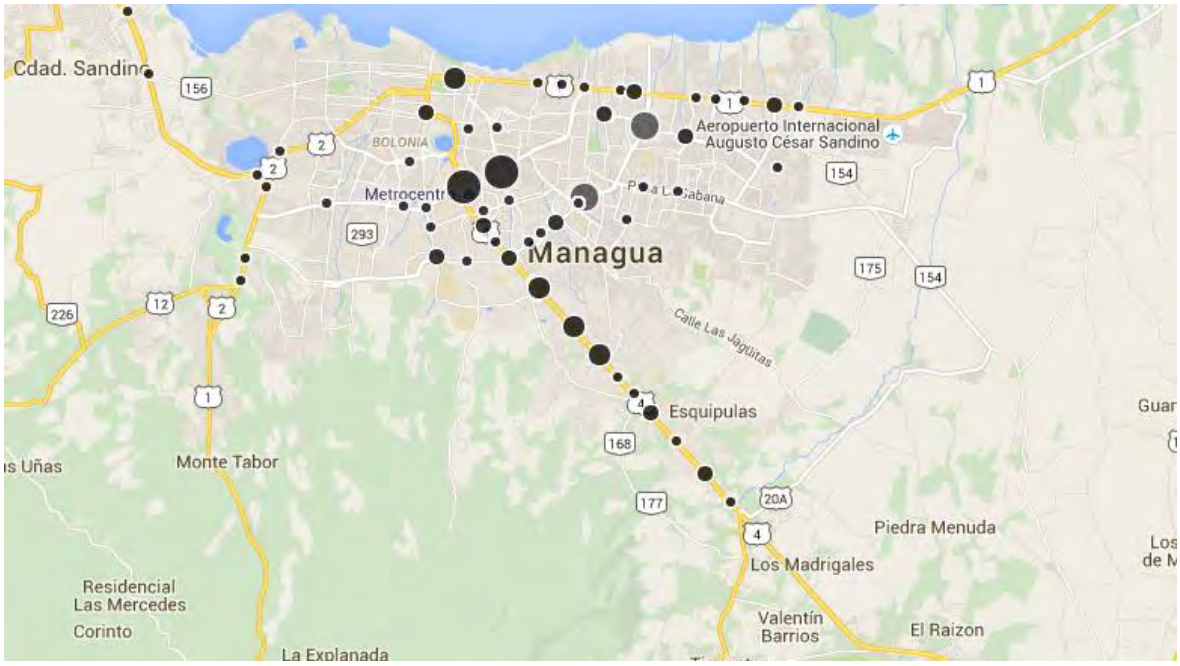
About 60% of all the traffic accidents with damage and around one third of fatal traffic accidents occur in Managua City. The motorcycles accidents is significant and increasing. In 2014, 46% of fatal accidents of motorized vehicles were motorcyclists, and this represents more than 40% of all fatal traffic accidents. Table 4.5.5 shows the statistics of traffic accidents in the city since 2007, it show the number of injured and dead from 2007 to 2014.

Table 4.5.5 Accidents and Consequences in Managua City, 2007-2014

Year	Accidents with Material Damage	Accidents with Victims	Dead	Injured
2007	11,341	1,077	108	1,318
2008	11,339	1,231	105	1,571
2009	11,818	1,276	135	1,597
2010	12,654	1,343	124	1,740
2011	12,835	1,166	111	1,467
2012	14,029	1,059	112	1,368
2013	14,858	1,170	96	1,492
2014	16,046	949	112	1,188

Source: National Transit Police

Figure 4.5.6 shows black spots, which is the critical points for accidents in the city up to the third quarter of 2015 and this is the latest data. It can be seen that the main occurrence location of traffic accidents are concentrated on the major intersections and major roads in the city. Cristo Rey and Rotonda Metrocentro are the most critical points, followed by the Carretera a Masaya and Pan-American North, Pista Juan Pablo II and Pista Solidaridad.

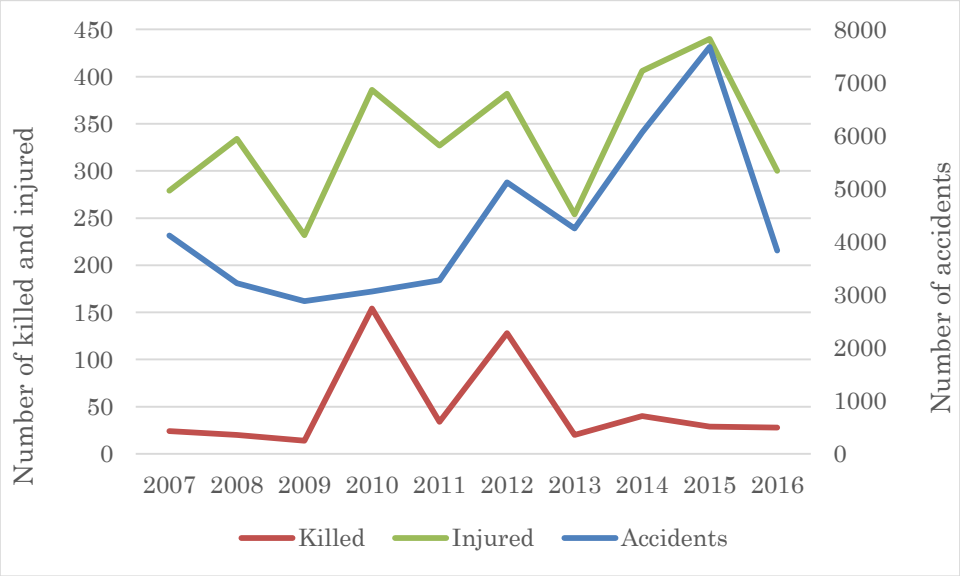


Source: JICA Study Team

Figure 4.5.6 Accident Black Points in Managua City

Traffic accidents have been increased regularly over time. Although the number of killed has diminished, while that of injured has significantly increased (normally, there is no information about injured people who die after a period of time related with the accident).

Figure 4.5.7 Number of Accidents, Killed and Injured, 2007-2016*



* 2016, from January to June
Source: National Police

Table 4.5.6 shows definitely that Rotonda Metrocentro roundabout is historically the highest traffic accidents poin. It is around three accidents per week normally until 2011 and it is increasing to five accidents weekly at present. It is important to observe that rondabouts are the most dangerous places for traffic accidents, namely: El Perdiodista, Cristo Rey, and Centroamérica.

Table 4.5.6 Trend of High Accidents Spot, 2007-2016

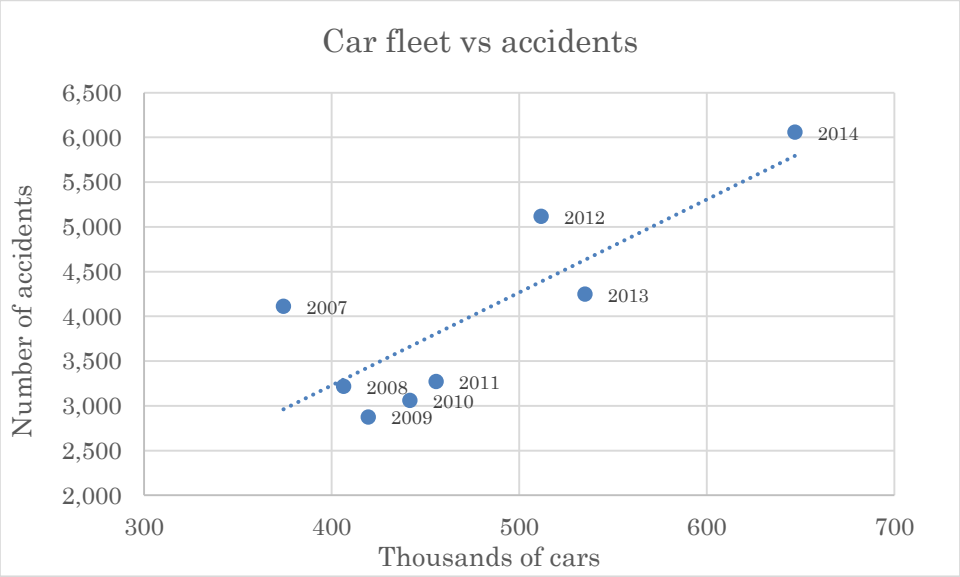
Address	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*	Total per Place
Frente Farmacia Konny Mercado Roberto Huembes								117			117
Interseccion Enacal Central					35						35
Interseccion Estadio Nacional Beisbol	54										54
Intersección Petronic La Cachorra							41		70		111
Km. 8 Carretera Sur	48										48
Km. 8 Semaforos I Entrada Las Colinas										41	41
Km. 9 Semaforos II Entrada Las Colinas										58	58
Rotonda Bello Horizonte			48								48
Rotonda Centroamérica	52	67	62	65	51	100	87	117	109	56	766
Rotonda Cristo Rey	83	68	76		41	89	80	155	183	94	869
Rotonda El Gueguense			61	42		52	65	77	76	36	409
Rotonda El Periodista	123	88	94	113	96	161	125	127	152	87	1166
Rotonda Galeria Santo Domingo	48	52	46	55	72	104	100	67	87	39	670
Rotonda La Virgen	49		43	38	45	78	69	63	95	83	563
Rotonda Metrocentro	163	146	146	113	139	262	261	264	267	145	1906
Rotonda Universitaria						47					47
Semaforo Antigua Pepsi				39							39
Semaforo Jonathan Gonzalez				48							48
Semáforos Casino Pharaohs						48					48
Semáforos El Dancing		56									56
Semaforos Enel Central					35						35
Semáforos Gancho Camino		39	40								79
Semáforos Hotel Hilton Princess	49										49
Semaforos I Entrada Las Colinas Km. 8 Carretera Masaya					47	51			98		196
Semaforos II Entrada Las Colinas Km. 9 Carretera Masaya									67		67
Semaforos La Parmalat		39									39
Semáforos La Robelo	54	44		38							136
Semáforos La Subasta							58			38	96
Semáforos Lozelsa		36									36
Semáforos Mercado El Mayoreo			42								42
Semaforos Suburbana Plaza Petropolis Km 8 Carretera Sur							42	84			126
Semaforos Vivian Pellla Km 10 Carretera Masaya								63			63
Semáforos Laboratorio Policia Nacional Km. 10.5 Carretera Masaya				37	33						70
Total yearly for the 10 places having more accidents	723	635	658	588	594	992	928	1134	1204	677	8133

* From January to June

Source: National Police

It is very clear that the number of accidents in Managua City is closely related to number of vehicles. Although the number of vehicles is national total, the following figure shows this relationship. Number of traffic accidents increases very regularly with the increase of number of vehicles in the country.

Figure 4.5.8 Relation between Accidents and Number of Vehicle, 2007-2011



Source: JICA Study Team

4.5.5 Traffic Education and Driving License System

The driver's license is given by the National Police with five years validity. To get it, the applicants must be over 21 years old, literate, and have previously passed a driving course in a school accredited by the police and passed the theoretical and practical exams. The license may be withdrawn at any moment for varying periods of time according to the violations committed by the drivers. It may even be confiscated indefinitely for repeated serious violations.

The Security and Road Safety Education Council, advisor to the National Police, promotes driver education courses in schools and education centers in the country as well as courses for drivers.

4.5.6 Current Parking Conditions

The Urban Control Plan dated 1984 is a municipal instrument that defines the conditions for the construction of buildings in the city. It regulates the design and location of parking lots. As shown in the table below, this plan establishes the requirements of parking spaces in buildings, separated from public or access restricted, according to the land use and size of buildings. Although it is regulated, its functionality is seldom considered and the requirement may require revision to take the current situation and the future trend into account.

Parking lots are regulated officially, but functionality is seldom considered. In the case of private parking, it is up to the local governments, in coordination with Traffic Police, to give the permits for operation and determine the parking fee taking into consideration the alleged area to be used. However, this kind of parking does not exist yetin the city.

Table 4.5.8 Requirements of Parking Sites According to Uses

Equipment	Requirement
EDUCATION	
Secondary and technical schools	2 per room
Universities	1 per every 6 rooms
CULTURE AND RELIGION	
Theatres	1 per every 20 seats
Auditoriums	1 per every 10 seats
Libraries	1 per every 100 m^2 of construction
Museums	1 per every 100 m^2 of construction
Churches in medium density residential zones	1 per every 20 m^2 of construction
Churches in high density residential zones	1 per every 50 m^2 of construction
ENTERTAINMENT AND SPARE TIME	
Buildings for sport spectacles, stadiums, plazas, etc.	1 per every 20 seats
Dancing rooms, night clubs and similar	1 per every 20 seats
First category	1 per every 10 seats
Second category	1 per every 30 seats
Third category	1 per every 60 seats
FINANCES	
Banks and financial companies	1 per every 30 m^2 of construction
ADMINISTRATION	
Public offices	1 per every 30 m^2 of construction
Private offices	1 per every 40 m^2 of construction
COMMERCE	
Wholesale	1 per every 100 m^2 of construction
Retail	1 per every 50 m^2 of construction
Supermarkets	1 per every 40 m^2 of construction
Commercials centers	1 per every 60 m^2 of construction
Hardware stores	1 per every 75 m^2 of construction
Hotels	1 per every 4 rooms
Motels and apart hotels	1 per room
Bars and restaurants	1 per every 20 m^2 of construction
Mechanical workshops	1 per every 80 m^2 of construction
INDUSTRIES	
Industrial plants	1 per every 100 m^2 of construction
Warehouses	1 per every 200 m^2 of construction
TRANSPORTATION	
Terminals (freight, passenger, air and ground)	According to necessities of project and MTI advice
SERVICES TO PEOPLE	
Shoes and leather articles repair, laundries, service agencies, hairdresser, beauty salons, gymnasiums	1 per every 70 m^2 of construction

Source: Plan Regulador de Managua

4.5.7 ITS

(1) Introduction

Managua City introduced the technological processes for transport management. This has allowed the integration to be easier and simpler than other cities.

In fact, intelligent transportation systems (ITS) is efficient for management, knowledge and practice for allowing easy learning and introduction for user.

In Managua City, there are three important ITS innovations in urban transport, namely: traffic management, locating and monitoring buses in real time, and fare collection system in public transport. The operation of each one will be reviewed here and their efficiency and potentiality will be evaluated.

(2) Traffic Management

The network of intelligent traffic signals is installed since 2015, and it consists of 52 intersections out of the total of 144 traffic signals in the city. They are installed in the following axes:

- 15 in Masaya Road
- 25 in North Road
- 5 in Av. Bolívar
- 4 in Av. Miguel Ovando y Bravo

Ten more traffic lights will be added on the following axes soon:

- 2 in North Road (Judicial Power)
- 3 in Masaya Road (at its southern end, which was part of the original project)
- 4 at the Huembes Market
- 1 in the terminal of the UCA

The new system for traffic signals includes 160 video cameras and 7 variable message sign. A dedicated fiber optic network supports it, with redundancies, organized in three rings (it could reach up to 8) with 14 to 17 traffic signals each. All the traffic signals are synchronized which allow the performance of any necessary action.

The main aspects of the modernized network are:

- The wiring of traffic singals is in underground.
- The green phasing may flash intermittently 3 seconds before the end of the pass.
- It has a count-down timer for pedestrian crossings, in both red and green lights.
- It has loop coil to detect the passage of vehicles at the turns of the traffic signal intersections.
- Real-time programming capability and in association with detected traffic volume.
- There are four Cameras at intersections, one of which is movable.

It has the possibility of programming different time schedules depending on the traffic volume for the hours of the day and night and for weekend days.

There is a Traffic Control Center, which area is 260 m^2, and it can carry out the traffic management by the new traffic signal system. Operation time is 24 hours a day, and it allows coordination with other institutions involved in road security. The traffic control center has 12 workstations equipped with computers and screens, installed in special consoles, and four stations for supervision with computers and double screens.

The traffic control center has a backup system for the power supply of the equipment. The backup system feeds the critical elements of the system. It also has a video wall with 16 screens, in 8x2 configuration. It includes video decoding machines and applications (1 per 4 screens) and the video wall system management server.

The communication system between the control center and the intersection is connected by optical fiber, which guarantees good signal quality, speed, and adequate video flow. It has a video recording system with recording capacity of up to 15 consecutive days.

The traffic control center has installed ARTIC software for the management of cameras and variable message panels and the COLORS management software that manages the traffic signals and other management systems, lights, inductive loops, etc. Different types of control devices could be integrated such as gas meters, weather, visibility, etc.

However, both system is not integrated. The old system is not synchronized and it has no cycle definition or integration. The new system was not installed vehicle counting devices, except for loop coild detection. In fact, there are problems with traffic management.

The availability of advanced and robust technologies characterizes the modern system. However, it suffers from several problems. The first is lack of interaction with the traditional system. Secondly, it lacks certain resources and has therefore limited actions since it is not accompanied by a traffic model that can guide decisions in real time according to traffic flows. Thirdly, it does not have an effective counting system. It is important to provide this system with all its potential capabilities and to provide it with an effective traffic management function.

(3) Locating and Monitoring Buses in Real Time

Starting with a GEF funding of USD 2.8 million, a traffic control center for bus operations was implemented in 2011. The original goal of the project was to improve the efficiency of public transport and thereby reduce emissions. It proposes the monitoring of the bus so that vehicles operation makes more efficiently, shortening distances travelled and consuming less fuel. Upto this end, GPS systems were installed in buses. These buses are controlled permanently and in real time from an IRTRAMMA office.

The units installed in the project are 120, and belong to four routes, namely: Route 104, Mini Route 4 (known as Route 261), Route 112, and Route 114.

The project began to be implemented in 2011 and the last equipment was installed in April 2016. The Spanish company, ETRA was in charge of the installation of the system in the buses and the monitoring

system. Operation allows to control schedules, especially the start and end of daily services. Monitoring is also carried out every two hours to produce the following information: number of units working, average and maximum speeds, and time of end of bus services.

The system has other potential regulatory abilities but they are not used such as regulation of frequencies and control of fuel consumption or picking up passengers. However, these capabilities have not been installed. The operators of each route have a terminal, and they can obtain all the information produced by the system from computer. Meetings are held between IRTRAMMA and operators to exchange ideas and analyze results every 15 days.

In April 2016, the government decided that all public transport vehicles must have a GPS. It has also been suggested that in the future all buses that are integrated to the public transport of the city should come with GPS and ticket validation systems installed.

In this perspective, the idea is also proposed to complement the GEF project by integrating the entire fleet in Managua City. The cost of integrating the entire fleet is estimated at an additional USD 2 million.

The application described here has a high potentiality and corresponds to the technology that is being widely used in the management of public transport in other cities. However, all potentially existing functions are not activated. The expansion of this system to its full capacity is very useful for the public transport operation.

(4) Public Transport Payment System

MPESO is the fare collection system in public bus transportation in Managua City. It is operated by a private company called MPESO and has operated since August 2013. The company has contracts with bus cooperatives (28 cooperatives) and with each partner within them (more than 600 operators), delivering services and information to both cooperatives and operators. It also includes services to two rural cooperatives in Managua City. Each operator individually receives the information about his vehicle, which he accesses in real time through a computer in his office. The operator can see how many people get on his bus from this information. Reports are made every half hour, and the system is updated every 3 minutes. IRTRAMMA also has a terminal and receives systematized information every 15 days.

The equipment is Japanese made, LECIP, with Swedish software, ISO 4011, NFC system. A Mifare Plus NXP card is used. It has 1,600 recharging points in the city and 35 points where to buy the card, whose value is NIO 50 per unit.

MPESO delivers the money collected to each cooperative daily and the cooperative must distribute the corresponding amount to each associate. The company charges NIO 0.16 for each payment transaction.

The system has great potential to collect the passenger information and to add user-friendliness, for example, passengers boarding and alighting. In the same way, it is possible to operate with differentiated tariffs, integrated fares, weekly or monthly cards, etc. The system collects NIO 1.6 million each day from approximately 1 million cards. It is estimated that only 15% of the users of the public buses in Managua City do not use the card and pay in cash.

An adequate operation of this system would allow real time information on the operation of the buses in the city (passengers transported, occupancy per zone, loading and unloading, distances traveled, etc.).

4.6 Issues in Transport Planning

(1) Lack of Coordination between Concerned Organizations

There are several organizations related to traffic and public transport matters. For example, ALMA and the Ministry of Transport and Infrastructure (MTI) are responsible for managing road projects, though their jurisdictional areas are different. When they work together, however, some issues for coordination take place. One of the issues is that ALMA does not have a transport planning division. Therefore, transport planning capacity is not accumulated within ALMA. The public transport is managed by another organization, the Regulatory Institute of Transport of the Municipality of Managua (*Instituto Regulador De Transporte del Municipio de Managua*: IRTRAMMA). It is essential that formulation of the planning is carried out to collaborate with each other and to share the vision. Transport problems in Managua, such as traffic congestion, traffic accidents, and lack of effective public transport will aggravate day by day in line with economic and population growth. Therefore, a traffic and public transport section in Managua, which is ALMA project department, IRTRAMMA Traffic Police, should be further strengthened for coordination and integration for urban traffic management between concerned organizations.

It is necessary to consider incorporating or determining an entity in charge of transport planning. This should allow to establish an adequate public transportation network in harmonization with infrastructure, to update operation frequency based on the passenger demand, and to strengthen the control center operation not only verifying the proper functioning of services but also providing a tool for control and monitoring of routes. For traffic issue, it would be necessary to consider establishing a permanent organization for traffic management including a new traffic light system as well. Integration of traffic information is utilized feedback to improve travel times and service levels.

(1) Limited Accumulation of Traffic Data

ALMA and MTI continue to conduct traffic counting in major intersections or cross sections every year, and they have experience in the traffic counting survey. IRTRAMMA has experience of a person trip survey for bus passengers. Although this survey focused on the public transport (bus and taxi) and other traffic data such as private vehicles and logistic vehicles were not largely gathered, these above mentioned data are also very important for transport planning.

As of this moment, the basic traffic data which ALMA/IRTRAMMA have, is limited and the data are not utilized properly for transport planning. It is important to accumulate the traffic related data for grasping traffic movement efficiently. The challenge is to improve data collection, to integrate all sources of data (counting, surveys, etc.), to analyse the data, to share it between related organizations and to maximize the utility of it.

ALMA has the control centre for traffic monitoring, but ALMA should work together with the police to ensure road and public security. The information can be obtained from the driver's behaviour, accidents, and especially enforcement of the traffic regulations (traffic violations, licenses, etc.).

Automatic traffic counting unit can obtain a continuous data. It is worth considering further expansion of facilities at critical intersections for better information gathering and also considering an alternative mobile device in non-equipped areas (i.e. video monitoring and information collection by closed-circuit television (CCTV), drone, etc.).

(2) Traffic Issues

Growth of fleet has been steadily positive at a rate of 7.9% (2010-2015); however, the infrastructure remains basically of more than 30 years (1984-2016) ago. It had been developed at 80% only at the arterial and collector roads. The expansion of the city without control has restricted development of the radial and ring road.

There are residential areas without proper planning such as road capacity analysis or revision of public transport routes. In other word, road planning in residential area does not take into account the criteria of road capacity and access to public transport services, which leads residents to the purchase of private vehicles (cars and motorcycles). The increase of number of vehicles worsens the traffic congestions and then worsens the quality of public transport service.

1) Insufficient Road Network

Managua has seen urban sprawl around the city or uncontrolled urban expansion without infrastructure and the existing road network became insufficient; especially ring roads and radial roads. There are missing links of road network in some areas and invasion to right of way for new roads construction is found.

Managua must establish a new metropolitan road network with better circulation. In road infrastructure planning, the existence of lanes or spaces for mass public transport infrastructures (lanes, stations, etc.) should be considered within the right-of-way when demand requires it, as well as contemplating important intersections. Update of the Road Regulator Plan and considering of the functionality between them is also needed. Roads in the city have high degrees of accident and traffic congestion. The road network is insufficient and inadequate and as a consequence, generates congestion and accidents. The lack of capacity in the road network requires expansion and greater connectivity. In addition, there are black spots (high degree of accidents), which requires a redesign of sections and intersections.

2) Bad Condition of Roads and Sidewalks

There are some unpaved roads and roads with no sidewalks. The sidewalk is very important because in Managua, 35% of the people are walking according to the result of the household interview survey and in the local streets; most of the people does not have a car and mobilizes by foot. These situations are found mainly in local roads. Main roads have wide sidewalks but

some roads do not have sidewalks or condition is very bad because there are obstacles, telephone poles, stalls, trash, etc. Furthermore, it is necessary that pedestrian paths are designed and constructed based on the universal accessibility standards.

3) Lack of Parking Space

Many vehicles are parked in local roads and these parked vehicles interrupt the smooth traffic flow. They have an impact in increasing traffic accidents with pedestrians because parked vehicles block the sight of pedestrians. Regulations to encourage the use of public parking should be promoted in order to reduce the parking on the public roads.

4) Inefficient Traffic Flow

Number of vehicles are increased as written in Chapter 4.3.2. An increasing number of vehicles is a primary traffic problem. The number of vehicles has been grown rapidly and the number of imported vehicles also have been increased almost 2.4 times from 2010 to 2015. Motorcycles have been increased by 2.7 times within the same period as well.

Table 4.6.1 Imports of Motorized Vehicles in Managua City 2010 - 2015

Description	Number of Vehicle						
	2010	2011	2012	2013	2014	2015	2016*
Motorcycle	20,905	32,263	43,525	45,751	42,781	54,728	10,756
Car/Van	6,794	9,064	12,043	12,195	12,339	15,407	2,333
Vehicle for transport of goods	6,130	7,396	9,521	9,984	9,749	10,814	1,579
Vehicle for transport of 10 people or more	469	894	957	862	738	813	118
Large Truck	490	456	599	741	745	741	103
Tractor	281	434	623	424	396	299	47
Cultivator	3	3	2	4	3	4	5
Total	35,072	50,510	67,270	69,961	66,751	82,806	14,941

*Until February 2016

Source: Nicaragua Customs

Fast growth of car ownership cannot be managed through road supply or even through traffic management as it happens very rapidly (even faster than economic growth). As a result, more cars with constant street capacity create more congestion and accidents faster than the capacity to control it.

Source: Nicaragua Customs

Figure 4.6.1 Imports of Motorized Vehicles in Managua City 2010 - 2015

Motorcycles are also one of the causes of traffic congestion. The number of motorcycles is increasing because their prices are low and drivers can move flexibly compared with passenger cars. Motorcycles occupy as much road space as cars, but motorcycle riding is normally more risky, affecting the driving of other vehicles and reducing the general flow. This affects the movement of the other vehicles. It is necessary to develop a better road network in consideration of increasing vehicles and motorcycles, better controlling of motorcycles, managing traffic flow, and providing more attractive public transport network by regulate frequencies, improvement of routes, etc.

5) Insufficiency of Traffic Signals

Traffic signals are already installed in Managua City and some traffic signals have a traffic signal control system depending on the traffic volume. A large number of signals are still under the old system and only 52 intersections have "intelligent traffic lights" system. The introduction of this advanced traffic signal system is in the first stage and these traffic signals are not working properly. Therefore, police officers often control traffic manually when traffic congestion occurs. It will be necessary to expand the advanced traffic control system (at critical points) with real time synchronized system using traffic sensors to respond to the unstable traffic behavior. In addition, it is necessary to install the information signs of streets because traffic signs are insufficient in the city.

(3) Public Transport Issues

Public transport is a key for sustainable transport. Some issues to be considered for improvement are listed below.

1) Old Routes of Urban Public Bus

The routes for urban public buses have not been radically modified since the 1980s, which makes service provision inequitable for the citizens living in different area of the city. Both IRTRAMMA and MTI recognize the current situation that intercity buses complement the traffic demand of citizen of Managua within the city, although it is not suppported by law. The renewal of the routes should be analysed and carried out.

2) Disorder and Insufficient Function of Bus Terminals

One of the problems for public transport is about the arrangement of bus terminals. There are a number of small shops inside or around the bus terminals, which often disturbs the circulation of buses and other vehicles in the area. In addition, the terminals do not accommodate any urban public buseses, which hampers the connectivity for passengers. It should also be noted that the terminals are now located near the city center. This provides intercity bus passengers with easy access, although these numerous relatively large buses are generating heavy load to the traffic and thus aggravating congestion in the city. In addition, since the bus terminals are operated by the Municipal Corporation of Managua Markets (*Corporacion Municipal de Mercados de*

Managua: COMMEMA) whose main scope is not transport, the improvement of transport condition is not being prioritized.

The development of new bus terminals with relocation could be a solution.This option shall be examined in relation with future land use plan and transport plan based on the result of traffic demand forecast. ALMA, MTI, and PRONicaragua are considering the renovation of bus terminals, which should be coordinated with the master plan.

3) Subsidized Bus Fare

Heavy subsidy on urban public bus system is another issue. A low fare of NIO 2.50 per ride is made possible for the passengers owing to a good amount of subsidy by the Central Government. Accordingly, an optimization mechanism for concession is not supposed to be working properly.

In addition, according to the passenger interview survey, it turned out that a majority of citizen is ready for higher fare for cleaner and more secured transport service. Taking the result into consideration as well as the possibility that the higher fare of public transport causes an increase in private vehicle users, the fare level and financial structure should be considered for future development of public transport service.

4) Lack of Control and Facility for in Operation of Public Transport

There are illegal taxies serving the city. Eventhough these situations are complained by the authorized concessioners and recognized by authorities, they are not controlled properly because mainly of lack of institutional capacity.

Lack of designated proper space for taxies and mototaxies to wait for passengers is also a problem. Taxies are generating more traffic while looking for their clients, and mototaxis are disturbing traffic flow by parking on the roadside.

Urban public bus has designated spaces of bus bays mainly on principle roads; however, it is not the case for all the bus stops. And even with the bus bays, buses often cause congestion by stopping without approaching adequately to the bus bays. Proper control and guidance on the behaviour of bus drivers shall be necessary.

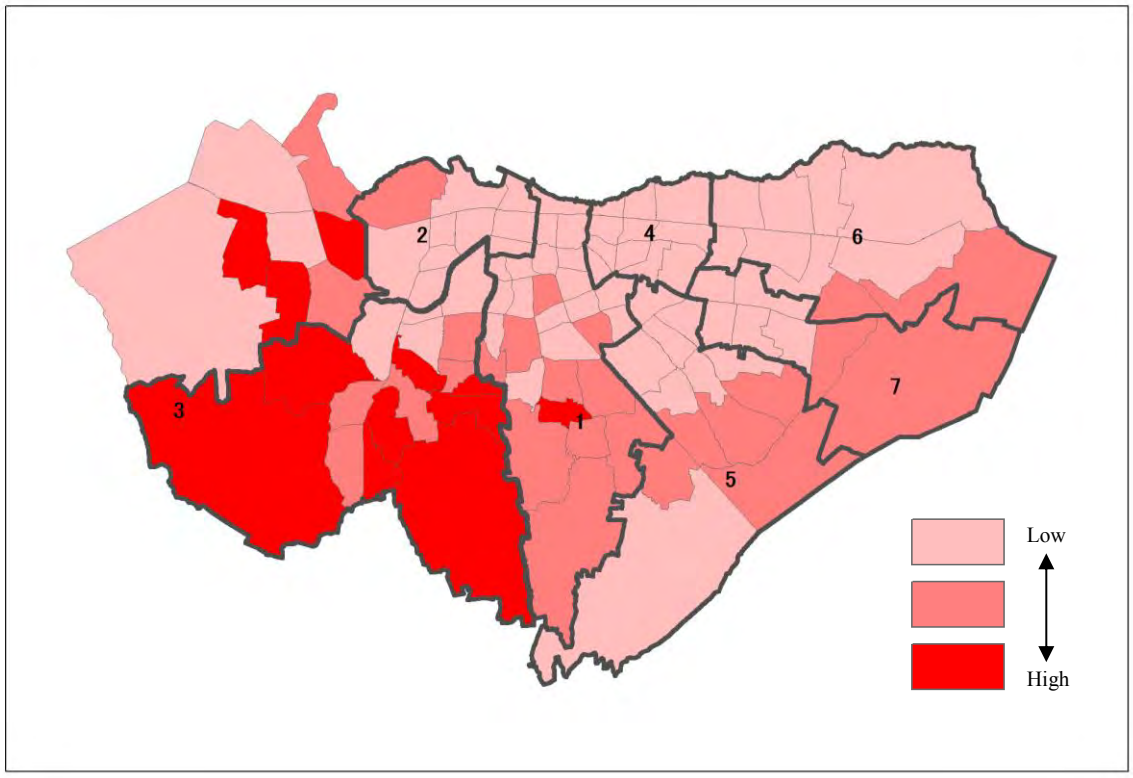
5) Lack of public transport

For the question about serious issues in the neighborhood, 7% of the people answered limited access to public transportation. Opinion about serious issues is summarized in the following table. Figure 4.6.2 shows the traffic zone that represents the percentage of the people who answered limited access to public transportation as a serious issue. The result indicates that peripheral area has a relatively higher ratio than center. Especially, District 3 has a high ratio. In the area with the highest ratio, around 47% of the people answered limited access. Some of the people need access to bus stop by using mototaxi or bicycle taxi. Such situation seems to be a reason.

Table 4.6.2 Most Serious Issue in Community or Living Environment

Item	Number of People	Ratio
Lack of basic infrastructure (water supply, electricity and sewage)	1,912	22%
Lack of safety	2,913	33%
Occurrence of disaster (flood, landslide)	316	4%
Environmental pollution/sanitation	641	7%
Bad or narrow roads	2,149	24%
Limited access to public transportation	641	7%
Other	235	3%

Source: JICA Study Team



Source: JICA Study Team

Figure 4.6.2 Ratio of People Who Answered "Limited Access to Public Transport"

CHAPTER 5 INFRASTRUCTURES AND DISASTER MITIGATION

5.1 Water Supply

5.1.1 Introduction

The potable water distribution system in Managua is managed by a governmental agency, the Nicaraguan Company for Water Pipes and Sewers (*Empresa Nicaraguense de Acueductos y Alcantarillados Sanitarios:* ENACAL). As suggested by the name of the entity, this is a nationwide agency responsible for the entire country and not just the capital.

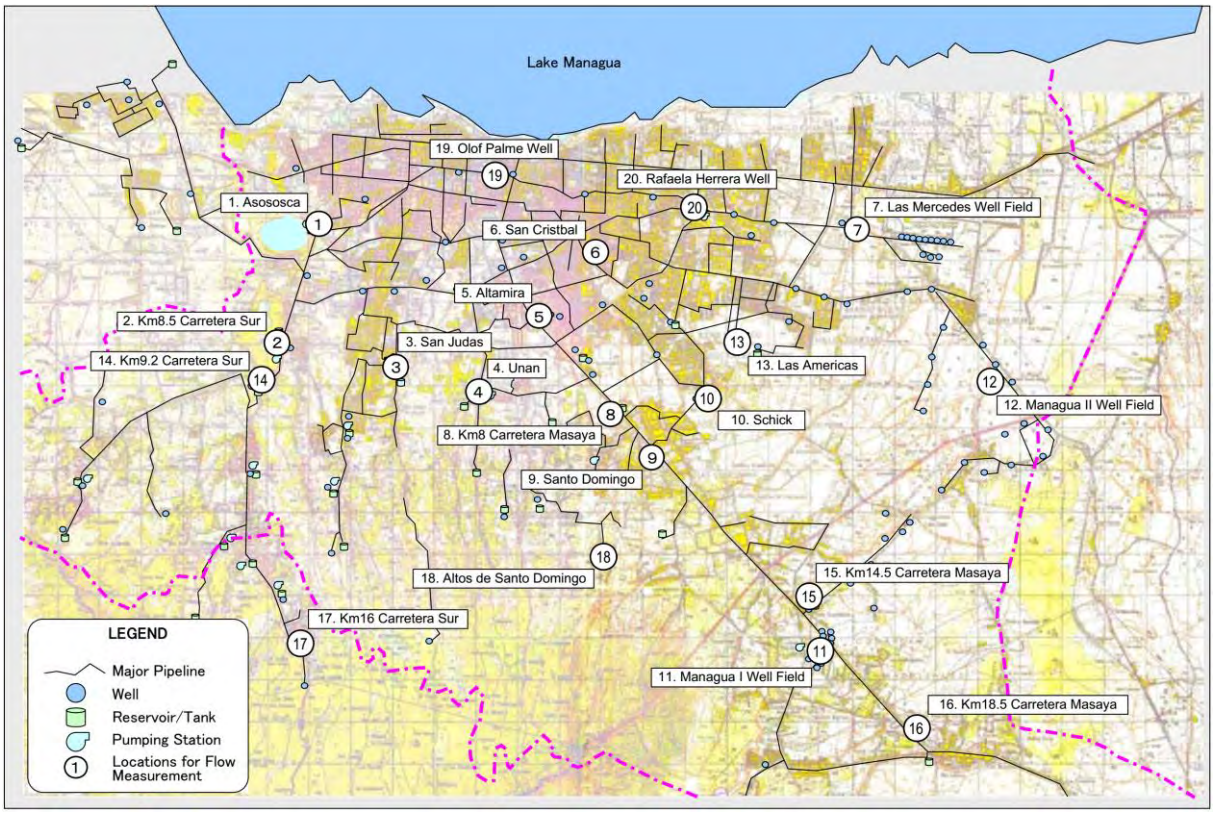
The ENACAL manages the water system for the entire country, and apparently, they have no official delineated area that they call "Managua". The limits established for the Urban Development Master Plan for Managua City (PDUM) are the official municipal boundary of Managua, and this is not likely coinciding perfectly with the area which ENACAL identified as "Managua". Populations, areas, and quantities of infrastructure all vary because of different study area limits.

The Managua region is in the tropical zone and receives approximately 1.2 m of rainfall annually. Most of this fall during the rainy season between the months of May and November and there are approximately 90 days of rain dispersed somewhat evenly among the season.

Managua is found to have a fairly well-developed water transmission and distribution system. The general water source for Managua are groundwater wells (there are approximately 100 groundwater wells), and pumping from Asososca Lake. At each source, pumped water is chlorinated and delivered to the transmission system, storage tanks, or directly to the distribution system.

The city is found on a gently sloping north face of an ancient volcano, up to the southern shore of Managua Lake. The elevations range from about 981 m at the southern boundary of the city to about 50 m at the lake shore. The average slope from north to south is about 3%. The utility identifies three different pressure zones. First is the low zone [*zona baja*], which ranges from 35 m to 85 m above sea level. Next is the high zone [*zona alta*], which ranges from 85 m to 135 m. And lastly, the superior zone [zona superior], which is above 135 m. Given the sloping face of the city, these zones generally run east-west across the city. Figure 5.1.1 illustrates the major facilities of the potable water system, as they existed in 2005.

Managua obtains its potable water from two sources: groundwater wells and Asososca Lake (which is a crater lake with virtually no watershed). All inflows to the lake are from the aquifers and there are three different aquifers identified in the city. These aquifers are termed west, central, and east aquifers. No rivers or reservoirs are utilized for water supply. From the available data in 2014, ENACAL reported that its water supply and distribution system provided water for approximately 94% of the people in its service area. Its service area covers a population of 1 million people, with approximately 200,000 retail connections.



Source: JICA 2005

Figure 5.1.1 Water Distribution System Major Components in 2005

In 2014, ENACAL stated that it produced 175 million m^3 of potable water, which is 480,000 m^3/d on average. Of the annual value, only 77 million m^3 was metered and accounted for. This value averages to 211,000 m^3/d (2.4 m^3/s). For the stated population served and the produced water value, the daily total water demand per capita is approximately 490 L/d/person. Performing this calculation for metered water and users, the value drops to a more reasonable value of 220 L/d/person.

The water extracted from various aquifers is generally of good character. The JICA study that was conducted in 2005 (see 5-1-2 (4)) identified a small number of wells that seemed to be presenting contamination. These wells were recommended to be taken offline. Otherwise, the extracted water is not treated, aside from chlorination.

5.1.2 Previous Studies and Projects

(1) The Study on Water Supply Project in Managua, JICA, 1993

The objectives of the project were to evaluate the groundwater potential in the area and propose new facilities to exploit the groundwater resource, and improve the delivery thereof to the system.

The project proposed the development of two additional well fields, pumps, and tanks, which will be all used to deliver extracted groundwater to the distribution system. The two well fields are denominated as Managua I and Managua II. These proposals were subsequently implemented in 1997 and 2000, respectively. This report has several important calculations and conclusions as follows:

- Total available groundwater yield of 158 million m^3/yr (432,000 m^3/d);
- Current groundwater withdrawals of 112 million m^3/yr (306,000 m^3/d);
- Current domestic per-capita demand of 175 L/d/person, excluding industrial uses;
- Future total per-capita demand of 300 L/d/person;
- Future demand of 526,000 m^3/d;
- Water leakage at 27%;
- Effective but non-revenue water at 26%; and
- Shifting of pumping from the central aquifer to new wells in the east aquifer.

(2) *Estudio de Diseño Básico para el Proyecto de Mejoramiento del Sistema de Abastecimiento de Agua Potable de la Ciudad de Managua*, JICA, 1995

This project sought to implement the first phase of improvements proposed in the study of 1993. The improvements were a new well field along the Masaya Highway (Managua I) in the southeast side of the city, plus transmission lines and storage tanks. The following were calculated:

- Domestic per capita demand of 187 L/d,
- Design demand of 312 L/d/person, and
- Leakage rate of 30%.

(3) *Estudio de Diseño Básico para el Proyecto de Abastecimiento de Agua de la Ciudad de Managua, Fase II*, JICA, 1998

This was the preliminary design for the second well field expansion recommended in the 1993 JICA study. Its objective was to produce 110,000 m^3/d from the new well field in the east aquifer (Managua II well field). It included the installation of 17 new wells, two storage tanks, and approximately 8 km of transmission piping. This report indicates a leakage rate of 45%.

(4) The Study on Improvement of Water Supply System in Managua, JICA, 2005

In early 2004, ENACAL and JICA signed an agreement to perform a comprehensive master plan for the water system, culminating in the December 2005 publication *The Study on Improvement of Water Supply System in Managua*.

This project performed the following:

- Extensive groundwater quality analyses,
- Detailed water balance study,
- Leakage surveys,
- Customer surveys to estimate use patterns,
- Flow and pressure monitoring,
- Hydraulic modeling, and
- Financial capacity evaluations.

It established a long-term plan consisting of the following:

- Rehabilitation and protection of existing water sources,
- Reduction of leakage and wastage,
- Increase in the efficiency of water transmission and distribution systems, and
- Establishment of a basic financial framework for the management of water services.

The study proposed a lengthy and detailed series of steps to improve the water supply and distribution system including the following:

- Rehabilitating and refurbishing wells;
- Removing from service certain wells with significant levels of contaminants;
- Micro-sectorizing as a method to reduce leakage and wastage;
- Macro-sectorizing of the network for better control and monitoring;
- Replacing more than 70,000 service meters at homes;
- Procure equipment to detect and repair leaks;
- Staged program to connect approximately 40,000 customers in unofficial settlements;
- Distribution system improvements (tanks and transmission lines);
- Provisions for future expansions of the distribution network;
- Independent accounting for Managua;
- Increases in water tariffs ranging from 5% to 30%; and
- Additional training.

These improvements were prioritized and segregated into 25-year phases with a total projected cost of USD 66 million (2005 costs).

Some noteworthy statistics and calculations from that document are given below. It should be noted that this study clearly includes suburban areas extending beyond the city limits.

- 1.05 million population served
- Projected growth rate of 2.0%
- Projected population of 1.3 million in 2015
- Per-capita demand of 175 L/d/person, after calculating a range of 151 to 278 L/d/person
- Calculated optimum withdrawals from Lago Asososca of 30,000 m^3/d
- "Sustainable" withdrawals of 403,000 m^3/d
- Projected water consumption of 271,000 m^3/d by 2015
- Projected water demand of 398,000 m^3/d by 2015
- Leakage rate of 35%, resulting from field studies and not just estimates

- Wastage rate of 10%
- At least 16% of existing water meters are ineffective
- Approximately 9% of existing connections are unauthorized or illegal

In the projections of future water use, they assume the leakage will be reduced from 35% to 23%, and wastage reduced from 10% to 2%, for a total of 25% ineffective water by 2015.

(5) *Proyecto de Agua y Saneamiento de Managua*, World Bank, 2008

The World Bank approved the *Proyecto de Agua y Saneamiento de Managua* in 2008. This project implemented some of the recommendations indicated in the JICA study in 2005. Implemented in the potable water system were the following:

- Pipes and valves to sectorize parts of the network,
- Installed new wells to increase supply,
- Construct new storage tanks,
- More than 30 km of pipelines,
- Nearly 6,000 service meters,
- Nearly 15,000 new service connections in unauthorized settlements,
- Replaced 72,000 meters, and
- Substituted nine wells from the Managua I and Managua II well fields.

(6) Proyecto de Optimación del Sistema de Abastecimiento, Mejora de los Indices de Macro y Micromedición, Planificación, y Mejoramiento Medio-Ambiental, Spanish Agency for International Development Cooperation (*Agencia Española de Cooperación Internacional para el Desarrollo:* AECID), 2008

This project was financed by the Spanish government. It attempted to implement some of the recommendations of the JICA study in 2005, plus some additional improvements determined in parallel to the JICA study. This project focused on attacking problems in the zona baja along Managua Lake. It included steps to detect and repair leaks, inventory the system in the study area, create hydraulic models of the system, and perform physical installations to sectorize the network.

The study identified nearly 2,000 m^3/hr of leaks in the project area. This is 48,000 m^3/d, or equivalent to the production from Lago Asososca, or more than 10% of the total daily production for Managua. In the leak detection regimen, it was found that roughly 3/4 of the detected leaks occurred at service connections and meters. It also concluded that for leaks occurring in distribution pipes, the most significant cause was joints in asbestos cement pipelines.

It identified withdrawals from Lago Asososca of 48,000 m^3/d on average, still exceeding the recommendations from the JICA study in 2005. It used a net consumption rate of 275 L/d/person, and up to 422 L/d/person demand to include leakage.

(7) Water Supply Program for Managua, IDB, 2010

The project funded by the Inter-American Development Bank (IDB) is titled the Water Supply Program for Managua (NI-L1029), and often identified by its loan number "2471/BL-NI". This project provided the funding for the improvement of the water distribution system in 20 settlements, installing over 50 km of pipelines, more than 8,000 new connections with meters, rehabilitating 50 wells, building 11 new wells, and other sectorization and leak reduction measures. This project also included many wastewater system improvements.

(8) *Programa Integral Sectorial de Agua y Saneamiento Humano de Nicaragua*, AECID, 2008

It is also worth mentioning this project referred to as PISASH is one of the largest investments in the sanitation sector in Central America. However, it has no allocated projects for potable water supply system in Managua.

(9) *Plan Maestro de Eficiencia Opertiva en ENACAL*, World Bank, 2015

This project was directly focused on reducing energy costs of the utility and to reduce non-revenue water. The study highlights that the non-revenue water greatly affects the costs for energy in the system. It also notes that non-revenue water remains high despite the previous projects designed to reduce it.

The project performed a water balance on the system using widely-recognized international calculations. It determined that the unaccounted-for water value was in the range of 50%. This is still extremely high, especially considering the efforts from the JICA study in 2005 to stem water losses. Likewise, it calculated that the water losses accounted for 40% of the total annual electricity cost to ENACAL.

The project also included a survey of approximately 13,000 ENACAL customers on the reliability of water service at their domiciles. Over half of respondents indicated the water service present 24 hours a day. Eighty percent of users reported water available more than 12 hours per day.

For 2014, ENACAL had about US$60 million in gross revenue, but $100 million in costs. As explained by the Executive Director of ENACAL, the deficit is covered by the national government.

The study recommended improved telemetry and data collection and more precise metering via ultrasonic flow meters for the more than 90 microsectors that had been created in several projects to date. This study included a detailed action plan in two stages, starting in 2016 and extending up to 2030, including a projected cost of over $70 million. The proposed actions were 3 main groups: improvements to planning and operation within the utility, reduction of leaks through physical improvements, and reduction in apparent losses through better metering and public relations. Because ENACAL spends $40 million a year on electricity, the return period for the investment was about 3 years.

(10) Strengthening of Capacity to Manage Unaccounted-for Water in Managua, JICA, 2016

A JICA Technical Assistance project commenced in January 2017. At the onset of the project, the team recognized that the many of the objectives established in the JICA study in 2005 are delayed or abandoned. The biggest problem for ENACAL is non-revenue water, and the project scope was adjusted

to focused on that. JICA will procure and deliver equipment to train ENACAL for more efficient activities in reducing non-revenue water. The project also includes training of ENACAL personnel. The project created a concise catalogue of the infrastructure of the water supply system in Managua.

(11) Report on Local Government, Municipality of Managua, ALMA, 2015

This document describes the availability of all public services to the citizens, segregated by Municipal Districts. The information reflects all services, ranging from electricity to water to sanitation to parks and cemeteries. It identified that inside Managua, 62% of residents have water supply connections to their homes, while another 37% have it available "outside their home but on their property". That left just 1% as using tanks, public faucets, etc.

The document reports on the problems within each district, identifying barrios that don't receive water, or have water for few hours per day. The descriptions here are general and anecdotal with no quantification. Generally, these descriptions of service by district and barrio present an image of water service that is significantly worse than that portrayed with the data showing water service arriving to the property of 99% of all residents. This draws some doubt to the confidence of this survey and other surveys on the water system as well. Perhaps the respondents do not understand the questions appropriately.

(12) Meeting with ENACAL Planning Director

JICA study team met with Director of Planning for ENACAL to discuss current problems in Managua and any on-going projects to fix. He identified that non-revenue water continues to be the main problem affecting Managua City. The director noted that water supply in the future is somewhat of an issue understanding that the current aquifer has a limited capacity. Anecdotally, ENACAL has not noticed grave dropping of the aquifer level in light of current pumping quantities. The director admitted that additional sources of water may be required in the future.

ENACAL is in the beginning stages of developing a project with the Inter-American Development Bank for a comprehensive water supply improvements (with a smaller component of sanitation) to address the problems in the water supply system. The value of the project is approximately US$300 million. The results of the current JICA Technical Assistance project will help define the scope and details of the project. In discussing the improvements and investments recommended in the Operational Efficiency study (see section (1) above), it was admitted that there was no specific plan, program, or funding in place to execute the action plan. He mentioned that the current SCADA system is incomplete, and that the water system has not been converted into GIS format.

5.1.3 Identified Problems

(1) Non-revenue Water

Water which is produced and pumped into the system but is not sold to customers is called non-revenue water. In Managua during 2014, ENACAL produced 175 million m^3, but only registered 77 million m^3 at the meters of consumers. This means 98 million m^3 of water was pumped from the ground, chlorinated, and otherwise pumped or stored in the distribution system at a cost to ENACAL, but was not purchased. In other words, ENACAL receives payment for only about 45% of the water it produces. In this case the value of 55% non-revenue water is known to be a problem, and has been the subject of several projects in the past decade. In a meeting with the Executive President of ENACAL, he identified it as still the biggest issue affecting the utility.

This value should be carefully considered because there are two major components of non-revenue water. The first component is water that is lost through physical problems in the distribution system that transports water to the consumers, i.e., generally leaks. This phenomenon can be detected and repaired. The second component is water successfully delivered to consumers, yet the provider receives no compensation for such water. This includes clandestine connections and erroneous meters.

The ENACAL has executed various projects through international lenders to address the issue of non-revenue water. These projects have included tasks to identify and repair leaks as well as procure and install more meters. The JICA study in 2005, after a pilot leak detection program, estimated that leaks accounted for 35% of total water produced and wastage accounted for 10%. It was also estimated that 9% of physical connections to the system were illegal or unauthorized. The subsequent project funded by AECID found roughly 20% leakage in half of the system, roughly corroborating the high non-revenue water factor. However, the latest figures from ENACAL suggest the value is still high even after the projects which were meant to control it were implemented.

The origin of leaks is uncertain, as previous reports vary on the attribution of leaks to either domestic connections and meters, or leaking pipes in the distribution system. The "*Proyecto de Optimación del Sistema de Abastecimiento, Mejora de los Indices de Macro y Micromedición, Planificación, y Mejoramiento Medio-Ambiental* (2008)" concluded that "for leaks occurring in distribution pipes proper, the most significant cause was joints in asbestos cement pipelines." Asbesto-cement pipes are prevalent in the older parts of the city, near the lake. These pipes are old, and due to their fragility tend to be vulnerable to seismic activity and other breaking phenomena. Other projects and programs have addressed the replacement of meters and domestic connections, but no pipe replacement projects for older pipes have occurred.

(2) Unreliable Water Service

Through a combination of well spacing, topography, network design, and pumping capacity, potable water is not available to all users 24 hours a day because the system is not capable of delivering water at pressure to all areas of the city at all times. A recent survey published in a local newspaper showed

that 40% of residents do not have a continuous water supply at their tap[1]. Of those, more than 20% described receiving water no more than once per month.

The performance of the distribution network has been studied by ENACAL and other consultants. A map from 2008 publicized by ENACAL suggests that only 1/3 of customers have water more than 20 hours per day. The ENACAL has undertaken a series of steps to alleviate this problem, namely, macro- and micro-sectorization and other control features to more optimally distribute water, as well as additional water storage tanks and groundwater pumping facilities.

(3) Water Supply Availability

The ENACAL has been pumping more than 450,000 m^3/d at least since 2010, with as much as 490,000 m^3/d in 2010. This is 20% larger than the sustainable yield of 400,000 m^3/d determined in the various water balance calculations performed above. However, anecdotally, the operators of the pumping wells at ENACAL stated that there were no problems in the well withdrawals. Given that the projected maximum sustainable yield from the groundwater sources is 403,000 m^3/d and that the utility has been pumping much more than that for so long, then it gives confidence that the source is viable and the 403,000 m^3/d is possibly conservative.

(4) Increase Service to Sub-Centers

As described in chapter 3, high density developments in designated areas will be encouraged. Currently, the typical level of water supply service in Managua is substandard. The water supply system is designed for the existing urban pattern of widespread low-density development.

A high-density development will create a point of water demand that the existing system will be unable to serve. As such, local water system improvements must be made at each of these locations. Since ENACAL operates consistently at a deficit, there must be a plan or funding mechanism recognized to make improvements to ensure those high-density developments can occur.

(5) Accommodate Long-Term Growth

Population estimates described elsewhere in this master plan show the population growth by 400,000 in the planning period. This population growth will increase the water demand. Considering that the current level of service in the water supply system is substandard now, the service will only deteriorate in the face of additional demands. ENACAL is currently operating at a deficit currently where the billing rate is insufficient to cover the costs in the agency. This deficit will continue to grow. Future capital investments in pumps, tanks, and pipelines will have to be made to serve the population as it grows. This should be a significant burden to ENACAL given their current financial standing.

[1] El Nuevo Diario, 20 April 2016

5.1.4 Evaluation

The scope of the infrastructure part of this master plan is to identify improvements to infrastructure to meet the minimum criteria for sustainable standard of living for the current population as well as for the future growth. The minimum criteria should accommodate the land use projections presented elsewhere in this study.

(1) Water Requirements Projection

In these projections, because non-revenue water is so high, it is important to distinguish two different water demand values. One is the effective water demand. This means water that is delivered to the customer's meter and is used by the customer in a conscientious manner. The second is the total water demand. This is the amount that must be pumped at the source and transported to provide for the effective water demand at the customer's meter; this includes leakage and other factors.

The projection of the effective water demand in Managua is dependent on many factors, first is the population. This is expected to increase continuously and exponentially for 24 years. If each person continues to use the same amount of water and leakage rates in the system are unchanged, then, the total water demand will rise equivalent to population.

Additionally, the percent of inhabitants connected to the system as paying metered customers should increase over time. That figure was estimated as 94% in 2014. The goal for any utility is 100%; every citizen lives in a domicile with a connection to the potable water system. In this projection, a coverage of 100% is assumed for the first year.

The projected water use per person also plays a large part in the calculation of total water demand. As calculated above, the effective water use per person was 220 L/d. Projecting this value in the future is highly subjective. Economic development may cause this value to increase, while a well-publicized water conservation campaign and responsive citizens could reduce this value. An increase in the water tariff as proposed in previous projects also could suppress this value.

Related to this factor is the number of customers that receive potable water service at all hours. Some customers in Managua do not receive water consistently. This can suppress the per capita water demand. As ENACAL continues to improve the system and water becomes more reliable for customers, water demand per capita could increase.

Figure 5.1.2 illustrates the projected effective water demand under several scenarios. In the average scenario, a projected population growth rate of 1.5% per year is assumed. Also, it is assumed that the average per capita consumption remains similar to today, i.e., 220 L/d/person. The higher demand scenario suggests a maximum case of 1.5% growth, but per capita demand increases to 300 L/d over the project period.

This projection of effective water demand should be considered with regards to the recommended sustainable water withdrawals from the underground aquifers: 403,000 m^3/d. Only the higher demand

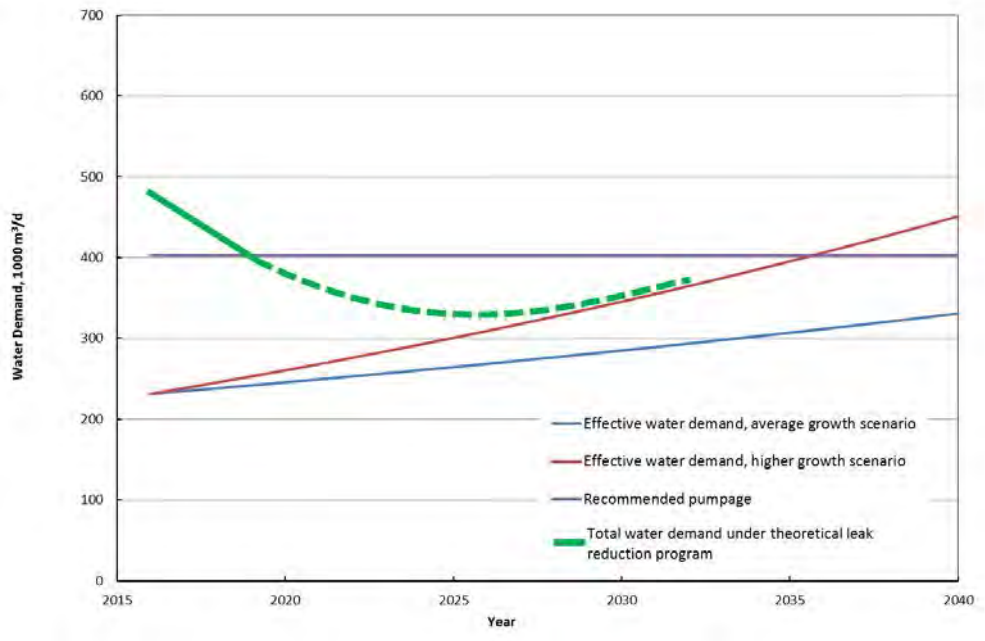
scenario reaches this value during the project planning period. Hence, the water supply is seemingly secure for the next 25 years.

However, it is also appropriate to consider the total water demand, illustrating the actual pumping and the impact of population growth. In the following figure the effective water demand scenarios are plotted with actual pumping and the recommended maximum withdrawal rate.

The current total water demand (as of 2014) was about 480,000 m^3/d. If no improvements were performed on the system, i.e., leakage and wastage continue at their current rates, the total water demand is expected to increase over time as the population within the project area increases (cyan line). Since the total water demand is starting well above the estimated maximum withdrawals, this clearly appears to be a non-sustainable situation.

What is necessary in this scenario is the improvement in the water supply and distribution system to bring the total water demand in line with the effective water use. The ENACAL should implement a program to reduce leaks, install effective metering, and reduce wastage. This could be a short-term priority goal to reduce total water pumping to the recommended level, say within five years. Then there could be a long-term goal to reduce leakage and wastage until the effective and total water demands are nearly equal.

To put this scenario in numbers, the total water demand in 2016 is approximately 484,000 m^3/d. The maximum sustainable water withdrawal rate is 403,000 m^3/d, so the utility must reduce leakage by about 80,000 m^3/d. This is a reduction of 15%, or maybe one third of the current leakage rate calculated in some previous studies. This could be done in five years, requiring a leak reduction program to repair 3% (16,000 m^3/d) per year.



Source: JICA study team

Figure 5.1.2 Potential Solution

(2) Water Supply Availability

Since 2010, ENACAL has been pumping between 160 to 180 million m^3 from the aquifer, through the 100 or so groundwater wells, plus pumping from Lago Asososca. This is equivalent to about 490,000 m^3/day.

According to the operators at ENACAL, this has not resulted in any lowering of the groundwater table. Hence, one may intuitively conclude that the withdrawals from the aquifer are acceptable and sustainable. Several studies have attempted to quantify the sustainable withdrawals from the aquifer but these numbers are varied, and additionally, the projections from each of the three different aquifers are varied as well.

The report of JICA study in 2005 stated that the maximum yield should be 403,000 m^3/d, a combination of wells and pumping of 30,000 m^3/d from Lake Asososca. They evaluated 13 years of data ending in 2003 that showed an increasing production from 100 million to 150 million m^3 per year.

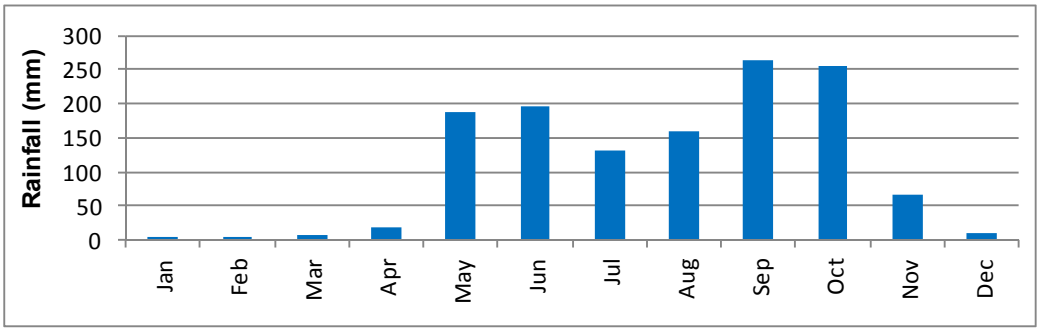
5.2 Water Resources

5.2.1 Hydrological Conditions in and Around the Study Area

This subsection describes hydrological conditions in and around the study area as fundamental conditions of water resources in the study area.

(1) Rainfall

The annual rainfall in the study area is ranging between 1,200 and 2,000 mm per year. Figure 5.2.1 shows the mean monthly rainfall from 1980 to 2010 at the international airport of Managua. The mean annual rainfall at the rainfall station in the airport is 1,301.2 mm.



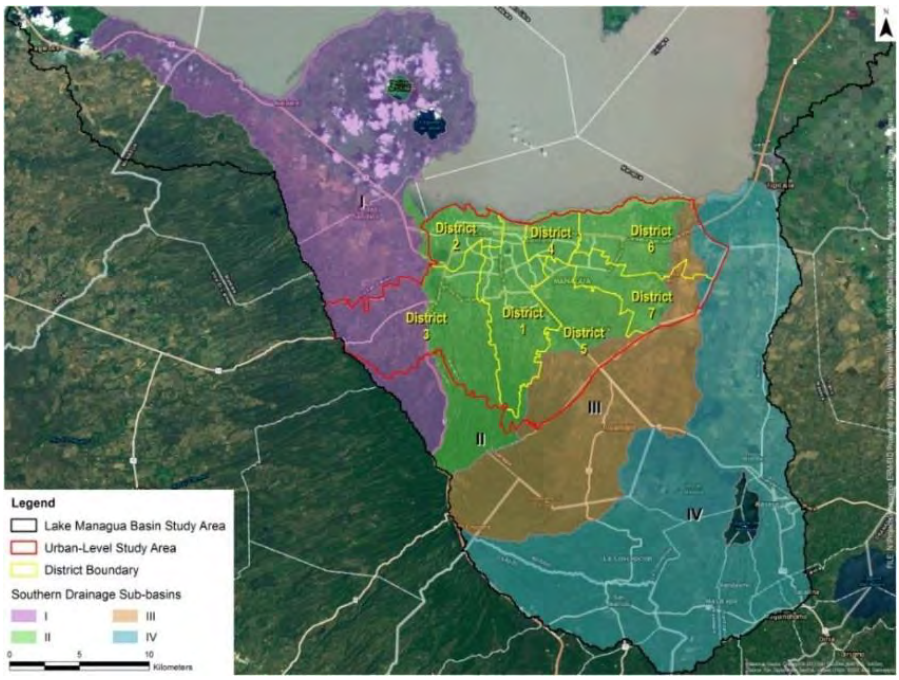
Source: Prepared by the JICA Study Team based on information of "*Informe Preliminar Caso de Estudio: Anexo A: Línea Base de las Condiciones Existentes*, IDB, March 2014".

Figure 5.2.1 Mean Monthly Rainfall in Managua City (1980-2010)

(2) River System

River basins in the south side of Managua Lake are classified into four sub-basins (i.e., I, II, III, and IV) based on geomorphological, environmental, and urban development characteristics. The four sub-basins cover an area of 825 km². As shown in Figure 5.2.2, most of Managua City is located in sub-basin II,

which covers an area of 217 km². The rivers flowing into Managua City originate in mountains at an altitude of 916 m and flow down the steep terrain northward, until they finally reach the Managua Lake with an average water level of 41 m. There is no large-scale "río" or river in the study area but small rivers namely "cauce" drain out surface water within the river basins. The river flow water in the study area is not reliable as a water resource of the area because all cauces dry up during the dry season. River flow discharges were not observed in the study area.



Source: *Informe Preliminar Caso de Estudio: Anexo A: Línea Base de las Condiciones Existentes*, IDB, March 2014.

Figure 5.2.2 River Basins in the South Side of Managua Lake

(3) Water Body

There are three major water bodies in the study area, namely: Asososca, Tiscapa, and Nejapa Lakes. The surface areas of the three lakes are 120.0 ha, 24.5 ha, and 22.9 ha, respectively, and they are specified as protected areas. The water body accounts for 1.14% of the study area.

5.2.2 Current Status of Water Resources

(1) Laws and Regulations for Water Resources

Previously, the legal framework for water management was historically deficient with a lack of a specific water law and relevant regulations for numerous agencies sharing management duties. There was a 1998 reform aimed at specifying management roles for each of the management institutions. Then, the National Water Law (Ley 620) was approved by the National Assembly in 2007 which stipulates water resources management. The water law regulates water use by different sectors and aims at protecting and preserving the country's water resources. Furthermore, Nicaragua's congressional environment and natural resources committee approved its 2010 work plan giving priority to create the National Water Authority (ANA: *Autoridad Nacional del Agua*). According to the water law, this council is composed of representatives of the following institutions and organizations:

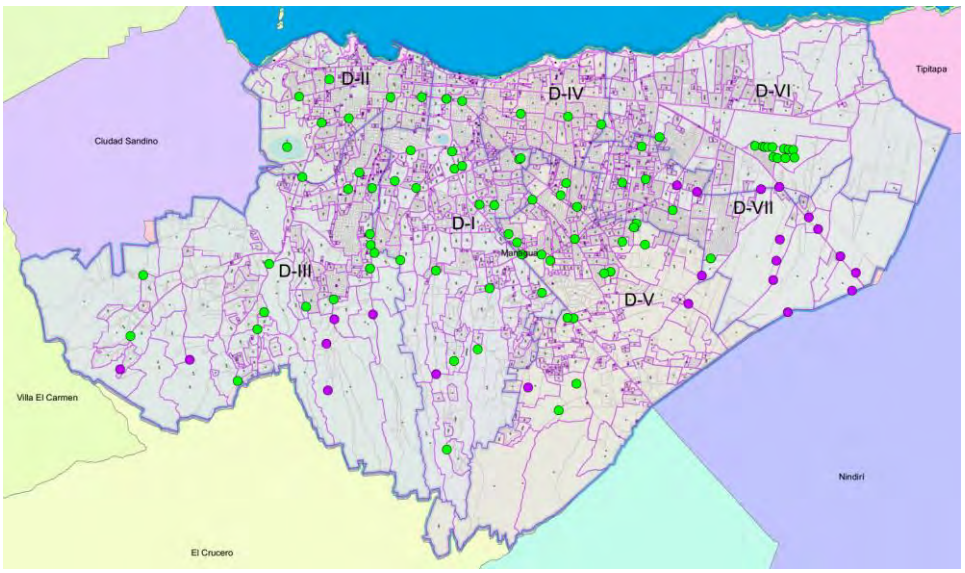
- Ministry of Environment and Natural Resource (*Ministerio del Ambiente y los Recursos Naturales:* MARENA) as chairperson;
- Ministry of Agriculture and Forestry (*Ministerio Agropecuario y Forestal:* MAGFOR[2]);
- Ministry of Health (*Ministerio de Salud:* MINSA);
- Ministry of Development, Industry and Commerce (*Ministerio de Fomento, Industria y Comercio:* MIFIC);
- Nicaraguan Institute of Territorial Studies (*Instituto Nicaragüense de Estudios Territoriales:* INETER);
- Intendance of Potable Water and Sewerage;
- Energy Administration;
- A representative of the Ministry of Energy and Mines;
- A representative of the National Commission of Water Supply and Sewerage;
- Health Authority (National Drinking Water and Sewerage Commission (*Comisión Nacional de Agua Potable y Alcantarillado Sanitario:* CONAPAS);
- A representative of each of regional council;
- Autonomous of Atlantic Coast;
- Four representatives of the productive sectors; and
- Four representatives of user organizations.

ANA is a decentralized organization with administrative and financial autonomy under the water law which will be responsible for drawing up a national water resources plan, keeping track of water levels in basins, maintaining a public registry of water rights, and promoting the use and development of water resources. The authority is also expected to monitor the development of water-related infrastructure.

(2) Water Sources for Water Supply in the Study Area

The ENACAL sources raw water from wells and the Asososca Lake for the domestic water supply in the study area. The Managua Lake, which has a 1,052.9 km² surface area, has a huge potential for becoming a water resource but is quite contaminated by heavy metals, pesticide and domestic wastewater according to related authorities and some previous study reports. Water taken from the lake have a risk of contamination for use as tap water. All 149 wells in Managua City are under operation. Figure 5.2.3 shows the locations of the existing water sources in the study area.

[2] MAGFOR is changed its organization to Ministry of Agriculture (MAG) and National Forestry Institute (INAFOR)



Source: Prepared by the JICA Study Team based on information of ENACAL.

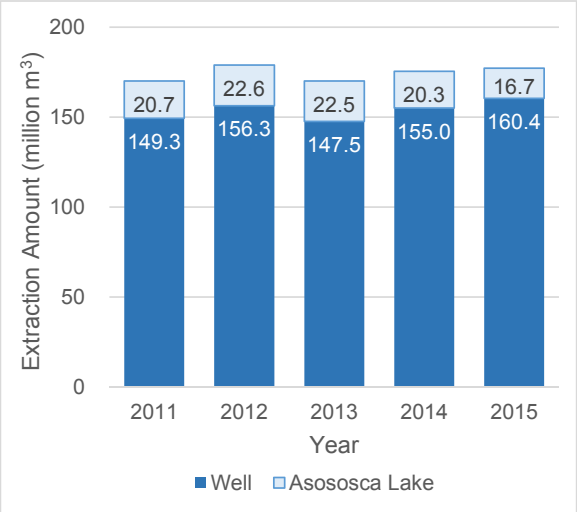
Figure 5.2.3 Locations of the Existing Water Sources in the Study Area

(3) Amount of Raw Water Intake

Figure 5.2.4 shows the recent annual extraction amount of raw water from wells in Managua City and Asososca Lake. Annual extraction amount of raw water in 2015 was 177.1 million m^3 of which 16.7 million m^3, or 9.4% of the total amount, was taken from Asososca Lake. Within the past five years, the daily average extraction amount of raw water from Asososca Lake ranges from 61,736 m^3 in 2011 to 45,657 m^3 in 2015.

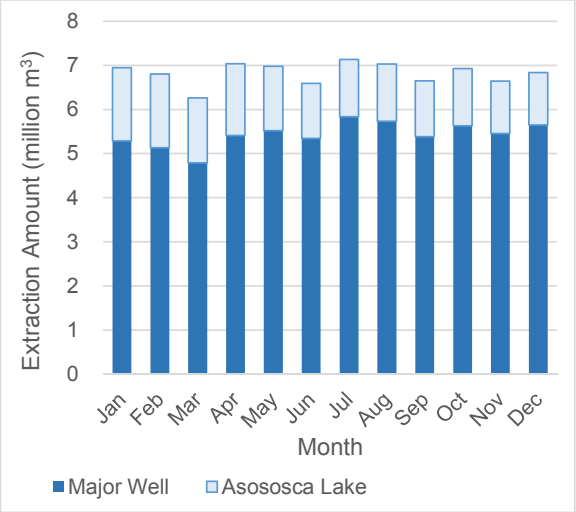
A JICA study in 2005, "Study on Improvement of Water Supply System in Managua in the Republic of Nicaragua", recommended that the daily extraction amount from Asososca Lake shall be less than 30,000 m^3 from the viewpoint of securing water quality; because contaminated water from Managua Lake will infiltrate to Asososca Lake when water the level of Asososca Lake is lower than that of Managua Lake. However, the operation status has not improved. Figure 5.2.5 shows the monthly extraction amount of raw water from major water sources, i.e., Managua I and II, Sabana Grande, and Las Mercedes areas in Managua City in 2015. The extraction amount from Asososca Lake during dry season, January to April, was approximately 1.6 million m^3/month which is slightly higher than the amount during rainy season. In order to reduce the extraction amount of raw water from Asososca Lake and to relocate some of the wells located near the Managua Lake coast, alternative water sources shall be developed but such future development plan is not yet pursued.

Currently, aged existing water source facilities lead tendency to reduce raw water extraction amount. Proper maintenance and renovations on the aged facilities to recover a water extraction function are required.



Source: Prepared by the JICA Study Team based on information from ENACAL

Figure 5.2.4 Recent Annual Extraction Amount of Raw Water in Managua City



Source: Prepared by the JICA Study Team based on information from ENACAL

Figure 5.2.5 Monthly Extraction Amount of Raw Water from Major Water Sources in Managua City in 2015

(4) Groundwater Recharge Area in Upstream Basin

Green areas including forests, grasslands, cropping areas, and recreation areas account for 14.97% of the study area according to the latest land use map in June 2016. Within this, forest area accounts for 5.42% of the study area. There are no national forests in river basins flowing into Managua City. Natural forests in the upstream area are often burned to be changed into cropping areas and farmlands as shown in Figure 5.2.6. Such cropping areas and farmlands often have no appropriate construction and maintenance works by owners (e.g., land with relatively steep slope requires bench terrace works to avoid rapid flow out of soil and rainwater from the land). The land use changes from forest to cultivation lands are not inacceptable but changed lands highly require appropriate construction and maintenance works to maintain the land from the viewpoint of water resources management. The National Forestry Institute (*Instituto Nacional Forestal:* INAFOR), ALMA, and other organizations have implemented reforestation program to recover the natural condition of the recharge area of the aquifer once developed as burned field and farmland since 2007.

An example of their activities is shown in Figure 5.2.6 and Figure 5.2.7 in the next subsection.

Many natural forests owned by local people are changed as agricultural lands.
Source: JICA study team

Figure 5.2.6 Burnt Field for Beans Production

Reforested area. Technical advice and young tree are given by INAFOR.
Source: JICA study team

Figure 5.2.7 Reforestation by INAFOR

5.3 Wastewater Disposal, Sewerage, and Stormwater Drainage

5.3.1 Sewage Collection Current Status

The urban development in Managua has focused on building new streets and barrios on the periphery of the old city including area in the periphery of Asososca Lake which is an important source of drinking water. In Managua, the low-income barrios tend to be located either in the center or on the outskirts of the city. Several of them have community development committees and access to health and education centers.

The sewerage systems and wastewater treatment facilities in Managua City are managed by ENACAL. ENACAL is a decentralized public organization engaged in the administration of drinking water and sewerage systems in the whole country. Table 5.3.1 shows the average sewage flow collected and treated. ENACAL declares (unpublished) that the actual coverage of the sewerage services at Managua Metropolitan area is approximately 74%.

Table 5.3.1 Estimated Sewage Flow Collected and Treated in Managua City

	Managua City Average Annual Sewage Flow m^3/sec					
Year	2010	2011	2012	2013	2014	2015
Collected Flow	1.17	1.20	1.39	1.49	1.50	ND**
Treated Flow	1.03	1.20	1.12	1.30	1.42	1.59

Source: ENACAL, based on estimated number of sewage connections x 0.8 of water per capita

There is still a large population in the settlements relying on simple latrines, infiltration pits, and in minor cases, discharging directly to stormwater drainage channels or no sanitary facilities at all. Besides, in other unsewered areas, septic tanks are commonly used. In the peri-urban areas, it is quite common

to see on-site sanitation systems such as latrines and toilets with no drainage. It is even more common to find septic chambers, both with and without absorption wells. As a result, fecal sludge and excreta from sanitation systems tend to exceed the capacity of on-site sanitary facilities and spill over into roads, ditches, gulley, and ravines near the collection point.

According to a World Bank study (2008), a household sampling survey in Managua City's peri-urban areas found that 50% of the households were connected to the sanitary sewerage network, 21% discharged their sewage into septic tanks or infiltration pits, and 23% used ordinary latrines. Of this last group, a large majority of the households had inadequate latrines or no sanitary facilities. The study concluded that the peri-urban barrios have conditions that are even more precarious than those in the country's rural communities and other small localities. The average income for a large proportion of the households in these low-income areas is about USD 161 to USD 428 per month. Latrine construction alone is not sufficient to eliminate the fecal threat. Latrine and septic or interceptor tank contents, or the so-called fecal sludge, have to be disposed and treated in an adequate manner to safeguard public health and the environment (one truck dumping sludge indiscriminately is equivalent to the open defecation of 5,000 people). In Managua City, the companies that provide septic tank and cesspool sludge removal services were originally in the business of plumbing and selling water from trucks. Subsequently, in response to the demand created by sectors of the population without access to the sanitary sewerage system, these companies began to engage in removal, transportation, and final disposal of sludge from septic tanks, latrines, cesspools, and treatment plants from the industrial sector which frequently request for sludge management services. Figure 5.3.1 shows two common problems frequently observed in low income settlements: (A) the greywater spilling into ditch, and (B) the houses next to the stormwater channel discharging sanitary wastes and garbage (Barrio Villa Reconciliacion Sur).

Only 2% of the households using on-site sanitation type facilities use these private companies that provide mechanical pit-emptying services. This leaves a large percentage of on-site sanitation users whose pits are not regularly emptied. A reasonable estimation could be that two-thirds of the on-site facilities are either not emptied, abandoned unsafely, or overflows to the environment when full; while the remainder are either abandoned safely when they fill up (by covering the pit with soil) or have not yet filled and safely contain the waste. Six of the ten known collection companies discharge their fecal sludge at the Augusto C. Sandino Wastewater Treatment Plant (MWWTP). The ENACAL charges them USD 0.30/m^3. The collection companies generate a monthly sludge volume of 863.51 m^3 and fees amounting to USD 3,165.16 (ENACAL 2011).

The ALMA does not play a very active role in managing the collection and disposal of fecal sludge. The municipality does not get involved in the control, monitoring, or regulation of fecal sludge collection and disposal services. Its role is limited to granting a business operating license for tax purposes. The local governments register the companies and recognize them as formal businesses. The companies then pay taxes so they can have an operating license. However, they are not specifically certified for the management of hazardous solid waste or special waste. The sewerage systems are completely separated from the stormwater drainage system which is under the administration of ALMA.

5.3.2 Description of the Existing Sewerage System

The sewerage system of Managua City consists of approximately 1,000 km long mainly gravity flow sewers, mostly composed of secondary sewers of 200-mm diameter concrete and PVC pipes, thousands of manholes made of brick and mortar, main sewer lines, and two interceptors. The ENACAL's Master Plan for Sewerage Systems of Managua (*Plan Maestro de Sistemas de Alcantarillado de Managua:*

(A)

(B)

Source: JICA Study Team

Figure 5.3.1 (A) Settlements Rely on Simple Latrines, Spilling Greywater into Ditches, (B) Houses Discharging Directly to Stormwater Drainage Channels

PMASM) was formulated at the level of feasibility in 1995-1996, with design horizon to the year 2025. Figure 5.3.2 shows the projections in population, coverage, and sewage flow estimation developed for PMASM; the target year was 2025. The study focuses on the drainage basins, with estimates of population, levels of coverage, and contributions of wastewater, among others. Based on the PMASM, ENACAL made the rehabilitations and extensions of collectors, especially at the lower part of the city. The PMASM has had modifications in subsequent revisions of the years 1998 and 2002 by the effects of the implementation of the final designs and construction of the interceptors and the MWWTP. Table 5.3.2 shows the area of influence of the Managua Water and Sanitation Project (*Proyecto de Agua y Saneamiento de Managua:* PRASMA). In the last five years, the sewerage collection system has grown by 154 km, due to investment projects: PRASMA and the IDB No.2471.

Source: JICA Study Team

Figure 5.3.2 ENACAL Main Collectors of Managua City Sewerage System (PRASMA)

Table 5.3.2 Projections from the Master Plan for Sewerage System of Managua (PMASMA)

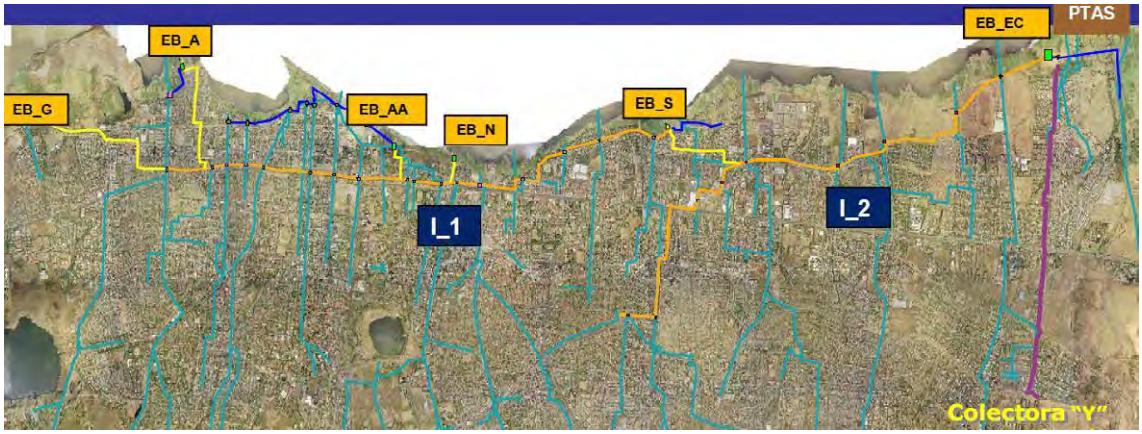
Description Target Year	2010	2015	2020	2025
Population in the Project Area, inhab	1,074,300	1,160,400	1,240,000	1,309,100
Sewerage Assumed Coverage, %	64	68	72	76
Designed Population, inhab	688,626	790,232	892,800	99,916
Assumed Connections	133,517	153,217	173,104	192,903
Annual Average Flow (Qav), m^3/s	2.113	2.392	2.559	2.725

ENACAL Magazine 2008

The ENACAL's PMASM defined the 28 main collectors arranged from south to north of the city, arranged by alphabetical order. The main collectors developed along the 200-km reach two interceptors of 22 km (planned length) and diameters between 750 mm and 2,000 mm. Interceptor No.1 is the coastal gravity trunk sewer, 15.0 km in length with diameters between 750 mm and 1,500 mm. Additionally, the Interceptor No.1 system has five main pumping stations distributed from west to east (sectors G, A, AA, N, and S) at the lowest level of the city, close to the floodplain of Managua Lake shore. These pumping stations collect the sewage from the lowest areas, and pump it up to Interceptor No.1.

Interceptor No.1 ends in the pumping station EBAS-S. One of the operational problems regarding maintenance of these six pumping stations is the accumulation of grit in the wet wells; volumes vary from 7 to 15 m^3/month. The ENACAL use Vactor trucks to eliminate grit with monthly or quarterly frequency. The main sewerage system is shown in Figure 5.3.3. The total collected flow is conducted from EBAS-S by a pressure main of 1,100 mm diameter to Interceptor No.2.

Interceptor No.2 is a gravity flow sewer, with 7.5 km length and diameters between 1,400 mm and 2,000 mm (reinforced fiberglass pipe - GRP), that leads sewage to the Cesar Sandino Wastewater Treatment Plant.



Source: JICA Study Team

Figure 5.3.3 Existing Main Sewerage System of Managua City

There is still pending construction by ENACAL for the upstream span of Interceptor No.2; that is a sewer main of 8.4-km length and 900 mm to 1,100 mm diameter. Table 5.3.3 shows the characteristics of the main pump stations of the system. However, there are also other ten minor pump stations in the system. To manage the exceptional overflows due to runoff inflow and infiltration into the sanitary sewers, and protect the main pump stations from damages (flood), there are 37 manually operated vortex-valves in the sewerage system, to control and divert the combined (sewage/stormwater) overflows (CSO), toward the nearest stormwater drainage channels. Just after a heavy storm event, ENACAL´s maintenance personnel visit all vortex-valve chambers to verify the proper operation of the valves and clean the chambers of debris.

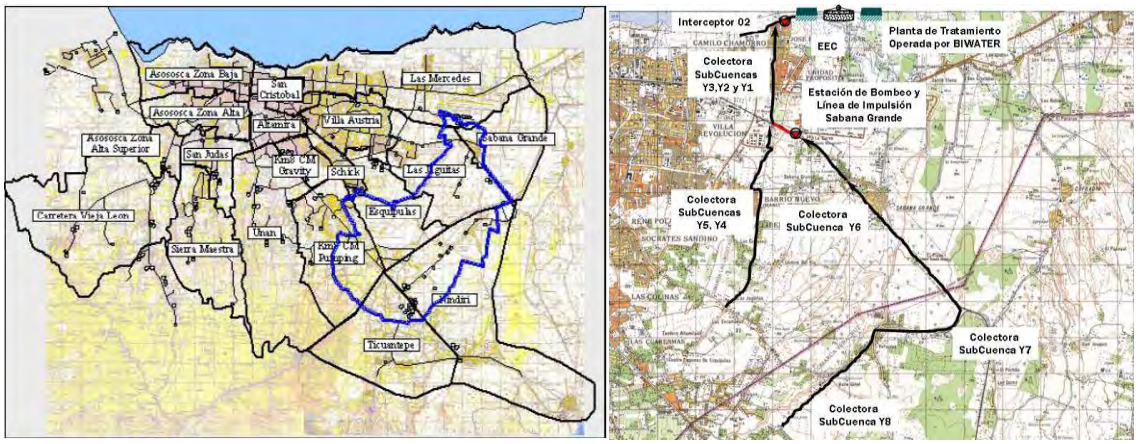
Table 5.3.3 Characteristics of the Main Pump Stations of Managua´s Sewerage System

Name	Barrio	No. of Pumps	Q pump L/s		Eff. Power by Pump kW	Screening/ Grit m^3/month	Pressure Line Diameter
			Design	Actual			
EBAS-G	Los Martinez	2+1	175	107	53	1 / 7	450-mm
EBAS-A	Acahualinca	2+2	103	76			300-mm
EBAS-AA	Pescadores	2+1	116	65		3 / -	300-mm
EBAS-N	Ruben Darío	2+1	14	0	Inactive - damaged by flood (2010)		
EBAS-S	J. Chamorro	2+1	1,538	1,126	235	8 / 13.3	1,100-mm
EBAS-lift Sta.	WWTP	2+2	4,270	1,800	247	10 / 15.0	4 x 1,100

Source: JICA Study Team. All the pump stations have mechanical screens, 40-mm opening and moto-generator.

Collector Y, a main collector recently built by ENACAL, has fundamental objective to minimize the risks of contamination of the Managua aquifer by collecting the sewage from a rapid population growth area; the sub-basin 3 of Managua, where there are main reserves of underground water for the capital.

This collector consists of 23.5-km total length and diameters ranging from ø 200-mm to ø 600-mm, through which most of the houses located east of Managua City, at the sectors of the Sabana Grande, Los Laureles, Valle Gothel, Veracru,z and Ticuantepe, could be connected to the current sewerage system to be finally treated in the MWWTP. The drainage area is divided into ten sub-basins, which can be identified from Y1 to Y10. Figure 5.3.4 shows (A) the area of influence of Collector Y, and (B) the geographical location of Collector Y and its branches. The ENACAL built the first phase that collects from sub-basins Y1, Y2, and Y3. It consist of 5.6 km in length and diameters from 200 mm to 600 mm. This first phase provides sewerage service to the neighborhoods of the Americas No.2, the Mercedes, sector of the wholesale market, Los Laureles North, until arriving to intercept with the road to Sabana Grande. It created the necessary conditions to convey to MWWTP the sewage from future connections from areas located to the south. The estimated beneficiary population is more than 50,000 people.



(A) (B)

Source: JICA Study Team

Figure 5.3.4 (A) Area of Expansion of Collector Y, (B) Projected Collector Y

The second phase of Collector Y by ENACAL still has a pending construction. It was already designed (2009), and initially, this collector was included in the package of projects to be financed by the World Bank through the PRASMA; but due to a cut in funding, this was set aside, and even now there is no source of funding. The second phase is composed of the sub-basins Y4, Y5, Y6, Y7, and Y8. Sub-basins Y4 and Y5 can drain by gravity into the Collector Y built in the first phase; however, to drain sub-basins Y8, Y7, and Y6, it will need a pump station to convey the pressurized flow to the existing Collector Y. Collector Y's second phase has an estimated length of 12.7 km, covering the neighbourhoods located south of Sabana Grande Road, the Jagüitas, Vera Cruz, and Gothel Valley, reaching Carretera a Masaya Road. The estimated beneficiaries will be more than 75,000 inhabitants. An additional benefit of Collector Y's second phase is the elimination of almost 27 little wastewater treatment facilities built by the developers. This important collector will no doubt contribute to improve the quality of life of the inhabitants of this vast sector and to reduce the risks of contamination of the groundwater aquifer to which the sub-basin is currently exposed. The great majority of developers are storing wastewater in systems that do not meet the technical standards, and the settlements where the use of latrines and septic

tanks prevail cause both problems and huge challenges to the residents of the capital. The estimated cost of the Collector Y second phase (2009) was USD 4.5 million.

More recently, simplified sewerage systems have made a way for improvements and enable to increase the service coverage at low-income neighbourhoods. It is achieved by using the condominial sewerage approach which combines simplified, shallow, and small diameter sewers with satisfactory results and economy. At present, a large condominial sewerage is under construction by ENACAL (sharing responsibility) at VI District, in Barrio Villa Reconciliacion Sur. The project benefited 9,700 low income persons. The works composed of a 26-km length of small diameter sewers (ø 100-mm, ø 150-mm and ø 200-mm), 90 manholes, 612 inspection boxes, and 1,617 sanitary connections. The cost of the complete system is around USD 3.0 million. The residents dig the trenches and also prepare inspection boxes in front of their houses. ENACAL's personnel provide technical assistance, pipes installation, and build the manholes. Figure 5.3.5 shows the condominial sewer construction works at Barrio Villa Reconciliacion Sur.

Source: JICA Study Team

Figure 5.3.5 Condominial Sewer System, Manhole Construction at Villa Reconciliacion Sur

The ENACAL's sewerage system in Metropolitan Managua includes the urban areas of Managua City, Tipitapa, Ciudad Sandino, and San Rafael South. To achieve the O&M of that service area, ENACAL counts on a sewerage department with supervisors, inspectors, and 182 workers. They are distributed by crews as follows: (i) wastewater treatment plant (WWTP) operators (for five WWTPs), (ii) operators of the six main pumping stations of the interceptor system and auxiliary systems, (iii) operators of small pumping stations, (iv) crew related to system of interceptors, (v) operation crews of the hydro-jet equipment for preventive sewer maintenance, (vi) operational crews of roto-rods for the attention of clogged sewers (unplugging) and manhole cleaning, (vii) construction crews for rehabilitation and network expansion, and (viii) crews for installation of new services. Regarding the equipment, the sewerage department has four hydro-jet trucks (Vactor), six roto-rods (rotosonda), hand rods, and tools for manhole cleaning.

The barrios and city sections where ENACAL's unplugging and cleaning services are repetitive in frequency, are the following: (i) 18 de Mayo, (ii) Walter Ferretí, (iii) Mercado Oriental, (iv) Hialeah, (v)

Mirna Ugarte, (vi) Ayapal, (vii) Jonathan Gonzalez, (viii) B-15, and (ix) Municipio de Tipitapa. Most of these troublesome areas require rehabilitation, reinforcement of the sewer capacity (by lack of capacity) and close coordination with ALMA to control the illegal disposal of trash inside the manholes, particularly in manholes next to wholesale markets.

5.3.3 Status of the Wastewater Treatment Facilities

The ENACAL is administrating 46 WWTPs around the country. The MWWTP is the largest of all, with a designed flow of 2,113 L/s, followed by the Ciudad Sandino WWTP with a designed treatment capacity of 180 L/s (recently enlarged). Most of the other WWTPs deal with design flows between 7 L/s and 90 L/s. The treatment technologies in use are aerobic and anaerobic processes: facultative ponds (primary and secondary) with only a few WWTPs including maturation ponds (for pathogens removal), primary treatment processes such as septic tank, Imhoff tank and up-flow anaerobic sludge blanket reactor (UASB) alone or combined with secondary treatment processes like lakes, wetlands, and anaerobic up-flow filters.

The general practice in the WWTPs under ENACAL administration is not to use a final disinfection process (chlorination, UV radiation, or ozonization) for the effluents. As a consequence of this practice, the effluents do not comply with Decree No.33-95 which specifies the maximum permissible limits for WWTP effluents in Article 22. The same decree rules among other parameters such as the allowable concentration of the biological indicator fecal coliform (FC) which is a reference for public health risk. The maximum permissible limits for FC cannot exceed 1,000 MPN/100 mL in 80% of a series of consecutive samples; and in any case, it should not exceed 5,000 MPN/100 mL. However, in the special case of the MWWTP, it discharges its effluent into Managua Lake (Xolotlan Lake) according to a specific Decree No. 77-2003 (Regulation for Treated Effluents Discharging in Managua Lake) in force. This decree, unlike Decree No. 33-95, in its Article 7 allows a maximum permissible limit for FC of up to 500,000 MPN/100 mL in the near-field (sub-aquatic outfall), and must be set in the discharge permit the limits of a virtual border call far-field (defined by coordinates), where the concentration of FC should be less than 1,000 MPN/100 mL. Table 5.3.4 shows the existing WWTP under ENACAL's administration in Metropolitan Managua.

The ENACAL has a department of sanitation in environmental management responsible for establishing the monitoring program of the wastewater from all the plants at the national level, with the purpose of evaluating the efficiency of operation in each system and establish its compliance. Monitoring is done by laboratory personnel, with limited means of transport, which are run with the rigor that is set in Decree No. 33-95, which indicates the realization of nine monitoring every 24 hours for each system, while ENACAL runs around two monitoring every 24 hours per year for each system.

Table 5.3.4 Existing Wastewater Treatments Plants Managed by ENACAL in Managua

Location Department	WWTP Name	Design flow L/s	Primary Treatment	Secondary Treatment	Disinfection

Managua	Managua	2,113	P. Settling	T. Filter+S.Settl.	No
	Ciudad Sandino	180	UASB	No	No
	V Sandino-Bethel		RALF/UASB	Wetland	No
	La Bocana		P. Lake	S. Lake	Mat. Pond
	Victoria de julio		P. Lake	S. Lake	Mat. Pond
	San Rafael del Sur		P. Lake	S. Lake	Mat. Pond
	Gruta Javier		RALF/UASB	Wetland	No
	Belen 1 y 2		RALF/UASB	Wetland	No

FAFA (by its Spanish name): Up-flow anaerobic filter

Source: ENACAL

In addition to the WWTPs operated by ENACAL in the Metropolitan Managua, there are 31 small sized WWTPs that correspond to an equal number of urbanizations. The developers of residential urbanizations located in unsewered areas must provide effective sewerage treatment to the new urbanization if there is no feasible connection to public sewerage system. Generally, after treatment, the effluents are discharged into stormwater drains and natural sinks. Either the developer or the residents (or both) must pay for O&M cost of the WWTP. However, most of the plants are patented package plants (a sort of the activated sludge process) that require among others, mechanical components (recirculation pumps and blowers) and sludge drying facilities. Frequently, when the plant equipment becomes damaged, the influent flow is then by-passed and discharged (untreated) to the nearest creeks. Usually, the effluent quality does not comply with Decree No.33-95. Most of the new urbanizations that own WWTPs, and also some of the larger unsewered low-income settlements are located in a highly sensitive area, where there are main reserves of groundwater for Managua City's water supply (see Figure 5.3.3). To preserve the aquifer from chemical and bacteriological contamination due to sewage infiltration (from by-passed WWTPs, latrines, and infiltration pits), the Collector Y (2nd phase) needs to be completed by ENACAL, which would allow the direct connection of most of the urbanizations and unsewered settlements to the public sewerage system and lead the closure of 27 small WWTPs.

The MWWTP is the main wastewater treatment facility of Managua City, is located at the east side of Managua City near the shoreline of Managua Lake in the vicinity of the airport. The MWWTP receives all the sewage flow collected by the ENACAL system. Its objective is to remove organic matters such as BOD5, COD, TSS, and grease among other compounds, present in wastewater and the reduction of the bacteriological load to be discharged in Managua Lake. The construction of the MWWTP has been one of the main measures taken by the Nicaraguan government to get the environmental recovery of Managua Lake. The MWWTP began its operations in 2009 and has a design capacity in its first stage (2010) of 182,500 m^3/day (average design flow of 2.11 m^3/s); actual average influent flow is 1.59 m^3/s. In terms of population served, the installed capacity of the plant amounts to cover 1,089,531 inhabitants while currently serving 972,583 inhabitants. Table 5.3.5 shows the projected and actual influent loads and concentrations, as well as the main effluent characteristics. Currently, ENACAL has an O&M

contractor, the British company Biwater. Besides the plant's O&M, the contract also includes the management of five main pump stations. The said contract expires in 2017. The operator's report shows the actual influent flow of 1.62 to 1.74 m^3/s.

Table 5.3.5 Projected and Actual Inflow Loads and Effluent Quality of MWWTP

Design Parameters		Unit	MWWTP Planning Period				Actual Operation Data (2015)		Maximum Permissible Limits (**)
			2010	2015	2020	2025	Influent	Effluent	
Equiv. Population		E.P.	1,089,531	1,202,678	1,312,776	1,415,067	972,583		
Min flow (Qmin)		m^3/sec	1.168	1.338	1.449	1.561			
Ave. flow (Qav)		m^3/sec	2.113	2.392	2.559	2.725	1.59		
Max. flow (Qhm)		m^3/sec	3.441	3.846	4.062	4.269			
Organic Load	BOD5	M. ton/day	50.66	58.02	61.92	65.80	33		
		mg/L	277.53	280.78	280.08	279.47	254	18	90
	COD	M. ton/day	101.33	116.05	123.84	131.60	78.3		
		mg/L	555.04	561.56	560.16	558.96	604	60	180
	TSS	M. ton/day	30.40	33.56	36.64	39.50	39		
		mg/L	166.51	162.40	165.72	167.76	300	20	80
	FC	MPN/100 mL	2x108	2x108	2x108	2x108	1x108	(*) 1x103	5x105

Source: ENACAL (*) Measured at the far field border, radial length=2,000 m from discharging point. (**) Decree No. 77-2003

(A) (B)

Source: JICA Study Team

Figure 5.3.6 (A) Aerial View of MWWTP, (B) Primary Settling Tanks

The MWWTP is a conventional type treatment facility, equipped with the sewage influent channel, as well as a facility for the fecal sludge and night soil transported by trucks for treatment. The treatment plant has two treatment lines: the water line and the sludge line. The water line consists of the following processes:

(i) Preliminary treatment: There are four mechanical fine screens where floating materials and solids of size bigger than 6 mm are retained, followed by five aerated grit chambers where grease and sand particles bigger than 0.2 mm are removed.

(ii) Primary settling: There are nine rectangular primary settling tanks that are lamellar plate type, without skimmers or sludge scrappers. Due to the normal sewage temperatures (28° to 31°C), a rapid fermentation of the settled sludge occurs. The gas bubbles produced by fermentation make masses of sludge float to the surface and deteriorate the quality of the effluent.

(iii) Secondary treatment: The biological treatment is by trickling filters process, six units filled of plastic media, each unit 35 m in diameter and 6 m in height. The distribution of wastewater is done through rotary arms that disperse water uniformly over the entire surface of the filtering media. The effluent is collected from the bottom of the filters and conveyed to eight secondary settling tanks. The clarified effluent is discharged to the lake without final disinfection. When the water level of the lake is higher than 40.5 masl, a pumping station is used.

The sludge line consists of the following processes:

(i) Thickening: The biological sludge is removed from the bottom of the settling tanks and is combined with the primary sludge at the gravity thickeners (2 u) to increase the solids contained in the sludge and reduce volume.

(ii) Anaerobic digestion: The thickened sludge is pumped to the digester (4 u) for its anaerobic stabilization. The digestion processes are archived by natural heating. Sludge is kept between 28°C and 30°C; the biogas production is 9,500 m^3/day.

(iii) Dewatering: The digested sludge is dewatered in two belt filter press (BFP) to a dry solid concentration of 28% to 30%.

(iv) Drying: The plant has three galleries for solar drying which perform the solar sludge dehydration that comes out of the BFP. This process lasts between 18 and 24 days depending on the weather conditions, obtaining at the end a high quality solid bio sanitary and environmental (Class A, according to USEPA) which can be used in agriculture for soil conditioning. The plant is surrounded by a protection dyke against floods. The crown has an elevation of 44.60 masl.

5.3.4 Implementation Framework for Water Sector

(1) Laws and Regulations Enforced Related to Water and Sanitation Sectors

This subsection describes the laws and regulations related to the water sector.

The main legal provisions relating to drinking water and sanitation sector are scattered in various legal instruments, as enumerated below. This set of laws, decrees, and regulations represent the laws that establish the main functions and missions of institutions, industry by ownership, stewardship, regulation, control, and provision of services that constitute the general legal framework of the sector.

- Law No. 620 General Law of National Waters and its Regulation, Decree No. 106-2007, considers that the natural water resource is a heritage of the nation, and therefore, it corresponds to the state to promote economic and social development through conservation, development, and sustainable use of it, thus preventing it from being subject to any privatization. Law 620 established the legal and institutional framework for the management, conservation, development, use, sustainable, equitable, and preservation in quantity and quality of all existing water resources in the country, while ensuring the protection of other natural resources, ecosystems, and the environment.
- Law No. 297 General Law of Potable Water and Sanitation Services and its reform, i.e., Regulation Decree No. 52-98. The particular objectives of this law are: (1) the exploration, production, and distribution of drinking water and the collection and disposal of sewage, (2) the granting, monitoring, revocation, or cancellation of concessions to establish and rationally exploit these potable water and sewerage in accordance with the provisions of this Act, (3) the audit of compliance with the rules relating to the provision of services and related productive activities and the application of sanctions in case of default, (4) relations between the concessionaires and service providers and between them and the state and users, (5) the general information and consideration, approval, and supervision of fixing tariff concepts, and (6) dictate and monitor compliance with the characteristics of public services of water and wastewater standards.
- Law 40, 08-97 Municipalities Act which establishes the powers of mayors, among which is

ensuring access to water and sanitation, as well as the ability to manage them when they are decentralized.

- Decree No. 45-98 has provisions for the fixing of rates in the field of drinking water and sewerage system and its reform. It sets limits on water rates. Resolution No 001, the Regulatory Decree for Tariff Setting for Drinking Water and Sewerage specifies the types and limits of tariffs, depending on the type of service.
- Resolution CR-RE-0.36-2007 - Specific amendment to the current prices for the service of sanitary sewer system, which will include a variable charge by sewage treatment with domestic features in Managua City and the charging for industrial effluent discharges in all systems managed by ENACAL.
- Law No. 169 State Property and Public Services Regulatory Agencies and its Reform
- Law No. 182 Act of Defense of Consumers and its Regulation Legislative Decree No. 2187
- Law No. 217 General Law of the Environment and Natural Resources and its Regulation, Decree No. 9-96, defines the protection of water and water sources as fundamental, as well as sanctions against pollution, being an obligation of the state and all natural or legal persons engaged in activities in national territory and its territorial waters, and the protection and conservation of aquatic ecosystems, ensuring its sustainability. It stipulates that any activity that generates wastewater require prior authorization for discharging wastewater as well as the maximum permissible limits of the main indicators of pollution for discharge of treated wastewater into receiving bodies or sewage systems.
- Law No. 559 Special Law of Crimes Against the Environment and Natural Resources.
- Decree No. 33-95 has provisions for the control of pollution from wastewater discharges of domestic, industrial, and farming that discharge into network sewer, and the same fulfillment of the quality of wastewater discharged in coordination with MARENA and its reforms, Articles 19, 22 and 23.
- Act No. 274, Basic Law for the regulation and control of pesticides, toxic substances, dangerous and other similar, its Regulation Decree No. 49-98, Decree No. 76-2006
- Law No. 626 which creates the Commission on Sustainable Development of the water basin of Lake Cocibolca and Rio San Juan
- Law No. 423 General Health Law, Its Regulation, Decree No. 001-2003, that determines the role of the Ministry of Health in monitoring water quality.
- Decree No. 394 Sanitary Arrangements
- Decree No. 432 Regulation of Health Inspection
- Law No. 28 Statute of the autonomy of the regions of the Atlantic coast of Nicaragua and instances of state institutions related to the potable water and sanitation sector.
- Decree No. 51-98 of creation of the CONAPAS and its reforms.
- Presidential Agreement No. 276-2004 to accredit the Central American Integration System

(*Sistema de la Integración Centroamericana:* SICA) to CONAPAS, members of CONAPAS, Secretariat of the Presidency (SEPRES), and the Nicaraguan Institute of Water Supply and Sewerage Systems (*Instituto Nicaragüense de Acueductos y Alcantarillado:* INAA).

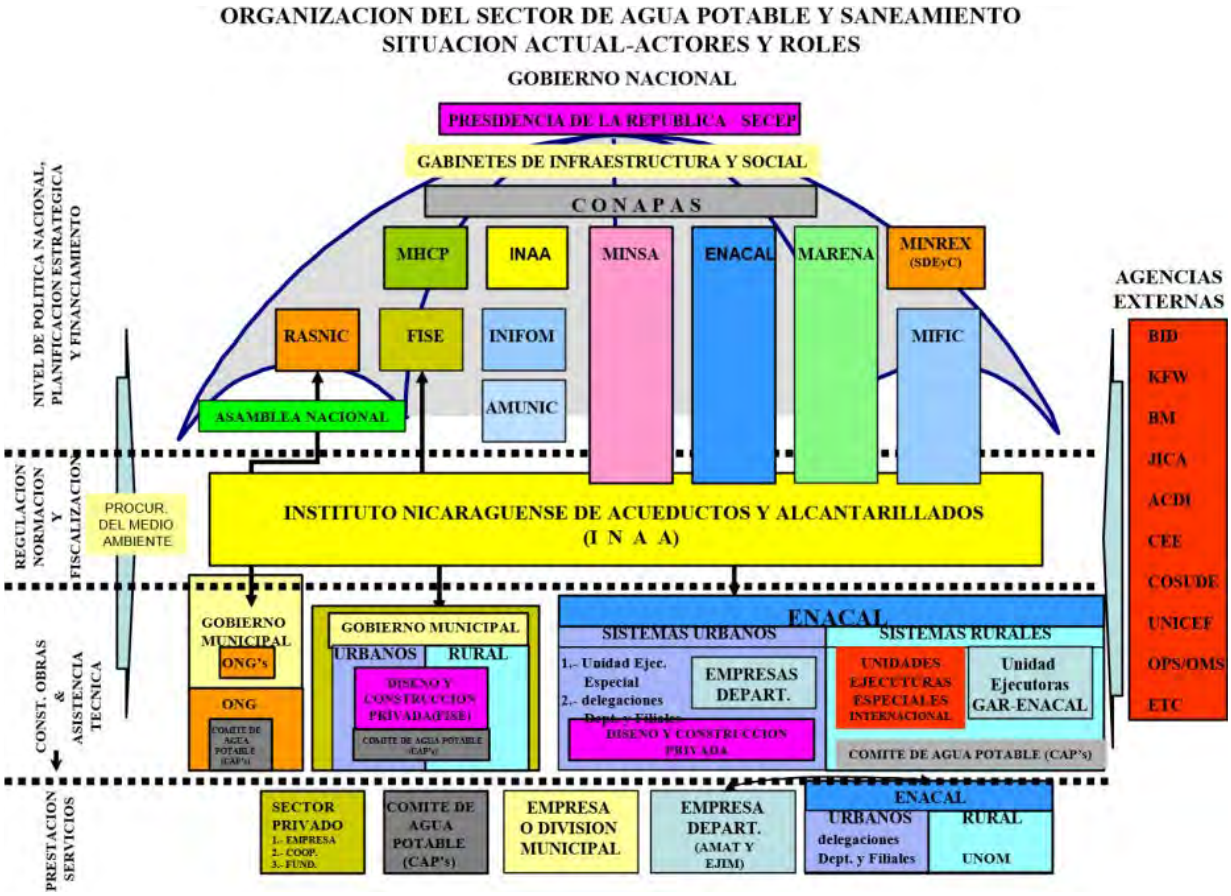
- Law 276 of 1998, Law establishing ENACAL which is credited with search functions, distribution, and sale of potable water and sewerage. In addition, Presidential Agreement No. 276-2004 to accredit the SICA to the CONAPAS, members of CONAPAS, SEPRES, and INAA.
- Decree No. 20 Creation of INAA
- Decree No. 123 Organic Law of INAA, and its reforms.
- Decree No. 25-98 Regulation of the law to reform the organic law of INAA.
- Law 276 of 1998 established ENACAL which is credited with search functions, production, and distribution of potable water; and sewage collection, treatment, and disposal.
- Law 290 Law of organization, competence, and procedures of the Executive Power Act and Regulations, the Ministry of Development, Industry and Commerce (*Ministerio de Fomento, Industria y Comercio:* MIFIC) is responsible for licensing of water use in the form of grants through the National Water Management, and its Regulation Decree No 71-98 290.
- Decree 59-90 of the creation of the Social Investment Fund for Emergencies (*Fondo de Inversión Social para Emergencias:* FISE) and Law No.347 creator of the Nicaraguan Institute of Municipal Development (*Instituto Nicaragüense de Fomento Municipal:* INIFOM), as decentralized institutions of the state and the creation of the Association of Municipalities of Nicaragua (*Asociación de Municipios de Nicaragua:* AMUNIC).
- Act No. 309, Law for the regulation, management, and certification of informal settlements. Social Framework.
- Nicaraguan Obligatory Technical Standard (*Norma Técnica Obligatoria Nicaragüense:* NTON) 05 002-99, Nicaraguan mandatory technical standard for the environmental control of the lakess cratéricas. Sets the drinking water use and exploitation of the Asososca lakes.
- Technical Resolution INAA. CD-RT - 011-00. General rules for the regulation and control of the services of drinking water and sewerage systems. Regulatory service for the user of ENACAL.
- M 04-01. ENACAL, Rules of internal control. A manual of rules and procedure for the use of sewage by enterprises of cleaning of septic tanks and sinks.
- Decree No. 68-2001, Creating Environmental Management Units. It establishes the functions of the environmental management units in state agencies.
- Decree No. 76-2006, Environmental Assessment System.
- Environmental Impact Decree 77-2003 - Establishment of the provisions that regulate the domestic wastewater discharges from treatment systems to Managua Lake. It is for the particular case of Managua City. The maximum permissible limits of different normed parameters are similar to those provided for in Decree 33-95, except for FC, for which a limit is set 5x105 NMP/100 mL. The authorities with regulatory mandate for control and monitoring systems, wastewater treatment,

sewerage systems, and discharges to receiving bodies are MARENA and the regulator, INAA.

- NTON 05-027-05 - Environmental technical standard to regulate wastewater treatment systems and their reuse. It aims to establish the provisions and technical regulations and environmental for the location, operation and maintenance, handling, and disposal of liquid and solid wastes generated by the systems of treatment of domestic sewage, industrial and farming; including the reuse of treated water, systems of wastewater treatment, and sludge management.

(2) Entities Responsible for Drinking Water and Sanitation Sector

The drinking water and sanitation sector of Nicaragua involves ministries and decentralized state agencies; decentralized entities; state regulators, association of municipalities, and municipal governments; commissions created by executive decree or ministerial level; non-governmental organizations; state and private companies; and international institutions, which in one way or another, affect the policies, strategies, objectives, goals, and in the quality of the provision of services in this sector. Figure 5.3.7 illustrates the location of the institutions and organizations involved in the sector, at the level of policies, strategic planning, and financing; regulation, regulation, and control; construction and technical assistance; and provision of potable water and sanitation services to end users.



Source: ENACAL

Figure 5.3.7 Organizational Chart of the Drinking Water and Sanitation Sector

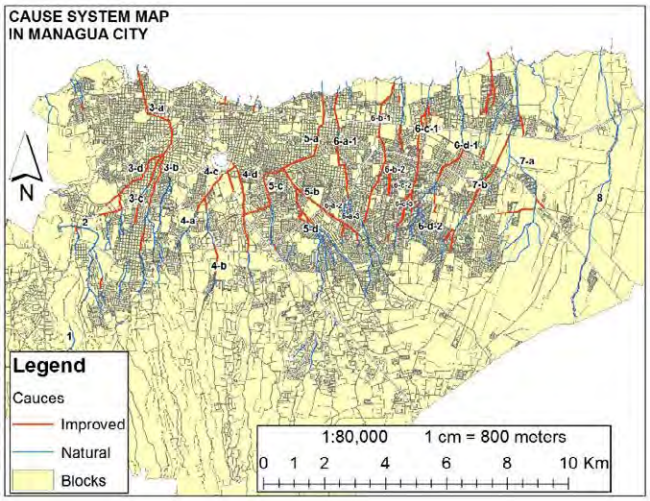
5.4 Flood Protection

5.4.1 River Systems in the Study Area

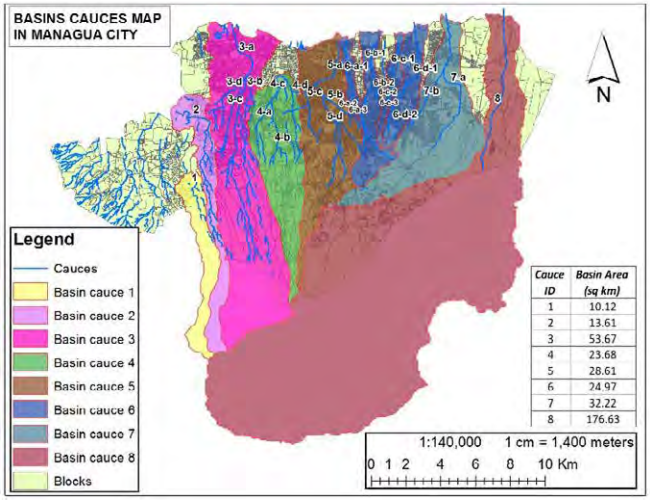
There are no large scale " *río* " or river, but there are eight major " *cauces* " (drainage canals) in Managua City as shown in Figure 5.4.1. The *Cauce* El Borbollon composed by sub-basin III with 176.33 km² is the largest *cauce* basin in the city.

Large scale floods often overflow from cauces (drainage canals). Fundamental data to study flood measures including existing flow capacity and probable floods of each cauces are no available. Assessment of existing flow capacity of each cauce against probable floods will be a first step of the improvement works.

(a) Cauce System in Managua City



(b) Cauce Basin



(c) Features of Major Cauces

No.	Cauce System	ID	Cauce	Catchment Area (km^2)	Length (km)		
					Improved	Natural	Total
1	Ticomo	1	Ticomo		0.00	2.50	2.50
2	Nejapa	2	Nejapa	13.60	0.00	4.50	4.50
3	Occidental	3-a	Occidental		3.08	0.00	3.08
		3-b	Ramal El Arroyo		2.20	2.60	4.80
		3-c	Ramal Pochocuape		2.80	1.70	4.50
		3-d	Ramal Cuajacjillo		2.00	3.00	5.00
			Sub-total	53.67	10.08	7.30	17.38
4	Tiscapa	4-a	Los Duartes		0.50	3.50	4.00
		4-b	Jocote Dulce		0.92	4.60	5.52
		4-c	Interseptor Tiscapa		1.94	0.00	1.94
		4-d	San Isidoro de la Cruz Verde		3.16	1.20	4.36
			Sub-total	23.67	6.52	9.30	15.82
5	Oriental	5-a	Oriental		3.18	0.00	3.18
		5-b	Camino Viejo a Masaya		1.50	1.70	3.20
		5-c	Ramal Santo Domingo		1.85	4.45	6.30
		5-d	Ramal Las Cuarezmas		1.53	3.99	5.52
			Sub-total	28.60	8.06	10.14	18.20
6	Nor-este	6-a-1	Bello Horizonte		3.70	2.30	6.00
		6-a-2	Ramal-I Bello Horizonte		0.60	0.00	0.60
		6-a-3	Ramal-II Bello Horizonte		0.76	0.00	0.76
		6-b-1	Portezuelo		5.09	1.91	7.00
		6-b-2	Ramal Portezuelo		1.00	0.40	1.40
		6-c-1	Waspan		3.14	2.66	5.80
		6-c-2	Ramal-I Waspan		0.62	0.00	0.62
		6-c-3	Ramal-II Waspan		0.96	0.00	0.96
		6-d-1	Americas-IV		2.48	6.02	8.50
		6-d-2	Ramal Americas-IV		0.61	1.39	2.00
			Sub-total	24.97	18.96	14.68	33.64
7	Aeropuerto	7-a	Aeropuerto		0.00	5.50	5.50
		7-b	31 de Diciembre				
			Sub-total	32.22	0.00	5.50	5.50
8	El Borbollon	8	El Borbollon	176.63			
Total				353.36	43.62	53.92	97.54

Source: JICA study team prepared based on information of ALMA.

Figure 5.4.1 Locations and Catchment Areas of Major Cauces in ALMA

5.4.2 Historical Floods in the Study Area

(1) Past Floods in and Around Managua City

In the last 20 years from 1992 to 2011, large flood disasters occurred 55 times in and around Managua City as shown in Table 5.4.1. It is remarkable that quite intense rainfalls were recorded in the last three years.

Table 5.4.1 Past Major Flood in and Around Managua City

Date	Cause	Affected Population (Person)	Remarks
Apr. 1996	Heavy rainfall	1,100	Severely damaged in Tangara, Pantanal, and Pedro Joaquín Chamorro
Oct. 1998	Hurricane Mitch	9,000	Length of damaged road: 2,750 m, Physical damage: USD 700,000.
Oct. 1999	Surged water level of Managua Lake	1,080	Damage along the lake coast.
Apr. 2002	Tropical storm No.8	1,750	Severe damage in Ayapa, Laberinto, and Hugo Chávez. Total of 435 residents evacuated.
Oct. 2008	Heavy rainfall	1,525	Total of 305 houses were damaged.
Apr. 2009	Heat wave No.1	2,210	Severe damage in Mercado Oriental, Fernando Vélez Páez, and Batahola Nort. Length of damaged road: 200 m
Apr. 2010	Heavy rainfall	144	Length of damaged highway: 100 km Length of damaged cauce: 680 m Total of 306 houses were damaged.
Sep. 2010	Surged water level of Managua Lake	85	Severe damage in Barrio La Bocana. Total of 17 houses were damaged.
Jul. 2011	Heavy rainfall	885	Length of damaged cauce: 169 km One house was completely destroyed Death toll: 1 person
Aug. 2011	Surged water level of Managua Lake	700	Severe damage in Barrio Manchester. Large number of affected people evacuated.
May 2013	Heavy rainfall	3,000	Severe damage in Managua, Ciudad Sandino, Tipitapa, Ticuantepe, and Mateare. Three hours of rainfall in Managua City recorded 53 mm.
(2014)	-	9,606	ALMA and *Defensa Civil* assessed potential of affected population by floods in Managua.
Jun. 2015	Heavy rainfall	10,000	Three hours of rainfall in Managua City recorded 206 mm.

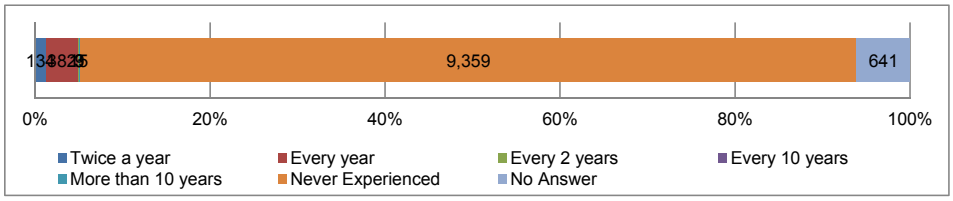
Source: Prepared by the JICA Study Team based on the "*Informe Preliminar del Caso de Estudio: Adaptación al Cambio Climático y Manejo Integrado de los Recursos Hídricos en Managua*, Nicaragua".

(2) Flood Experiences of Managua Citizen

The Household Interview Survey in this project carried out in June to September 2016 on 10,000 households revealed flood damages of residents at own houses in Managua City.

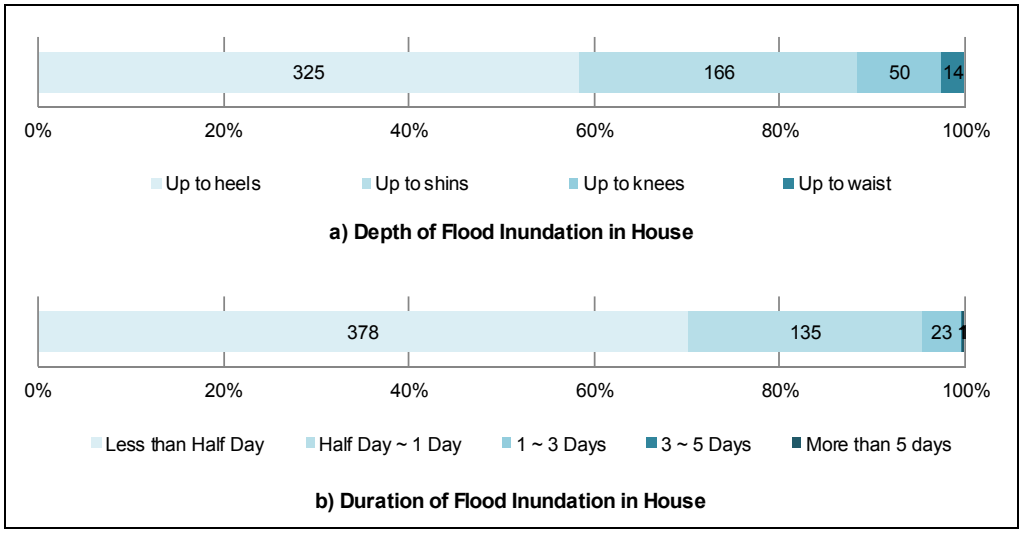
Figure 5.4.2 shows flood experiences at own houses in Managua City. 9,359 households (93.6%) have never experienced flood inundation in their own houses. However, 134 households have the experiences twice a year and 382 households have the experiences every year. Thus, majority of citizens lives safer houses but 5.2% of citizens have repeatedly suffered from flood inundations in their houses.

For 543 households who have the experiences of flood inundations, HIS questioned the depth and duration by the most serious flood. Figure 5.4.3 shows that the results. The maximum flood inundation depth on house for 325 households (59.9%) is up to heels (around 5 cm). Nine households (1.7%) experienced the depth up to waist (around 1 m). For the maximum duration of flood inundation, 378 households (69.6%) experienced less than half day. 27 households (5.0%) experienced the duration of more than one day. The longest duration is more than five days experienced by a household.



Source: JICA study team

Figure 5.4.2 Flood Experiences at Own Houses of Surveyed Households



Source: JICA study team

Figure 5.4.3 Depth and Duration of the Most Serious Flood Inundation at the Own Houses

On the other hand, the most of urban areas are covered by concrete and asphalt except for limited gardens, public parks and *micropresas* in the study area. Hence, rainwater does not infiltrate to the ground and discharges to lower land immediately. The reduction of rainwater storage and infiltration functions increases flood disaster risk in the study area.

(3) Flood Damages along the *Cauce* Oriental

The JICA Study Team carried out an interview survey along the oriental cauce with ALMA staffs. Flood management is a priority issue in Managua City. Floods often overflow and flow down to Pista Juan Pablo II due to shortage of flow capacity of the cauce, according to the drainage section of ALMA. Flood damage situations collected by the interview survey are as following (the alphabets on head of list correspond to ones shown in Figure 5.4.4);

a) Floods do not overflow around the river mouth with Managua Lake but flood water levels often increase to immediately below the bank shoulder of the cauce with high velocity. The durations of floods are approximately one to one and a half hours. Soil erosion occurs along the Coast of Managua Lake due to wind waves.

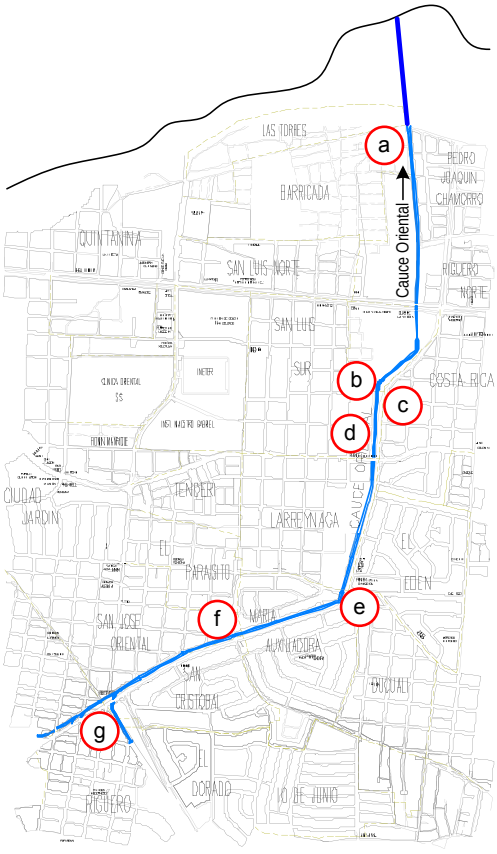
b) Floods overflow every year. Their average inundation depth is 50 cm and the average inundation duration is approximately two hours on the site. The most severe flood damages occurred in 1993 and 1994. The inundation depth in each year was 1.5 m and from 2.0 m to 3.0 m, and the inundation durations were from six hours to three days. The Hurricane Mitch in 1998, one of the major floods, did not cause severe flood damage. The residents along the cauce often put concrete blocks along the bank shoulders of the cauce by themselves as emergency response to floods.

c) Floods overflow every year. Their average inundation depth is 50 cm to 100 cm and their average inundation duration is approximately half hours on the site. The overflows have quite high velocity. The most severe flood damages occurred in 2013 and 2014.

d) The site had a flood inundation for a whole night in 2010 with inundation depth of 30 cm. In 2013, a pedestrian on Pista Juan Pablo II was captured by an overflowed flood and dropped down into the cauce. The victim passed away.

e) Floods violently overflow outside of the curving location of the cauce (right bank: the Pista Juan Pablo II side). The overflowed floods flow down the highway with relatively high velocity.

f) Floods overflow once or twice a year. The maximum inundation depth was approximately 100 cm and the inundation duration in approximately 10 minutes in average. In 2014, huge amount of sediment flowed downstream due to a landslide disaster in the southeast part of the city.



Source: JICA study team

Figure 5.4.4 Interview Locations along Cauce Oriental

g) Floods overflow every year. Their average inundation depth is approximately 50 cm and their average inundation duration is approximately one hours on the site. The improvement works on the Camino Viejo a Masaya cauce, the tributary of the oriental from junction, was completed but still have flood damages.

Along the right bank of the cauce is one main highway: the Pista Juan Pablo II.

Source: JICA study team

Figure 5.4.5 Oriental Cauce Constructed in 1970s

A resident living near the cauce indicating the maximum flood inundation water level at his house wall.

Source: JICA Study Team

Figure 5.4.6 Indicated Water Level of Flood Inundation from Oriental Cauce

(4) Flood Damages in June 2015

In June 2015, Managua City suffered from severe and frequent floods due to heavy rainfalls. On June 2, 2015, a 206-mm rainfall in three hours was recorded. Approximately 10,000 people and 2,050 households were affected by a series of floods in June 2015. Table 5.4.2 summarizes the damage situations of the floods.

Some lowlands such as Barrio Altagracia were inundated by a series of heavy rainfalls. Some houses along cauces were affected by bank erosion caused by high velocity floods. Floods overflowed at the junction of the Camino Viejo a Masaya cauce and the Oriental cauce, and propagated around Pista Juan Pablo II Highway flooding houses on the roadside.

Source: http://www.el19digital.com/

Figure 5.4.7 Flood Inundation in June 2015

Table 5.4.2 General Status of Flood Damages of June 2015 in Managua City

Date	Recorded Rainfall (mm)	Damaged Houses (no.)	Affected Barrios (no.)	Severely Affected Barrios
Jun. 2	206 (three hours)	72	40	Carlos Nunez, Carlos Fonseca, Ruben Dario, Jonathan Gonzalez
Jun. 9	60 - 68	59	9	Carlos Nunez, Golfo Persico, Colonia Oscar, Perez Cassar, Altagracia
Jun. 10	30 - 80	32	12	Memorial Sandino, Pablo Ubeda

Source: Prepared by the JICA Study Team based on "*Los Primerons Golpes Del Invierno*" provided by ALMA.

5.4.3 Current Status of Flood Management

(1) Laws and Regulations for Flood Management

"*Reglamento de Drenaje Pluvial para el Area del Municipio de Managua*" approved by ALMA in September 1991 determines technical requirements of flood drainage system in Managua City, which includes design scale: scale of probable flood of cauce and rainwater drainage pipe network, determination of green belts and maintenance roads on both side of cuace, method of hydrological and hydraulic analysis to design flood drainage system, dimensions of road drainage, and criteria of construction material and construction method. The design scales of crossing structures on cauce, such as bridge, cauce, and rainwater drainage pipe network, are determined as shown in Table 5.4.3. The adopted hydrological analysis method to determine design flood discharge is the rational method.

However, there are some illegal settlements along *cauces* e.g. *Cauce Ramal El Arroyo* although the both sides of *cauces* are regulated as a green belt. Such houses are facing a large flood damage risk. At the time of June 2016 flood, settlements along *cauces* suffered from floodings.

Table 5.4.3 Design Scale of Flood Management Structures in Managua City

Structure	Design Scale (Probable year)
Crossing structures on cauce	25
Cauce	15
Rainwater drainage pipe network	10

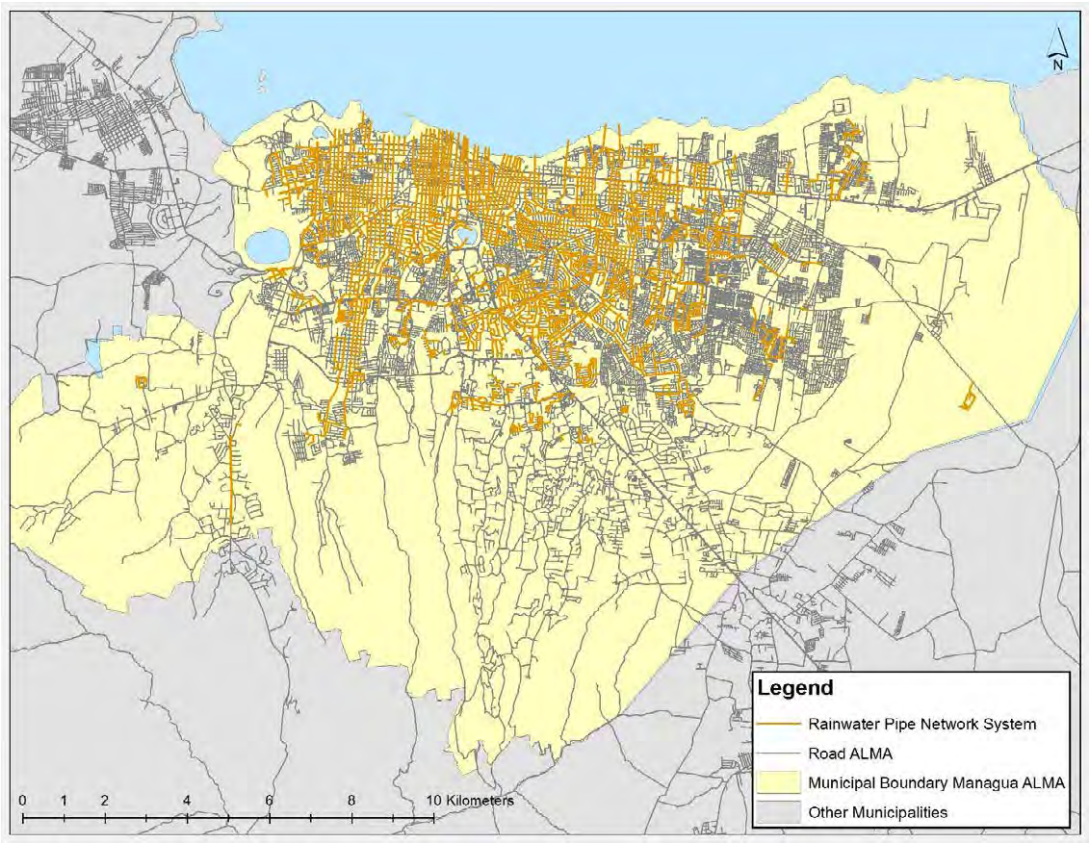
Source: Prepared by the JICA Study Team based on "*Reglamento de Drenaje Pluvial para el Area del Municipio de Managua*".

(2) Structural Measures

There are three types of flood structural measures implemented by ALMA as described in following.

1) Rainwater Drainage Pipe Network

Figure 5.4.13 shows the rainwater drainage pipe network in Managua City constructed in 1960's which is managed by *Dep. Hydraulic red maintenance* of ALMA. The total length of the pipe network is approximately 296 km long according to "*Infovias*" (a GIS data base) established by ALMA. The existing pipe network flows northward to the Managua Lake but downstream portion have been reduced their flow capacity due to aging. The study on master plan of flood drainage will design two tunnel rivers to drain out rainwater in the central urban area according to the drainage section of ALMA.



Source: Prepared by the JICA Study Team based on information from ALMA.

Figure 5.4.8 Rainwater Drainage Pipe Network in Managua City

2) Protective Works on Cauce

The downstream stretch of cauces has been improved with concrete linings (e.g., Table 5.4.4 shows a typical structure) with a length of 43.62 km in total as shown in Figure 5.4.1 (c). All cauces were cleaned up by Department of Hydraulic Red Maintenance of ALMA from November to April before the start of the rainy season.

3) Micropresa

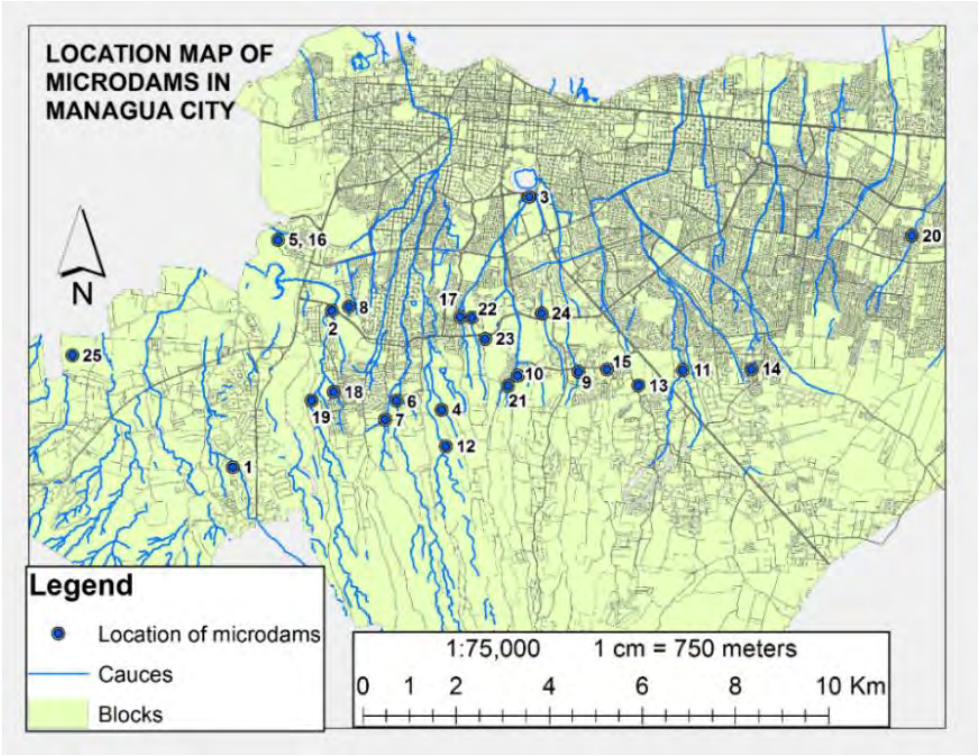
i) General Features of Micropresa

A *micropresa*, or a regulating dam, provides temporary storage of flood water during rainy season to reduce the amount of flood flowing down the urban areas downstream. (e.g. Figure 5.4.13. Figure 5.4.9 shows the locations of *micropresas* in Managua City. Table 5.4.4 shows general features and maintenance record of *micropresas* in Managua City. The *micropresas* capture not only flood water but huge amount of sediment and garbage. The Department of Hydraulic Red Maintenance periodically excavates the sediment and garbage in the reservoirs of *micropresas* to maintain the function. The oldest

Source: JICA study team

Figure 5.4.9 Typical Micropresa (Las Colinas, Cauce Oriental)

ones were constructed in 1980's but most of their fringe areas are occupied by illegal settlers and they disturb the maintenance excavation according to ALMA. The authority wish to make such *micropresas* to be functional. Thus, 21 *micropresas* out of the existing 26 are under periodical maintenance excavation. The *micropresa Sierra Maestra Sur in the Occidental* system has accumulated the largest amount of sediment and garbage with an amount of 310,218 m^3, since its construction in 1990. The second largest amount of sediments and garbage captured by a micropresa occurred in the *San Isidro de Bolas* in the *Occidental Cauce* system. Approximately 2 million m^3 of sediments and garbage were excavated from all *micropresas* since 1992.



* Numbers shown in the figure are shown in Table 5.3.4 as identification numbers of micropresas.

Source: Prepared by the JICA Study Team based on information from ALMA.

Figure 5.4.10 Locations of Micropresas in Managua City

Table 5.4.4 General Features and Maintenance Record of Micropresas in Managua City

No.	Name*	Cauce System	Cauce	District	Catchment Area (km^2)	Const. Year**	Reservoir Area (m^2)	Ground Elevation (m)	Storage Capacity (m^3)	Sediment Excavation Volume (m^3)		Op. Period
										Total	Ave.	
1	Alemana	Ticomo	Ticomo	III	1.53	1992	21,015	?	9,769	32,191	1,400	23
2	Suburbana	Nejapa	Nejapa	III	9.12	?	3,200	88.55	12,800	65,008		
3	Gaucho-Tiscapa	Tiscapa	Los Duartes	I	12.73	2005	19,200	95.40	14,400	43,891	4,389	10
4	Los Ladinos	Occidental	?	I	6.84	1992	19,541	91.35	9,393	73,663	3,203	23
5	Ayapa II	-	-	III	0.94	2006	2,400	?	3,200	11,768	1,308	9
6	Sierra Maestra Norte	Occidental	Ramal El Arroyo	III	7.13	1990	90,000	98.80	34,830	111,959	4,478	25
7	Sierra Maestra Sur	Occidental	Ramal El Arroyo	III	11.50	1990	110,000	?	52,299	310,218	12,409	25
8	Tierra Prometida	Occidental	Ramal Cuajacjillo	III	0.07	2001	3,600	94.76	4,500	20,168	1,441	14
9	Villa Fontana	Tiscapa	San Isidoro de la Cruz Verde	I	6.85	1984	?	93.50	?	171,344	5,527	31
10	INAA	Tiscapa	Jocote Dulce	I	1.37	1992	15,405	88.00	6,480	63,047	2,741	23
11	Las Colinas	Oriental	Ramal Las Cuarezmas	V	5.03	1995	26,693	?	93,000	133,672	6,684	20
12	San Isidro de Bolas	Occidental	?	I	6.84	1990	9,600	98.70	12,000	246,742	9,870	25
13	Santo Domingo	Oriental	Ramal Santo Domingo	I	3.61	1992	24,956	99.60	16,380	115,423	5,018	23
14	Bariloche	Nor-este	Ramal Portezuelo	V	1.86	1996	6,400	?	9,600	49,238	2,591	19
15	Barricada	Oriental	Ramal Santo Domingo	I	1.38	1988	8,900	?	11,600	86,824	3,216	27
16	Ayapa I	-	-	III	-	2006	4,800	?	6,400	11,768	1,308	9
17	Duarte Occidental	Tiscapa	Los Duartes	I	1.01	1984	8,672	93.75	15,520	104,703	3,378	31
18	Embalse Ca,ilo Ortega (Loma Linda)	Nejapa	Nejapa	III	0.66	2012	5,040	?	10,080	2,172	724	3
19	Embalse El Laurel	Nejapa	Nejapa	III	2.75	2011	4,675	?	13,280	3,414	854	4
20	Embalse 31 de Diciembre	Aeropuerto	31 de Diciembre	VI	6.85	2012	5,544	?	11,088	6,407	2,136	3
21	Cementerio	Tiscapa	Jocote Dulce	I	1.34	1984	?	?	?	31,969	1,031	31
22	Duarte Oriental	Tiscapa	Los Duartes	I	0.49	1984	?	?	?	85,333	2,753	31
23	Experimental	Tiscapa	Los Duartes	I	0.49	1983	?	?	?	258	22	12
24	Pedagogico	Tiscapa	San Isidoro de la Cruz Verde	I	0.77	1985	?	?	?	36,096	2,005	18
25	Pozo Norte	Oriental	Ramal Las Cuarezmas	V	6.17	1993	?	?	?	78,196	7,820	10
26	Embalse Recreo Norte	?	?	?	-	?	?	?	?	13,432		
Total					97.33		389,641		346,619	1,908,906		

Note: *Yellow colored micropresas presently have no maintenance. **Yellow colored construction years are estimations by the JICA Study Team.

Source: Prepared by the JICA Study Team based on information from Department of Pluvial Drainage and Department of Hydraulic Red Maintenance of ALMA.

ii) Current Issues on Micropresas

The current issues to maintain micropresas function can be summarized as following;

- Infringement by illegal settlements and illegal garbage habitats

- Excessive sediment production in upper basins due to soil erosion by human activities
- Shortage of maintenance budget for *micropresas*

Figure 5.4.11 and Figure 5.4.12 show that current conditions of roads in upper basins. Mostly upper stretch of cauces are conventionally used as road. Some side slopes along such upper stretch of *cauce* as roads are unsteable and frequently collapse. Such uses accelerate sediment production. ALMA carried out some countermeasures for them such as lamp installation on steep road, pavement and bank protection by gabion mattress but construction of such structures on all erodive location is inpracticable from view point of road use population and budget. Agricultural land use practices in upper basin as shown in Figure 5.2.6 also cause excessive sediment production.

Upper stretch of *cauces* are conventionally used as roads.

Source: JICA study team

Figure 5.4.11 Upper Stretch of A *Cauce*

Some side slopes along an upper stretch of cauce are unsteable and frequently collapse. The slope set back two meters to land side.

Source: JICA study team

Figure 5.4.12 Side Slope along Upper Stretch of *Cauce*

Table 5.4.5 shows past budgetary arrangements for maintenance works of *cauces* and *micropresas* in Managua City. The arranged budget is not enough to complete the excavation works on *cauces* and *micropresas* according to some participant's comments on TWG-III held on 13th May 2016. Required maintenance budget is depending of amount of sediment flow which is depending on hydrological conditions. Therefore, the budgetary arrangement of the maintenance activities require some flexibility based on actual demand on each year.

Table 5.4.5 Past Budgetary Arrangement for Maintenance Works of *Cauces* and *Micropresas*

Unit: C$

Year	2011	2012	2013	2014	2015
Budget for Maintenace of Cauces and Micropresas	18,808,285	10,646,148	9,000,000	23,967,160	23,967,160

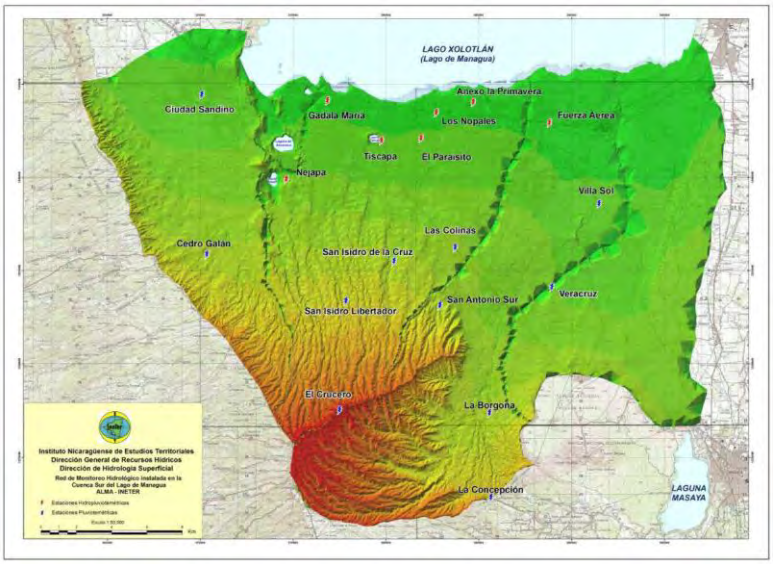
Source: JICA study team prepared based on information from *Dep. Hydraulic red maintenance* of ALMA.

(3) Non-structural Measures

1) Flood Early Warning System

There are 20 rainfall stations in and around Managua City as shown in Figure 5.4.13. Daily rainfall records from 1980 to date are available on these stations. The rainfall stations at the international airport and the National Autonomous University of Nicaragua - Rubén Darío University Campus (*Universidad Nacional Autónoma de Nicaragua - Recinto Universitario Rubén Darío:* UNAN-RURD) have accumulated observed short time rainfall records with a record interval from five minutes to one hour, since 1972 and 1980, respectively. These rainfall stations provide only short time rainfall data, but with long enough period to analyse flood characteristics in and around Managua City. Some other rainfall stations have started hourly rainfall observation since 2011 according to INETER. The institution said that they would need to accumulate more rainfall record of short time basis to establish early warning system against floods, though they have no specific plans yet to establish one.

Intense rainfalls in upper basins cause large floods in lower basins. Local people living in lowland areas shall have to evacuate timely in view of large floods but prior flood information for evacuation is not systematically given



Source: Draft Term of Reference for Master Plan of Flood Drainage in Managua City, May 2016 provided by ALMA.

Figure 5.4.13 Location of Rainfall Stations Managed by INETEL

2) Watershed Management

Soil erosion from bare lands in upper basins (e.g. Figure 5.2.6 and Figure 5.4.14) produces a large amount of sedimentation in *cauces* and *micropresas*. Sedimentation reduces flow capacity of *cauces* and causes malfunction of *micropresas*. The ALMA has implemented a watershed management program namely "*Programa de BONOS Ambientales*" since 2009. The objectives of the program are conservation of upstream basins of cauces flowing into Managua City to reduce soil erosion and to maintain quality and quantity of groundwater as main water resources

in Managua. The program comprises five components: i) reforestation, ii) compressed levees, iii) trenches of infiltration of water, iv) buckets of infiltration, and v) barrier for living area as shown in Figure 5.4.14.

The INAFOR also has carried out a reforestation program at upstream basins of cauces flowing into Managua City since 2007. They made an agreement with private land owner to implement reforestation activities.

i) Reforestation: The program provides wooden you tree e.g. cedro, teca to participating farmers as incenti of reforestation activities.

ii) Diques con postes prendedizos: To reduce flash flood energy on steep slope.

v) Barrera viva: To protect "zanjas de infiltration de agua" against flash flood.

iv) Cubetas de infiltracion: Small ditch conveys rainwater to there to infiltrate rainwater.

Source: JICA study team

Figure 5.4.14 Components of "Programa de BONOS Ambientales"

5.5 Solid Waste Management

5.5.1 Legal Framework and Administrative Structure

(1) Laws and Regulations for Solid Waste Management

Laws, regulations, and guidelines related to solid waste management in Nicaragua are listed in Table 5.5.1.

Table 5.5.1 Laws and Regulations Related to Waste Management in Nicaragua

Number	Name	Date Issued
Ley No. 217	Ley General del Medio Ambiente y los Recursos Naturales	Jun 6, 1996
Ley No. 647	Reforma y adiciones a la Ley 217 Ley General del Medio Ambiente y los Recursos Naturales	Apr 3, 2008
Ley No.168	Ley que Prohibe el Trarico de Desechos Peligrosos y Sustancias Toxicas	Jun 2, 1994
RM 122-2008	Reglamento Sanitario de los Residuos Sólidos Peligrosos y No Peligrosos	Jul 2, 2008
Decreto No. 47-2005	Politica Nacional sobre Gestion Integral de Residuos Solidos	Aug 23, 2005
Decreto No. 91-2005	De Politica Nacitonal para La Gestion Integral de Sustancias y Residuos Peligrosos	Nov 28, 2005
NTON 05-013-01	Norma Tecnica para El Control Ambiental de los Rellenos Sanitarios para Desechos Sólidos No Peligrosos	Apr 22, 2002
NTON 05-014-02	Norma Técnica Ambiental para el Manejo, Tratamiento y Disposición Final de los Desechos Sólidos No Peligrosos	May 24, 2002
NTON 05-015-02	Norma Técnica Obligatoria Nicaragüense para el Manejo y Eliminación de Residuos Sólidos Peligrosos	Nov 5, 2002
Hospital Waste		
Ley No. 423	Ley General de Salud.	May 17, 2002
Decreto No. 01-2003	Reglamento a la Ley General de Salud	Jan 10, 2003

Source: *Compendio de Normas Ambientales para Sectores Industriales Micro, Pequeña y Mediana Empresa* (MIPYME)

On the national level, "Special bill for integrated waste management and solid waste hazardous and nonhazardous[3]" has been under consideration since 2011 as a new special bill solely related to solid waste management including recycling, and is expected to be promulgated soon. In addition, Managua City enacted the "Municipal Ordinance No. 02-2006, Damage and Penalties for Environment in the Municipality of Managua". This was revised in 2013 to further strengthen the environmental management as a Municipal Ordinance No.01-2013[4].

(2) Administrative Structure for Solid Waste Management

1) Central Government for Solid Waste Management

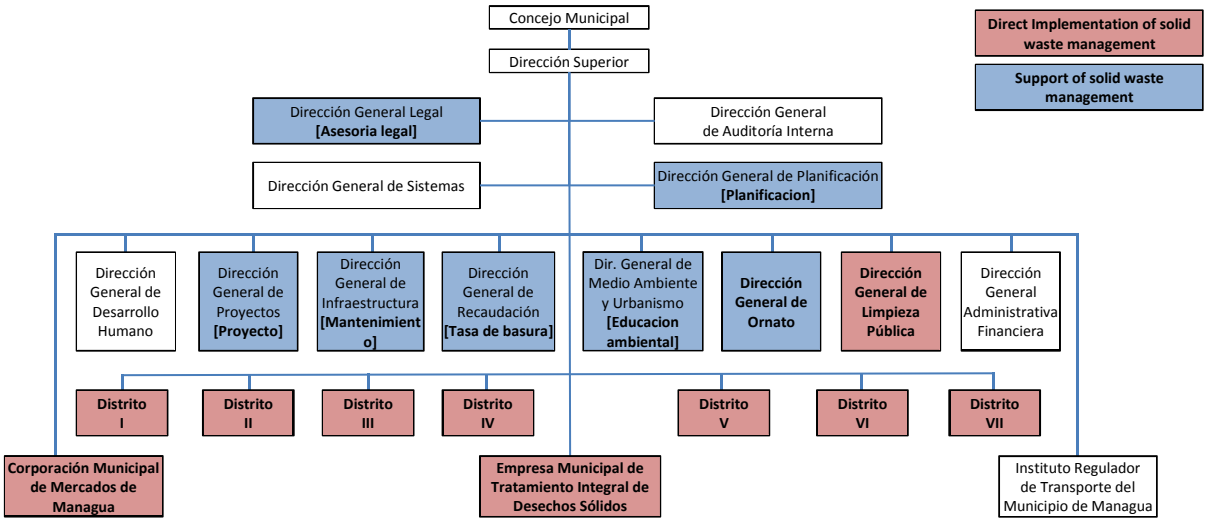
In the central government of Nicaragua, MARENA and MINSA are implementing policies related to solid waste management. The MARENA is responsible for solid waste management

[3] Ley especial de gestión integral de residuos y desechos sólidos peligrosos y no peligrosos
[4] La Ordenanza Municipal Nº 01-2013, Daños y Multas Ambientales en el Municipio de Managua

of the waste generators, authorization and auditing related to operators of waste collection/treatment services as well as hazardous waste treatment; whereas MINSA deals with authorization and auditing related to hospital waste management.

2) Organization of Solid Waste Management in ALMA

For non-hazardous waste management within the district under ALMA, the Directorate General for Public Cleaning (*Dirección General de Limpieza Pública*) collects and transports the waste from households, small retailers, institutions, transfer stations, and communitarian boxes. The Directorate General for Public Cleaning has its own depot for waste collection vehicles and conducts easy maintenance on their own. Each district office conducts street cleaning and residential waste collection from the areas not covered by the Directorate General for Public Cleaning as well as management of communitarian box. The waste collected and transported are treated and disposed by the Municipal Solid Waste Treatment Company (*Empresa Municipal de Tratamiento de Desechos Sólidos:* EMTRIDES). In addition, waste collection from the markets is conducted by the Municipal Corporation of Managua Markets (*Corporación Municipal de Mercados de Managua:* COMMEMA). The Directorate General for the Environment and Urban Planning is responsible for registration and auditing of the business, the waste service companies, and micro-waste collectors as well as conducting environmental education such as awareness-raising campaign on waste issues targeting residents, businesses, service companies, and communities, in cooperation with central government, such as MARENA and others. Periodical maintenance and repairs of collection vehicles are conducted at the workshop owned by the Directorate General for Infrastructure. Departments related to solid waste management in ALMA and Directorate General for Public Cleaning district offices and EMTRIDES organization structure are shown in Figure 5.5.1. Many other departments, such as the Department of Planning, Department of Projects, Department of Fee collection, and Department of Revision of Laws are in charge of certain tasks related to solid waste management. The number of staff actually engaged in solid waste management in each department are shown in Table 5.5.2. The total number adds up to approximately 1,500, of which about 1,000 persons conducting street cleaning and waste collection.



Source: ALMA

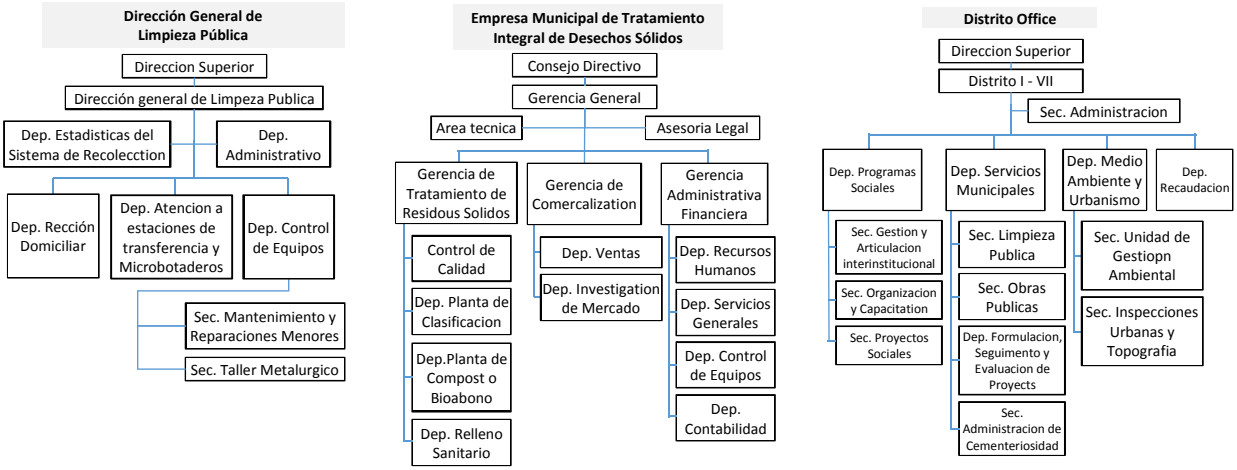


Figure 5.5.1 Organization Structure of ALMA

Table 5.5.2 Number of Staff for Solid Waste Management *Dirección General de Limpieza Pública*, District Office, and EMTRIDES

	Limpieza Pública	D-I	D-II	D-III	D-IV	D-V	D-VI	D-VII	EMTRIDES	Total
Officer	15	1	1	3	2	2	1	1	21	47
Staff	159	18	9	6	15	24	22	22	87	362
Operator	392	45	40	39	34	40	48	32	415	1,085
Total	566	64	50	48	51	66	71	55	523	1,494

Source: Prepared by the JICA Study Team based on the information provided by ALMA and EMTRIDES.

5.5.2 Status of Solid Waste Management in Managua City

(1) Solid Waste Management Plan

The development plan of the ALMA devised in 2013[5] depicts a future plan regarding waste management (Table 5.5.3). These projects are in progress, though slowly. The 18 projects in this plan are those of the revised "La gestion de integral de los residous solid de Managua (GIRS)" which was devised in 2010 with the support of AECID into more practical contents.

Table 5.5.3 Plan for Solid Waste Management in the Development Plan of ALMA

Plan	Program	Project
Chapter I: Urban development and Environment		
Integrated waste management plan	Strengthening program for the solid waste disposal	1. Improvement of the solid waste management system and implementation for recycling
		2. Construction of transfer stations for solid waste in Districts I, III, V and four municipal markets
		3. Installing waste bin to Key Points and Public Transport Stations
Chapter III: Equipment and Municipal Services		
Strategic Plan for Comprehensive Management of Solid Waste of Managua	Institutional strengthening for GIRS	1. Creating and implementation of a municipal legislative framework to strengthen the organic-operative structure GIRS
		2. Improvement and extension of collection and transport system for the solid waste collection service for residential and industrial
		3. Construction and operation of small transfer stations for each district
	Financial sustainability for the waste collection system	4. Implementation of a system for monitoring and controlling the costs and revenues of solid waste management
		5. Expanding the tax base and implementation of different tariff collection systems for waste collection service
	Treatment and disposal of solid waste in sanitary landfill site	6. Creating rules for the management, treatment, and disposal of solid waste
		7. Endowment for heavy equipment of the sanitary landfill site operation
		8. Construction and operation of a new landfill equipped with biogas plant and bio manure for inter-municipal or metropolitan level
		9-1. Annual budget allocation
		9-2. The equipment for the entire complex
		9-3. Financial resources management for the budgetary allocation to the landfill management
		10. Promoting environmental education and citizen participation for the solid waste management
		11. Construction of a small-scale compost production plant
		12. Established a control plan for hazardous and hospital waste management
	Promoting environmental education and citizen participation	13. Training coordinated with the Directorate of Environmental Management and the Department of Occupational Hygiene and Safety for workers of DGPC
		14. Targeted campaigns and trainings focused on local issues and specific sectors
		15. Developing and applying of monitoring manual, and follow-up campaigns and training

Source: Propuesta del Plan de desarrollo del municipio de Managua

[5] *Plan de desarrollo del municipio de Managua 2013*

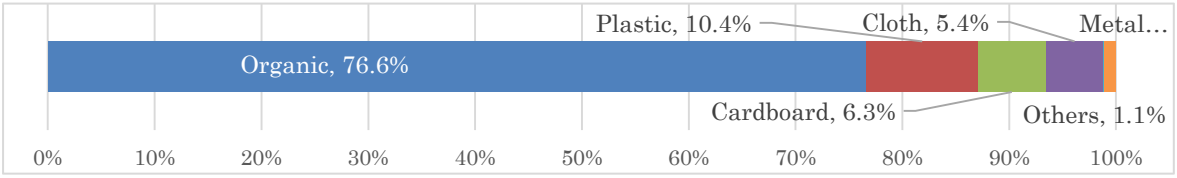
(2) Development Plan for Waste Management Facility

The existing sanitary landfill site is expected to reach its full capacity within three to five years. Therefore, the alternative treatment technology and construction of a new landfill site are currently under consideration. In particular, construction and operation of a waste to energy incineration plant and waste plastic liquefaction systems by concession method (to a Canadian private company) are said to be in progress, as well as construction of a regional landfill site covering the neighboring city of Sandino. For either of the above developments, no public announcement has been made so far.

(3) The Amount and Quality of Solid Waste

1) Waste Composition and Unit of Waste Discharge per Person per Day

According to a waste composition study for the household waste conducted by EMTRIDES in 2016 (Figure 5.5.2), the composition of household waste is organic (77%), followed by plastic (10%).



Source: Prepared by the JICA Study Team based on EMTRIDES data (excluding construction and bulky waste)

Figure 5.5.2 Waste Composition

The unit of waste discharge per person per day is 0.70-0.81 kg/day/person.

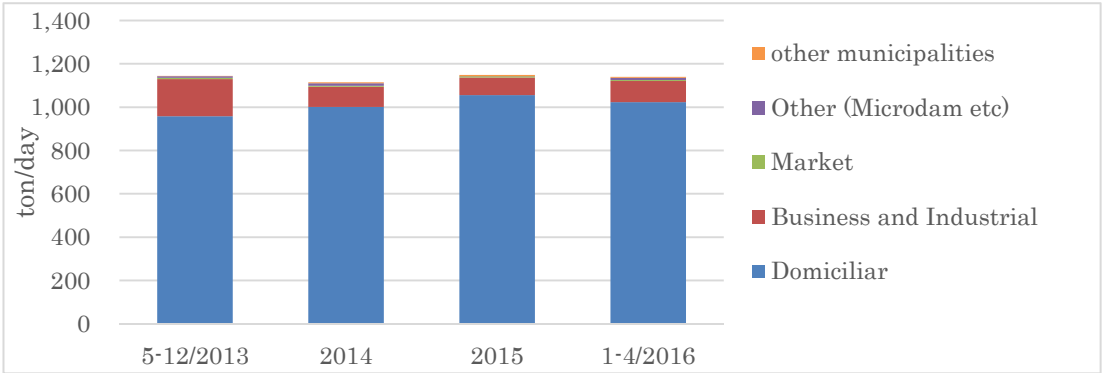
Table 5.5.4 Unit of Waste Discharge per Person per Day

	5-12/2013	2014	2015	1-4/2016
Population	1,262,246	1,283,704	1,305,527	1,327,721
kg/day/person (only *domicilios*)	0.76	0.78	0.81	0.70

Source: Prepared by the JICA Study Team based on ALMA and EMTRIDES data

2) Amount of Solid Waste Discharge

The amount of waste taken in the final disposal site per day in the past four years are shown in Figure 5.5.3. It totals up to 1,000 to 1,100 tons per day, of which 900 to 1,100 tons are from households and small retailers, whereas industrial waste only consists of 100 to 200 tons per day. The trend generally continues to be flat.

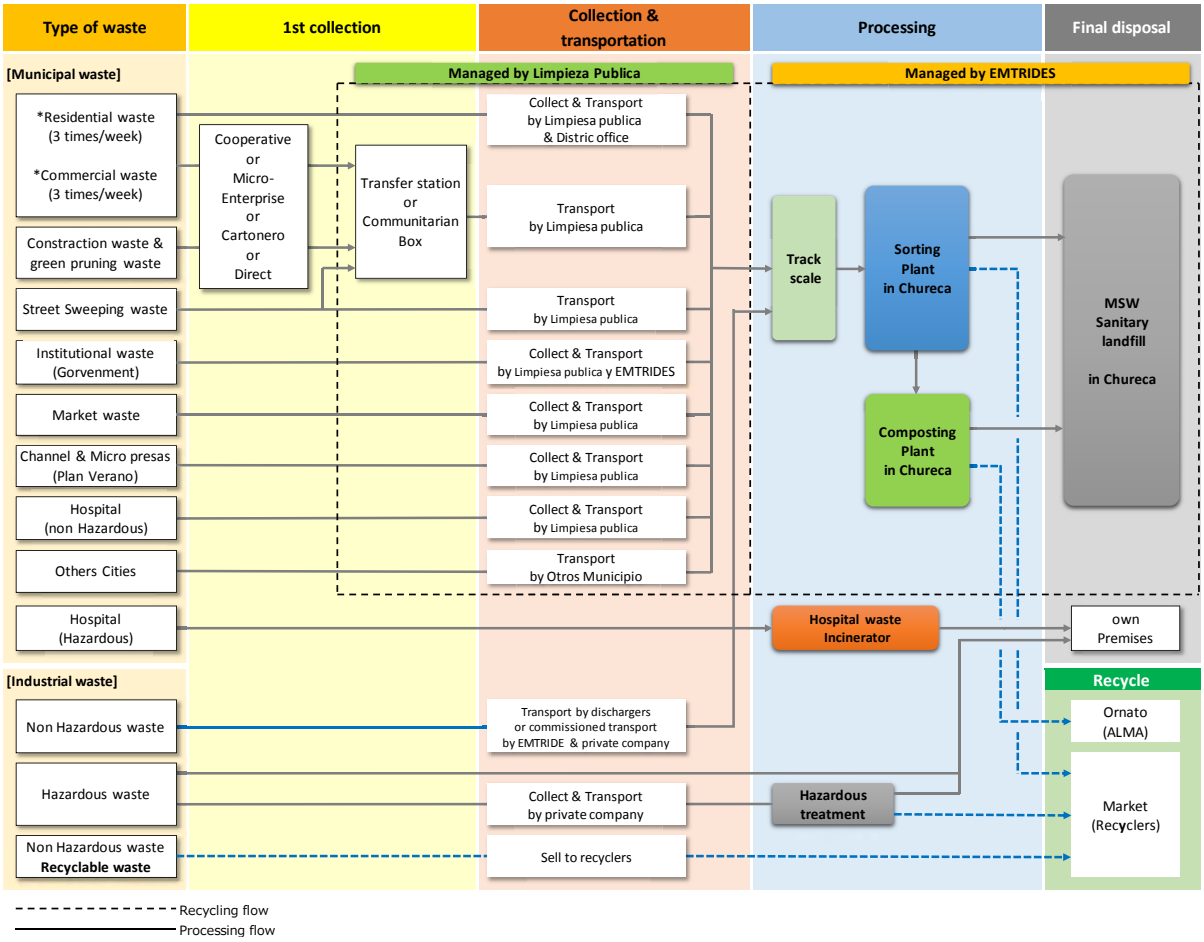


Source: Prepared by the JICA Study Team based on ALMA and EMTRIDES data.

Figure 5.5.3 The Amount of Waste Collected

(4) Solid Waste Management

The flow chart of solid waste management in Managua City are shown in Figure 5.5.4.



Source: Drawn by the JICA Study Team based on ALMA data

Figure 5.5.4 Solid waste management in Managua City

1) Waste Collection

There are two types of waste collection methods from households and small retailers in Managua City. Type 1 is door-to-door collection by the Directorate General for Public Cleaning and district offices. Type 2 is the primary collection to the transfer station done by micro-waste collectors for the areas not covered by door-to-door collection, the green pruning waste and construction waste (less than 3t).

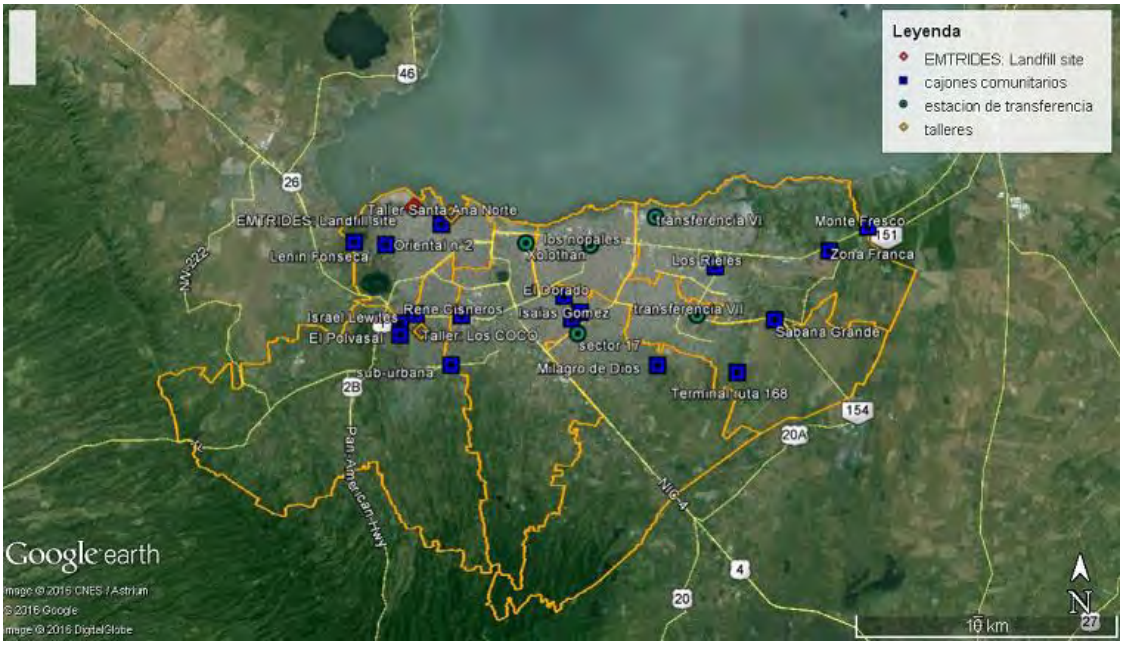
There is a specific waste collection route for door-to-door collection. The waste collection service is provided three times a week in each area. The collection vehicles usually make two trips a day starting from 5:30 a.m. In addition, non-hazardous waste generated by public facilities, hospitals, factories and other businesses are collected by batch (container) by the Directorate General for Public Cleaning, EMTRIDES, and the waste collection service companies authorized by MARENA.

Micro-waste collectors use pushcarts and carriages to collect waste from household, retailers, and other offices; and transport it to transfer stations or communitarian boxes. The characteristics of each transfer station are described in Table 5.5.5. Collected wastes are transported to the final disposal site by dump of the Directorate General for Public Cleaning. The locations of these storage facilities are shown in Figure 5.5.5.

Table 5.5.5 Characteristics of Transfer stations and communitarian Boxes

Type	Contents
Transfer Station	-There are five transfer stations managed by the Directorate General for Public Cleaning in each transfer station. -At the transfer station of District V and VII, cooperatives and micro-enterprises restarted are recycling from the waste collected. The construction of transport station was supported by Italy (District V,) and UN HABITAT and AECID (District VI).
Communitarian Box	-There are 19 communitarian boxes managed by the district office in each box. -These boxes are made of reinforced concrete and are for public use. -The communitarian boxes are emptied and cleaned twice a week.
Common Items of Transfer Station and Communitarian Box	-The operator works from 7 a.m. to 4 p.m. -Solid wastes allowed to be deposit are organic waste, residential waste, and construction waste. And the waste is classified in two, organic/residential and construction waste. -Micro-waste collectors and trucks can deposit garbage freely. -Trucks that enter the locations have to be smaller than 3 tons. -People can take construction wastes and use it for soil filling.

Source: Prepared by the JICA Study Team based on the ALMA data



Source: JICA Study Team

Figure 5.5.5 Map of Landfill Site, Transfer Stations, Communitarian Boxes, and Workshops

Source: JICA Study Team

Figure 5.5.6 Transfer Station

Source: JICA Study Team

Figure 5.5.7 Communitarian Box

Micro waste collectors are registered either as cooperatives, micro-enterprises, and "*carretonero*[6]". However, many *carretonero* are not registered yet. And the waste that they deal with are scattered into open channels and illegal dumping sites which requires improvement.

Table 5.5.6 The Number of Micro Waste Collectors and Transfer Station in Each District

Number	D-I	D-II	D-III	D-IV	D-V	D-VI	D-VII	Total
Transfer station	0	0	0	2	1	1	1	5
Communitarian box	4	3	3	0	1	5	3	19
Cooperatives registered	0	0	0	0	0	1	2	3
Micro-enterprises registered	0	0	0	0	0	0	3	3
Carretonero identified	36	70	49	106	161	74	103	599

Source: Prepared by the JICA Study Team based on the ALMA and district office data.

- Illegal Dumping Site

  A number of small illegal dumping sites are observed in the vacant plot and open channels in the areas where waste collection is not properly done. The construction waste and green pruning waste not collected by the door-to-door collection constitute a large proportion of illegally dumped waste. The locations of these illegal dumping sites are specified by each district office (Table 5.5.7). The cleaning and transportation of illegal dumping waste are done by each district office. Around five illegal dumping sites are closed every year by the efforts of the district offices. There were reportedly over 200 illegal dumping sites in 2013, but those were halved as of now. There are plans to introduce 40 communitarian boxes by closing the illegal dumping sites in the future, but the progress is reportedly slow due to opposition by residents.

Table 5.5.7 Number of Illegal Dumping Sites in Managua City

	D-I	D-II	D-III	D-IV	D-V	D-VI	D-VII	Total
Number of illegal dumping sites	6	17	6	10	23	10	7	79

Source: District office

- *Micropresas* Cleaning (Plan Verano)

  There are 20 *micropresas* or regulating reservoirs in Managua City which were constructed to mitigate the effect of downpour and flooding. The Directorate General for Public Cleaning conducts a seasonal cleaning of *micropresas* and open channel called "*Plan Verano*". It aims at

[6] "Carretonero" is the person who collect wastes with carts and wagons.

preventing malfunctioning of the reservoir by removing illegally dumped waste which may clog open channels and reservoirs. *Plan Verano* is conducted from the second week of January (before the rainy season) through May.

Source: JICA Study Team

Figure 5.5.8 Illegal Dumping Site

Source: JICA Study Team

Figure 5.5.9 Micropresas

2) Treatment and Disposal

A sorting facility, composting facility, and a sanitary landfill site were constructed with the support of AECID from 2008 to 2013. These facilities started operation in January 2013. Non-hazardous wastes collected or transported directly are weighed (approximately 1,200 tons/day), and sent to the sorting facility (approximately 800 tons/day). The remaining 400 tons/day are landfilled at the sanitary landfill site.

- Treatment

Intermediate treatment of the waste is done by a sorting facility with a treatment capacity of 800 t/day and composting facility with an output capacity of 25 t/day. At the sorting facility, large waste objects unsuitable for primary trammel are manually sorted out. Then, organic wastes and non-organic wastes are sorted by the primary trammel. Non-organic wastes are then sorted manually to recyclable material types (plastic, paper, and bottle). Then, recyclable materials are compacted and sold to recyclers. Organic wastes are matured at the composting yard. Then composts are produced by the composting facility (trammel) by which removal of impure substances and adjustment of particle size are conducted.

Source: JICA Study Team

Figure 5.5.10 Sorting Facility

Source: JICA Study Team

Figure 5.5.11 Composting Facility

- Final disposal

A sanitary landfill site has been in operation since 2013. This sanitary landfill site was constructed on the original landfill site. The landfill site is equipped with impermeable liner, leachate collection pipes, gas pipes, and cover soil. Leachate is collected into two leachate ponds which are then dispersed over the landfill area for evaporation. There are four landfill sections planned, of which two have been completely filled with the third section being filled currently. The EMTRIDES estimates the remaining sections are to be filled within three to five years. There are land adjacent to the landfill site where two additional landfill sections can be constructed. In order to elongate the landfill site, there are plans to construct an above-mentioned waste to energy incineration plant and waste plastic liquefaction systems by concession scheme, although the progress of these plans is still unknown.

Source: AECID

Figure 5.5.12 Sanitary Landfill Site

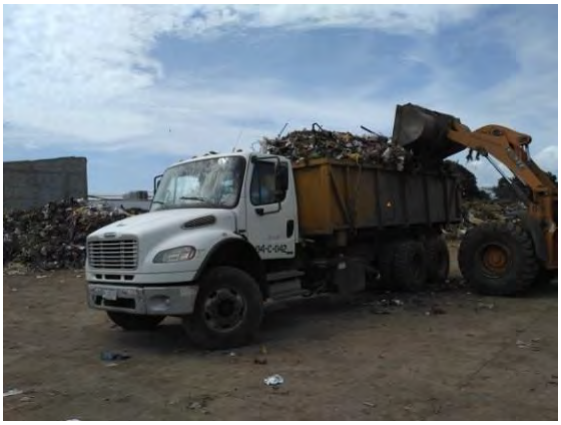
3) Equipment

Waste collection vehicles are managed by the Directorate General for Public Cleaning, each district office, and EMTRIDES.

Table 5.5.8, Table 5.5.9, and Table 5.5.10 list the collection vehicles available in Managua. Many of these are old, and have been used over a long time with repairs and maintenance.

Source: JICA Study Team

Figure 5.5.13 Garbage Compactor Truck



Source: JICA Study Team

Figure 5.5.14 Dump Truck and Front-end Loader

Table 5.5.8 Equipment for the Waste Management of the Directorate General for Public Cleaning

No	Work Area	Type of Equipment	Number	Capacity
1	Waste collection	Garbage compactor truck	87	7 m^3 and 8 m^3
		Farm tractor	5	3
		Motorcycle (supervision)	7	-
		Container for institution, hospital, and others	31	15 m^3
2	Transfer station	Detachable container system truck	15	5 m^3 and 7 m^3
		Dump truck	12	4
		Mini loader	17	-
		Motorcycle	2	0
3	Workshop and minor repairs	Truck crane with boom	1	20 t
		Truck crane trailer towing truck	1	20 t
		Crane truck trailer	4	-
4	Administration	Truck	13	4 t
		Motorcycle	1	-

Source: ALMA

Table 5.5.9 Equipment for the Waste Management of Each District Office

Type of Equipment	D-I	D-II	D-III	D-IV	D-V	D-VI	D-VII
Push cart for road cleaning	36	35	45	40	20	30	4
Dump truck	5	6	6	6	6	7	5
Tractor	2	2	2	2	3	2	2
Front-end loader	1	2	1	2	2	2	1
Mini loader	1	2	2	2	1	1	1
Retroexcavadora			1				
Patrol	1	1	2	1	2	1	1

Source: District Office

Table 5.5.10 Equipment for the Waste Management of EMTRIDES

No	Work Area	Type of Equipment	Number	Capacity
1	Sorting Plant	Front-end loader	2	2.5 m^3
		Truck crane	2	3 t and 4 t
		Dump truck	5	12 m^3
		Mini loader	1	0.79 t
		Fork lift trucks	1	4 t
2	Landfill	Caterpillar tractor	3	
		Tanker truck	1	2000 GLS
3	Waste Collection	Garbage compactor truck	7	14 m3
		Detachable container system truck	2	15 m3
		Container for industry and/or company	352	1m3
		Container for industry and/or company	42	15m3

Source: EMTRIDES

4) Maintenance

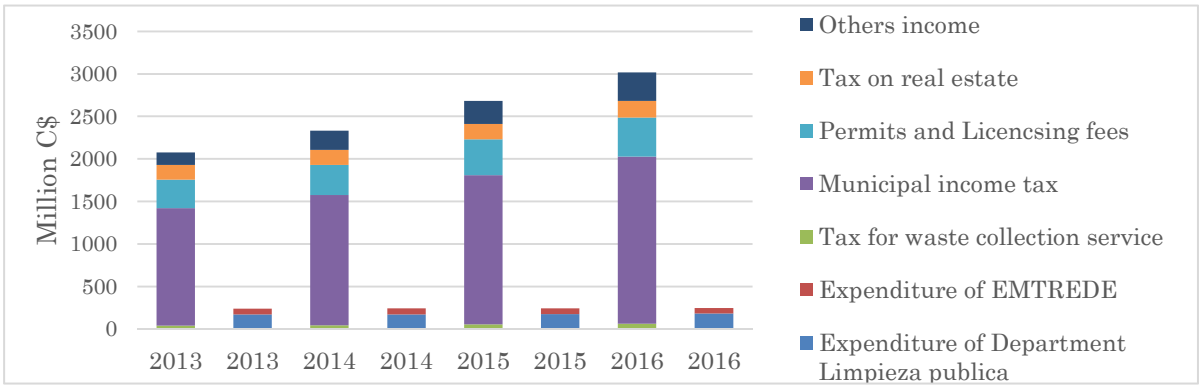
Daily maintenance, such as oil filling, is done by el planta de COCO. Other maintenance, such as exchanges of tires, maintenance of the engines, electric systems, car bodies, overhauling, and periodical maintenance, are conducted at the main workshop in Santa Ana Norte where maintenance for all the ALMA vehicles are conducted. There are cases where sufficient repairs are not possible for supplies of spare parts by the manufacturer has been ended for old vehicles that are still used in Managua City. In addition, there is also an issue of additional time required for repair works, if parts must be ordered from overseas.

(5) Recycle

Recyclable materials are taken away by waste collection staff at the time of door-to-door collection. Cooperatives, micro-enterprises and *carretonero* also sort and take out recyclable materials from the waste they collect. Moreover, the waste transported to the final landfill site are also recycled via the sorting facility and composting facility. Recyclable materials sorted are sold to the five recyclers within the city. Hazardous waste oil is recycled at the recycler located in Managua City.

(6) Financial status

City expenditure for solid waste management and city tax revenue in 2015 are shown in Figure 5.5.15[7]. 2.0% of city tax revenue is collected as waste collection fee. And 9.5% of city tax revenues are consumed for solid waste management. Although tax revenue is growing, expenses spent on waste management are not growing.



Source: Prepared by the JICA Study Team based on the information provided by ALMA and EMTRIDES

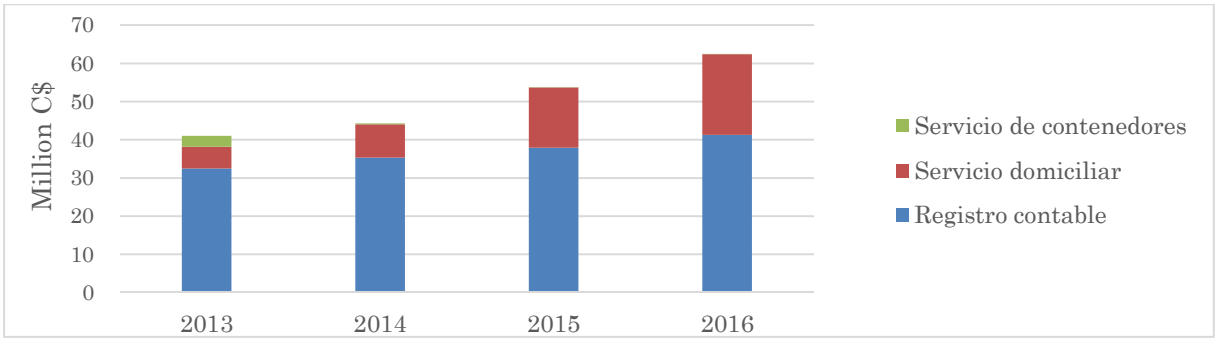
Figure 5.5.15 Solid waste management financial analysis

Waste collection fee is set by housing and business typology under an ordinance enacted in 1993. However, the fee structure is not suited to the current economic status. In Managua City, the fee has been raised on a trial basis since 2015. The fee payment can be made either at the municipal office and district office or to the fee collector when they visit houses for fee collection. The system allows that they pay the waste collection fee along with other municipal taxes. According to an interview with the Directorate General for Tax Collection, the collection rate is low not only collection rate of waste

[7] The expenditure of solid waste management carried out by District office is not included.

collection fee but also collection rate of property tax which is tax from citizens. Especially citizens have low willing to pay waste collection fee. For example, the payment rate for the property tax, which is collected by the same way as waste collection fee, is only 40% for the household section.

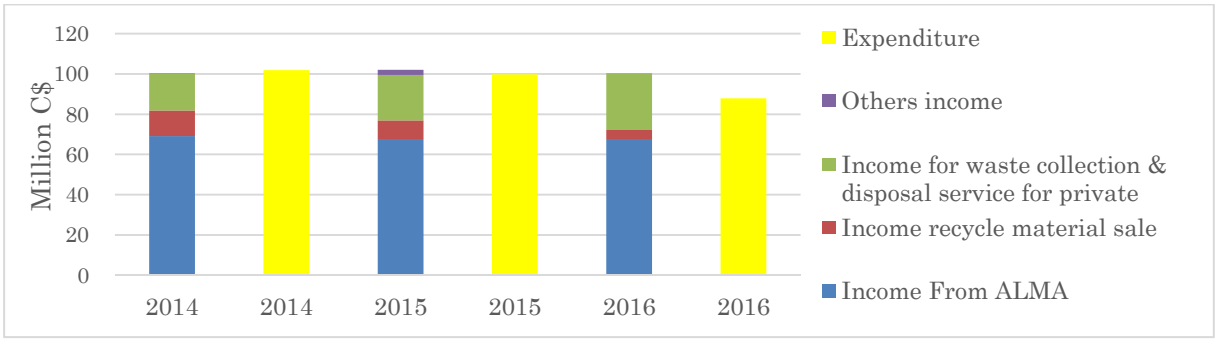
The breakdown of the waste collection fee collected is as follows.



Source: ALMA

Figure 5.5.16 Income of waste collection service by category

The financial balance of EMTRIDES, the municipal solid waste management company, which maintains the final disposal site and recycling facility and manages the solid waste collects, processes and disposes from private companies, is as follows. The subsidies from ALMA account for about 80% of EMTRIDES's income in 2016.



Source: Prepared by the JICA Study Team based on the information provided by EMTRIDES

Figure 5.5.17 Balance related to solid waste management in EMTRIDES

(7) Hazardous and Hospital Waste Management

1) Hazardous Waste Management

The MARENA is in charge of overseeing hazardous waste and ALMA does not deal with hazardous waste. Residential waste is not classified as hazardous and non-hazardous wastes. Residential waste is not classified hazardous and non-hazardous waste. Business entities must commission authorized waste collectors by MARENA for transportation. There are recyclers for hazardous oil wastes. Other types of waste, however, are either stored or landfilled within the premise of each business.

2) Hospital Waste Management

The MINSA is in charge of overseeing hospital waste management. Waste generated from either public or private hospitals are separated into hazardous (infectious) wastes and non-hazardous

wastes within the hospital. Non-hazardous wastes are taken by the municipal collection. Infectious wastes are treated either by autoclaving machine or incinerator installed at several of these hospitals. Infectious waste generated from the hospitals and health centers which do not have any incinerator are transported to the hospitals with such a facility for communal treatment, though the treatment capacity is not sufficient. Incineration ashes are disposed into a hole dug within the hospital premises.

Table 5.5.11 List of Hospitals and Incinerator

Type	No. Name of Hospital	incinerator	Capacity	Date
Public	1.Hospital Militar, 2. Hospital Policía, 3. Hospital Cruz Azul, 4. Hospital Central	-	-	-
Private	1.Vivian Pellas, 2. Mt. eEpaña, 3. Bautista, 4. Salud Integral, 5. Su Medico	Bautista 1	-	-
Government	1.Antonio Lenin Fonseca, 2. Manuel Morales, 3. Berta Calderon, 4. Manuel de Jesús Rivera, 5. Aldo Chavarria, 6. Dermatologico, 7. Phsicosocial, 8. Centro Nacional de Oftalmolgia, 9. Alemán Nicaragüense, 10. Solidaridad, 11. Fernando Belez Paiz (under construction)	Antonio Lenin Fonseca: 1 Manuel Morales: 1 Berta Calderon: 1 Manuel de Jesús Rivera: 1 Alemán Nicaragüense :1 Fernando Belez Paiz : 1	70 lb/hr 45 lb/hr 45 lb/hr 44 lb/hr 44 lb/hr -	2003 2005 2005 2005 2005 -
Total	20	7		

Source: MINSA

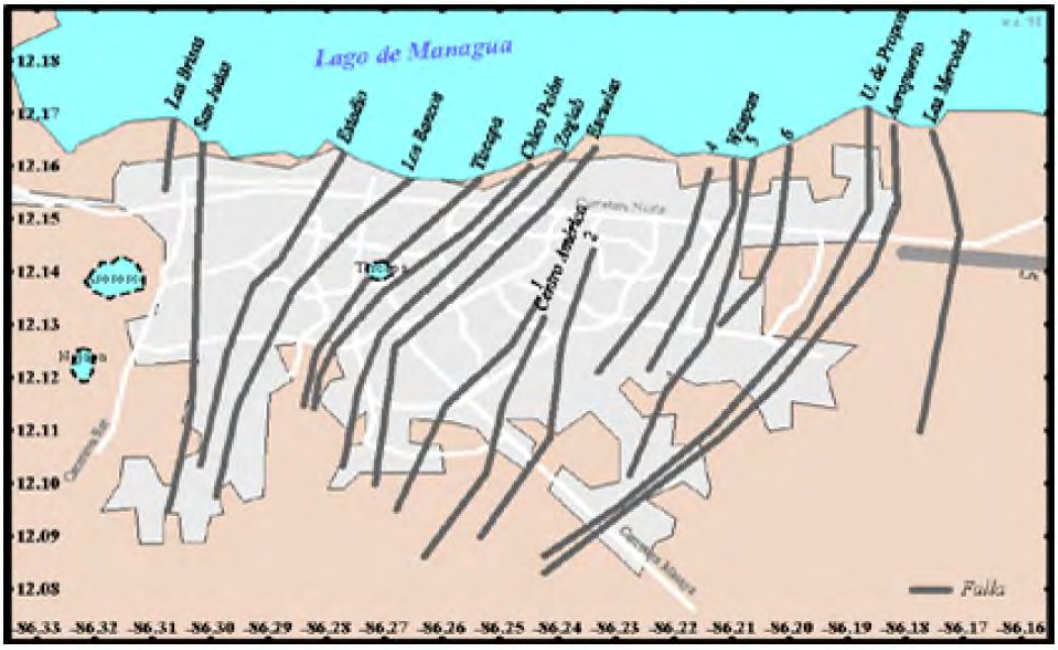
5.6 Disaster Mitigation and Risk Management

5.6.1 Major Natural Disasters

There are various kinds of natural disasters in the Republic of Nicaragua, of which (1) earthquake, (2) flood inundation (also detailed in Section 5.4), and (3) landslide are identified as major disasters in the Managua Metropolitan area by ALMA as explained hereunder.

(1) Earthquake

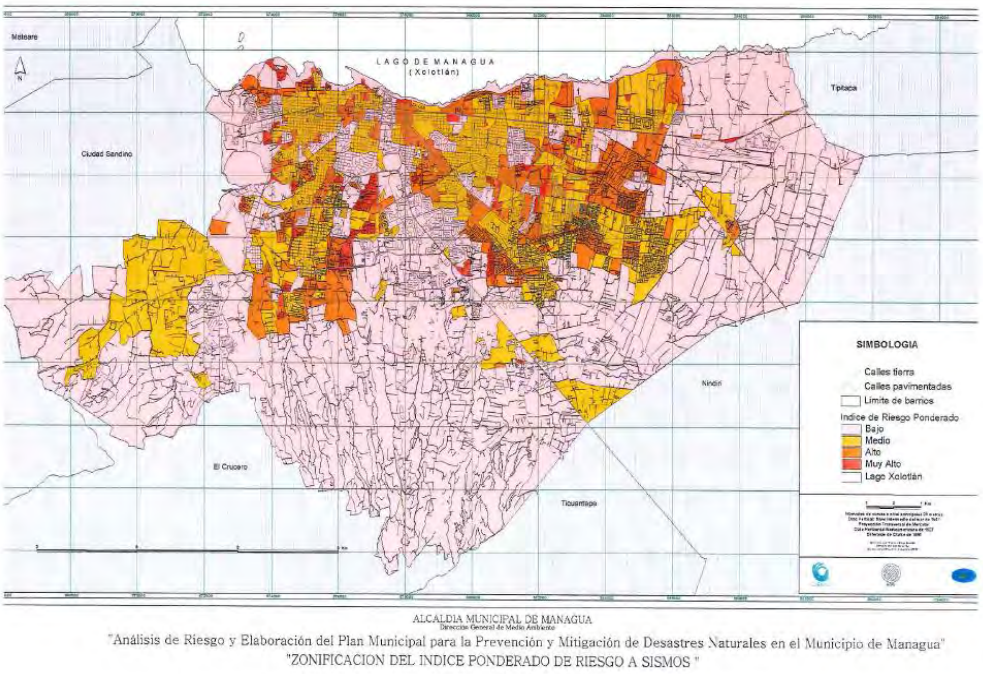
There are 28 fault lines identified mainly running from the southwest to the northeast in the Managua Metropolitan area. Of these, 18 are judged highly active as shown in Figure 5.6.1, which may cause earthquake in the area. The fault lines, namely, Fallas Estadio, Los Bancos, Tiscapa, Chico Pelon, and Aeropuerto, were the major active lines during the big earthquake in 1972. It is also recognized that the average interval of the occurrence of big earthquake is considered at about 50 years and the latest earthquake happened on April 10, 2014 with a magnitude of 6.2 near the Managua Metropolitan area.



Source: SINAPRED

Figure 5.6.1 Highly Active Fault Lines in Managua

The seismic hazard map for Managua was prepared by JICA in October 2006 under the technical assistance to INETER. Later on, the map was updated by INETER. The seismic hazard map with 4-categorized intensities (weak, medium, strong, and very strong) was issued in 2002 by the Managua City is shown in Figure 5.6.2.



Source: ALMA, prepared in 2002

Figure 5.6.2 Seismic Hazard Map for Managua

The Department of Geology and Geophysics of INETER has been operating earthquake observations since 1992, and provides warning information (if greater than M 3.4 for local earthquakes, if greater than M 4.0 for regional earthquake, and if greater than M 6.0 for remote earthquake) using 45 short period seismometers, 21 broadband seismometers, and 24 strong motion seismometers (accelerometers) in the country.

The warning information by the following three alert levels was also been given by INETER for the Managua Metropolitan area as shown in Table 5.6.1.

Table 5.6.1 Warning Information by Three Alert Levels for the Managua Metropolitan Area

No.	Type of Alert	Magnitude of Earthquake
1	Green	Occurrence of three earthquakes with magnitudes less than 3.5 in less than 12 hours
2	Yellow	Occurrence of ten earthquakes with magnitudes less than 3.5 in less than 12 hours Occurrence of three earthquakes with magnitudes less than 4.5 in less than 24 hours
3	Red	Occurrence of at least an earthquake with magnitude greater than 4.5

Source: JICA Study Team

(2) Flood Inundation

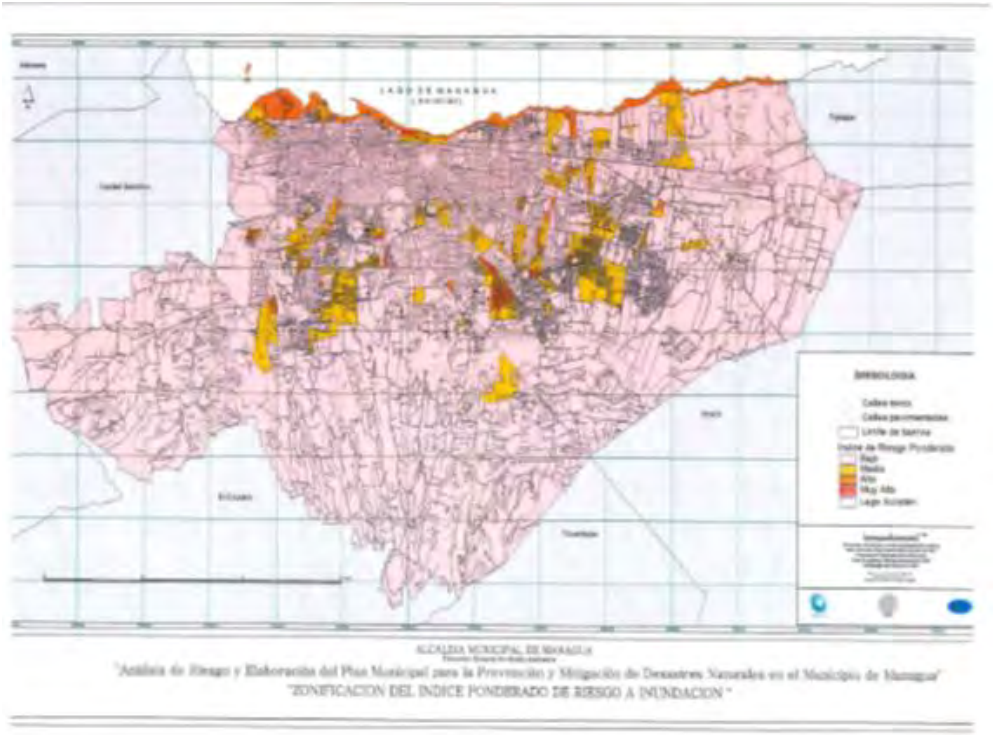
The physical characteristics of the river systems in Managua is summarized in Section 5.2. As one of the hydraulic characteristics in the area, there are no big rivers, while there are several cauces in the low lying area located in the north, and 23 micropresas in the middle reach of the mountain slope area (EL between 300 to 400 m), mostly located in Micro-Cuenca II.

The river channel system map and flood inundation hazard map for Managua issued by Managua City are shown in Figure 5.6.3 and Figure 5.6.4, respectively.

The average annual rainfall in Managua Metropolitan area is about 1,200 mm with the rainy season from May to October. Due to hurricanes and high intensity rainfall during rainy season, and insufficient capacity of cauces and micropresas, some areas along the Cauce 31 Deciembre, Cauce Oriental, Cauce Las Cuerezmas, and Cauce Los Duartes are habitually inundated (shown in color orange).

Source: ALMA

Figure 5.6.3 River Channel System in the Managua Metropolitan Area

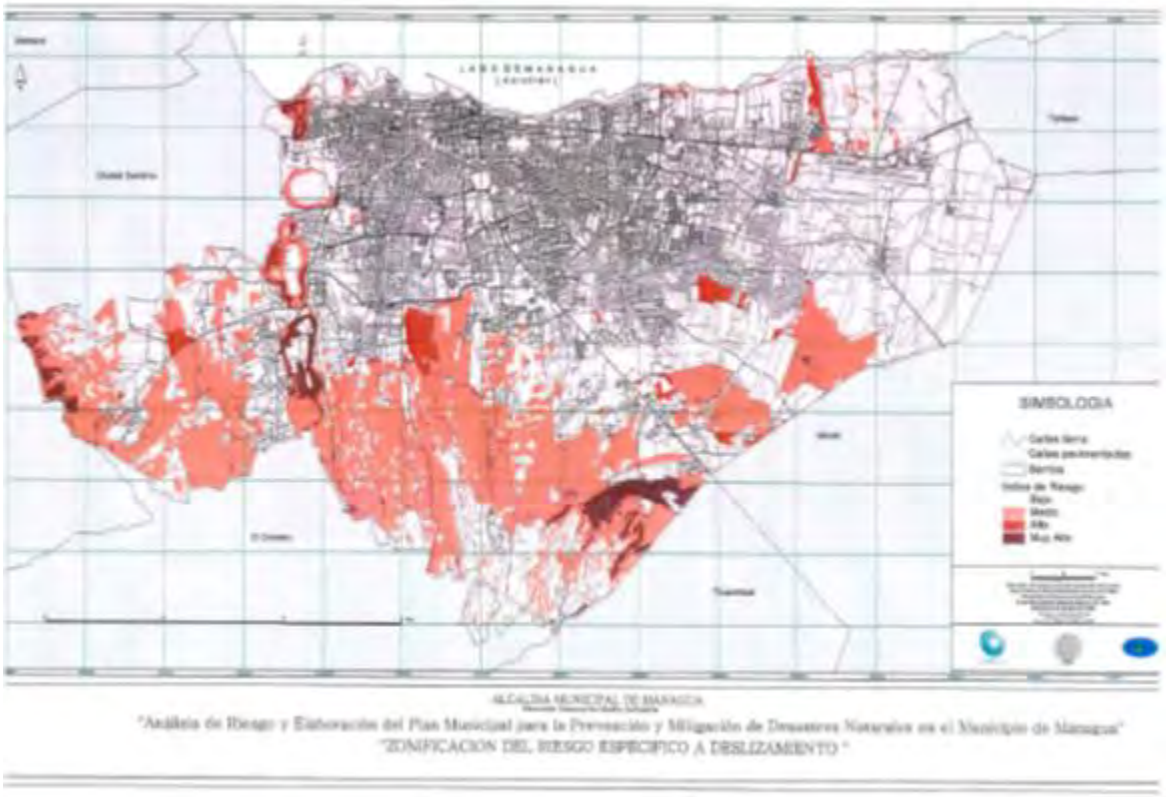


Source: ALMA, prepared in 2002

Figure 5.6.4 Flood Inundation Hazard Map for Managua

(3) Landslide

The landslide hazard map for Managua issued by ALMA is shown in Figure 5.6.5.



Source: ALMA, prepared in 2002

Figure 5.6.5 Landslide Hazard Map for Managua

The area in the slope of the mountain in the southern area is subject to erosion and landslide due to recent land developments by private firms mainly for residential, agricultural, and pasture activities. This erosion has resulted in a shortage of capacity of micropresas and shortage of flow capacity of cauces due to the increase of sediment discharge to the downstream area.

5.6.2 Government's Organization Structure for Natural Disaster Prevention Planning/ Management and Risk Assessment

(1) National Government

In the national level, the National System for Prevention, Mitigation and Attention to Disasters (*Sistema Nacional para la Prevención, Mitigación y Atención de Desastre:* SINAPRED) was established in November 2000, and is in charge of formulation of a national plan, implementation of measures, and dissemination of warning for disaster prevention planning/management and risk assessment, as shown in the organization chart in Figure 5.6.6. SINAPRED is a name of system established be law 337, coordinator for the role of SINAPRED is called Co-Direction of SINAPRED(CD-SINAPRED) and Co-Management.

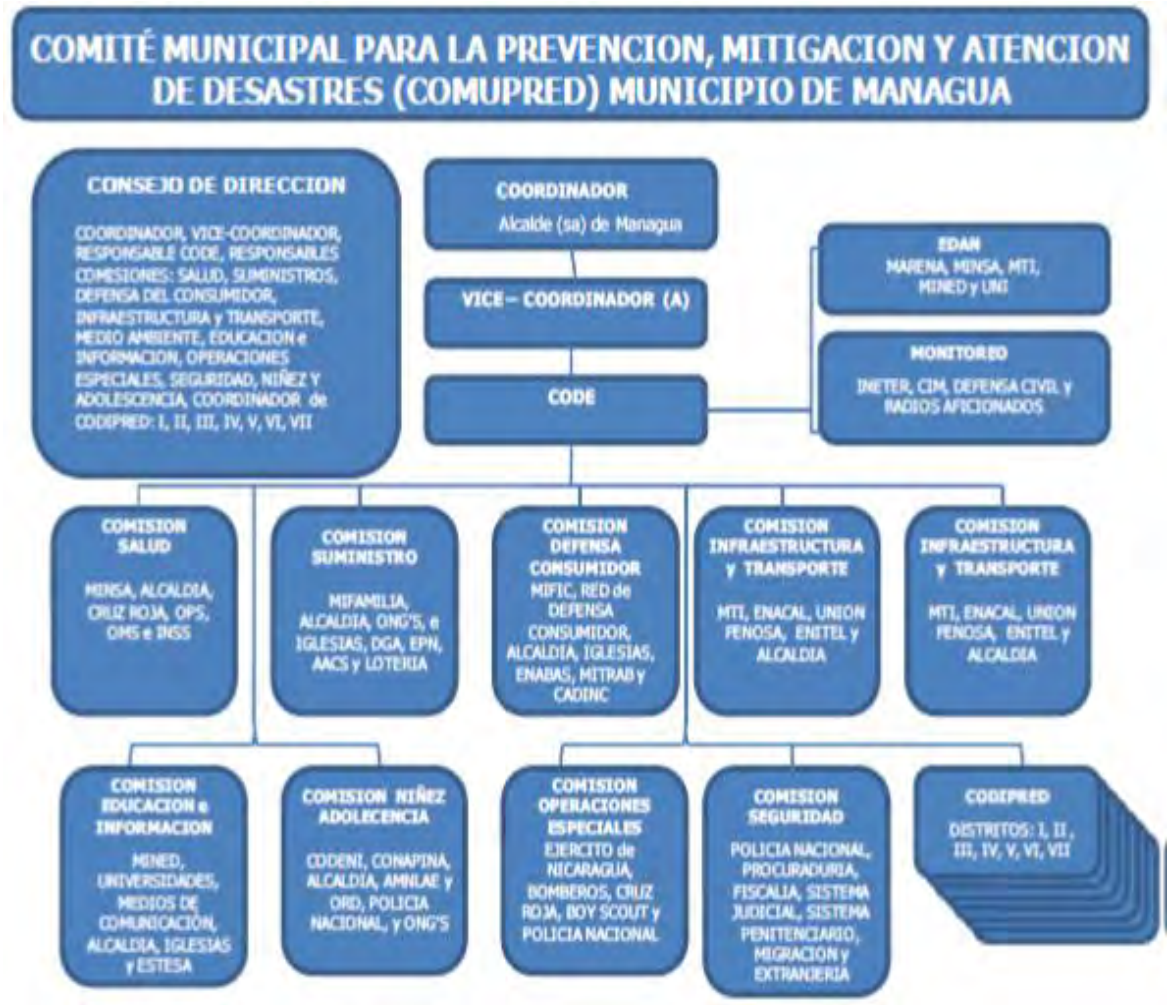
It is noted that the Civil Defence is in charge for emergency response, and INETER is in charge of implementation and formulation of various hazard maps and dissemination of disaster information. It is also noted that in the local level, there are the Departmental Committees for Prevention, Mitigation and Disaster Relief (*Comité Departamentales para la Prevención, Mitigación y Atención a Desastres:* CODEPRED) in departments, the Municipal Committees for Prevention, Mitigation and Disaster Relief (*Comité Municipales para la Prevención, Mitigación y Atención de Desastres:* COMUPRED) in municipalities/cities, the District Disaster Prevention, Mitigation and Attention Committee (*Comité Distrital para la Prevención, Mitigación y Atención de Desastres:* CODIPRED) in districts, and the Neighborhood Committee for Prevention, Mitigation and Disaster Relief (*Comité de barrio para la Prevención, Mitigación y Atención de Desastres:* COBAPRED) in barrios under SINAPRED.

Source: SINAPRED

Figure 5.6.6 Organization Structure of SINAPRED

(2) Managua City

In Managua City, the COMUPRED is in charge for disaster prevention planning/management and risk assessment as shown in Figure 5.6.7.



Source: ALMA

Figure 5.6.7 Organization Structure of the COMUPRED of Managua City

There are also CODIPRED for seven districts as well as COBAPRED for 1,022 barrios in the city. The COMUPRED of Managua City forecasted possible affected families/people by earthquake, flood inundation, and landslide disasters in the city as shown in Table 5.6.2**.**

Table 5.6.2 Possible Affected Families/People by Earthquake, Flood Inundation, and Landslide Disasters in Managua City

District	Earthquake		Flood Inundation		Landslide	
	Family	People	Family	People	Family	People
1	10,190	50,950	143	613	570	2,852
2	13,503	67,515	196	990	30	150
3	10,614	53,071	123	519	1,802	9,010
4	6,429	32,145	280	1643	116	580
5	19,038	95,190	601	3,032	0	0
6	8,776	43,881	110	561	120	600
7	8,517	42,583	370	2248	0	0
Total	77,067	385,335	1,823	9,606	2,638	13,192

Source: ALMA

There are parks and open spaces that can be utilized as safety open areas for evacuation. Schools, hospitals, and public facilities can also function as evacuation centers. These are all identified by Managua City and is shown in Table 5.6.3.

Table 5.6.3 Features of Evacuation Center in Managua City

District	No. of Safety, Open Areas for Evacuation	Capacity in No. of People for Evacuation	No. of Evacuation Centers	Capacity in No. of Families in Evacuation Centers
1	6	40,000	4	900
2	4	60,000	3	240
3	4	35,000	5	385
4	2	25,000	4	165
5	4	80,000	9	637
6	3	60,000	6	454
7	2	70,000	13	613
Total	25	370,000	44	3,394

Source: ALMA

5.6.3 Policies and Laws for Natural Disaster Prevention Planning/Management and Risk Assessment

(1) National Policy for Integrated Risk Management of Nicaragua

The National Policy for Integrated Risk Management of Nicaragua indicates general principles of risk management countermeasures aiming at reducing the threat of natural and manmade phenomena, and climate change affecting the security of citizens.

(2) Law 337

The Law 337 stipulates the establishing of SINAPRED and indicates the role and responsibility of organizations regarding disaster prevention, mitigation, response, and recovery, wherein CD-SINAPRED will function as the coordinator.

(3) Regulation Regarding *Cauce* and *Micropresa*

As a land use restriction along the existing river channel, Managua City set a regulation that the area from the edge of the river channel with a width of 5 m (in case of concrete lining channel) or 7 m (in case of natural channel) is restricted to be used for any purpose as a minimum required margin space based on the Memorandum in February 2002. Furthermore, Managua is going to set a similar regulation for areas along the retarding basin with a width of 10 m based on an agreement drafted in 2009.

However, there are many areas in the city where such regulation is not functional due to illegal settlements and improper management of land.

(4) Regulation on Building Permit by Geological Fault

Based on the past experience of earthquake in 1972, Managua City has been introducing regulation on building permit by type of geological fault in location. There are five colored corresponding map of

guide to reduce risk of geological fault (red as active major, orange as active minor, blue as probable major feature, green as doubtful minor feature, and white as no evidence); and guide of permission use categorized as 1, 1a, 2, 3, 4, 5, and 6.

5.6.4 Preliminary Risk Assessment

(1) Earthquake

The Central America region is located on the western edge of the Caribbean Plate, surrounded by the North American, Cocos, Nazca, and South American Plates. As the Coco Plate subducts under the Caribbean Plate, relative displacement occurs between each of these plates which may have caused an earthquake to happen in the past. It is recognized that the average interval of the occurrence of big earthquake is considered at about 50 years shown in Table 5.6.4.

Table 5.6.4 Major Earthquake Damages in the Past for Managua Metropolitan Area

Year	Magnitude	Damages
1931	M 6.0	About 1,000 people died.
1972	M 6.2	About 10,000 people died, 20,000 people injured, and 250,000 people evacuated.
2014	M 6.1	Only damages to the buildings

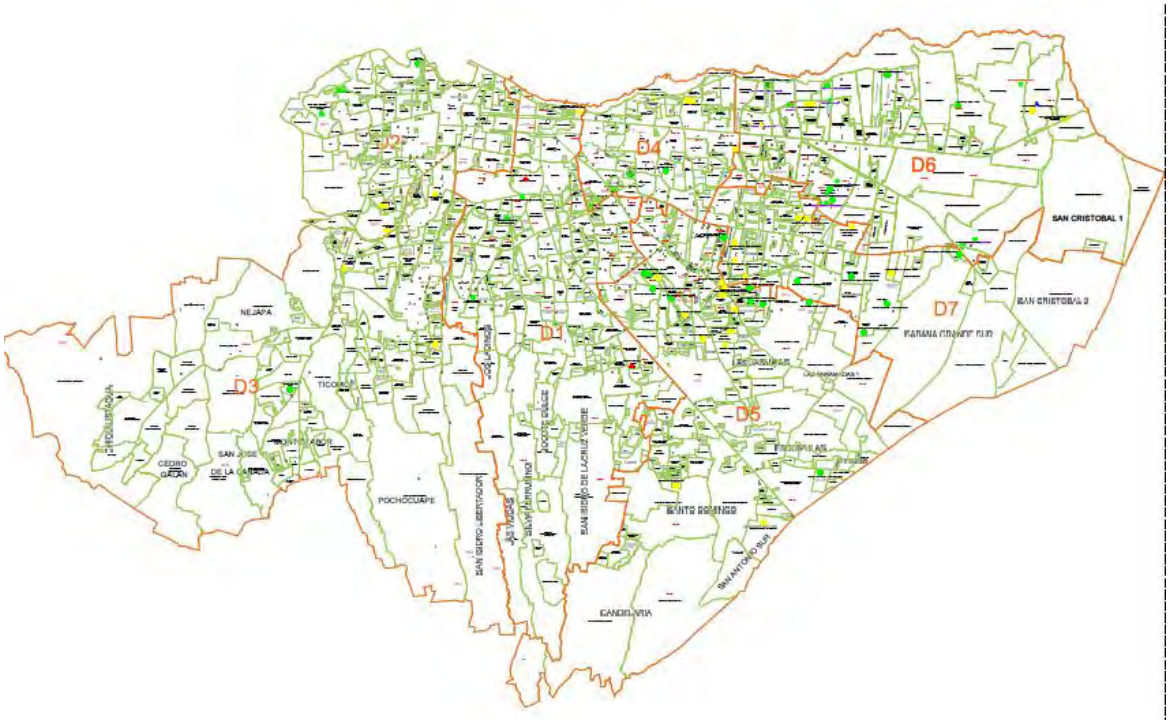
Source: SINAPRED

Nonetheless, a big earthquake could happen anytime. And so, Managua City together with SINAPRED and other concerned agencies have made various efforts to reduce an earthquake disaster risk since 1972. In recent years, a seismic hazard map was prepared, monitoring devices were installed, warning information were provided, four earthquake drills were conducted, and other measures were also introduced.

It was preliminarily assessed that these efforts are reasonable and should be continued. Although, some improvements in hazard map by GIS, monitoring devices, warning information system, and drills, could be done further. Meanwhile, improvements will be necessary in the proposed Master Plan with regards to the evacuation system and land use/building control by seismic hazard map or regulation. It is noted that one of the main causes of the death of people in recent earthquakes in Japan were caused by the destruction of houses/buildings due to insufficient structures. Therefore, structural measures for reinforcement of houses/buildings with appropriate law and regulation for seismic requirement are also important.

(2) Flood Inundation and Landslide

ALMA has prepared a location map of critical areas for flood inundation and landslide in 2015 and is shown in Figure 5.6.8. The map preparation started in 2011. Using the data from 2011 to 2015, flood inundation and landslide hazard maps were prepared, which are updates of the old maps made in 2002.



Source: ALMA
Note: "○" shows area for flood inundation, "Δ" landslide, and "green" colored area show low impact area, "yellow" for medium, and "red" show high.

Figure 5.6.8 Critical Points for Flood Inundation and Landslide in 2015

Based on the data shown in the Table 5.6.5, the number of critical points for flood inundation and landslide has been generally reduced from 84 in 2011 to 65 in 2015, with an exception of 2013 when the number recorded a temporal increase. This would probably mean that, due to some effects of ALMA and concerned agencies on structural and non-structural measures for flood inundation and landslide, the number of critical points may be reduced in the short term, though continuous effects and further significant measures shall be proposed to undertake in the Master Plan.

Table 5.6.5 Number of Critical Points for Flood Inundation and Landslide

Risk Level	2011	2012	2013	2014	2015
A	13	8	5	7	2
B	34	15	20	19	27
C	23	42	45	37	30
D	14	13	14	9	5
E	-	3	2	-	-
Total	84	81	86	72	65

Source: ALMA

5.7 Issues in Infrastructure and Disaster Mitigation

(1) Issues in Water Supply

1) High Level of Non-revenue Water

The ENACAL currently is paid for only about 45% of the water it produces at the wells and pumping facilities. This is a very low ratio and the situation means customers pay more for utilities for extra electricity to pump water but a lot of pumped water is leaked from the water supply system and never reaches the customers. The utility is keenly focused on trying to reduce the amount of non-revenue water.

Produced water does not generate revenue due to two major factors: the first is leaks in the network and the second is through unregulated connections, where people receive water for free, or pay a nominal fixed amount, a situation which can lead to wastage or inappropriate use of water. ENACAL has executed various projects through international lenders to address the issue of non-revenue water. Studies have found that leakage may be 35% or more of the produced water. A study in 2015 showed that the value is still high, even after several projects intended to control it.

2) Unreliable Water Service

This situation has not been carefully quantified in the previous studies, but it is known that not all users have consistent water service available at their homes. A recent newspaper poll stated that 40% of residents do not have water 24 hours a day and a significant portion of them do not receive water on many days.

3) Water Supply Availability

The subterranean aquifer is Managua's source of potable water. Many studies have estimated the sustained yield from the aquifer, and it is known that the ENACAL has been pumping significantly more water from the aquifer than the suggested sustained yield. There have been no hydrogeological studies to show any impact of this pumping. One danger of over-pumping the aquifer is that the level of the aquifer will drop and the higher levels in Managua Lake will allow that source to infiltrate the drinking water aquifer. The quality of Managua Lake is poor in terms of drinking water, and the intrusion of those waters into the drinking water aquifer would be a very bad situation.

(2) Issues in Water Resources

1) Contamination of Water Resources

Managua Lake is one of the largest surface water resources in the country, but the water is significantly contaminated by heavy metals, pesticide and domestic wastewater. Water taken from the lake have a risk of contamination for use as tap water.

2) Deforestation in Watershed

Deforestation in the watershed is a serious problem with its devastating environmental consequences in this country which decreases the amount of recharge to aquifers by increasing surface runoff, damages ecosystems, accelerates soil erosion, and increases turbidity of floods. On the other hand, rainwater infiltration function is reduced due to urbanization: construction of buildings, road pavements and so on.

3) Deterioration of Existing Water Source Facilities

Aged existing water source facilities lead tendency to reduce raw water extraction amount. Proper maintenance and renovations on the aged facilities to recover a water extraction function are required.

4) Lacking Future Development Plan of Alternative Water Resources

In order to reduce the extraction amount of raw water from Asososca Lake and to relocate some of the wells located near the Managua Lake coast, alternative water sources shall be developed but such future development plan is not yet pursued.

(3) Issues in Sewerage

1) Inadequate Wastewater Disposal

One of the problems investigated in depth by ENACAL resides in the risk of contamination of underground water reserves due to inadequate wastewater (raw or treated) disposal by the real estate developers and settlements located in the sub-basin III (South West) of Managua City. Analysis by ENACAL Environmental and Treatment Systems Division shows that, in the urban developments of that area, the effluents of most of the wastewater treatment plants (WWTPs) although satisfying with the established quality limit (MPL) regarding BOD5 and COD. There is a significant non-compliance regarding the quality standards for faecal coliform and nutrients (phosphorus and nitrogen) concentration. ENACAL developed an extensive awareness-raising to stop these practices that jeopardize groundwater sources. New settlements are growth-fast sector. Disorderly expansions and lacking of any urban planning technical criteria become a problem to ensure water supply and sanitation programs.

2) Unsewered Low Income Settlements

The most significant physical problems identified in the previous reports and confirmed by ENACAL are situation that low income settlements are still unsewered. Detailed information as the scale and spatial distribution were not available at this moment. Therefore, further data will be collected for the next assignment.

In the future activities of this project, the above items will be evaluated based on the more detailed (updated) data from ENACAL and general solutions will be incorporated.

(4) Issues in Flood Management

1) Shortage of flow capacity of *cauces*

Large scale floods often overflow from *cauces* (drainage canals). Fundamental data to study flood measures including existing flow capacity and probable floods of each *cauce* are not available. Assessment of existing flow capacity of each *cauce* against probable floods will be a first step of the improvement works.

2) Malfunction of flood management structures due to illegal dumping of garbage

Excessive sediment productions in upper basins reduce storage capacity of *micropresas* and flow capacity of *cauces*. Soil erosion from bare lands in upper basins produces a large amount of sedimentation in *cauces* and *micropresas*, or small regulating dams. Sedimentation reduces flow capacity of *cauces* and causes malfunction of *micropresas*. Beside, downstream portion of the existing rainwater pipe network in central urban area have been reduced their flow capacity due to aging. In addition to this, huge amount of garbage which are thrown into *cauces* and *micropresas* illegally by citizens deteriorates their original functions. ALMA repeatedly remove such illegal garbages from the flood management structure every dry season but the maintenance budget is not enough amounts.

3) Significant flood damage risks along *cauces*

Steep topography in Managua City makes high velocity floods which often threat people living and/or moving along *cauces*. There are some illegal settlements along *cauces*, although the both sides of *cauces* are regulated as a green belt. Such houses are facing a large flood damage risk. At the time of June 2016 flood, settlements along *cauces* suffered from floodings.

4) Lack of prior information to evacuate against large floods

Intense rainfalls in upstream basins cause large flood in downstream basins. Local people living in lowland areas shall have to evacuate timely in view of large floods but prior flood information for evacuation is not systematically given.

5) Reduction of rainwater storage and infiltration functions due to rapid urbanization

Most of urban areas are covered by concrete and asphalt except for limited gardens, public parks and *micropresas* in the study area. Hence, rainwater does not infiltrate to the ground and discharges to lower land immediately.

(5) Issues in Solid Waste Management

1) Illegal Dumping Site due to Incomplete Waste Collection and Transportation System

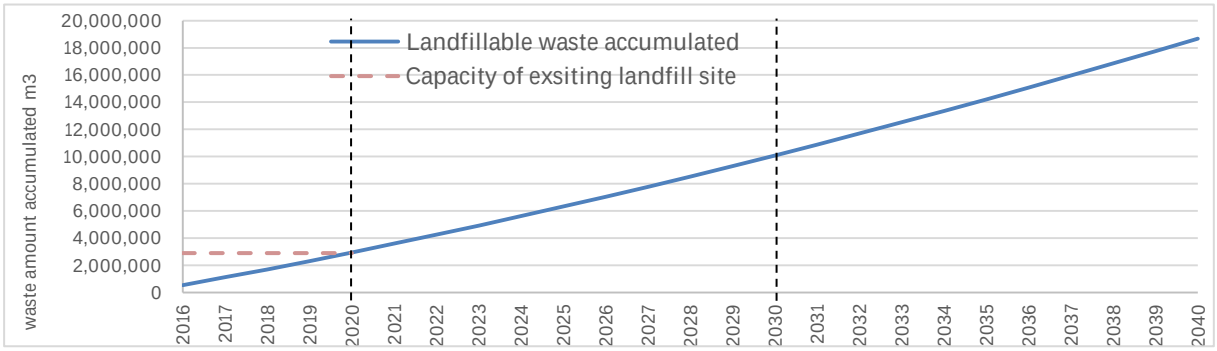
Waste collection is currently done by the General Department of Public Cleaning [Direcction general de Limpieza Publica] of ALMA and district offices are not covering the entire Managua City requiring "*cartoneros*," or wagons. However, many of these micro-waste collectors are not

registered and inappropriate waste collection have been carried out by them. They engage in illegal dumping practices at the open channel and open spaces creating unsanitary conditions to the surrounding area. Especially, the illegal dumping at the open channel is having an impact on the function of flood management. In addition, new residential areas which need waste collection services are increasing and to meet these new demands. Therefore, an improvement of the waste collection and transportation system is necessary.

2) Need for Ensuring the Final Disposal Site for Solid Waste Management

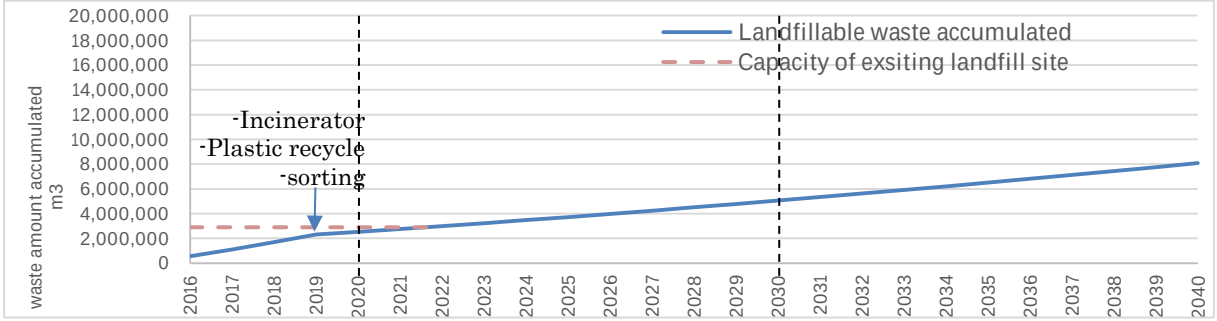
According to the discussion with technical working group, there is a plan to construct a waste-to-energy incineration plant by a concession agreement with the private sector, which aims at reducing the load on the sanitary landfill site. Generally, a waste-to-energy incineration plant is said to be costly for operation and maintenance. If the plan of waste-to-energy incineration plant were not to take off well, the remaining capacity of the current landfill site would become imminent. From the estimation of the waste amount based on population and economic data in the future, in the case of the current waste management system, the current landfill capacity will be full in 2020 (Figure 5.7.1). Even if the incineration treatment will be started from 2019, it is estimated that a new final disposal site will be necessary from 2023 according to the estimated amount of waste (Figure 5.7.2).

Therefore, there is a definite need for a sanitary landfill sites as one of the basic infrastructure of urban hygiene.



Source: JICA study team based on the information provided by EMTRIDES

Figure 5.7.1 The period of existing final disposal site with current waste management system



Source: JICA study team based on the information provided by EMTRIDES

Figure 5.7.2 Incineration, oil recycling and segregation recycling

3) Old and Deteriorated Equipment for Waste Collection and Transportation

Many of the vehicles used for waste collection are old and deteriorated. Frequent repairs are imposing maintenance costs as well as lowering the collection capacity. This would eventually lead to a lowering of willingness to pay for the waste collection service and an increase of illegal dumping. Periodical updating of collection equipment are needed to maintain efficient and stable waste collection services.

4) Low Collection Rate of Waste Collection Fee

The collection rate of waste collection fee from industries is high, whereas that from residents are low. Therefore, the revenue is insufficient to carry out the proper waste management. For financial improvement of waste management and fair cost sharing, the promotion of appropriate fee collection system is important based on the premise that appropriate waste collection services would be provided.

5) Promoting Understanding and Cooperation of Residents and Business to the Solid Waste Management

According to an interview with the district office, some residents discharge their waste to illegal dumping site by themselves, and/or discharge to *cartoneros* even if there is an official waste collection services in the areas of their residence. It was also reported that installation of a communitarian box to close the illegal dumping sites are not in progress due to an opposition from the local residents who are worried that the location of communal waste collection point which functions as transfer stations at the time of waste collection would become a new illegal dumping site. These facts hinder the closing of illegal dumping sites. In the future, there is a possibility to introduce a collection system of segregation at source to extend the life expectancy of the final landfill site and for effective operation of the waste to energy incineration plant, if introduced. Therefore, promoting understanding and cooperation toward solid waste management among the residents and businesses is essential.

6) Hazardous Waste Management

There are laws and regulations regarding hazardous waste management although not sufficient. The actual situations of treatment and final disposal are not sufficient to conduct an appropriate waste management. In particular, hazardous wastes are generally stored or disposed within the business premises of the waste generators, while the Ministry of Environment and Natural Resources (*Ministerio del Ambiente y los Recursos Naturales*: MARENA) does not have a grasp on the overall status. In addition, medical waste incinerator is not sufficiently installed, and medical waste generated are also stored or disposed within the hospital premises. An appropriate management practice such as Hazardous Waste Manifest System for clarification and practice of policies on handling, storage, collection, processing, and disposal for each hazardous waste should be introduced.

(6) Issues in Disaster Mitigation

1) Pursuit of a Resilient City

Managua City has experienced extensive and deadly damage from natural disasters, such as earthquake and landslides. As controlling the occurrence of natural disasters is hardly possible, various measures need to be devised to mitigate potential damage of natural disasters, and thus make Managua City more resilient to natural disasters. Some of experiences in other countries including Japan could be utilized as a frame of reference. This may include resilient emergency activity centers, securing of emergency roads, and logistic space for rescue operation.

2) Mitigation of Earthquake and Landslide Risks

The basic approach in the Disaster Risk Reduction Management (DRRM), including well balanced structural and non-structural measures are described in Chapter 12.

The key issues to be considered in the master plan for earthquake were given by the Technical Working Group III: Disaster Prevention in May and October 2016 as follows;

(Earthquake Risk)

- Update of location map for seismic hazard area
- Land use regulation planning for seismic hazard area
- Update/establishment of escape route
- Disaster Prevention Center like "Civic Core in Nagaoka City in Japan"
- Some equipment like Bosai car for education, which use interactive method by simulation
- Update of regulation for construction, etc. based on being revised National Building Regulations (RMC-07, ASD-99, AISC-9th Edition, ACI-318-08, 318-14)
- Adaptation of simple and economic technics to strengthen structures
- Monitoring of construction of building
- Further Studies
- Capacity development for local residents and concerned agencies

(Landslide Risk)

- Relocation of settlements and relocation of local families (from the hazard area (slope)
- Slope protection works by *cubas* (vats), *diques* (dikes), *barreras viva*s (barrier), *zanjas de infiltracion* (infiltration trench), *reforestacion* (reforestation)
- Analysis of mountain formation at the top of southern basin to identify slip-prone sites
- Consideration of type of soil and vegetation cover
- Consideration of effect of deforestation
- Prohibit construction in high risk areas
- Proper management of land use regulation
- Capacity development

CHAPTER 6 INSTITUTIONAL SYSTEM AND CAPACITY DEVELOPMENT

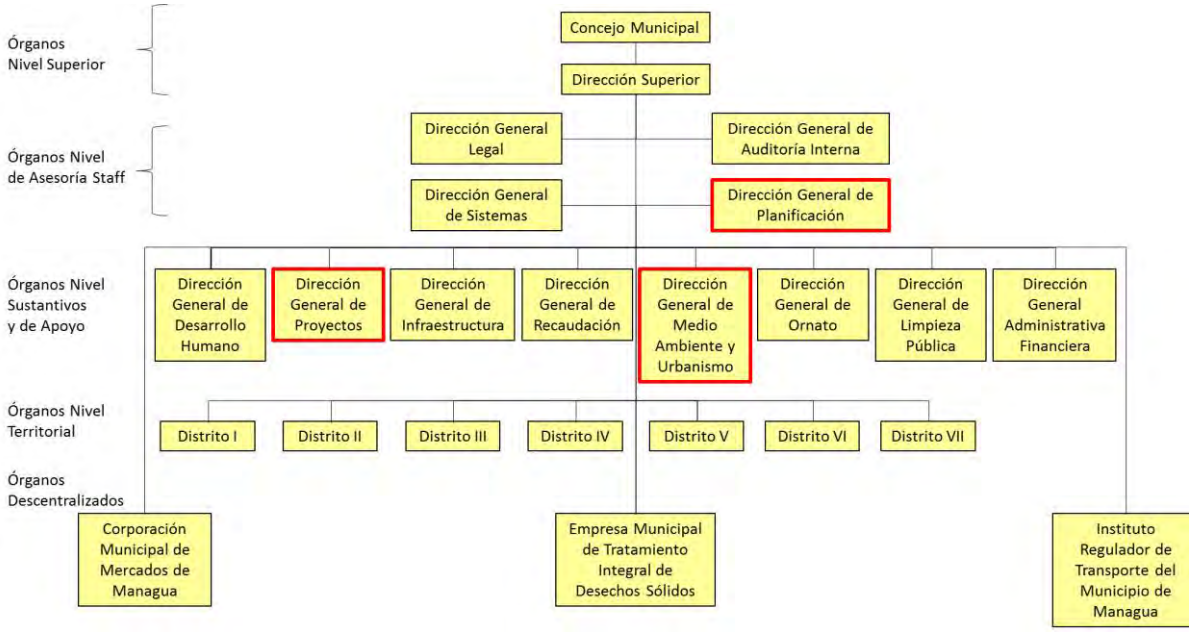
6.1 Overview

This master plan project regards it vital to support the development of institutional capacity of the organizations related to urban planning of Managua city. It is aimed that Alcaldia de Managua (ALMA) will in future revise and utilize the master plan by itself after the completion of this master plan study. Accordingly, JICA study team carried out the necessary capacity development of ALMA and analysed necessary actions for institutional systems throughout the study.

6.2 Clarification of Actual Institutional System

6.2.1 Institutional Structure

An organization structure of ALMA is presented in Figure 6.2.1. General Directorate of Environment and Urbanism [Dirección General de Medio Ambiente y Urbanismo], General Directorate of Projects [Dirección General de Proyectos] and General Directorate of Planning [Dirección General de Planificación] are the main counterpart of JICA study team, focusing on the main institutions concerning urban development planning, highlighted by red squares in Figure 6.2.1.

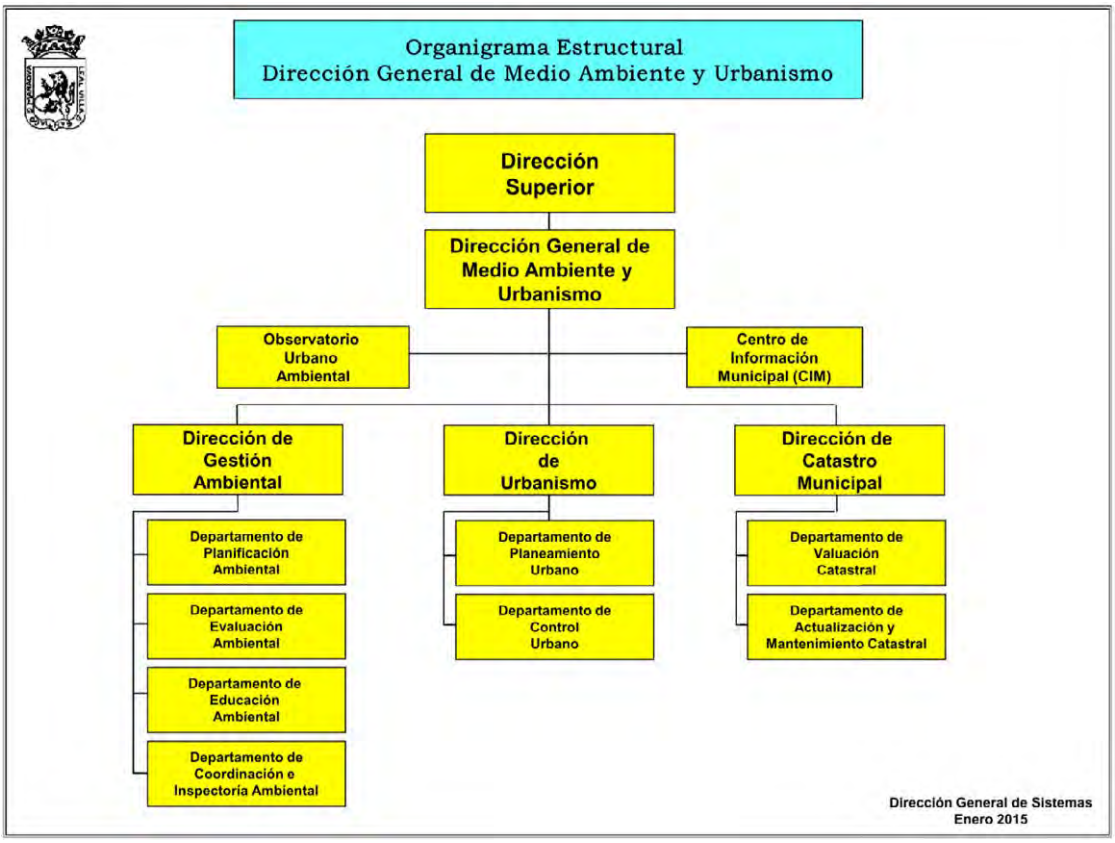


Source: ALMA (2015), with red squares added by JICA study team

Figure 6.2.1 Organization structure of ALMA

General Directorate of Environment and Urbanism has its directorates including Directorate of Urbanism [Dirección de Urbanismo] that is responsible to ensure the urban development of Managua city and to monitor that construction projects comply with the regulations and rules. There is Department of Urban Planning [Departamento de Planeamiento Urbano] in this directorate. Besides, Directorate of

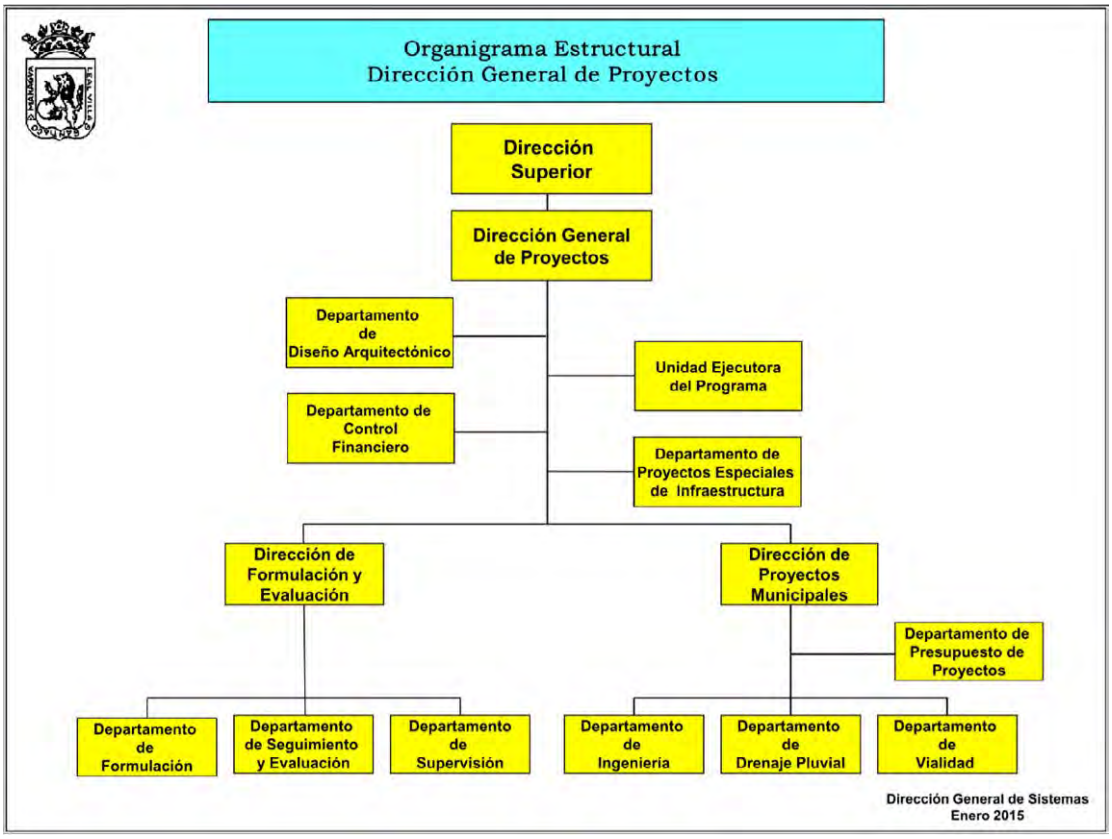
Municipal Cadastre [Dirección de Catastro Municipal] has its roles to administrate, maintain, update and expand the municipal cadastre using GIS. Directorate of Environmental Management Directorate [Dirección de Gestión Ambiental] has its roles to environmental monitoring for the environmental permit application.



Source: ALMA (2015), with red squares added by JICA study team

Figure 6.2.2 Organization structure of General Directorate of Environment and Urbanism

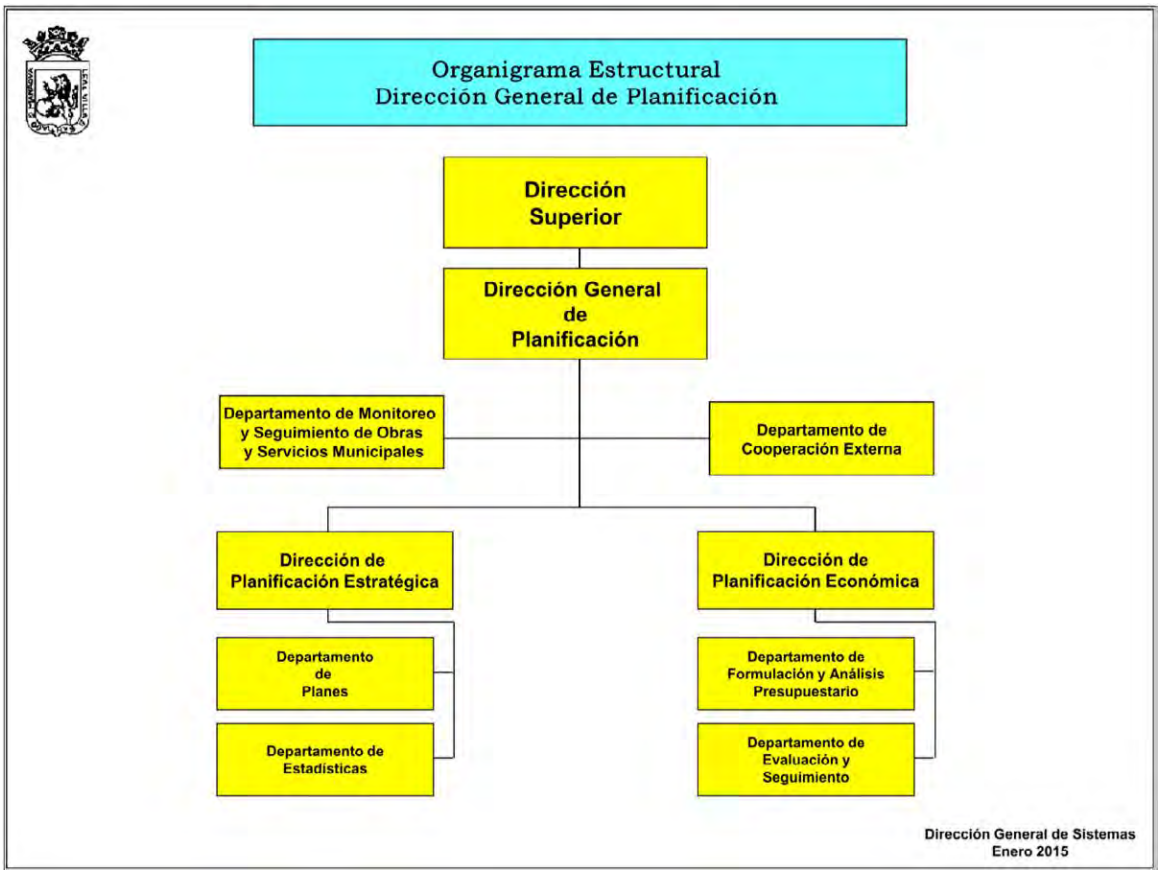
General Directorate of Projects has two directorates; Directorate of Formulation and Evaluation [Dirección de Formulación y Evaluación] which is responsible for project implementation proposals and for project evaluation at different stages, and Directorate of Municipal Projects [Dirección de Proyectos Municipales] which is responsible for designs, drawings and construction supervision of infrastructure development.



Source: ALMA (2015)

Figure 6.2.3 Organization structure of General Directorate of Projects

General Directorate of Planning is located at a advisory staff level of the municipality, and is responsible for establishing the policies, strategies, management plans, physical and financial programs and projects. This General Directorate is also responsible for internal coordination among all general directorates of the municipality as well as external coordination with institutions related to development plan of Managua city.



Source: ALMA (2015), with red squares added by JICA study team

Figure 6.2.4 Organization structure of General Directorate of Planning

There is no specific directorate or any other institute who is in charge of transport planning. Department of Highway [Departamento de Vialidad] under Directorate of Municipal Projects has eight traffic surveyors who carry out traffic count surveys at intersections for data collection for road design, but there are not any transport planners. IRTRAMMA has some experiences of project related to transport planning, but its main role is regulation and management of transport.

6.2.2 Human resources

According to the payroll data provided on April 2016 by Directorate of Human Resources, there are 3,848 staff working in ALMA, of which 304 belong to the three general directorates mentioned above. Although it should be noted that this data might not be updated frequently as far as the payroll works, 53 persons among them are registered as directors and 177 persons as technician, as detailed in Table 6.2.1.

Table 6.2.1 Human resources in main General Directorates for urban development

General Directorate / Directorate / Department	Director	Technician	Others	Total
General Directorate of Environment and Urbanism	**28**	**99**	**26**	**153**
Directorate and Coordination of Environment and Urbanism	3	17	8	28
Directorate of Environment Management	7	18	1	26
▪ Directorate and Coordination of Environmental	2	3	1	6

General Directorate / Directorate / Department	Director	Technician	Others	Total
Management				
▪ Department of Environmental Planning	1	6	0	7
▪ Department of Environmental Evaluation	1	3	0	4
▪ Department of Environmental Education	1	5	0	6
▪ Department of Coordination and Environmental Inspection	2	1	0	3
Directorate of Urbanism	7	16	7	30
▪ Directorate and Coordination of Urbanism	1	8	7	16
▪ Department of Urban Planning	1	1	0	2
▪ Department of Urban Control	5	7	0	12
Directorate of Municipal Cadastre	11	48	10	69
▪ Directorate and Coordination of Municipal Cadastre	0	12	2	14
▪ Department of Cadastral Valuation	5	21	6	32
▪ Department of Cadastral Update and Maintenance	6	15	2	23
General Directorate of Projects	**17**	**55**	**38**	**110**
Directorate and Coordination of Projects	6	25	14	45
▪ Office of General Directorate of Projects	4	18	10	32
▪ Department of Architectural Design	1	1	0	2
▪ Department of Financial Control	0	2	0	2
▪ Project Executing Unit	1	4	4	9
Directorate of Formulation and Evaluation	4	14	4	22
▪ Directorate and Coordination of Formulation and Evaluation	3	4	4	11
▪ Department of Supervision	1	10	0	11
Directorate of Municipal Projects	7	16	20	43
▪ Directorate and Coordination of Municipal Projects	1	0	1	2
▪ Department of Project Budget	1	1	0	2
▪ Department of Engineering	2	9	8	19
▪ Department of Rain Drainage	2	3	0	5
▪ Department of Highway	1	3	11	15
General Directorate of Planning	**8**	**23**	**10**	**41**
Directorate and Coordination of Planning	4	10	8	22
▪ Office of General Directorate of Planning	1	2	6	9
▪ Department of Monitoring and Follow-up of Works and Services	1	4	1	6
▪ Department of External Cooperation	2	4	1	7
Directorate of Strategic Planning	2	7	1	10
▪ Directorate and Coordination of Strategic Planning	0	0	1	1
▪ Department of Plans	1	3	0	4
▪ Department of Statistics and Census	1	4	0	5
Directorate of Economic Planning	2	6	1	9
▪ Directorate and Coordination of Economic Planning	1	0	1	2
▪ Department of Programming and Budgetary Analysis	0	3	0	3
▪ Department of Evaluation and Follow-up	1	3	0	4
Total of three General Directorates	**53**	**177**	**74**	**304**

Note: “Others” include administrators, worker and services.

Source: Prepared by JICA study team based on payroll data provided by ALMA

Besides, according to a hearing on April 2016, Department of Urban Planning under Directorate of Urbanism has only five members, including a director. Except two newcomer, three of them have long enough working experience. However, major urban planning work involving revision of extensive zoning has not been conducted for more than 10 years, so the experience in the field is supposed to be insufficient, and only five urban planners for a city of 1.5 million habitants are considered absolutely not sufficient.

Department of Highway has eight traffic surveyors, registered as administrators in the payroll data. These traffic surveyors are designated to conduct traffic survey on site and are not supposed to become transport planners.

6.3 Needs Assessment

6.3.1 Definition of Necessary Capacity

Before evaluating the capacity of ALMA, JICA study team defined the necessary capacities for a public institute in general to revise and utilize the urban development master plan, especially for aspects of urban and transport planning, through internal discussions based on different experiences and perspectives of experts. The whole process is divided into four major areas, namely "Analysis of situation", "Establishment of the Vision", "Master plan formulation", and "Utilization of master plan".

(1) Analysis of situation

For urban planning, the first step is to understand the actual condition of each aspect of the entire project including socio economic frameworks, land use and transport networks. Based on those information, the future urban structure should be considered. A variety of essential information for urban planning needs to be compiled into a unified system. For this purpose, the planning entity should have its basic GIS database including a current land use map which is to be periodically updated.

Then the future land use should be previewed. In practice, socio-economic framework with trend information should be formulated and applied to preview the future situation in a quantitative manner. Besides, characteristics of land should be evaluated and land to be urbanized should be identified.

Transport planning also starts from the understanding of current condition of the entire project area. A comprehensive traffic survey including traffic counts and person trip survey should be planned and carried out.

Then future transport demand should be forecasted. For the forecasting, in addition to comprehensive current traffic data, accumulated traffic-related data from the past must be referenced and utilized. And socio-economic framework should be again applied in the model of transport. A traffic analysis software is almost mandatory to analyse the transport properly.

(2) Establishment of the Vision

A future development vision must be established to determine the preferred direction of the development, and the vision must be based on fundamental knowledge and experience as well as global trends and

lessons from various cases. Such transfer of knowledge and experience, and continuous collection, accumulation and evaluation of worldwide information should be carried out.

Defined vision must be then shared among related internal and external institutions and stakeholders. Smooth communication and consensus facilitation are the essential capacities to share the vision.

(3) Master plan formulation

Based on the defined vision, master plan must be formulated in a manner that component plans for subordinate sectors are mutually matching and generating positive synergy effect. For that the information of plans must be systematically gathered and their mutual relation must be confirmed.

For urban planning, a land use plan should be prepared with a basis of the future framework. For the plan, alternatives should be analysed and evaluated properly to find out the best solution. In order to implement the land use plan, the issues of existing zoning system shall be discussed. The land use plan will need to be implemented mainly by a regulation scheme adopted and enacted by the municipality.

Furthermore, area development plans for prioritized zones of the city should be considered, initiated and led by the local administrative body in collaboration with the private sector. Harmonization with the surrounding area and with its history, expected function of the area, and expected outcome and risks of the area development should be well recognized and evaluated.

For transport planning, project long list has to be prepared and priority projects must be selected, including, for example, new construction and/or widening of roads, intersection improvements, possible introduction and/or improvement of public transport traffic control and other. The necessary capacities are to prepare the preliminary plan of each project to be registered in the long list, and to evaluate the priority of these projects based on certain criteria.

(4) Utilization of master plan

In reality, most of the land development is conducted by private actors. Accordingly, land use regulation must be efficiently and effectively enforced to realize the decided land use plan. For the enforcement, the regulation map should be published so that the citizens including developers can easily make access to and confirm it. Some other important data organized in GIS database should also be published for public use. In this regard, applications for building permit should be quickly processed without delay. In addition, for the planned area development of prioritized zones, an effective implementation scheme need to be considered initiated by the public institution, otherwise the institute invite and collaborate with private developer to realize the plan.

Regarding transport plan, the priority projects should be more detailed and implemented one after another. Necessary procedure such as feasibility study, basic design, detailed design, construction supervision and operation and management must be planned and carried out. It is required at several stages of project to evaluate its financial and economic viability to acquire the necessary budget. Meanwhile, depending on the transport situation, appropriate projects from mid and long-term project

lists should be taken to be considered for implementation. Accordingly, traffic data should be continuously obtained to evaluate quantitatively the validity of projects.

6.3.2 Evaluation of Actual Capacity of ALMA

Actual capacity of ALMA for urban development planning was evaluated by JICA study team through discussions and interviews with personnel of ALMA and based on recent work results by ALMA.

(1) Analysis of situation

For urban planning, Directorate of Municipal Cadastre has digital maps of Managua city in a detailed level, and they are carrying out the necessary supplemental survey by outsourcing. However, the maps are not entirely organized as a basic GIS database of the city, and are not ready to be utilized for immediate analysis of city's land use situation. In addition, the available maps at present are produced by incoherent software such as Auto CAD and ArcGIS. Besides, ALMA uses mainly Latino GIS, which has only a limited analysis function.

For transport planning, Department of Highway under Directorate of Municipal Projects has eight traffic surveyors who mainly conduct traffic counting at intersections. Planning and implementation of a comprehensive traffic survey have not been carried out. Some past traffic-related data are available but data formats are not organized in a uniform way, which indicates that the past data are not fully utilized for transport planning. After all, there is no specific institution in charge of transport planning. Accordingly, any transport planning activity is not systematically carried out, including traffic analysis.

Regarding a socio-economic framework, General Department of Planning possesses some related data, but they are not enough nor well organized to be utilized in urban and transport planning.

(2) Establishment of the Vision

For formulation of future development vision, it seems the fundamental knowledge and experience as well as worldwide trend and case information are not consistently accumulated. The information is possibly possessed only by some experienced personnel, but their collection and accumulation are not systematically carried out to create common knowledge. So the information is not well accumulated nor evaluated.

As needed, several related institutions gather and work as a committee to share the information and make a consensus. The process is quick and productive in general.

(3) Master plan formulation

The above-mentioned committee is the place where members from several institutions discuss plans together so that they match mutually. The coordination seems fair, however there is not enough integration between different sectors such as urban planning and transport planning. Policy packaging is necessary to generate synergy effect beyond limitation of sector.

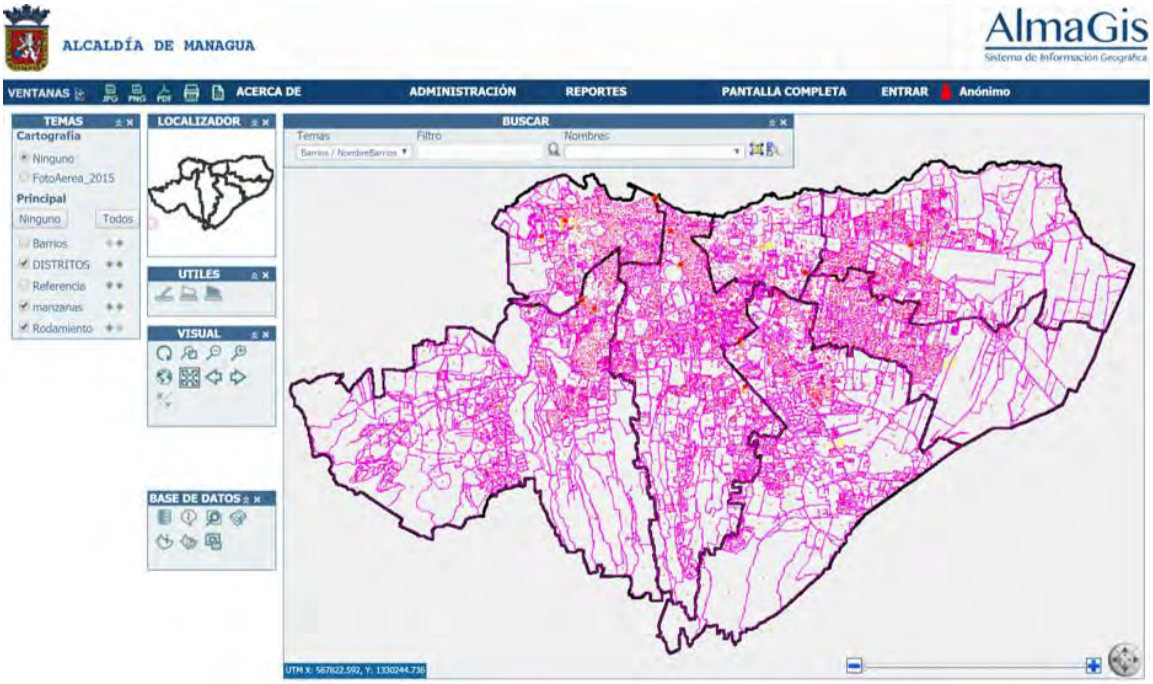
For urban planning, land use plan and regulation have not been revised since more than ten years. Accordingly, the capacities of alternative evaluation for the best land use solution and of establishment

of appropriate regulation to realize the land use plan are supposed to be insufficient. While there are a number of project proposal, the actually realized projects are few. As the city is composed mainly of private investments such as houses, offices, shopping complex, etc., the collaboration and partnership of the private and public sectors are essential, but such cases have not been seen much in Managua city.

For transport planning, project long list along with conceptual descriptions is prepared referring to past pending projects. The priority is given based on budgetary availability with regards to necessity as well as capacity or experience of ALMA.

(4) Utilization of master plan

For the urban plan, the land use regulation map is not properly integrated in the GIS database. This makes the application for development by the citizens and developers laborsome as they would need access to the regulation map at the time of application. Partial information is already published as presented in Figure 6.3.1, but the data is not well organized. For the application of building permit, the process is taking too much time to look for regulation parameter corresponding to the applied land.



Source: AlmaGIS (http://alma-srw.managua.gob.ni/almagis/)

Figure 6.3.1 Published GIS data from ALMA

Concerning transport plan, a variety of missions of international organizations come and carry out the necessary procedure including financial and economic analysis for the priority projects, which are left behind somewhat mal-digestion. Meanwhile, traffic data are periodically recorded at several locations, while these data are not analyzed effectively for evaluation of on-going and future projects.

6.4 Preparation of Capacity Development Plan

6.4.1 Scoping of Capacity Development Plan

The capacity development matrix summarizing the necessary and actual capacity of ALMA as well as corresponding capacity development activities to be carried out in this master plan project was formulated as presented in Table 6.4.1. There are some items of capacity that shall not be treated within the scope of this project but should be intensively followed-up afterword.

Table 6.4.1 Capacity Development Matrix

Ideal status	Necessary capacity (capable of)	Actual situation	Capacity development activity	Sl No.
Analysis				
[Urban plan] Actual status of entire city is understood	Understand actual urban structure including land use, road network	Land use map, road network map etc. are formulated	(no specific needs)	-
	Manage in an integrated form (by making database) the basic data including current land use map and periodically update it	Data are not integrated and not managed as database	Interactive learning in TWG on GIS database and its updating policy	1
	Carry out necessary supplement survey for updating of current land use map etc.	Supplement survey is carried out by subcontract	(no specific needs)	-
	Utilize GIS software for urban planning	Latino GIS with limited analysis function is used	OJT of ArcGIS	2
[Urban plan] Future urban structure and land use are previewed	Formulate and apply socio-economic framework of past, today and future	Proper socio-economic framework based on quantitative data is not formulated	Interactive learning in TWG on collection and analysis of statistical data	3
	Draw future urban structure based on socio-economic framework	Urban structure map of entire city considering land use and transport is not prepared	Interactive learning in TWG on analysis and planning of urban structure	4
	Evaluate characteristics of land and identify land to be urbanized	Characteristics of land are not evaluated quantitatively	Interactive learning in TWG on evaluation of land characteristics	5
[Transport plan] Actual transport of entire city is understood	Plan and implement comprehensive traffic survey including traffic count and person trip survey etc.	Only traffic count at intersection is periodically conducted	Interactive learning in TWG on planning and implementation of traffic survey	6
			OJT of traffic survey	7
[Transport plan] future transport is forecasted	Accumulate and utilize past traffic data	Some data are available but in different formats, and not fully utilized	Interactive learning in TWG on standard traffic data format and data record policy	8
	Formulate and apply socio-economic framework of past, today and future	Proper socio-economic framework based on quantitative data is not formulated	Interactive learning in TWG on collection and analysis of statistical data	9
	Forecast future transport and identify necessary development or improvement of transport infrastructure etc.	Traffic analysis software is not utilized, and future traffic demand is not estimated	Interactive learning in TWG on traffic analysis	10
			OJT of JICA STRADA	11
Vision				
Future development vision is established based on fundamental knowledge, experience,	Continuously collect and accumulate worldwide information on urban development	Fragmental information is unintentionally collected	Lecture on basic skill for information collection and accumulation	12

global trends and various cases	Evaluate the accumulated information referring to fundamental knowledge	Information is not accumulated as institution, and knowledge is unevenly owned by experienced staff	Lecture in Joint-TWG on various practices of urban development in the world	13
			Training in Japan for practices of comprehensive urban development	14
Vision is shared among related internal / external institutions	Smoothly communicate and facilitate consensus among related institutions	Technical committees composed by related institutions share the information and reaches a consensus	(no specific needs)	-
Plan				
Plans are mutually matching and generate synergy effect	Systematically gather information of numerous plans and confirm their mutual relation	Several institutions discuss plans together in technical committees but proposed plans don't necessary generate synergy effect	Interactive learning in Joint-TWG on formulation of policy packages	15
			Training in Japan for practices of comprehensive urban development	16
[Urban plan] Land use plan is prepared	Evaluate alternatives of land use and find out the best solution	No recent experience of proactive revision of land use plan based on urban vision	Interactive learning in TWG on land use planning	17
			Training in Japan for practices of land use plan	18
			(following project) Revision of land use plan and support for its approval process	S-1
[Urban plan] Land use regulation is prepared	Establish a regulation that realizes the land use plan	No recent experience of proactive revision of land use regulation based on land use plan	Interactive learning in TWG on land use regulation	19
			Training in Japan for practices of land use regulation	20
			(following project) Support for revision of land use regulation and its approval process	S-2
[Urban plan] Public-led area development can be planned	Evaluate expected outcome and risk of area development	No experience of comprehensive area development planning	Interactive learning in TWG on area development planning	21
			Training in Japan for practices of area development	22
[Transport plan] Project long list is prepared	Prepare preliminary plan including location, route, project cost etc. of each project	Project long list based on forecast, analysis and evaluation cannot be prepared	Interactive learning in TWG on transport project planning	23
			Lecture on planning of transport project	24
			Training in Japan for practices of transport systems	25
			(following project) Support of planning and implementation of transport project	S-3
[Transport plan] Priority projects are selected	Give priorities to projects based on certain criteria	Alternative comparison from technical, economic and social viewpoints based on certain criteria is not sufficiently carried out	Interactive learning in TWG for prioritization of of transport projects	26
Utilization				

[Urban plan] Land use regulation is efficiently and effectively enforced	Publish land use regulation map along with other useful data for easy access for citizens	GIS database is not prepared, and publication tool is not organized	Interavtive learning in TWG on GIS database and publication tool	27
			Training in Japan for practices of management and utilization of GIS database	28
	Quickly process applications related to building permit	Processing takes longer than period defined by regulation by ALMA	Training in Japan for practices of management and utilization of GIS database and open data	29
			(following project) Support for revision of building permit system and its approval process	S-4
	Control illegal land use	Insufficient control of illegal land use because of lack of human resources and lack of technical capacity	(following project) Support for control system improvement	S-5
[Urban plan] Public-led area development is implemented	Carry out planned area development or invite and collaborate with developer	Despite prepared plan, invitation to developers are not responded and project doesn't proceed	Interactive learning in TWG on implementation strategy of area development	30
[Transport plan] Priority projects are detailed and implemented	Plan and carry out necessary procedure of FS/BD/DD/CS/OM*	Missions of international organizations carry out the procedure, and ALMA cannot carry them out properly by itself	(following project) Project implementation	S-6
	Evaluate financial and economic aspects of projects to acquire budget	Missions of international organizations carry out the procedure, and ALMA cannot carry them out properly by itself	(following project) Project implementation	S-7
[Transport plan] Appropriate projects from mid and long-term project lists corresponding to ongoing situation are implemented	Obtain traffic data at appropriate locations to evaluate the validity of project implementation	Traffic data are periodically recorded at several locations, but these data are not analyzed to be associated with mid and long-term projects	Interactive learning in TWG on periodic traffic survey policy for mid and long-term projects	31
[Transport plan] Related institutes cooperate with each other on traffic management	Coordinate with related institutes of road and transport, and implement comprehensive traffic management	Some roles overlap between institutes, and each institute carries out its measure individually, not necessarily coordinated with others	(following project) Restructuring of roles of institutions and development of institutional capacity	S-8

Note: FS stands for Feasibility Study, BD for Basic Design, DD for Detailed Design, CS for Construction Supervision and OM for Operation and Management

Source: JICA study team

6.4.2 Capacity Development Plan

Considering the schedule of each specialist of JICA study team, the Capacity Development Plan was established as presented in Table 6.4.2. TWG meetings are considered to be the basic occasions for capacity development, since they allow interactive learning while developing the master plan. And countless communication out of the meetings between TWG members complemented the understainding of the subjects. Unless mentioned as "OJT" or "Lecture" and except the subjects of training in Japan, all the subjects are treated by the style of interactive learning in TWGs. "Matrix No." in the middle indicates the corresponding numbering at the right end of Table 6.4.1.

Table 6.4.2 Capacity Development Plan

Sector with methodology / Subject	Matrix No.	2016											2017				
		2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Urban Planning																	
TWG meeting																	
Analysis and planning of urban structure	4			■					■	■		■	■				
Evaluation of land characteristics	5	■										■					
Land use planning based on urban development vision	17											■		■		■	■
Land use regulation based on land use plan	19																■
Area development planning	21													■			
Implementation strategy of area development	30													■			
GIS database and updating policy	1	■															
GIS database and publication tool	27												■				
On-the-Job Training																	
Qualified data development for spatial analysis using ArcGIS	2					■							■				
Mobility and Transport																	
TWG meeting																	
Planning and implementation of traffic survey	6		■	■	■			■	■	■							
Standard traffic data format and data record policy	8												■				
Periodic traffic survey policy for mid and long-term projects	31													■			
Traffic analysis	10								■	■			■	■			
Planning of transport project	23												■	■		■	■
Prioritization of transport projects	26													■		■	■
On-the-Job Training																	
Practice of traffic survey	7				■			■	■	■							
Traffic analysis using JICA STRADA	11												■				
Lecture																	
Planning of transport project	24				■					■							
Socio-Economic																	
TWG meeting																	
Collection and analysis of statistical data	3,9			■			■	■		■							
Integration of multiple sectors																	
Joint TWG																	
Analysis and planning of urban structure	4								■	■			■				
Various practices of urban development in the world	13									■							
Formulation of policy packages	15												■				
Training in Japan																	
Practices of comprehensive urban development	14,16						■										
Practices of land use plan and regulation	18,20						■										
Practices of area development	22						■										
Practices of disaster management	22						■										
Practices of transport systems	25						■										
Practices of GIS database and open data	28,29						■										
Lecture																	
Basic skill for information collection and accumulation	12									■							

Note: "Matrix No." in the middle indicates the corresponding numbering at the right end of Table 6.4.1
Source: JICA study team

6.5 Record of Capacity Development Activities

6.5.1 Urban Planning

(1) TWG meetings

Urban Planning Technical Working Group is composed of members from various departments of ALMA related to urban development, mainly from General Directorate of Environment and Urbanism and General Directorate of Planning. The meeting was held 10 times since the beginning of the project by April 2017. Date and treated subjects are summarized in Table 6.5.1.

Table 6.5.1 Record of Urban Planning TWG meetings

Date	Subjects
19 February 2016	Basic Development Policy, Development Vision, Socio-economic Framework
25 February 2016	GIS, Land Evaluation for Land Use Planning
15 April 2016	Functions and structure of Managua City in regional perspective
29 April 2016	Functions and structure of Managua City in regional perspective
5 May 2016	Basic Development Policy and Development Vision of Managua City
10 June 2016	Current land use map
3 August 2016	Urban vision and structure
16 December 2016	Urban densification
2 February 2017	Planning of urban centers and industrial zones
2 March 2017	Future land use map

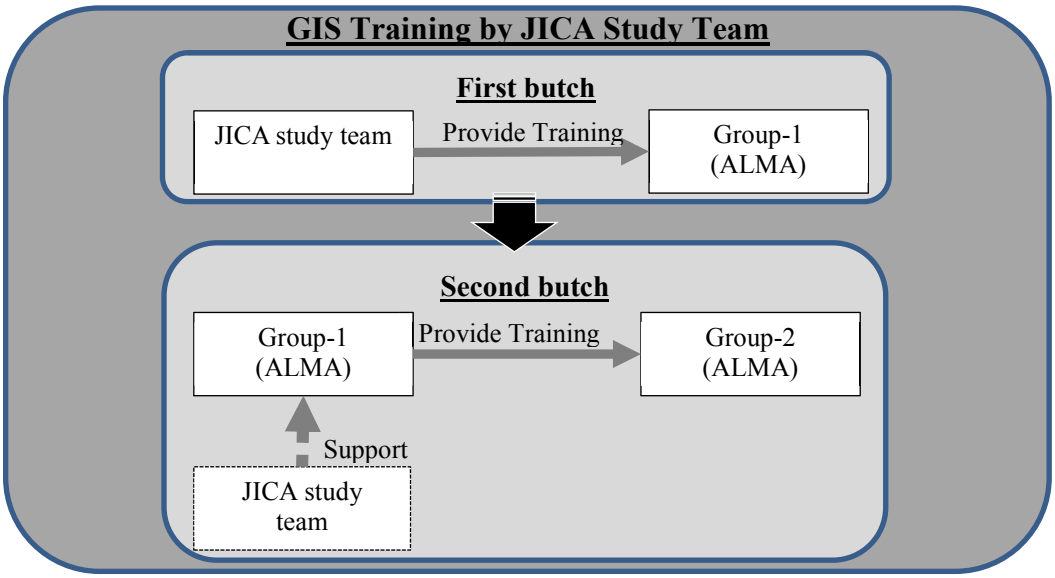
Source: JICA study team

Source: JICA Study Team

Figure 6.5.1 Scenes of Urban Planning TWG meeting

(2) On-the-Job Training

JICA study team conduct an intensive training on GIS using ArcGIS software which is commonly used in the world. As level of GIS experience was largely different among trainees of ALMA, the trainees were grouped into two, namely Group-1 and Group-2, based on the initial level. Firstly, JICA study team provided GIS training to Group-1 as TOT (Training on Trainee), then Group-1 provides training to Group-2 assisted by JICA study team, so that the Group-1 can acquire deeper understandings.



Source: JICA Study Team

Figure 6.5.2 Structure of GIS Training

The contents of training focused on spatial analysis which is significantly important knowledge for urban planning in addition to GIS data editing. The training was carried out in two series, in June 2016 and January - February 2017. The first series of training in June 2016 started from understandings of basic GIS concept and basic functions and usages of ArcGIS software, and differences between ArcGIS and LatinoGIS that has been mainly used by ALMA. In the second series in January - February 2017, the treinees learned advanced spatial analysis techniques using ArcGIS spatial analyst extension to analyze raster data and also learned multiple data analysis. The trainees also learned management of GIS data and its related editing methodology, so called topological editing to update and maintain data more accurate without topological errors which were often identified in existing data developed by ALMA.

GIS Training for Group-1
(JICA Study Team Provide Training)

GIS Training for Group-2 (Group-1 members teach to Group-2 with support by JICA study team)

Source: JICA Study Team

Figure 6.5.3 Scenes of OJT on GIS

JICA study team considers that most of participants got more interested in GIS and ArcGIS software functions according to comments after the training. Some of trainees who could join all the sessions of training already obtained a good ability to teach others with a little assistance by JICA study team. After

these GIS trainings, it is expected that the trainees would share their obtained skills to other staff in ALMA and utilize it in their daily work to keep and update skills of GIS.

6.5.2 Mobility and Transport TWG

(1) TWG meetings

Mobility and Transport Technical Working Group is composed of members from General Directorate of Projects and IRTRAMMA. The meeting was held 15 times by April 2017. Date and treated subjects are summarized in Table 6.5.2.

Table 6.5.2 Record of Mobility and Transport TWG meetings

Date	Subjects
23 February 2016	Traffic survey concept and methodology
March - May 2016 (7 meetings)	Traffic survey methodology and implementation (survey form, survey plan, implementation strategy, ect.)
5 August 2016	Transport planning along with urban vision
26 August 2016	Traffic survey methodology and implementation
4 October 2016	Analysis of traffic data, concept of transport planning
24 January 2017	Planning of transport projects
14 February 2017	Planning of transport projects
23 March 2017	Future update policy of traffic survey data
7 April 2017	Planning of transport projects and the priority projects

Source: JICA study team

(2) Lecture on transport planning

Lectures on basic knowledge of transport planning have been done mainly for technicians from General Directorate of Projects and of IRTRAMMA, while people from other departments were also welcomed.

Table 6.5.3 Record of lectures on transport planning

Date	Subjects
20 May 2016	Road planning; road and intersection design
7 October 2016	Public transport planning and benchmarking of Latin American cities
14 October 2016	Model, technology and evaluation of transport project

Source: JICA study team

The first lecture was provided with the focus on road planning, including basic knowledge on road design, design criteria, characteristics of different designs includind ground and multi-level infrastructure, etc. The second lecture focused on public transport planning, including introduction of different types of mass-transit systems, characterictics comparison of these systems, examples and experiences in the world especially in Latin American cities, etc. The third lecture was about the transport planning as a whole, such as summary of transport solutions, combination of different types of solutions including hard and soft solutions, elavuation of transport project, etc.

Source: JICA Study Team

Figure 6.5.4 Scene of Mobility and Transport TWG meeting

Source: JICA Study Team

Figure 6.5.5 Scene of lecture on transport planning

(3) On-the-Job Training

1) Traffic survey

Traffic survey is a basic activity to correctly understand the traffic condition of city, and its main components are to count the volume and to interview people. Although ALMA had constantly conducted the traffic count survey, interview survey had rarely been conducted and its knowledge and skill had not been acquired nor accumulated in ALMA. Accordingly, JICA study team carried out On-the-Job training on traffic survey, emphasizing interview survey.

Roadside traffic survey

Eight traffic surveyors belonging to Department of Highway participated in various types of roadside traffic survey as a part of survey team of subcontractor for roadside traffic surveys in May 2016, such as Screen Line Survey and Truck Movement Survey. However, without enough time for preparative training, the trainees' actual activities were limited to the traffic count to which they had been already used. For the follow-up, JICA study team provided training on interview survey, and the trainees carried out the Passenger Interview Survey in September 2016 with assistance by JICA study team.

Household interview survey

The elaboration of survey form and implementation plan was done in Mobility and Transport TWG meetings. In addition to it, two engineers belonging to Department of Highway participated in the supervision of the actual work. The trainees participated in the meetings of JICA study team with the implementation subcontractor and also joined the site observation. The trainees also learned the database structurization for the survey resul. After all, the trainees could experience the entire process of household interview survey from preparation, implementation (supervision) to data accumulation.

In addition, requested by ALMA to let its human resource acquire more experience, 44 surveyors belonging to General Directorate of Infrastructure whose normal work is social interview survey joined the household interview survey as the field surveyor. Training and pilot survey were conducted at the

beginning, and site accompanying and feedback meetings were conducted during the implementation period by the subcontractor as well as JICA study team. Because the household interview survey for transport behavior includes different concepts and complicated methodology in detail for these social surveyors, such as detailed trip information like time, purpose, mode, origin and destination, transfer point etc., the follow-up was carefully and continuously conducted, and improvement of survey quality (speed, number of errors etc.) was in fact observed along with advance of survey.

Household interview survey

Meeting with subcontractor for Household interview survey

Source: JICA Study Team

Figure 6.5.6 Scenes of OJT on Traffic Survey

2) Traffic demand forecast (JICA STRADA)

When any of transport projects is to be planned, it is indispensable that traffic analysis including traffic demand forecast is carried out with the obtained data from traffic surveys. ALMA had collected and analyzed traffic count data, but it hadn't allowed to estimate the future traffic demand. JICA study team carried out the training on traffic demand forecast using JICA STRADA, so that ALMA can analyze more in detail the traffic flow of the city including estimation of future traffic demand, based on the above-mentioned survey result from interview surveys.

The training was carried out three times in Juanuary 2017 for three engineers belonging to Department of Highway, including two engineers who took the training on traffic survey so that they could see the whole process from planning of traffic survey to analysis of the survey results. Considering the fact that the traffic demand forecast had not been carried out by ALMA before this master plan project, the objectives and basic flow were initially confirmed. Then the trainees learned methods to obtain necessary input data for traffic demand forecast from the traffic survey as well as road network data, socio-economic framework etc., and learned also the basic methodology of traffic demand forecast (four-step method). Simplified dataset of Managua city was prepared by the JICA study team for the taraining, and the trainees practiced the traffic demand forecast using JICA STRADA.

Source: JICA Study Team

Figure 6.5.7 Scene of OJT on Traffic Demand Forecast

The trainees learned importance and general procedure of traffic demand forecast, however it was observed that they need more time to get used to the interface and actual work with JICA STRADA, which couldn't have been fully realized within the period of this master plan project due to the time constraint. Since the software of JICA STRADA was provided to ALMA for their own use, it is expected that the trainees continue to use it for their work and improve their skill and knowledge.

6.5.3 Socio-Economic TWG

Socio-Economic Technical Working Group is composed of members mainly from General Directorate of Planning. The meeting was held 5 times. Date and treated subjects are summarized in Table 6.5.4.

Table 6.5.4 Record of Socio-Economic TWG meetings

Date	Subjects
22 April 2016	Population framework
25 April 2016	Population framework
12 August 2016	Population and economic framework
17 August 2016	Population and economic framework
19 October 2016	Population and economic framework

Source: JICA study team

6.5.4 Integration of multiple sectors

(1) Joint TWG

Joint Technical Working Group was formulated as a group of members from different technical areas, mainly the members of Urban planning TWG and Mobility and Transport TWG but also others such as experts for disaster management. The objectives of the Joint TWG were to elaborate the urban development vision that integrates and accord with the different sectors.

In order to facilitate the discussion of more than 20 participants, group work with different sectors were often organized. For elaboration of the vision, SWOT analysis on Managua city was carried out by group. In addition, JICA study team did several presentations showing experiences of other cities in the world for reference. The participants of training in Japan also made a presentation about what Managua city could apply from the lessons learned in Japan.

The meeting was held 5 times. Date and treated subjects are summarized in Table 6.5.5.

Table 6.5.5 Record of Joint TWG meetings

Date	Subjects
11 August 2016	Development vision and policy
25 August 2016	Development vision and roles and functions
9 September 2016	Development vision and concept
29 September 2016	Development scenarios
20 October 2016	Development scenarios and strategies

Source: JICA study team

Source: JICA Study Team

Figure 6.5.8 Scene of Joint TWG meeting

Source: JICA Study Team

Figure 6.5.9 Scene of SWOT analysis of Managua city in Joint TWG meeting

(2) Training in Japan

Training in Japan was carried out for nine persons, including directors and technicians. Eight persons from ALMA and one technician from SINAPRED participated, as listed in Table 6.5.6. One more participant from ALMA and another from IRTRAMMA couldn't join the training because of unexpected reasons.

Table 6.5.6 Participants for training in Japan

Name	Title	Institution
Juana Cecilia Vargas	General Director of Planning	General Directorate of Planning
Héctor Gonzalez	Director of Traffic Management Center	Directorate of Infrastructure
Ena Ardon Menjíbar	Leader of Urban Planning Department	Directorate of Urban Planning
Andrea Garcia	Official of Urban Planning	Directorate of Urban Planning and Land Use Consistency
Zoila Muller	Advisor	Directorate of External Cooperation
Harold Ruiz Medrano	Leader of Revising and Maintaining the Cadastral Data, GIS	Directorate of Municipal Cadaster
Wendy Espinoza Fonseca	Road Specialist	Road Department, Direction of Projects
Amaru Silva	Planner	Directorate of Planning

Jorge Larios Arguello	Territorial Organization Technician	Directorate of Territorial Organization (SINAPRED)

Source: JICA study team

The training was carried out for two weeks from the beginning of July 2016. In order to see many cases, most of the time were allocated for visits with lectures, as presented in Table 6.5.7. At the end of the training program, the participants made a presentation of the findings.

Table 6.5.7 Training activities in Japan

Main sector	Activity	Place
Urban	Visit & lecture: Regional Disaster Prevention Park	Nagaoka Disaster Prevention Civic Core District, Nagaoka city
	Lecture & discussion: compact city and urban revitalization	Nagaoka University of Technology
	Visit & lecture: Compact and Resilient City	Toyama City
	Visit & lecture: Compact City with Open GIS	Kanazawa City
	Visit & lecture: Urban Revitalization and Smart City	Yokohama City
	Visit & lecture: Urban Revitalization	Marunouchi, Tokyo
	Visit & lecture: Art and Urban Development	National Art Center, Tokyo
	Lectures: Sustainable Cities for the Future and genealogy of sustainable urban formation in Japan	Nippon Koei, Tokyo
Urban and Transport	Visit & lecture: Water Front Urban Development	Odaiba, Yurikamome etc., Tokyo
Transport	Visit & lecture: Bus Terminal	Yokohama City
	Visit & lecture: Intelligent Transport Systems	VICS Center, Tokyo

Source: JICA study team

The training was highly appreciated by the trainees who requested more occasions to share their experiences and lessons learned. Accordingly, the participants made two presentations in Managua city, once in the steering committee and another in the Joint TWG meeting.

Source: JICA Study Team

Figure 6.5.10 Scene of Training in Japan

Source: JICA Study Team

Figure 6.5.11 Scene of presentation on Training in Japan by trainees

(3) Lecture

JICA study team made a lecture to ALMA personnel about basic skill for information collection and accumulation from all over the world using free information sources, in order that ALMA becomes capable of knowing the development trends and practices in the world. 11 persons from different departments including ones not directly related to the master plan project participated in the lecture.

The lecture introduced methodologies to initially orient oneself toward a subject, find good information sources, follow efficiently the updated information, and accumulate the interesting information found.

6.6 Evaluation of Capacity Development Activities

Table 6.6.1 presents the results of self-evaluation by trained officials of ALMA on the effect of capacity development activities provided by JICA Study Team. Evaluation value 1 means "No idea" and 5 means "able to explain to others". All the items saw improvement comparing the values of Before and After.

Table 6.6.1 Self-Evaluation of Capacity Development Activities

Ideal status	Necessary capacity (capable of)	Act. No.	Evaluation		
			Bef.	Aft.	Var.
Analysis					
[Urban plan] Actual status of entire city is understood	Understand actual urban structure including land use, road network	-	N/A	N/A	N/A
	Manage in an integrated form (by making database) the basic data including current land use map and periodically update it	1	3.0	4.0	+1.0
	Carry out necessary supplement survey for updating of current land use map etc.	-	N/A	N/A	N/A
	Utilize GIS software for urban planning	2	N/A	3.7	N/A
[Urban plan] Future urban structure and land use are previewed	Formulate and apply socio-economic framework of past, today and future	3	2.9	4.3	+1.4
	Draw future urban structure based on socio-economic framework	4	3.0	4.5	+1.5
	Evaluate characteristics of land and identify land to be urbanized	5	3.0	4.5	+1.5
[Transport plan] Actual transport of entire city is understood	Plan and implement comprehensive traffic survey including traffic count and person trip survey etc.	6,7	1.8	4.1	+2.3
[Transport plan] future transport is forecasted	Accumulate and utilize past traffic data	8	1.5	4.0	+2.5
	Formulate and apply socio-economic framework of past, today and future	9	2.9	4.3	+1.4
	Forecast future transport and identify necessary development or improvement of transport infrastructure etc.	10,11	1.4	4.0	+2.6
Vision					
Future development vision is established based on fundamental knowledge, experience, global trends and various cases	Continuously collect and accumulate worldwide information on urban development	12	2.5	3.9	+1.4
	Evaluate the accumulated information referring to fundamental knowledge	13,14	2.8	4.6	+1.8
Vision is shared among related internal / external institutions	Smoothly communicate and facilitate consensus among related institutions	-	N/A	N/A	N/A
Plan					
Plans are mutually matching and generate synergy effect	Systematically gather information of numerous plans and confirm their mutual relation	15,16	2.8	4.6	+1.8
[Urban plan] Land use plan is prepared	Evaluate alternatives of land use and find out the best solution	17,18, S-1	2.6	4.2	+1.6
[Urban plan] Land use regulation is prepared	Establish a regulation that realizes the land use plan	19,20, S-2	3.0	4.3	+1.3
[Urban plan] Public-led area	Evaluate expected outcome and risk of area	21,22	2.6	4.4	+1.8

development can be planned	development				
[Transport plan] Project long list is prepared	Prepare preliminary plan including location, route, project cost etc. of each project	23,24, 25,S-3	2.2	4.3	+2.1
[Transport plan] Priority projects are selected	Give priorities to projects based on certain criteria	26	2.1	4.5	+2.4
Utilization					
[Urban plan] Land use regulation is efficiently and effectively enforced	Publish land use regulation map along with other useful data for easy access for citizens	27,28	2.7	4.0	+1.3
	Quickly process applications related to building permit	29, S-4	2.4	4.0	+1.6
	Control illegal land use	S-5	N/A	N/A	N/A
[Urban plan] Public-led area development is implemented	Carry out planned area development or invite and collaborate with developer	30	3.0	4.5	+1.5
[Transport plan] Priority projects are detailed and implemented	Plan and carry out necessary procedure of FS/BD/DD/CS/OM	S-6	N/A	N/A	N/A
	Evaluate financial and economic aspects of projects to acquire budget	S-7	N/A	N/A	N/A
[Transport plan] Appropriate projects from mid and long-term project lists corresponding to ongoing situation are implemented	Obtain traffic data at appropriate locations to evaluate the validity of project implementation	31	1.5	4.5	+3.0
[Transport plan] Related institutes cooperate with each other on traffic management	Coordinate with related institutes of road and transport, and implement comprehensive traffic management	S-8	N/A	N/A	N/A

Note: "Bef." represents "Before", "Aft." represents "After" and "Var." represents "Variation"
Note: Evaluation 1 means "No idea" and 5 means "able to explain to others"
Source: JICA study team

According to the observation by JICA Study Team referring to feedback questionnaires, the capacity to analyse actual situation got improved through numerous meetings of TWGs and through OJT. As a whole, the importance of accumulate and update data was well recognized, especially through the socio-economic data collection and analysis. For urban planning, OJT on Spatial Analyst of ArcGIS contributed the improvement of their basic skills, which should keep improving through continuous use of the software. Also, the importance and work flow of land use analysis could be evaluated as well understanding by means of a series of TWG meetings. Implementation of same level of analysis might be still difficult for ALMA by itself, however they could carry out the necessary works by contract out judging from the quality of local consultant since ALMA understands the importance of analysis and relevant data updates. OJT was conducted also for transport planning on the subjects of traffic survey and traffic demand forecast. It should be noted that most of the traffic data used in this study were collected by trainees of ALMA with guidance by JICA Study Team. Traffic demand forecast was a completely new subject for ALMA, accordingly the OJT was carried out with a large focus on the basic knowledge and skill. It is expected that ALMA continues to improve its skill by using the provided software of JICA STRADA.

For vision establishment, training tour in Japan contributed quite well to enrich the vision of the participants, who then diffused their experiences in Japan to their colleagues. The whole discussion, especially on future transport system, also improved recognition of importance to establish a future vision for long term, apart from confronting daily issues. It is important that ALMA continues to hold the vision defined through this study while keeping the eyes on trends and practices in the world.

Planning is the main component of this master plan project, and a number of meetings held for the plan elaboration enforced knowledge and understanding of ALMA in this regard. For urban planning, land use plan was prepared through meetings of the TWG, and the principle ideas were well understood. The next step to realize the plan is to revise the zoning system, which was not in the scope of this study and accordingly needs assistance by specialist for proper revision in the near future. Public-led area development was also discussed and the principle ideas were well understood. In particular, through the external training in Japan, many examples such as the civic core and modern bus terminal seem to have left practical impressions for them. The experience could cultivate possible roles and functions of public-led area development. For the transport planning, discussion based on traffic survey and traffic demand forecast was carried out repeatedly. The basic ideas were well understood, however, due to absence of entity assigned for transport planning as well as lack of experience, a large part of the transport plan needed to be elaborated mainly by JICA Study Team. For future transport development, ALMA needs to enforce further the transport planning capacity to identify solution alternatives and to select a best solution through comprehensive analysis. As a whole, the importance of synchronizing and harmonizing different projects in different sectors was well recognized, for which the practices in Japan also assisted the understanding.

In terms of utilization of master plan, this master plan study could only suggest future actions for ALMA, on the other hand the principle ideas were transferred through discussion. One of the remarkable output that was already achieved is the launch of existing zoning map based on GIS database on ALMA's website. It is expected that the data will be updated periodically for use of citizens and developers. Concerning the public-led area development, some basic tools for implementation such as FAR bonuses were explained, however, the actual implementation will require more detailed analysis and decisions based on experience, for which ALMA should be assisted by experienced specialists. For transport planning, the principle ideas were transferred mostly through meetings and sometimes through lectures by specialists of JICA Study Team, however, transport projects require detailed studies specified for each one of projects, and especially projects for mass-transit systems shall require a technical assistance because it doesn't exist yet in the country.

6.7 Suggestions for improvement of Institutional System

6.7.1 Challenges

In order that ALMA becomes capable of implementing and revising the master plan after this project, JICA study team identified several challenges in institutional systems through process of the study in general and through discussion with ALMA personnel on this issue.

(1) Challenges for implementation

Lack of implementation capacity is a critical issue. Although the capacity development activities during this master plan project helped a lot the development of the capacity of personnel, it was mostly for the planning capacity. Implementation phase shall require other sorts of capacity; for urban development,

capacity to lead new CBD development collaborating with private developers as well as capacity to control illegal land use are the important items for implementation. For transport development, estimation of demand and evaluation of financial and economic impact of project in detail are important capacity to be improved.

Lack of budget is always a problem for realization of project. Recently the Law and the Regulation for Public-Private Partnership (PPP) passed, which is expected to become a meaningful tool for the future investment.

(2) Challenges for revision

One of the most critical challenge shall be absence of responsible unit of the revision. This master plan project has been carried out by a mutual collaboration of ALMA and JICA study team, but a fact is that larger contribution from ALMA for integration and packaging of the entire master plan composed by different sectors was mainly given by indivisuals belonging to different units. This became possible under the special condition to be collaborated with JICA study team, but the same coordination is not expected at the moment of revision that is to be done by ALMA itself.

Another challenge is lack of appropriate system to accumulate and take over the knowledge and experience among officers, especially to new generation. During this master plan project, it was observed that the new generation lack much of the hand-on experiences in formulating, revising and implementation actual urban master plan like those done in 1980s and 90s.

There is also a challenge of the change of human resources. According to interviews to ALMA personnel, it is often observed that officers move to another job after getting experience in ALMA. In the same way, it cannot be promised that the personnel who took part in this master plan project continue to work for ALMA until when the master plan is to be revised.

Insufficiency of urban planning capacity is another challenge. Currently there are only five urban planners in the Urban Planning Department including two new young staff without adequate experience, which is absolutely not sufficient for Managua city that has 1.5 million of habitants.

For the transport planning, currently there is no specific institution in charge of the planning. Accordingly, no one is carrying out comprehensive traffic survey and traffic analysis to understand the traffic situation of entire city, which is a fundamental need for the transport planning.

Socio-economic framework based on statistical data including demographic trend in Managua City and Nicaragua is the base for the planning, however, such statistical data are not collected in a proper manner. During this master plan project, it turned out that different departments of ALMA possesses a part of the data such as the number of births/deaths and changes in residential registrations, without sharing constantly with the other departments. For some data such as number of students and the forecast of national population growth, ALMA hadn’t possessed.

6.7.2 Suggested actions

(1) Responsible unit for follow-up of master plan

It is suggested that ALMA has a responsible unit for the follow-up of the master plan, whose main roles shall be listed below;

- Monitor the implementation status of each one of the projects in the master plan in different sectors
- Velify the relevance of project implementation and indicate the necessity of modification considering the then situation and the balance with other projects in other sectors
- Monitor the viability of the master plan considering the whole social situation with base of socio-economic indicators
- Promote the necessary capacity development activities and institutional system improvement for the implementation and revision of the master plan

It doesn't mean the unit shall carry out all the follow-up works only by itself, but the unit shall take the responsibility and initiative for the follow-up of the master plan, to be supported by the others; for instance, the unit shall request the General Directorate of Human Development to organize some training courses that are necessary for project implementation, or the unit shall lead the legistation process of the land use plan with coordinating with Department of Urban Planning

The roles can be taken by an existing department or by a completely new unit. General Directorate of Planning, in charge of establishing the policies and strategies etc., seems to be the relevant directorate to take the roles of follow up. The general director of this general directorate participated in and contributed a lot to this master plan project, on the other hand the participation of the other officers had been limited because of their time constraint. This option of incorporating the roles into existing department shall reduce the political and administrative difficulty of institutional transition, on the other hand the lack of visible change in the institution might weaken the propulsion for the master plan. Reallocation of existing tasks and increase of human resource must be considered, becaue it shall mean additional tasks for the department.

Another option is to create a new unit, which is so-called Program Management Unit. The creation of a dedicated unit shall give a clear message for promoting the master plan. A disadvantage would be the need of institutional transition that takes sometimes much time to be realized. In this option, the necessary human resource would be four members; Unit Chief, technical manager, finance manager, and Assistant.

As a combination of the two options, a possible option is to create the new unit within General Directorate of Planning.

(2) Continuous capacity development and accumulation of experience and skill

Continuous capacity development needs to be done, and, as observed typically with Urban Planning Department, the accumulation of the experience and skill should be reinforced. Even though everyone

already has plenty of assigned tasks, continuous effort to acquire the knowledge and skill is very important, which will improve the productivity and efficiency.

GIS was a good example. Historically ALMA had developed spatial data in microstation or AutoCAD format since 1990's, and these data had been accumulated and utilized through LatinoGIS application developed by ALMA. These accumulated data are significantly valuable for activities in ALMA, however, if ALMA knew GIS with spatial analysis function, these data could have been utilized much more effectively for urban planning.

In practice, internal workshop or conference inviting expert such as professors could be the methods. On-the-Job traning as done for GIS could be continued internally by ALMA, as there are already some officers who acquired a good level of skill, at least for GIS. Carrying out some researchs to be submitted to any academic society could be also a method to deepen the knowledge as well as to leave written material, to be easily shared with others. Preparation of manuals based on the experience should also be a method for the accumulation of institutional capacity. Also, systemization of periodic analysis of land use and traffic situation etc. shall contribute to the continuous improvement of the skill, which is definitely important also to keep updated on the city's latest situation.

(3) Strengthen of urban planning capacity

In addition to the above-mentioned activity, for the urban planning, it is necessary to increase the urban planner. Department of Urban Planning will require at least five additional planners including core planners with adequate experience dedicated for the coming modification of zoning regulation, as well as one or two planners dedicated for public-led area development. For the moment, some planners could be transferred from Department of Urban Control that has more human resources to fulfill the necessity of urban planning, while also recruiting new staff. It is expected to increase further the capacity of urban planning in the longer term.

(4) Establishment of institution for transport planning

It is necessary to have an institution for transport analysis and planning, in order to cope with increasing traffic and to realize efficient and low carbon emission transport system as the entire Managua City. The institution should be able to take the leadership on the transport planning and implementation of transport infrastructure projects and traffic management. The main features are described in "10.3 Proposal for Appropriate Transport Institution System" in Chapter10 of the report.

(5) Systematic collection and accumulation of socio-economic data

Socio-economic data collection and accumulation process should be improved and systematized so that the data can be used to estimate and update the socio-economic framework regularly. It is recommended to establish a system that one department, namely General Directorate of Planning, collects the basic data from different departments of ALMA as well as from external institutions in a constant manner, for example by a monthly report for in/out migrants and by a yearly report for students.

CHAPTER 7 FINANCIAL CONDITIONS AND INVESTMENT PLANNING

7.1 Financial Conditions of ALMA

ALMA is the main stakeholder of the implementation of master plan. When ALMA is the implementation organization of a project, the first option of the funding source is ALMA's own annual budget. In order to assess ALMA's financial conditions, its revenue and expenditure patterns for the past five years should be reviewed. The municipal law requires each municipality to publicize its financial statistics. The annual financial data of ALMA are documented and managed in good condition. ALMA's financial policy is to keep a balanced budget. The annual flow of general revenue and expenditure is stable, but there have been some volatilities in extraordinary revenue and expenditure.

7.1.1 Annual Revenue of ALMA

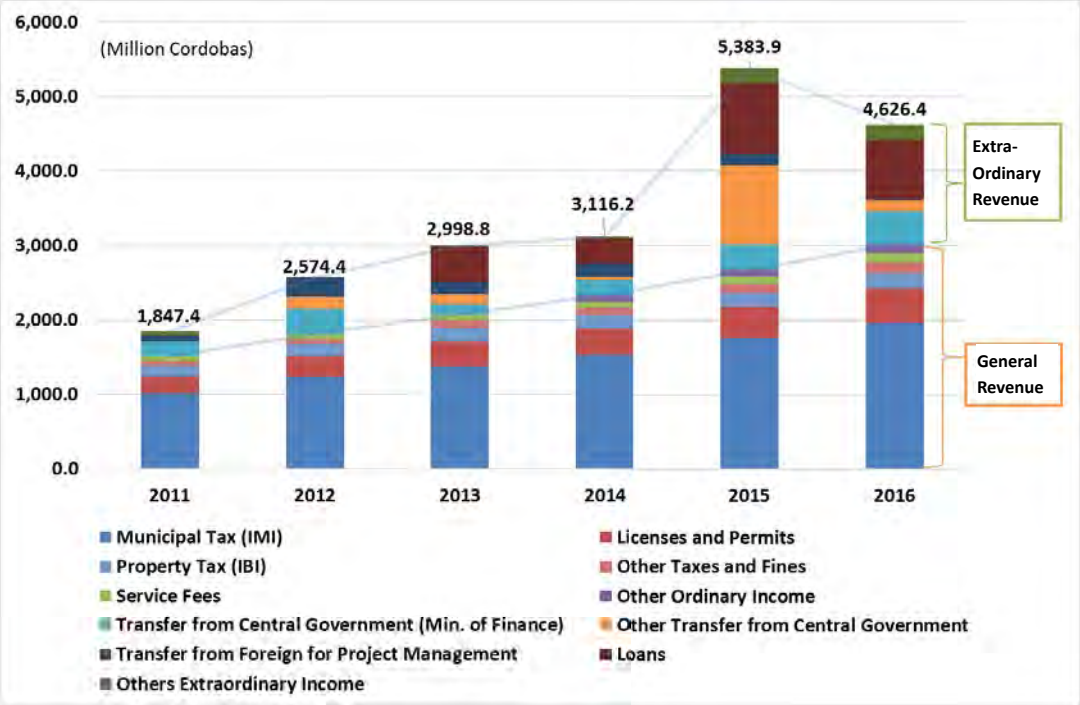
Table 7.1.1 shows the revenue structure of ALMA. The revenue structure can be broken down to two major categories, namely, general revenue and extraordinary revenue.

Table 7.1.1 Revenue Structure of ALMA

1. General Revenue			
	(1) Municipal Tax		
		1) Municipal Corporate Tax (IMI)	1% revenue paid monthly
		2) Permits and Licensing Fees	2% of revenue of the last 3 months of business paid annually
		3) Property Tax (IBI)	1% of owned property value paid annually
		4) Car Permission Tax	NIO 100 paid annually (a.k.a. Rodamiento)
		5) Other Taxes and Fines	Some indirect taxes
	(2) Service Fees		
		1) Garbage Collection	Fees fixed by the National Law
		2) Cemetery Operation	-
		3) Rental Income	-
	(3) Other General Revenue		-
2. Extraordinary Revenue			
	(1) Transfer from National Government (Fixed Amount)		Share fixed by the National Law
	(2) Other Transfer from National Government		Provided on-demand basis
	(3) Transfer from Foreign Organizations		Provided on-demand basis
	(4) Loans		From Commercial Banks
	(5) Other Extraordinary Revenue		-

Source: JICA Study Team based on the data from ALMA

Although the Constitution of Nicaragua guarantees "financial autonomy" of the municipalities, many factors are fixed by the central government under the National Law including notably the rates of municipal taxes. The taxes on personal income are paid directly to the national government. Then, some share of the national budget is channeled to municipal governments as transfers. Figure 7.1.1 shows the trends of revenue growth from 2011 to 2016.



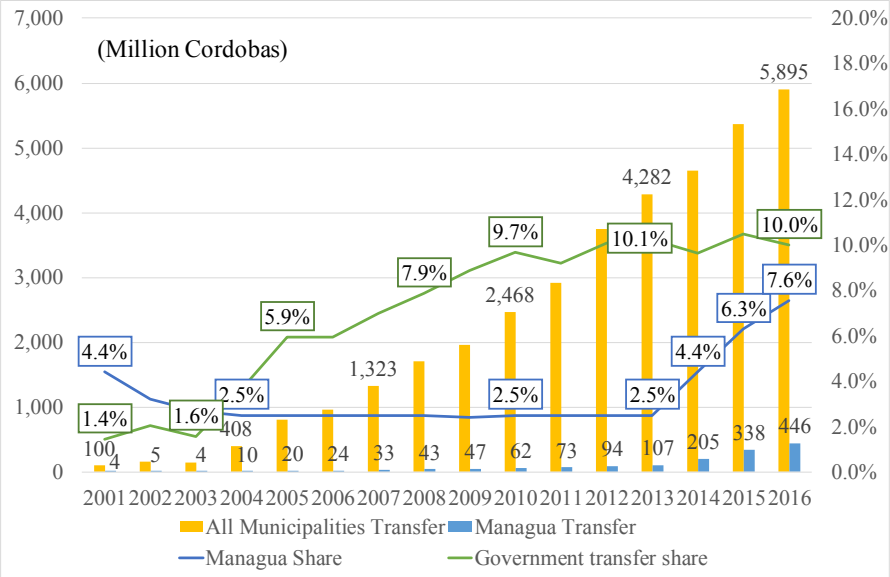
Source: JICA Study Team based on the data from ALMA

Figure 7.1.1 Annual Revenue by Category of ALMA

The most fundamental and consistent part of the revenue comes from the municipal tax, or IMI. The combined three main revenue sources, i.e.: municipal taxes or IMI, licenses and permits, and property tax or IBI, account for approximately 90% of the general revenue every year. Other taxes and service fees consist of the remaining 10%. In the past years, the annual general revenue of ALMA observes a rapid growth of 14.8% per annum on average. As the tax rates have been fixed by the National Law as mentioned earlier, the growth of general revenue may be attributed to the growth of regional economic activities and improvements in collection efficiency. The macro statistics indicates that the total gross domestic product (GDP) of Nicaragua grew 5.2% per annum in the last five years. Managua City has a higher growth of gross regional product (GRP) than the rest of the areas in Nicaragua. There are no specific data but tax collection efficiency is estimated at around 65% in recent years. There have been some policies imposed in recent years to improve the collection rate by providing incentives to tax payers for paying taxes on time. Therefore, the general revenue of ALMA is expected to grow stably in the near future, unless the economy of Managua City will observe a sharp downturn.

The total general revenue of ALMA was NIO 3.0 billion in 2016. By applying the population of Managua City at 1.5 million in 2016, the revenue of ALMA from each resident, most of which are from municipal taxes and service fees, is approximately NIO 2,000 per year. This means that the size of available municipal service budget per person is within the municipality revenue. In contrast, the general revenue of the national government of Nicaragua is NIO 63.3 billion. Tax burden for the entire population of 6 million in Nicaragua is approximately NIO 10,550 per year, which is more than five times higher than that of Managua City. Thus, there are plausible reasons for municipal governments to request for transfers from the national government.

These transfers are included in ALMA's extraordinary revenue. ALMA is entitled to receive transfers from the national government through the Ministry of Finance and Public Credit (MHCP) every fiscal year. There are both fixed portion and on-demand portion of transfers. Based on the Fiscal Transfer Law (2003), the national government is obliged to transfer 10% of the total tax revenue to the municipal governments every year. The share of the transfers to Managua City is 2.5% of all transfers from the central government by law but the actual share of Managua City is expanding to over 7% in the all transfers from national government to municipalities in 2016. The minimum of 2.5% is certain, but the additional growth of ALMA's fixed transfer share for the future is indefinite.



Source: JICA Study Team based on the data from MHCP

Figure 7.1.2 Annual Fixed Amount Transfer from the Central Government to ALMA

On top of the fixed amount transfers from the national government, there is an on-demand portion of transfer that is given to municipalities on a project basis. The national government orders ALMA to invest in some large projects, such as national stadium. ALMA secures funds from commercial banks at market rates until receiving the fund from the national government. In 2015, the large amount of on-demand transfer was approved including some of the pending disbursement from the past years. Therefore, the total revenue in 2015 increased drastically. The current debt on commercial loan held by ALMA is expected to be repaid through these on-demand transfers from the national government in the coming years.

While the national government approves disbursement, ALMA needs to take several procedures to apply for loans from commercial banks. First a request is raised to the municipal council to gain approval. Once the request is approved by the municipal council, the authorization from the MHCP is then required. After that, ALMA can take a commercial loan with an average interest rate of 8.5%.

ALMA receives some funds from external organizations. The received amount varies every year, but the amount reached NIO 210.9 million in 2015 and NIO 213.8 million in 2016 which are close to

approximately 4% of the total revenue of ALMA. Most of the external funds are provided to ALMA on grant basis and the funds are tied to specific projects.

7.1.2 Annual Expenditure of ALMA

Table 7.1.2Figure 7.1.2 shows the expenditure structure of ALMA's budget. The expenditure side is divided also into general expenditure and extraordinary expenditure.

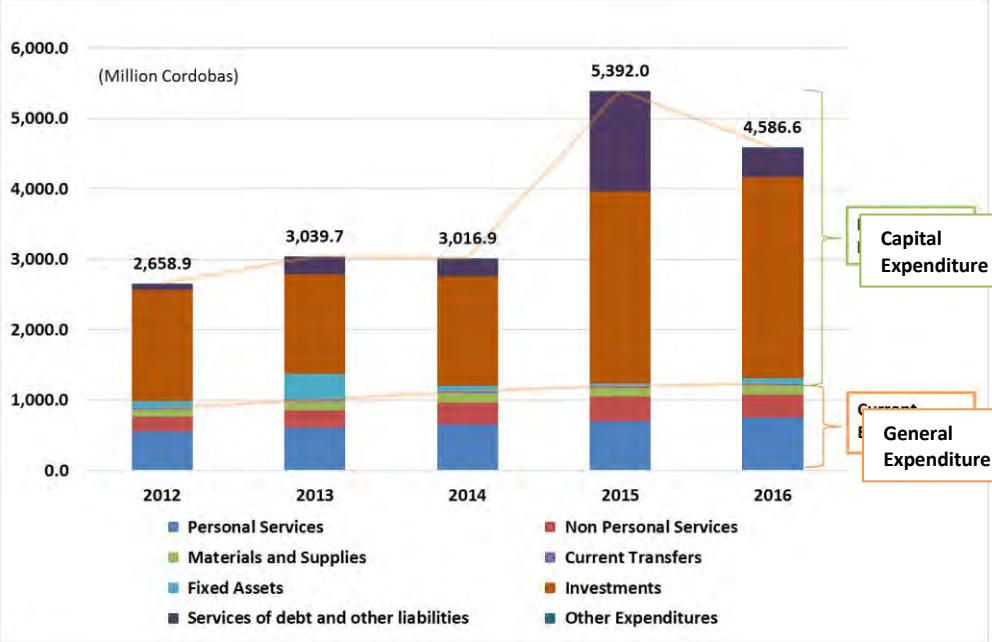
Table 7.1.2 Expenditure Structure of ALMA

1. General Expenditure	
	(1) Personnel Services
	(2) Non-Personnel Services
	(3) Materials and Supplies
	(4) Current Transfers
2. Extraordinary Expenditure	
	(1) Fixed Assets
	(2) Investment
	1) Investment on Infrastructure Projects and Districts
	2) Investment on Human Development
	3) Investment on Information Systems
	4) Investment for Institutional Strengthening
	(3) Services of Domestic and Foreign Debt and Other Liabilities
	(4) Other Capital Expenditures

Source: JICA Study Team based on the data from ALMA

The general expenditure covers the operation expenses that are needed every year to provide ALMA's services to the citizens of Managua City. The investment on fixed assets is listed in the extraordinary expenditure. The Municipal Budget Law (reformed in 2013) stipulates that municipalities such as ALMA shall spend a minimum of 40% of the general revenue on investment. The general expenditure is thus capped at 60% of general revenue.

Figure 7.1.3 shows the expenditure structure of ALMA in the past five years.



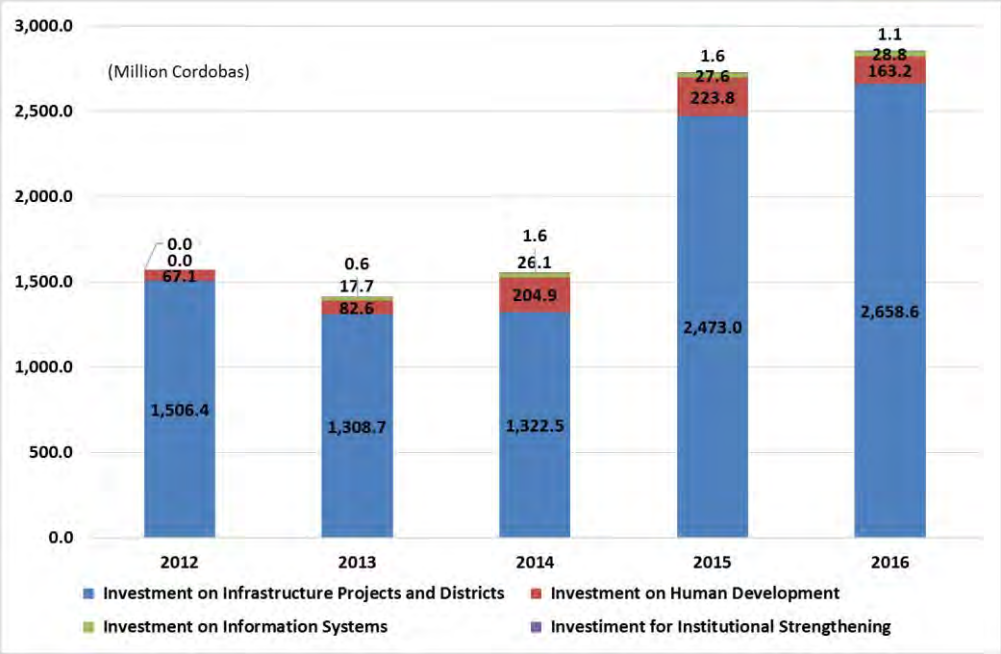
Source: JICA Study Team based on data from ALMA

Figure 7.1.3 Annual Expenditure by Category of ALMA

General expenditure of ALMA increased by 8.2% per annum on average in the years from 2012-2014. However, the expansion of the general expenditure was kept under 6.8% in 2015 and 2.3% in 2016. Payment for personnel services composes approximately 60% of the general expenditure. The rest of the general expenditure is spent on non-personnel service (26%), materials and supplies (12%), and transfers (2%). The ratio of general expenditure to general revenue is 49% in 2012. Since then, the share has been decreasing and the rate dropped to 41% in 2016. As specified in the law, an adequate share of the general revenue is left for investment activities.

In 2015, the capital expenditure expanded considerably. The components of capital expenditure include depreciation of fixed assets, investments, and service for debts and liabilities, and accounting budget might not be affected and the service for debts and liabilities might not have depreciation. In 2012, the share of capital expenditure to the total expenditure was 66%; however, the share of capital expenditure became 77% in 2015 and 73% in 2016. The amounts of investment compared with the general revenue were 87% in 2012, 102% in 2015 and 95% in 2016, which exceed the minimum investment amount required by law.

Figure 7.1.4 shows the types of investment made by ALMA in the past five years.



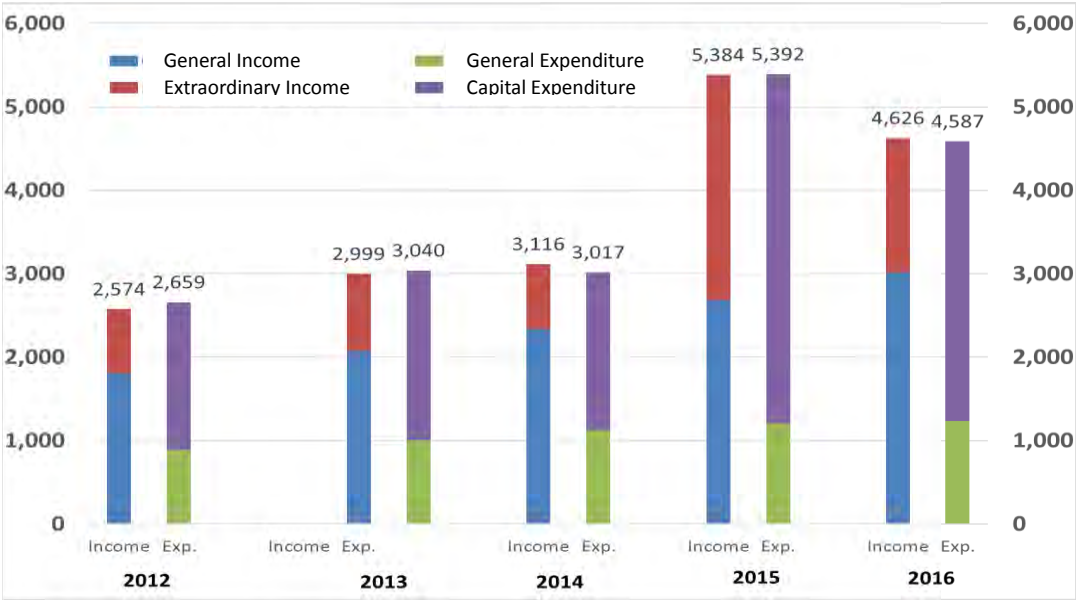
Source: JICA Study Team based on data from ALMA

Figure 7.1.4 Types of Investment of ALMA

When focusing on the types of investments of ALMA, it spends a large portion of investments on infrastructure and district development. Also, investment on human development is expanding every year. Investment on information systems and institutional strengthening started in 2013 and is gradually increasing. In 2016, ALMA invested in 447 projects using its investment budget including the transfers from the national government and external organizations.

7.1.3 Financial Balance of ALMA

Figure 7.1.5 shows ALMA's revenue flow against expenditure flow in the past five years. The total revenue and expenditure are relatively kept balanced. In addition, the daily operational budget is kept under its legal limit. However, the balance including the investment expenditure is sustained by large inflow of transfers from the national government and the investment of the national government in Managua city shows the increasing trend. This shows ALMA's weakness in allocating sufficient fund for investment.



Source: JICA Study Team based on data from ALMA

Figure 7.1.5 Annual Flow Budget Balance of ALMA

Table 7.1.3 shows ALMA's balance sheet at the end of the fiscal year 2015.

Table 7.1.3 ALMA's Balance Sheet (as of December 31, 2015)

Liabilities	2011	2012	2013	2014	2015
Current Liabilities	**710.5**	**1,121.4**	**1,246.9**	**909.6**	**872.3**
A. Documents and Accounts Payable	201.6	474.6	450.9	498.0	300.2
B. Accrued Expenses and Deductions Payable	226.4	330.0	430.8	34.1	159.4
C. Wages and Withholdings	20.0	31.0	35.5	41.5	47.6
D. Provisions of Liabilities	262.6	285.9	329.8	336.1	365.1
Deferred Income	**56.9**	**87.1**	**64.0**	**72.4**	**82.1**
Fixed Liabilities	**320.3**	**388.7**	**807.0**	**922.8**	**981.6**
Liabilities Total	**1,087.7**	**1,597.2**	**2,118.0**	**1,904.8**	**1,936.1**
Equity	2011	2012	2013	2014	2015
Equity Accounts	**19.4**	**-16.8**	**-587.9**	**-494.3**	**-575.3**
A. Municipal Equity	19.4	-16.8	-587.9	-494.3	-575.3
Accounts Surplus (Deficit)	**-32.2**	**-571.1**	**-398.9**	**-81.9**	**603.7**
EquityTotal	**-12.7**	**-587.9**	**-986.8**	**-576.2**	**28.4**
Liabilities and Equity Total	**1,075.0**	**1,009.3**	**1,131.3**	**1,328.6**	**1,964.5**

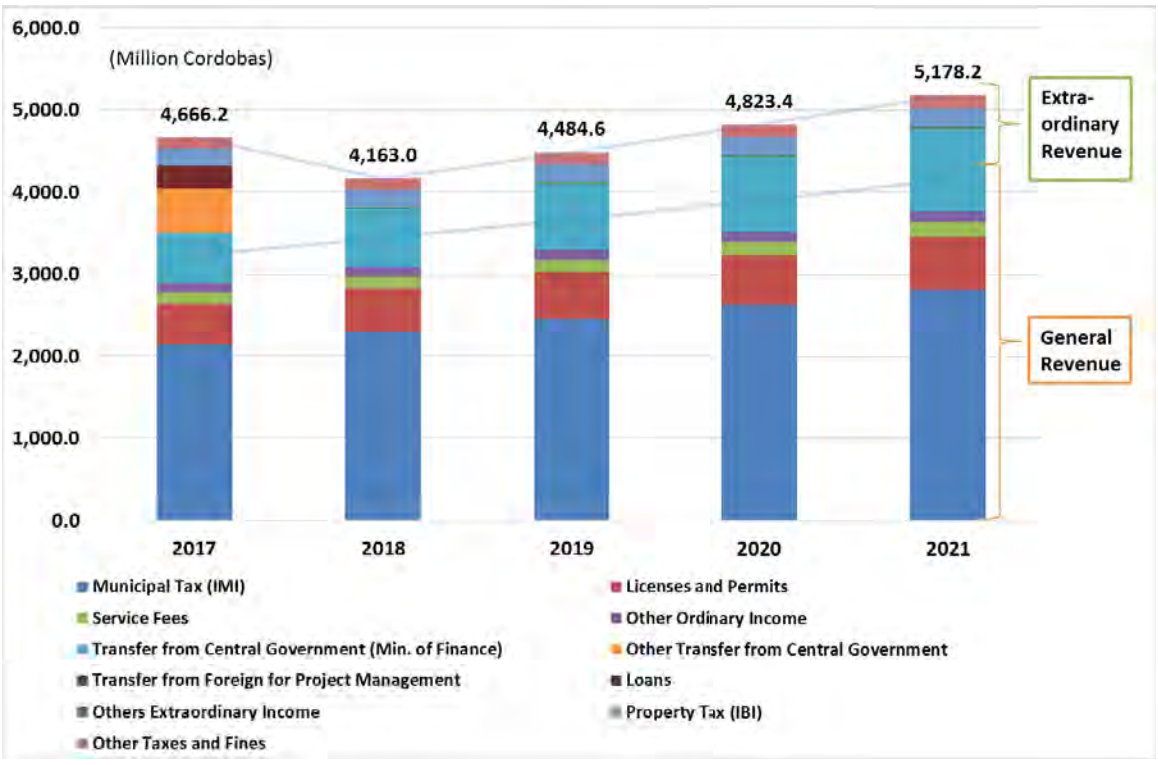
Current Ratio	94.6	53.0	41.1	82.1	168.0
Quick Assets Ratio	62.7	26.6	31.4	63.1	117.4
Fixed Ratio	-3,159.3	-70.6	-62.7	-100.9	1,757.8
Fixed Assets to Fixed Liability Ratio	131.0	-208.3	-344.3	167.8	49.4
Capital Adequacy Ratio	-1.2	-58.3	-87.2	-43.4	1.4

Source: JICA Study Team based on data from ALMA

In 2015, the balance sheet showed a capital surplus of approximately NIO 600 million. The transfer from the national government had arrived at ALMA in 2015.

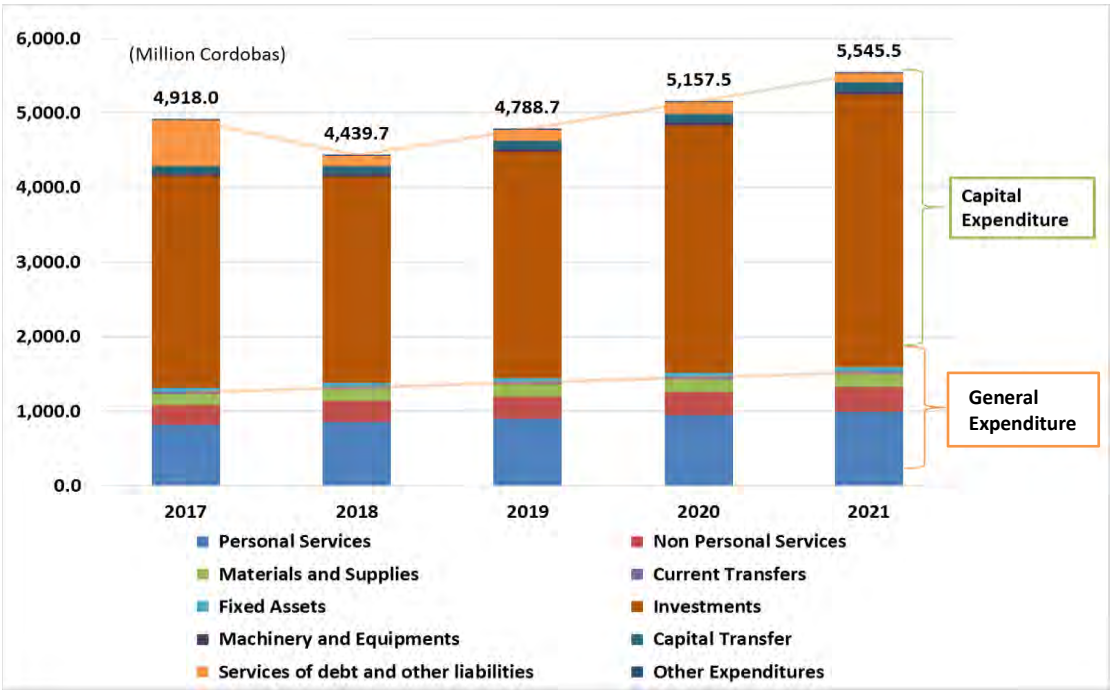
7.1.4 ALMA's Current Financial Plan

ALMA prepared its financial plan up to 2020 and the plan was published in March 2016, and it was renewed up to 2021 in March 2017. The growth rate and share of each category to the total are roughly estimated. Figure 7.1.6 and Figure 7.1.7 shows the predicted revenue and expenditure charts for ALMA in the next five years. At this point, there is no project list after 2022. The revenue in figure 7.1.6 does not include the revenue arising out of external management. The medium-term and long-term projects can be arranged in the future project considerations with priority.



Source: JICA Study Team based on data from ALMA

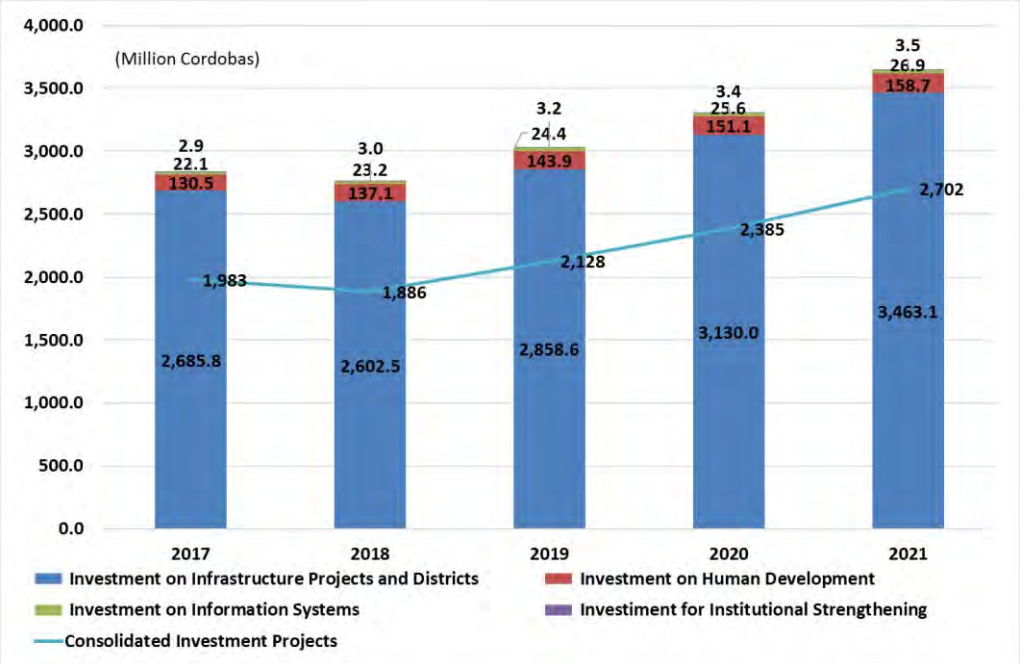
Figure 7.1.6 Projected Revenue Chart for ALMA in the Years 2016-2021



Source: JICA Study Team based on data from ALMA

Figure 7.1.7 Projected Expenditure Chart for ALMA in the Years 2017-2021

In the current financial plan, ALMA expects continuous growth of general revenue at 6.5% per annum. Compared with the past trend of growth at 15.4% per annum, the growth expectation is rather moderate. The growth is estimated at the least expected so that the planned size of investment does not become too large to handle in the future. Therefore, the planned revenue does not include unplanned on-demand revenue or external revenue. With the revenue side in mind, the size of expenditure is kept moderate. The growth in general expenditure is only predicted at 5% per annum while its growth trend in the past five years was at 11.38% It was reduced to 6.8% from 2014–2015 achieving desired balance as project. The rate of general expenditure to general revenue is reduced to less than 40% by the year 2020. Figure 7.1.8 shows the trend of future investment in the next five years.

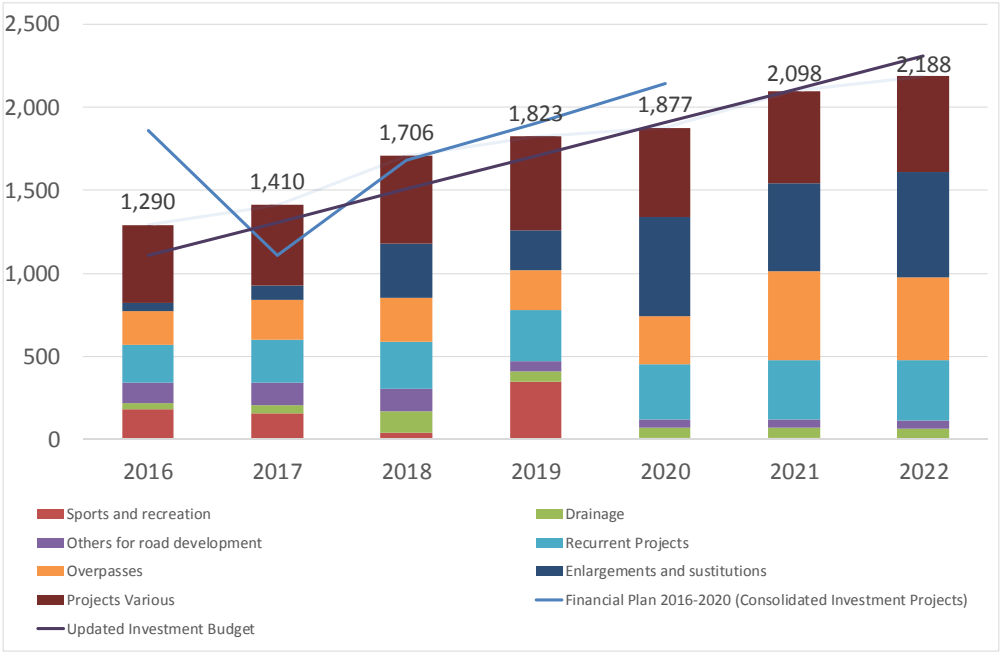


Source: JICA Study Team based on data from ALMA

Figure 7.1.8 Investment Plan in 2017-2021 (Financial Plan in March 2017)

The size of investment in 2017 is expected to be large. There are projects to be covered by on-demand transfer from the national government, but the size is reduced to its budget size in 2017 to keep a balanced budget. On average, ALMA continues to spend 65% of the total revenue on investment in the future years. Within the total investment, about 70% are allocated on consolidated investment projects. Other investment expenditures include costs for studies and maintenance works.

The updated investment plan is presented in Figure 7.1.9.



Source: JICA Study Team based on data from ALMA

Figure 7.1.9 Latest Investment Plan 2016-2022 (August 2016)

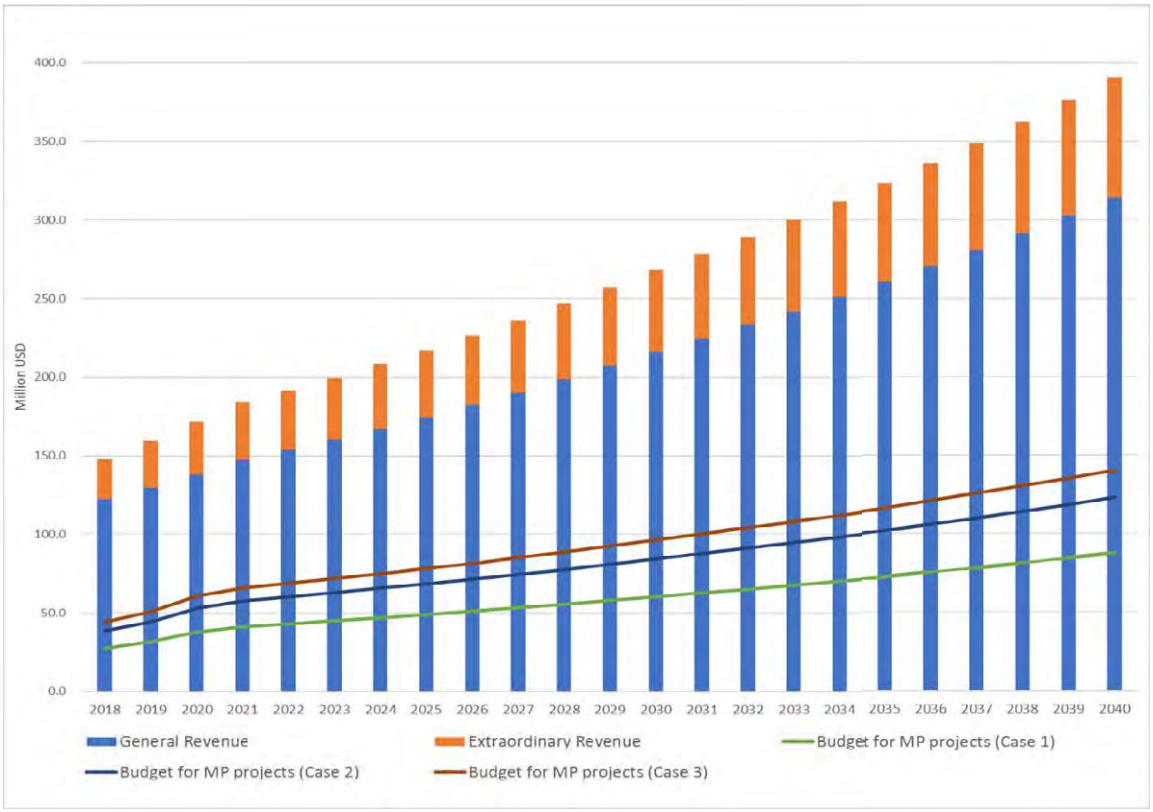
Until the year 2022, some budget is allocated to projects that are already planned. Thus, the development plan of ALMA and budget for planned projects should be rearranged to accommodate with the MP projects. Some of the MP projects are the same or similar to the projects on the existing development plan of ALMA, then the funding for these projects could be utilized for the MP projects.

In addition to ALMA's own revenue, the external finance is an important financial resource for the MP projects. The external resources are grant from international donors, lending from international donors, and domestic commercial lending. However, grant is expected to cease in due course because Nicaragua is graduating from the low-income country as classified by the international institution. To compensate the shortage of funding, Nicaragua and ALMA would need to seek for the international lending from the developmental financial institutions and bilateral-donors.

7.1.5 Analysis and Estimation of Available Budget for MP projects

Source: JICA Study Team

Figure 7.1.10 shows the long-term estimation of total revenue of ALMA and possible three cases of the budget for the MP projects up to 2040, based on the previous trend and current financial plan of ALMA. In the estimation, the revenue projection from 2018 to 2040 is obtained by extending the projection in Economic Financial Plan 2017-2021. After 2021, it is assumed that ALMA's total revenue would be increased by 4.3% from 2022 to 2030, and 3.8% from 2031 to 2040 in average, considering the future growth rate of GDP of Nicaragua, GRDP of Managua city and population in Managua City from the economic and population framework. (The effects of change in inflation and currency exchange are not considered here.) The commercial bank loan and external assistance are not considered here for the simplification. The budget to be allocated to the infrastructure investment projects from total revenue is assumed to be 45%, based on the past trend and ALMA's investment plan of 2017-2021. The budget to be allocated for the MP projects among the budget of infrastructure investment projects is assumed in three cases; namely, (1) Case 1: 50%, (2) Case 2: 70%, and (3) Case 3: 80% of the budget of infrastructure investment project will be spent on the MP projects respectively. Table 7.1.4 shows the expected amount of budget to be allocated to the MP projects by the period in each case. In this estimation, the total budget which will be spent on MP project by ALMA during the MP period will be (1) 1,700 million USD in Case 1, (2) 2,238 million USD in Case 2, and (3) 2,507 million USD in Case 3.



Source: JICA Study Team

Figure 7.1.10 Long-term Forecast of Revenue of ALMA

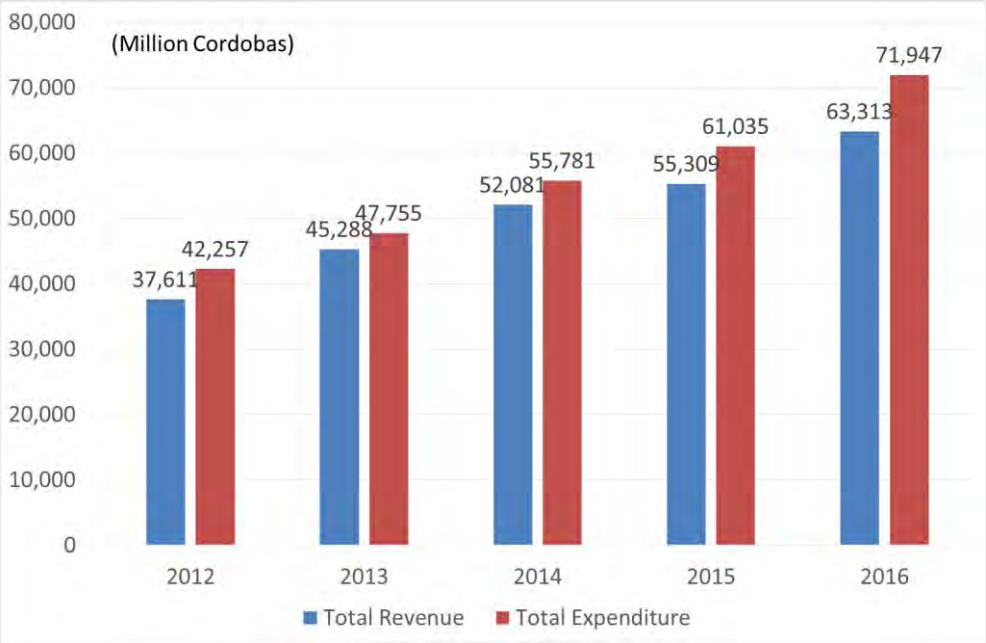
Table 7.1.4 Estimated budget of ALMA for MP project

(Million USD)		Short-term	Middle -term	Long-term	Total
Case 1 (50% of infrastructure investment budget will be used on MP projects)	ALMA's own revenue	96.8	502.5	746.5	1345.8
	Average per year	39.9	79.4	74.6	70.8
Case 2 (70% of infrastructure investment budget will be used on MP projects)	ALMA's own revenue	135.6	703.4	1045.1	1884.1
	Average per year	49.6	99.5	104.5	93.4
Case 3 (80% of infrastructure investment budget will be used on MP projects)	ALMA's own revenue	154.9	803.9	1194.4	2153.2
	Average per year	54.5	109.5	119.4	104.5

Source: JICA Study Team

7.2 Financial Conditions of the National Government

Figure 7.2.1 illustrates the growth of the national budget in Nicaragua.

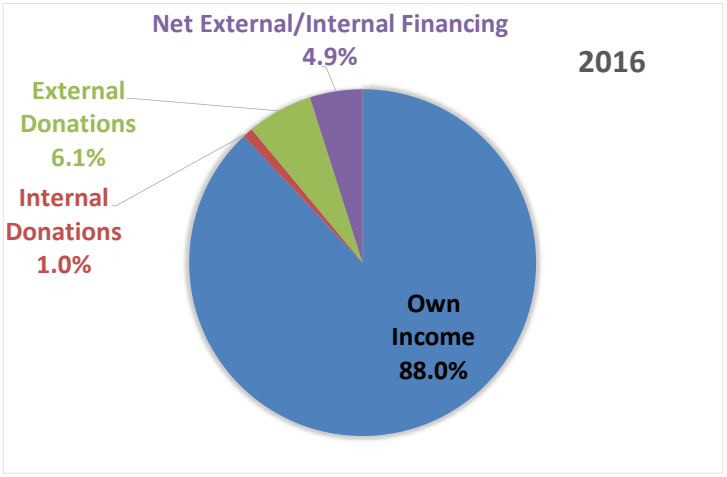


Source: JICA Study Team

Figure 7.2.1 Budgeting of the Nicaraguan National Government (2012 -2016)

Since 2012, both the national revenue and expenditure have been growing at a rate of approximately 14% per year. The general revenue accounts for almost all of the total revenue despite of some fiscal deficit every year. The general revenue is composed of tax revenue, non-tax revenue, property rentals, and current transfers. Out of this, the revenue from tax accounts for over 90% of the general revenue. The main tax collections come from personal income tax, value added tax, consumption tax, stamp tax, and import duties. As discussed earlier, the size of per capita tax collection (burden) for the national government is five times larger than that of ALMA. Therefore, the overall tax collection system is said to be centralized in Nicaragua and the national government has larger financial power than the local government in terms of fiscal allocation.

Figure 7.2.2 illustrates the financing of the national expenditure.



Source: JICA Study Team

Figure 7.2.2 Funding Sources of the Nicaraguan National Government Budget (2016)

Nicaragua manages to finance 88% of its expenditure through its own income such as tax and rental revenues. The remaining 12% relies on donations mostly from financing from external entities. In 2012, the share of external donations was close to 10%, but it has been reduced to 6% in 2016. The share of own income has not changed over the past five years, and the size of external financing has been enlarged. The heavy use of external financing will result in larger amortization in the future years. Given that the national government revenue trend is to increase according to Figure 7.2.1, it is considered the transfers and investment in projects in local governments might be increased, in accordance with the Development Policy and Projects described in Table 7.2.1 (modernization of the municipality of Managua).

In 2016, the national government issued the *Policy and Projects for Development and Potential Investment 2017 – 2021*[1]. The paper laid out 33 national projects that are considered to benefit the national economic and social growth.

Table 7.2.1 National Priority Projects

No.	Project Name	Cost (USD Million)	Finance Source	Managua*1
Projects that have financing already				
1	Program to Strengthen the Competitiveness of Nicaragua's Foreign Trade in Border Crossings Peña Blanca, San Pancho and El Guasaule	57.7	IDB	
2	Modernization of the City of Managua	1,200.0*2	-	◎
3	Highway Naciones Unidas –Bluefields	95.1	IDB/WB Japan/Nicaragua	
4	Highway El Rama –Laguna de Perlas	89.8	BCIE (partly)	
5	Highway Mulukukú –Las Minas	42.3	BCIE	
6	Highway Malpaisillo –La Paz Centro –Puerto Sandino	97.5	BCIE (partly)	
7	Highway El Rama –Wapi –Tortuguero	38.7	IDB (design only)	
8	Capacity Building at the Augusto Cesar Sandino Airport	133.5	Russia	◎
9	Implementation of the Broadband Project	107.0	IDB/South Korea	○
10	Development of the Telecommunications Infrastructure in the Caribbean Coast (CARCIP)	22.7	WB	
11	Project for the Establishment of a Nicaraguan Airline	49.0	Russia	
12	Program of Electricity Generation of 141.1 MW	-	-	
13	Program of Development of the National Interconnected System (SIN)	449.2	IBD/EIB/BCIE/ KEXIM/LAIF/ India/Nicaragua	
Projects without financing yet (open for investment)1				
1	Project of the Coastal Highway of the Pacific	120.0	-	
2	Construction of Air Terminal in Bilwi	7.0	-	
3	Installation of Fuel Supply Systems for Airports Outside of Managua	15.0	-	
4	Managua -Masaya -Granada Railway	130.0	-	◎
5	Construction Project for Inter-City Bus Terminals in the Municipality of Managua	50.0	-	◎
6	Construction of Cruise Terminal in San Juan del Sur	40.0	-	
7	Corinth Port Modernization Project	50.0	-	
8	Bluefields Port Construction Project	200.0	-	
9	Phase II Project of the Integral Program of Water and Human Sanitation (PISASH)	322.0	-	○
10	Metropolitan Managua Project	120.0	-	◎
11	Pilot Project for a National Irrigation Plan	-	-	

[1] Politicas y Proyectos de Desarrollo Para Potenciar la Inversion 2017 – 2021 (2016)

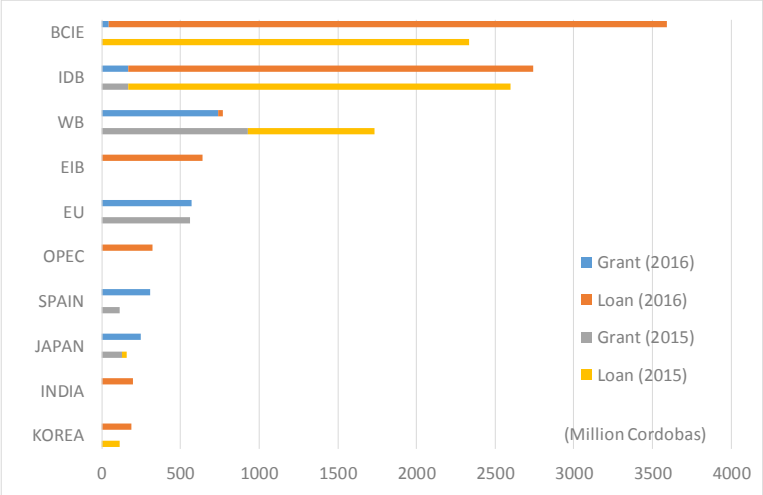
12	Irrigation Program for the Dry Corridor and Isolated Regions of National Production	20.0	-	
13	Project of Fish Processing Plant, Creation of Cold Chain for Fishery Products and Acquisition of New Fishing Fleet	50.0	-	
14	Remodeling of Tourist Centers in Nicaragua	44.6	-	○
15	Development of Tourist Routes	20.3	-	○
16	Program for Reducing Emissions from Deforestation and Forest Degradation	8.5	-	
17	Electrical Generation Program of 412.9 MW	1,184.3	-	
18	Equipment with Mobile Devices in Preschool, Primary, and Secondary Schools	264.0	-	○
19	Endowment of Computer Equipment to All Teachers, Directors and Sub-directors of Pre-school, Primary, and Secondary, Public Servants of the Basic Education System, Equipment, and Internet to Schools Headquarters of TEPCE and Departmental Centers of Technical Support for Technological Support	43.1	-	○
20	Development of Teaching Capacities in Technologies for Integral and Quality Education, through Centros de Innovación Educativa and la Universidad Abierta Virtual	37.0	-	○

*1: ◎ indicates projects that are strongly related to Managua
○ indicates projects that include Managua
*2: USD 400 million is allocated but USD 800 million is yet to be financed and the project period is estimated to be ten years.
KEXIM: Export–Import Bank of Korea
LAIF: Latin America Investment Facility (EU)
Source: JICA Study Team

The total investment size of these 33 projects is estimated at approximately USD 5,229.23 million. Out of the 33 projects, 13 have financing already. Some projects, including "Modernization of City of Managua", have only partial finances and the total investment volume is yet to be covered. Five projects are closely related to infrastructure development in Managua Region. In addition, seven projects are nationwide projects and Managua City is a part of the targeted areas. The national government can implement these projects in Managua City on its own or indirectly finance to ALMA or other executive agencies. ALMA would need to coordinate with the national government to arrange implementation and finance of MP projects which have been listed as the national priority projects in the national plan.

7.3 Donor Participation in Managua City and Nicaragua

Nicaragua is listed as one of the lower middle-income countries in the list of official development assistance (ODA) recipients. Figure 9.7.1 shows the participation of major active donors (top 10 in 2016) in Nicaragua in 2015 and 2016.



Source: JICA Study Team based on data from ALMA

Figure 7.3.1 Latest Investment Plan 2016-2022 (August 2016)

The two major donors in Nicaragua are Central American Bank for Economic Integration (BCIE) and Inter-American Development Bank (IDB). There is a high volatility in the grant and loan amount every year from each agency. This implies that the financing to Nicaragua from these multilateral and bilateral agencies are given on an ad-hoc project basis. Out of the countries that are not listed above, Table 7.2.1 (National Priority Projects) showed that the Russian Federation is seen to be aggressive in financing national projects. Also, Taiwan has been engaged in various projects in Managua City. Managua City has received various such international assistance. Therefore the international assistance will be one of the important financial options. It is necessary for Managua City to formulate appealing investment plan in order to attract donor participation for financing of infrastructure development projects.

7.3.1 JICA's Presence in Nicaragua

The Japan International Cooperation Agency (JICA) has been showing continuous presence in donor activities in Nicaragua. In 2016, JICA dispatched the second largest amount of grant in the bilateral cooperation categories after Spain. Table 7.3.1 shows the record of Japanese ODA assistance in Nicaragua from 2010 to 2014.

Table 7.3.1 Record of Japanese ODA Assistance in Nicaragua

Year	Loan (USD million)	Grant (USD million)	Technical Cooperation (USD million)
2010	-	10.3	10.0
2011	-	24.0	9.2
2012	-	23.4	10.9
2013	14.6	6.4	8.4
2014	-	14.1	6.2

Source: Ministry of Foreign Affairs, Japan (Adjusted to USD with JICA rate)

In the past, JICA has assisted the development of Nicaragua through grant and technical cooperation programs. JICA's projects include constructions of 25 bridges and formulation of the national transport plan. Also, capacity development of national and local level government staffs has been one of the key features in Japanese assistance. In order to support the strong economic growth of Nicaragua, JICA

recently broadened its assistance approach to providing loans for infrastructure projects in harmony with the conventional grant and technical cooperation approaches. The USD 14.6 million loan to the energy sector in 2013 was the first loan project after 20 years. This loan was a joint funding with IDB, applying the Co-financing for Renewable Energy and Energy Efficiency (CORE) Scheme. JICA and IDB have agreed to expand the size of investment on the renewable energy and energy efficiency sector. The CORE Scheme has the fund size of USD 3 billion for investment towards selected Latin American and Caribbean countries.

The other distinctive lending scheme of JICA is the Special Terms for Economic Partnership (STEP). STEP was introduced in 2002, aiming to enhance the visualization of Japanese ODA and utilize advanced technologies of Japanese firms to the recipient countries in the sectors such as the urban mass transit system, trunk roads/dams, environmental projects, and disaster prevention system/equipment, which Japanese technologies and/or equipment could be utilized. Although STEP scheme has several eligibility requirements and conditions to be fulfilled, such as procurement condition that the Japanese firms should be a prime contractor or a leading partner of the joint venture, STEP has an advantageous interest rate. If MP projects of the relevant sectors such as transport and disaster management are applicable to STEP, it would be worth utilizing STEP scheme.

Table 7.3.2 summarizes JICA's target sectors for assistance based on Nicaragua's national policy guidelines and Japan's cooperation policy. To facilitate assistance from JICA, the projects need to be in line with these target sectors.

Table 7.3.2 Target Sector for JICA Assistance

Nicaragua National Development Policy	Japan Cooperation Policy	Target Sector
Economic Growth and Poverty Reduction	Infrastructure Development for Economic Growth	➢ Logistics Transport ➢ Private Sector Development (Trade and Investment) ➢ Private Sector Development (Local Industry and Tourism) ➢ Agricultural Development ➢ Urban Development ➢ Water Resources and Sanitary
Social Welfare and Equality	Social Development in Rural and Poverty Area	➢ Education ➢ Healthcare ➢ Social Security
Climate Change and Disaster Risk Management	Environment Protection and Disaster Management	➢ Energy ➢ Disaster Management ➢ Environmental Management
Cross-Cutting Approach	-	➢ Governance ➢ Gender

Source: JICA Country Analysis Paper 2016 in Nicaragua