2.5 Public Transport

2.5.1 Type of Road Public Transport

(1) Classification by Service Area

a) Interprovincial Public Transport

Most interprovincial public transport routes concentrate on the Bimodal Terminal in Santa Cruz de la Sierra. The travel distance and time of interprovincial public transport routes are long. Large buses, including double deck buses, are operated for the interprovincial routes. In addition to large buses, small size cars are used for some interprovincial routes. Since Warnes belongs to the Warnes Province, public transport services between Warnes and Santa Cruz de la Sierra are considered as inter-provincial public transport services, although the characteristics of the routes are similar to the intermunicipal public transport between Cotoca and Santa Cruz de la Sierra.

b) Intermunicipal Public Transport

Intermunicipal public transport services are provided for passenger transport between municipalities. The most routes concentrate on some terminals in Santa Cruz de la Sierra. Passengers need to transfer local transport to reach the final destination, although most intermunicipal routes pass major markets in Santa Cruz de la Sierra, which is the final destination for many passengers.

c) Intra-Urban Public Transport

Intra-urban public transport systems are operated within the jurisdiction of each municipality. All public transport systems within each municipality charge the fixed fare irrespective the distance traveled, but the passengers need to pay every time they transfer to another vehicle. For example, minibuses in Santa Cruz de la Sierra charges the flat fare of Bs. 2. The fare of taxi depends on the distance and sometimes it is decided by negotiation.

(2) Classification by Vehicle Type

Road public transport in the Santa Cruz metropolitan area consists of the following types of service;

a) Microbus

Microbus is a dominant mode of public transport in Santa Cruz municipality. Most of them are Toyota Coaster, which equips with a 4000cc gasoline engine. The original seating capacity is 20 to 24 passengers, but one row is removed to accommodate standing passengers. Only one door is available for passenger boarding and alighting.

According to an ordinance, a microbus should have at least 20 seats, and the height on the bus should be at least 1.8 meters, although the majority of microbuses do not comply with the bus fleet standard. In addition, microbuses should equip with two doors; one for entrance and the other for exit. The existing microbuses have not had two doors on the body yet. The newly introduced microbuses comply with the ordinance with two doors and a sufficient number of seats and height for passenger convenience.

b) Minibus

Minibuses are smaller than microbuses, and its passenger capacity is 11 persons. Minibuses are operated on the routes between Santa Cruz and the surrounding municipalities in suburbs of Santa Cruz municipality.

Since minibuses have not yet officially authorized as public transport by neither the Department nor the Municipality, they do not have any standard on bus fleet.

c) Trufi (Taxi Ruta Fija; Fixed Route Taxi)

Trufi is fixed route taxi, and they are operated on the corridors with relatively small passenger demand by small vehicles. Since their routes are fixed, characteristics of service are basically bus transport. The passenger capacity is four for sedan type and seven or eight for Toyota Noah and Toyota Ipsum. The vehicle size is small consequently there is no standing passenger on these vehicles.

Like taxis, trufi should have seats for minimum four passengers.

d) Chuturubi

Chuturubi is a medium-size bus, which has been recently introduced in Santa Cruz municipality. Chuturubi operated on the 1st Ring Road is manufactured by Marco Polo Co., Ltd. in Brazil. It equipped with a 4800cc diesel engine, and its vehicle length is 8.6 m. The seating capacity is 24 and two doors are available for passengers boarding and alighting.

e) Taxi

Taxis provide door to door service by passenger car, and its passenger capacity is four to five persons.

f) Toritos (3-wheeler) operated on no fixed route

Toritos is a three-wheeler which provides door to door service similar to taxi.

g) Mototaxi

Mototaxis have been increasing in suburban area, and they also provide public transport service like taxi using a motorcycle.

2.5.2 The Number of Public Transport Vehicles

Table 2.5-1 and Table 2.5-2 shows the number of registered microbuses and minibuses, respectively. The statistics include not only public transport but also official use and private use. The number of microbuses has not been increasing much after 2008, while the number of minibuses has been increasing rapidly in the recent years 2011 - 2013.

The majority (89%) of microbuses are registered in Santa Cruz de la Sierra as shown in Table 2.5-1. Many minibuses are also registered mainly in Santa Cruz de la Sierra, and its composition amounts to 73% in the metropolitan area. However, the number of minibuses has increased rapidly in Warnes and La Guardia as shown in Figure 2.5-1 probably due to increase in travel demand in the suburban areas.

Table 2.5-1 Number of Registered Microbuses by Municipality 2003-2013

Municipality	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Santa Cruz de la Sierra	4,496	4,966	5,047	5,069	5,272	5,586	5,611	5,584	5,559	5,482	5,743
Warnes	227	230	238	245	257	319	366	389	445	536	491
La Guardia	7	8	9	11	32	53	70	89	103	130	122
Cotoca	1	1	1	1	1	4	16	31	40	43	43
El Torno	27	31	32	32	30	32	35	33	39	36	37
Porongo	0	0	0	0	2	2	2	2	1	1	1
Total	4,758	5,236	5,327	5,358	5,594	5,996	6,100	6,128	6,187	6,228	6,437

Note: including Official, Private and Public Transport
Source: RUAT

Table 2.5-2 Number of Registered Minibuses by Municipality 2003-2013

Municipality	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Santa Cruz de la Sierra	986	1,169	1,268	1,291	1,361	1,462	1,488	1,604	1,713	1,901	2,205
Warnes	78	91	96	107	133	155	169	223	279	372	525
La Guardia	6	6	6	7	10	16	17	26	54	106	217
Cotoca	2	2	2	2	2	3	9	13	22	26	41
El Torno	3	6	6	5	5	7	6	6	7	8	11
Porongo	2	2	2	2	1	2	2	3	3	3	3
Total	1,077	1,276	1,380	1,414	1,512	1,645	1,691	1,875	2,078	2,416	3,002

Note: including Official, Private and Public Transport
Source: RUAT

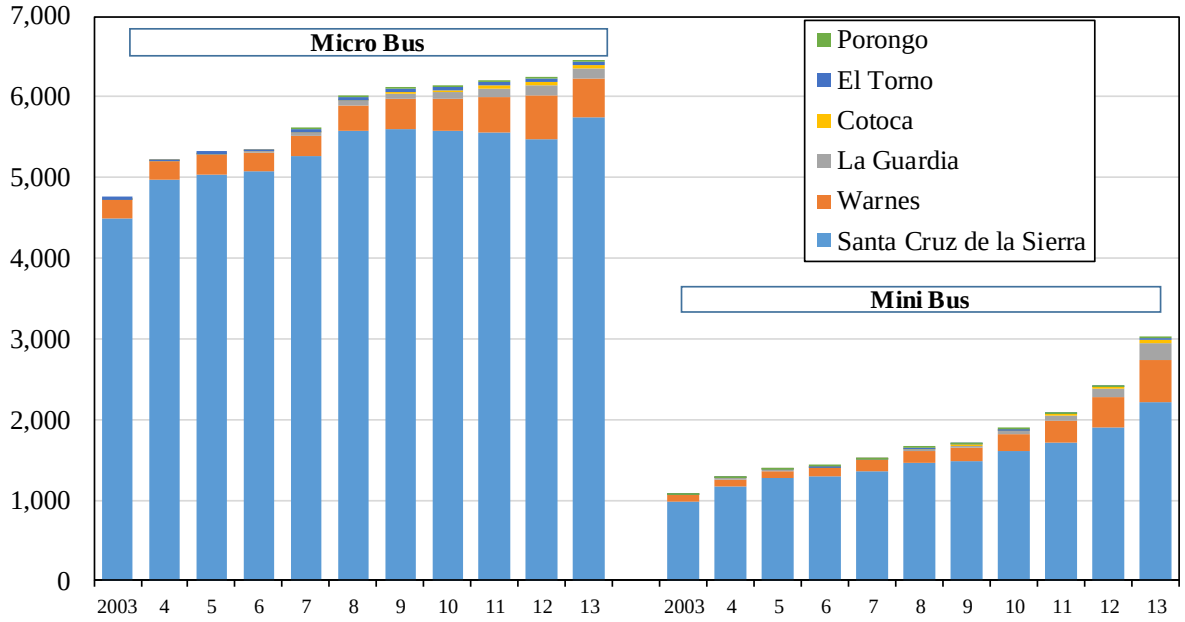


Figure 2.5-1 Number of Registered Micro Buses and Minibuses by Municipality: 2003-2013

Table 2.5-3 indicates the breakdown of vehicle registration by use, that is, government, private and public transport. This statistics shows that about half of microbuses are used for public transport. The registered number of minibuses for public transport is only 45 vehicles because minibuses are not officially registered as public transport.

The total number of microbuses registered in Santa Cruz de la Sierra amounts to 2,955 as of July 2016 while the total number of minibuses registered as the private vehicle is 3,696. However minibuses are not officially registered as public transport vehicles; thus, the traffic and transport agency of Santa Cruz de la Sierra does not have official records of the number of minibuses in the municipality.

Table 2.5-3 Registered Number of Vehicles by Vehicle Type in Santa Cruz de la Sierra

Vehicle type		Official	Private	Public	Total
Automovil	Car	26	70,640	1,229	71,895
Camion	Truck	305	18,300	2,102	20,707
Camioneta	Pickup	826	42,224	72	43,122
Furgon	Van	14	2,523		2,537
Jeep	Jeep	348	19,954	45	20,347
Micro bus	Microbus	19	3,147	2,955	6,121
Mini bus	Minibus	37	3,696	44	3,777
Moto	Motorcycle	1,134	36,924	3	38,061
No Declarado	Undeclared		1		1
Omnibus	Bus	26	885	808	1,719
Quadra track	Quadra track	66	992		1,058
Torpedo	Torpedo		10		10
Tracto-camion	Trailer truck	25	1,893	1,007	2,925
Vagoneta	Station wagon	209	109,969	3,511	113,689
Total		3,035	311,158	11,776	325,969

Source: RUAT
Note: as of July 2016

2.5.3 Organization and Institution

(1) Bus Operators

There are several types of organizations for bus operators in the Santa Cruz Metropolitan Area. A syndicate gets the permission for the business establishment from the State and is defined as a non-profitable organization. Syndicates are exempted from tax on their revenues.

Association is similar to syndicates, and they also enjoy tax exemption for their business. Association can get the permission for the business establishment from the Department. They are smaller than syndicates in terms of organization size. An association consists of at least three members, but one member can own only one or two buses.

Private bus companies should pay 13% of VAT (Value Added Tax), 3% of Transaction Tax, and 25% of Income tax. To avoid the high tax rate, public transport operators prefer the organization of syndicates, association or cooperatives.

As a result, many small-scale bus organizations have entered bus transport industry in the Santa Cruz Metropolitan Area.

(2) Regulation of Bus Transport

The regulation of the urban public transport of the municipality of Santa Cruz de la Sierra is Act 192/2002—*Reglamento del servicio de transporte urbano de la Ciudad de Santa Cruz de la Sierra*. The regulation stipulates that the municipal government may

- grant and renew the permit for urban automobile public transport (Article 6)
- determine the routes and its frequency of service (Article 6)
- establish service standard (Article 6)
- determine the number of vehicles for each route and increase if necessary (Article 14)

The municipal government, however, does not have sufficient information on supply and demand of the existing bus transport. For bus route planning and modification, the municipality should have the information on the passenger demand by bus route as well as passenger capacity of bus transport.

(3) Bus Fare Revenue Sharing

Bus drivers contract with the organizations such as syndicates and associations. The bus drives pay a fixed amount of bus rental fee per round trip, and they also pay gasoline/diesel cost.

Syndicates and association put GPS devices in the bus fleet to monitor and control the bus operation. The management records the bus operation by bus and checks the number of round trips per day. Syndicates and associations set the maximum round trip time by bus route to avoid for bus drivers running buses too slowly to get more passengers.

The Syndicates or association charge penalty if drivers do not follow the instruction given by them.

(4) Bus Fare Collection

Drivers tend to get passengers as many as possible because the more passengers get on the bus, the more money the drivers can earn.

Some buses carry a conductor for the fare collection, while many buses are operated merely by a bus driver, and the driver collects the fare while driving. This is dangerous practice since a driver looks back passengers and does not watch traffic situation in front during fare collection.

2.5.4 Public Transport Infrastructure

(1) Bus Stops

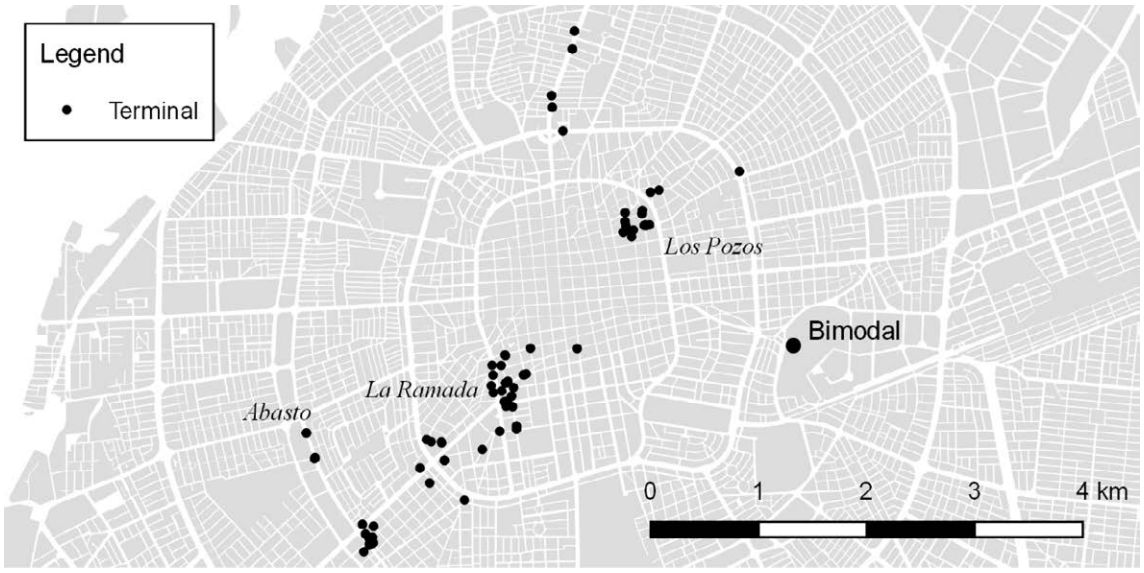
Bus stops are placed along the streets, but in practice, passengers can get on and off at different places other than bus stops. As mentioned above, bus drivers would like to get passengers as many as possible, so they are willing to stop anywhere bus passengers want to get on the bus. This results in longer travel time for buses as well as passengers.

(2) Bus Lanes

Exclusive bus lanes are installed to provide priority for bus transport in the central area. However, private passenger cars invade the bus priority lane, which disturbs the bus operation. Although separators are put to identify the bus priority lane, the bus priority lanes are easily occupied by private cars because they run in the same direction.

(3) Terminal

The Bimodal Terminal is operated for interprovincial and intermunicipal public transport and the passenger railway, located to the east of the 2nd Ring Road. There are 30 large bus operators and 20 small vehicles (minibus, van, micro) operators using the Bimodal Terminal. The frequency of large buses is as small as one to four trips per day, while small vehicles are operated every 30 minutes during peak hours and every 2 hours during off-peak hours on average. Other terminals used by 114 operators in Santa Cruz de la Sierra for interprovincial and intermunicipal public transport are located along Av. Cristo Redentor, Av. Grigota, and at major markets such as Los Pozos. The locations of bus terminals are shown in Figure 2.5-2.



Source: Elaborated based on data of Direction of Transportation, SOPOT

Figure 2.5-2 Locations of Interprovincial and Intermunicipal Terminals

2.5.5 Public Transport Network

(1) Process of Bus Network Formulation

Historically, the private sector has formed the bus network in the Santa Cruz Metropolitan Area. The role of the Department and the municipalities is to evaluate the route proposal from private bus operators and to approve the routes officially.

Bus routes to connect Santa Cruz de la Sierra and its surrounding areas are managed by the transport division of Department of Santa Cruz. The traffic and transport division of the Department determines the route between municipalities, but the municipality has right to determine the route within their jurisdiction.

(2) Bus Route Structure in Santa Cruz de la Sierra

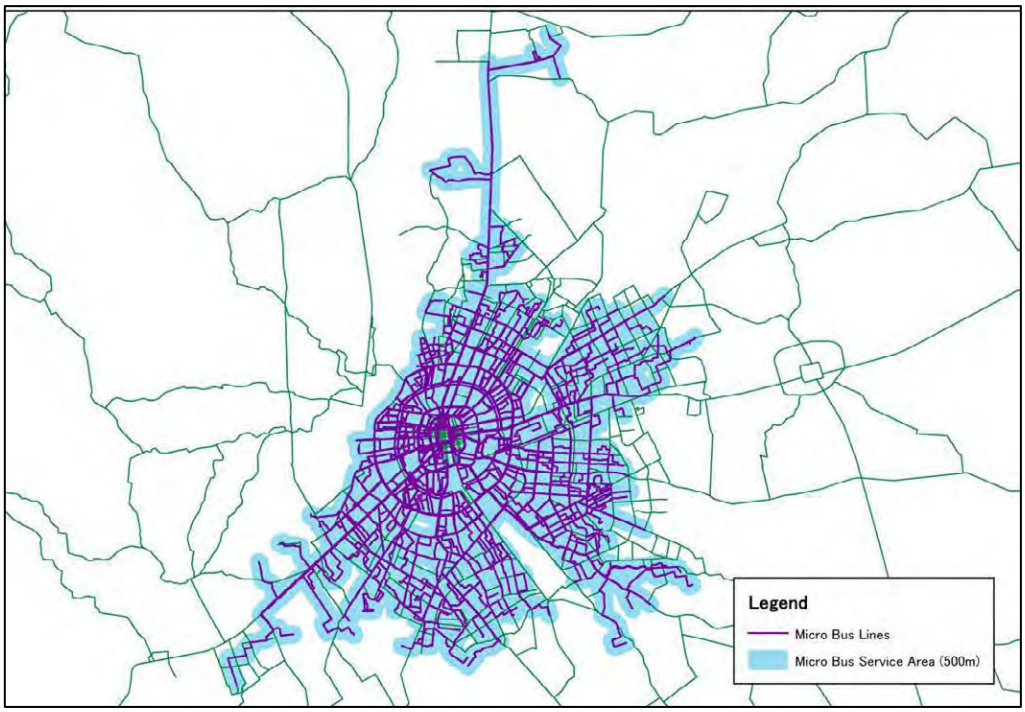
There are approximately 140 microbus lines in Santa Cruz de la Sierra as shown in Figure 2.5-3. The microbus network covers most urbanized areas of Santa Cruz de la Sierra, and the microbus service is available within walking distance from the origin and destination in most cases. Figure 2.5-4 shows the area within 500 m from microbus lines.

The bus routes of microbuses are concentrated in the central area of the Santa Cruz de la Sierra and overlapped each other. It is one of the causes of the traffic congestion in the city center.

Many microbus routes start or pass traditional markets where many bus passengers would like to use buses. For example, 45 routes pass or arrive at the Mercado La Ramada, 25 routes at Mercado Mutualista, 15 routes at Mercado Abasto and 25 routes at Mercado Los Pozos. Figure 2.5-5 shows the 45 routes that stop at the Mercado La Ramada.

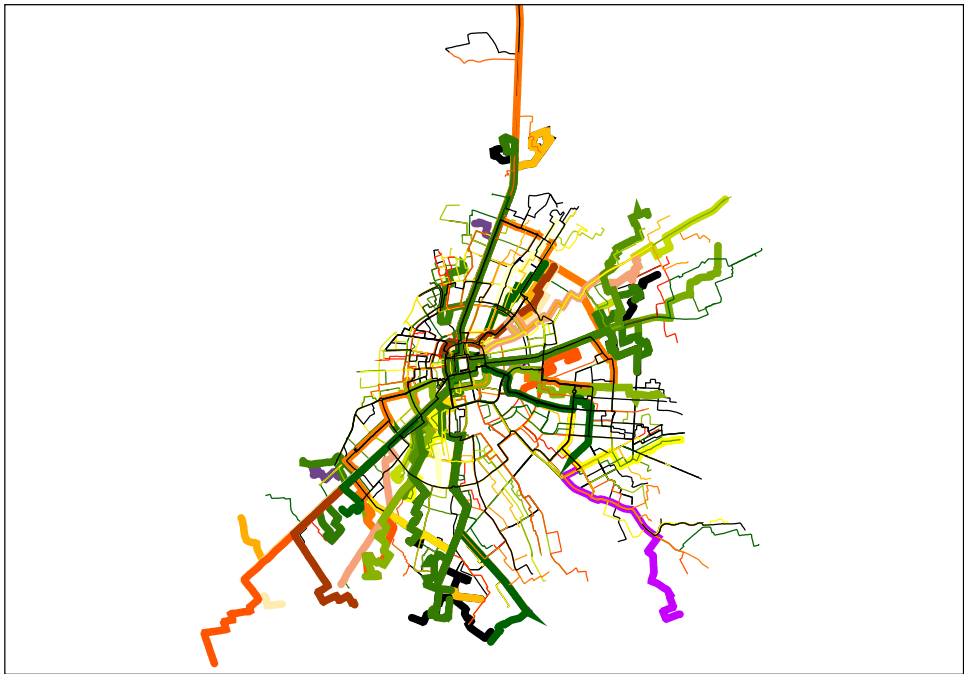
Source: Elaborated based on information of Santa Cruz de la Sierra

Figure 2.5-3 Microbus Network



Source: Elaborated by JICA Study Team

Figure 2.5-4 Microbus Service Area

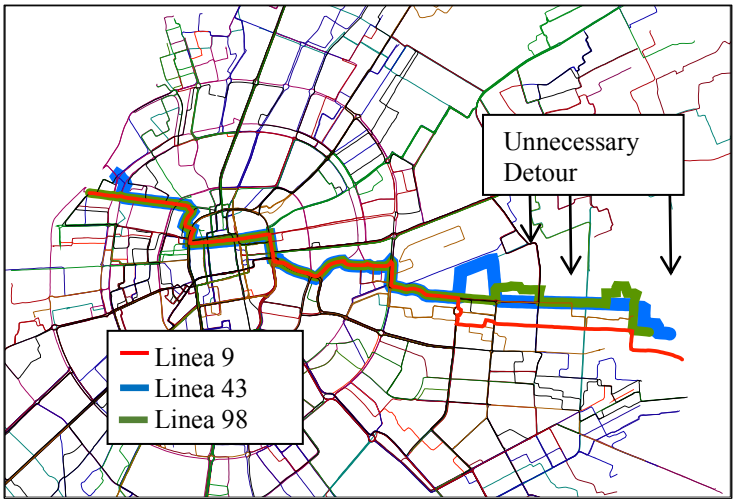


Source: Elaborated by JICA Study Team

Figure 2.5-5 Microbus Routes Departing from La Ramada

When a new bus route is proposed for permission, the traffic and transport division of Santa Cruz municipality investigates whether competitive routes already registered or not. If the competitive route exists, then coordination between the operator of the existing route and the operator of the new route is taken place. The operator of the new route is urged to avoid an overlapped section not to take bus passengers from the existing one. As a result, the bus route includes detour at a competitive section and turns to be a zig-zag route. An example of the unnecessary detour is shown in Figure 2.5-6. From total bus operation point of view, the existing bus route structure is not efficient due to having unnecessary detours. The bus route

structure, therefore, should be reviewed and a new structure should be built from scratch.



Source: Elaborated by JICA Study Team

Figure 2.5-6 Inefficient Bus Route Structure

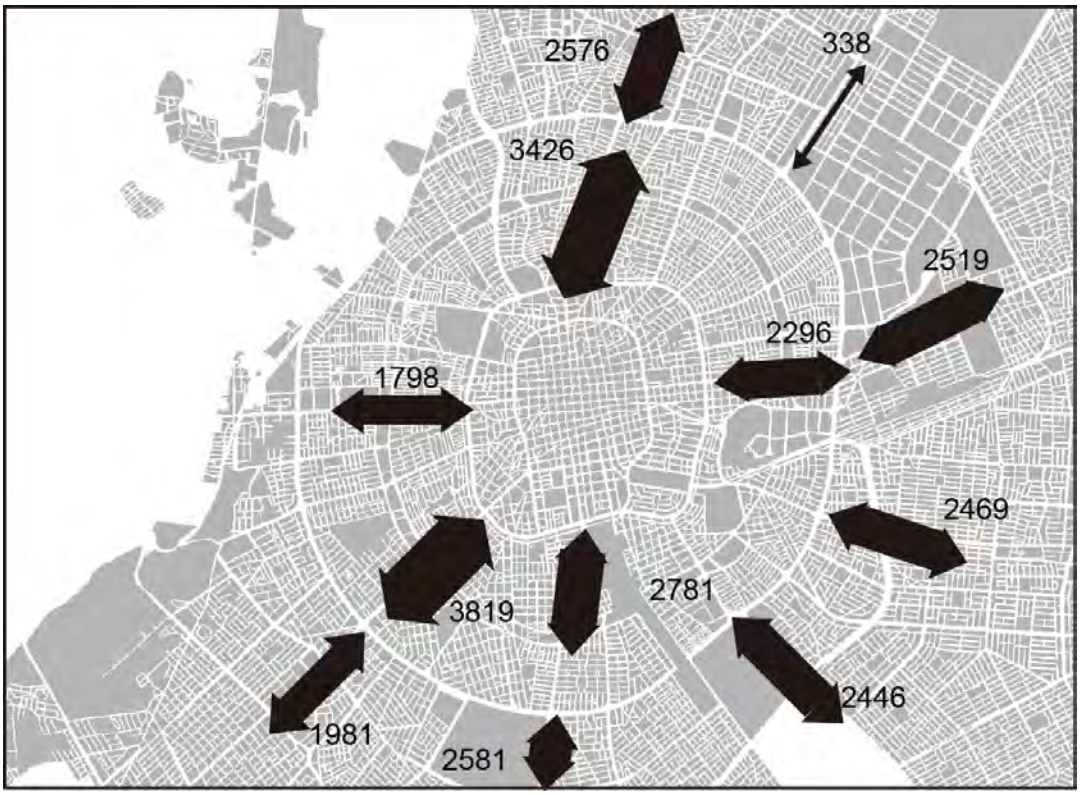
2.5.6 Bus Operation Performance

(1) Bus Operation in Santa Cruz de la Sierra

More than 2,000 microbuses are operated on the major roads in Santa Cruz de la Sierra as depicted in Figure 2.5-7. The numbers of microbuses in operation have increased inside 4th Ring Road; as many as 3,819 microbuses are operated on the radial road between LaGuardia and the center of Santa Cruz municipality. The second largest microbus traffic is observed on the radial road between Warnes/Satelite Norte and the city center of Santa Cruz de la Sierra, and it is served by 3,426 buses in a day.

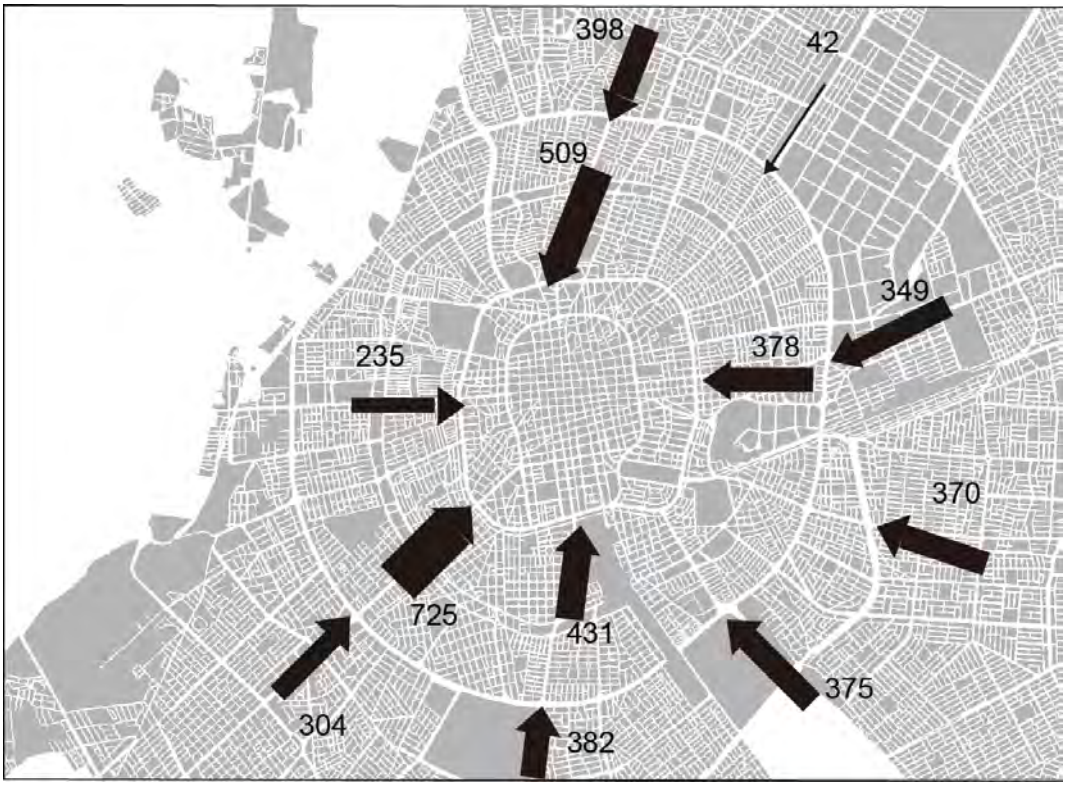
In the morning peak period from 7:00 to 9:00, 398 microbuses carry passengers from Warnes/Satelite Norte to the city center of Santa Cruz de la Sierra as illustrated in Figure 2.5-8. On the other hand, 304 microbuses come from La Guardia. At the intersections of the 4th rind road with major radial roads, more than 300 microbuses are operated from suburb to the city center.

The number of large buses passing the Cordon Line survey station No.1 of the south border of the metropolitan area was only 89 buses per day for both directions. The number of large buses at of the survey station No. 2 at the north border was 330 buses per day, but 160 buses (48%) passed the survey point from 20:00 in the evening until 7:00 in the morning. The number of large buses at the station No. 3 at the east border was 221, but 118 buses (53%) were operated from 20:00 to 6:30 in the morning.



Source: Traffic Count Survey, 2016

Figure 2.5-7 Number of Microbuses Per Day for Both Directions

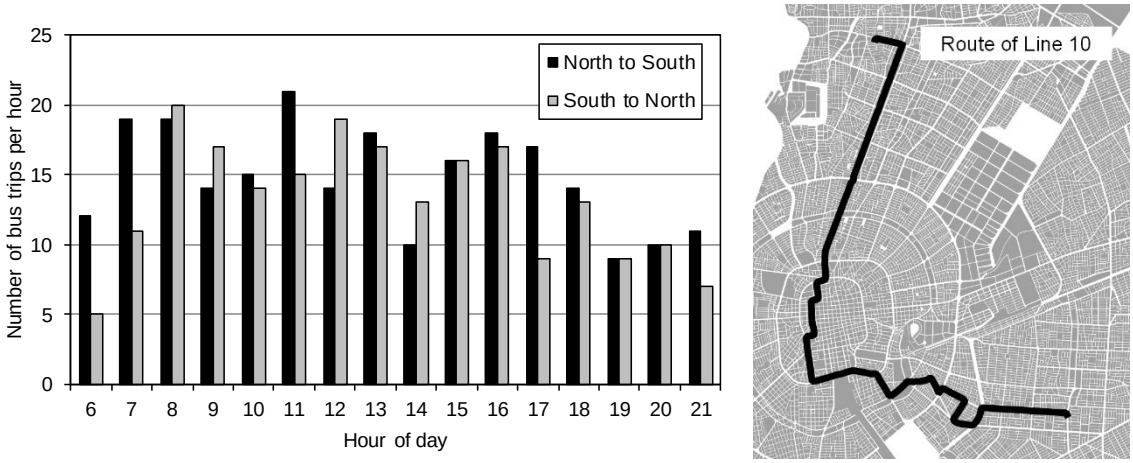


Source: Traffic Count Survey, 2016

Figure 2.5-8 Number of Microbuses in Morning Peak Hours (7:00-9:00) for Inbound Direction

(2) Hourly Fluctuation of Bus Operation

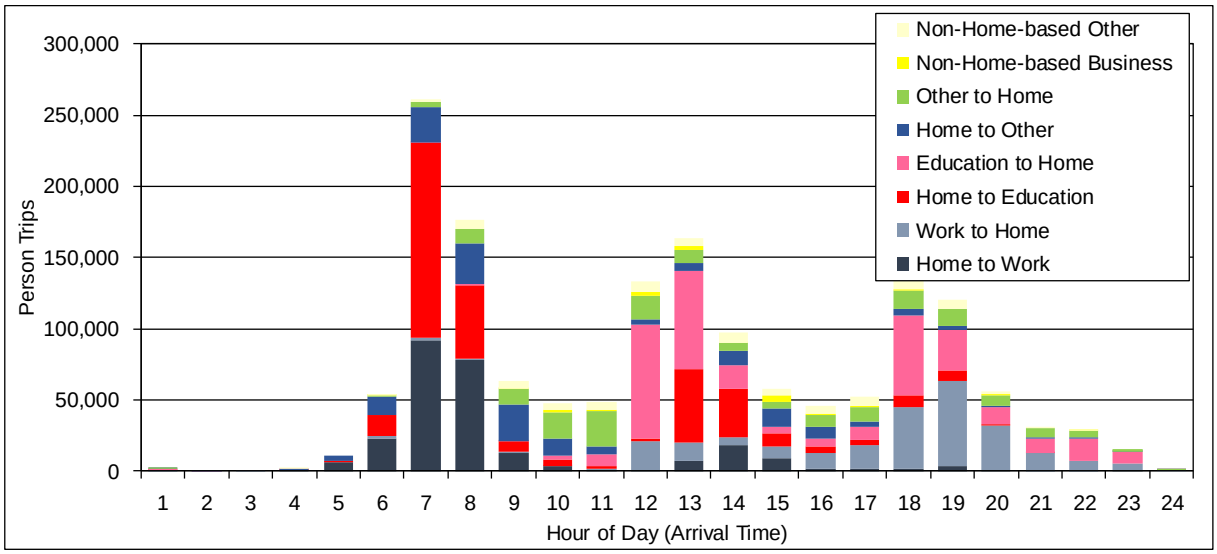
Although bus operators state they dispatch more buses during the peak hours and less during off-peak hours, the actual practice shows no such big differences between peak and off-peak hours. Hourly fluctuation of bus operation of microbus Line 10 is illustrated in Figure 2.5-9, and it shows that difference of the number of buses is not significant by the hour of the day.



Note: Survey station = TC-08, Bus Route = Micro Bus Line 10
Total number of bus trips = 212 trips per day average interval 4.4 minutes

Figure 2.5-9 Hourly Fluctuation of Bus Operation (Line 10)

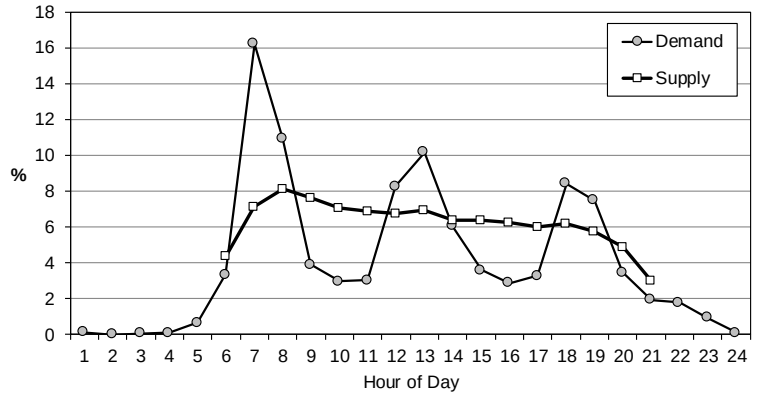
In contrast, hourly fluctuation of bus passenger trips indicates sharp peaks in the morning, noon and afternoon as depicted in Figure 2.5-10. The peak rate at 7:00 to 8:00 in the morning amounts to 16.2 percent, followed by 10.2 percent in the noon peak period from 12:00 to 13:00. This indicates the gap between demand and capacity of bus transport.



Source: Home Interview Survey, 2016

Figure 2.5-10 Hourly Fluctuation of Bus Passenger Trips by Trip Purpose

Passenger demand on public transport indicates sharp peaks as illustrated in Figure 2.5-11. The number of buses operated on the roads does not have such high supply in the peak period. The gap between demand and supply leads to the over-crowded situation and over-supply of bus transport capacity during the off-peak period.

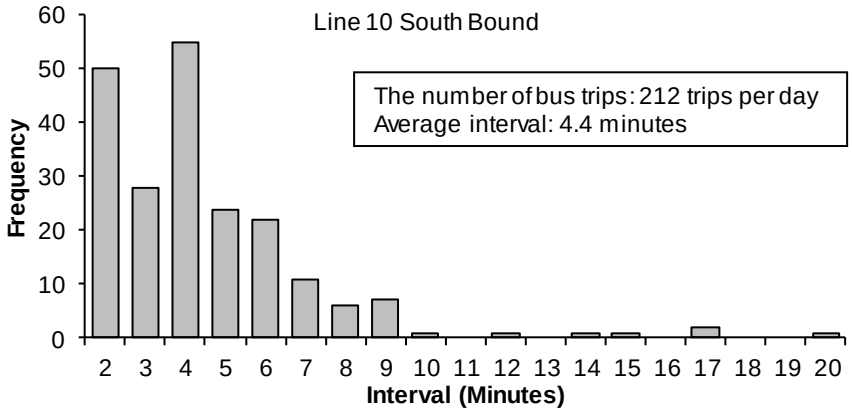


Note: Hourly fluctuation of supply is calculated by the number of microbuses of 86 routes observed in Bus Frequency Survey 2016. Hourly fluctuation of demand is calculated based on estimated person trips made by bus transport observed in Home Interview Survey 2016.

Figure 2.5-11 Hourly Fluctuation of Bus Passenger Demand and Bus Transport Supply

(3) Interval of Bus Operation

Microbus Line 10 provides convenient service since it usually arrives at intervals of 2 to 4 minutes as shown in Figure 2.5-12. However, in some occasion passengers wait for more than 10 minutes without any information on the anticipated next bus arrival time.



Note: Regarding the route of Line 10, please refer to the route map in Figure 2.5-9

Figure 2.5-12 Bus Frequency Distribution (Line 10)

(1) Comparison of Bus Operation Interval: Microbus vs. Minibus

Minibuses operate more frequently than microbuses as indicated in Table 2.5-4. Preliminary analyses of the Bus Frequency Survey conducted in the Study shows the average interval of the minibus operation is estimated at 4.1 minutes whereas that of microbus is 8.4 minutes.

Table 2.5-4 Comparison of Interval of Bus Operation by Bus Type

	Microbus	Minibus
Number of Surveyed Routes	64	6
Average Number of trips per route in 16 hours	229	468
Average Interval (minutes)	8.4	4.1

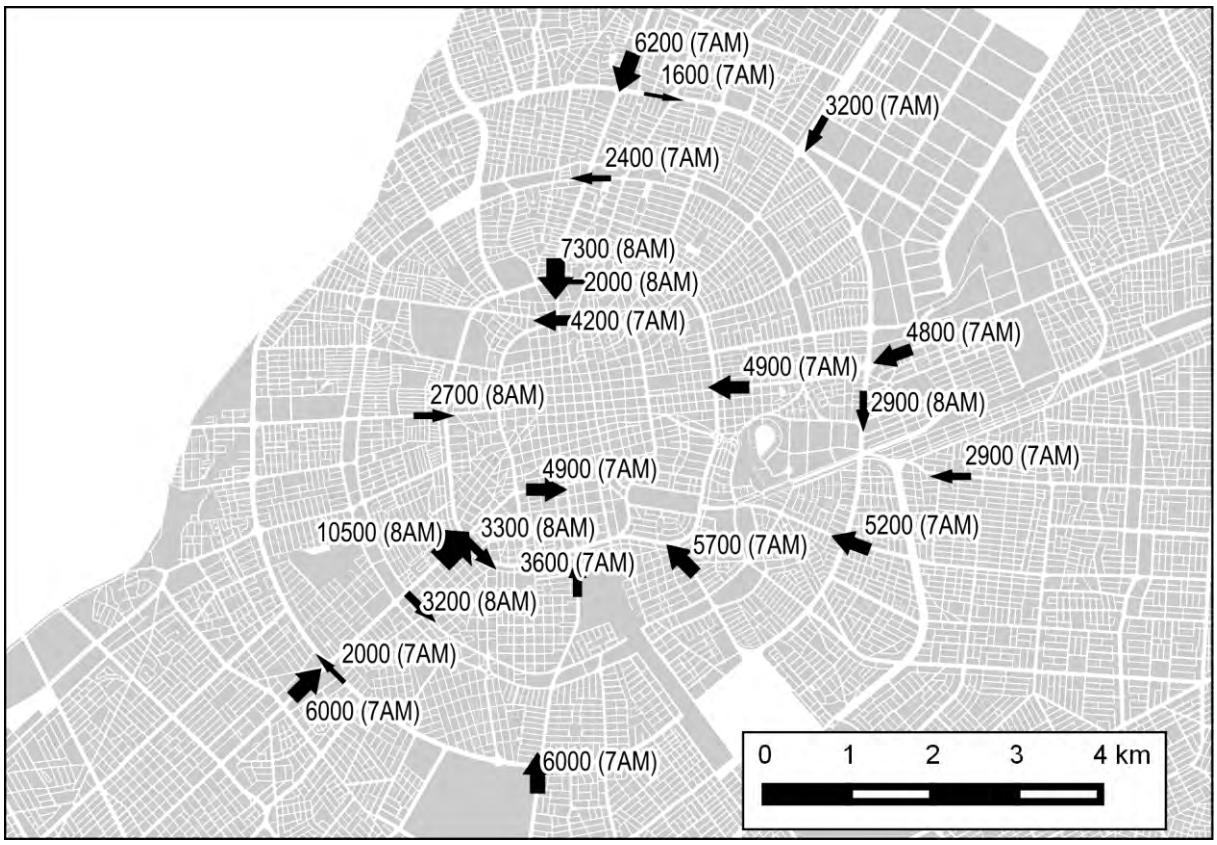
Source: Bus Frequency Survey, JICA Study 2016

2.5.7 Bus Passenger Demand

Public transport is the dominant transport mode especially for low-income groups as analyzed in Chapter 5 (5.2.6).

(1) Bus Passenger Demand in Morning Peak Hour

Passenger demand on radial arterial roads at intersections on 4th Ring Road varies from 3,200 persons to 6,200 persons per hour as illustrated in Figure 2.5-13. The largest passenger volume, 10,500 passengers per hour, was observed on the road in front of Mercado La Ramada. Compared to the passenger demand on the radial roads, those on the ring roads are relatively small and was in the range from 2,000 to 4,900 persons per hour.

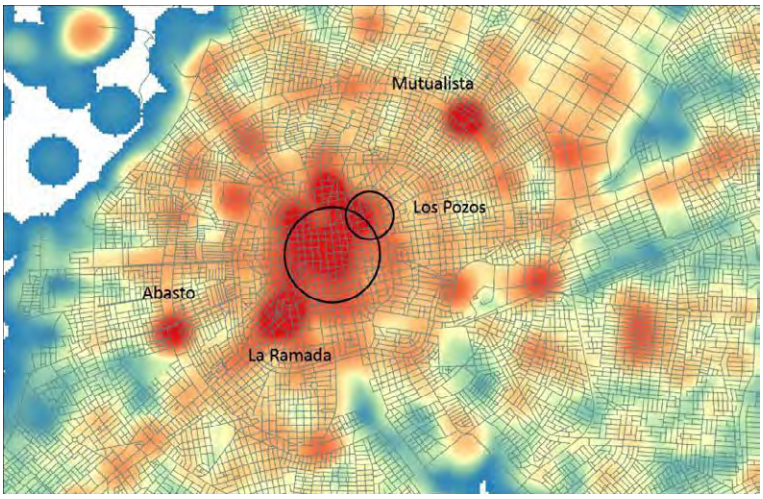


Source: Traffic Count Survey and Vehicle Occupancy Survey, 2016, JICA Study Team

Figure 2.5-13 Public Transport Passenger Demand in Morning Peak Period

(2) Home to Work Trips

The density of employees at workplace concentrates on the center of the Metropolitan Area, especially inside the 1st Ring Road, as is shown in Figure 2.1-17 which is elaborated based on the statistics of ICE in which the population of informal sector was not included. Figure 2.5-14 shows a heatmap of the number of workers at the workplace, which includes workers in the informal sector. The other high dense area areas are observed near markets such as La Ramada, Abasto, Los Pozos and Mutualsita.



Source: Home Interview Survey and Commuter Survey 2016

Figure 2.5-14 Job Density in Santa Cruz Municipality

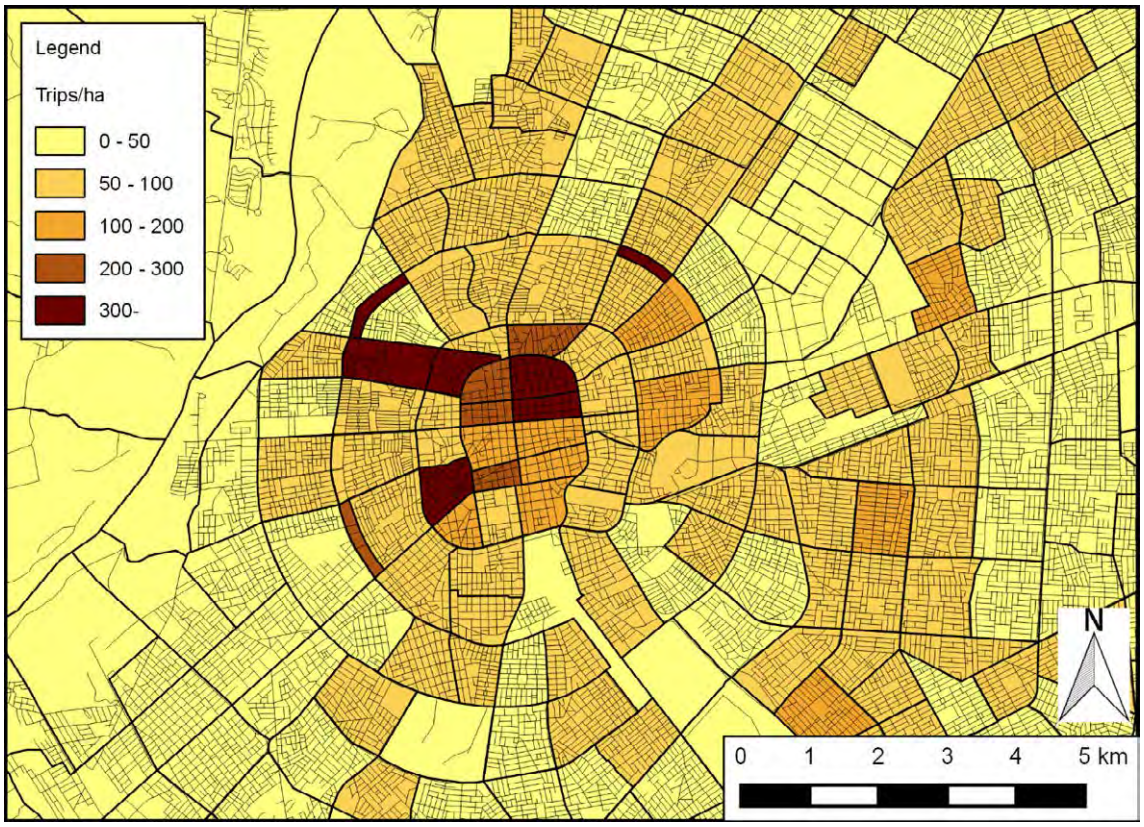
(3) Trip Generation Density of Trips made by Bus Transport

Dependence on bus transport can be seen in Figure 2.5-15. High-density areas of bus trip generation are in the central area enclosed by 1st Ring Road and areas close to Mercados La Ramada, Abasto, Los Pozos and Mutualsita. The area enclosed by Avenida Busch, Avenida Hernando Sanabria and 2nd and 3rd Ring Road where Universidad Autonoma Gabriel Rene Moreno is located, indicates the high density of trip generation by bus transport.

(4) Share of Bus Transport

The high share of bus transport is seen in the area where *Universidad Autonoma Gabriel Rene Moreno* is located since many students come to the area as shown in Figure 2.5-16. The other areas of high dependence on bus transport are seen in the outskirt of the Santa Cruz Municipality.

Less dependence on bus transport can be seen in the north-western part of the areas between 3rd and 4th Ring Road and south-eastern part of the areas between 2nd and 4th Ring Road.



Source: Home Interview Survey 2016

Figure 2.5-15 Trip Generation Density of Trips by Bus Transport

Source: Home Interview Survey 2016

Figure 2.5-16 Share of Bus Transport by UV Level Zone

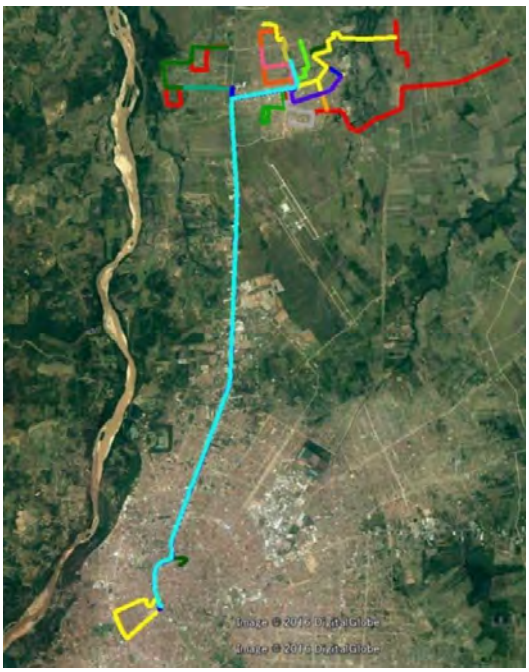
2.5.8 Public Transport in Municipalities

(1) Warnes

Mototaxi is the major mode in the central area of Warnes, while toritos and mototaxis are operated in Satelite Norte. There are at least four fixed routes of public transport in Satelite Norte. Minibuses and trufis are operated as the public transport service between the central area of Warnes and Satelite Norte. Inter-municipal public transport is provided between Santa Cruz de la Sierra and Warnes (minibus), Satelite Norte (minibus and microbus), and Villa Sanchez (microbus).

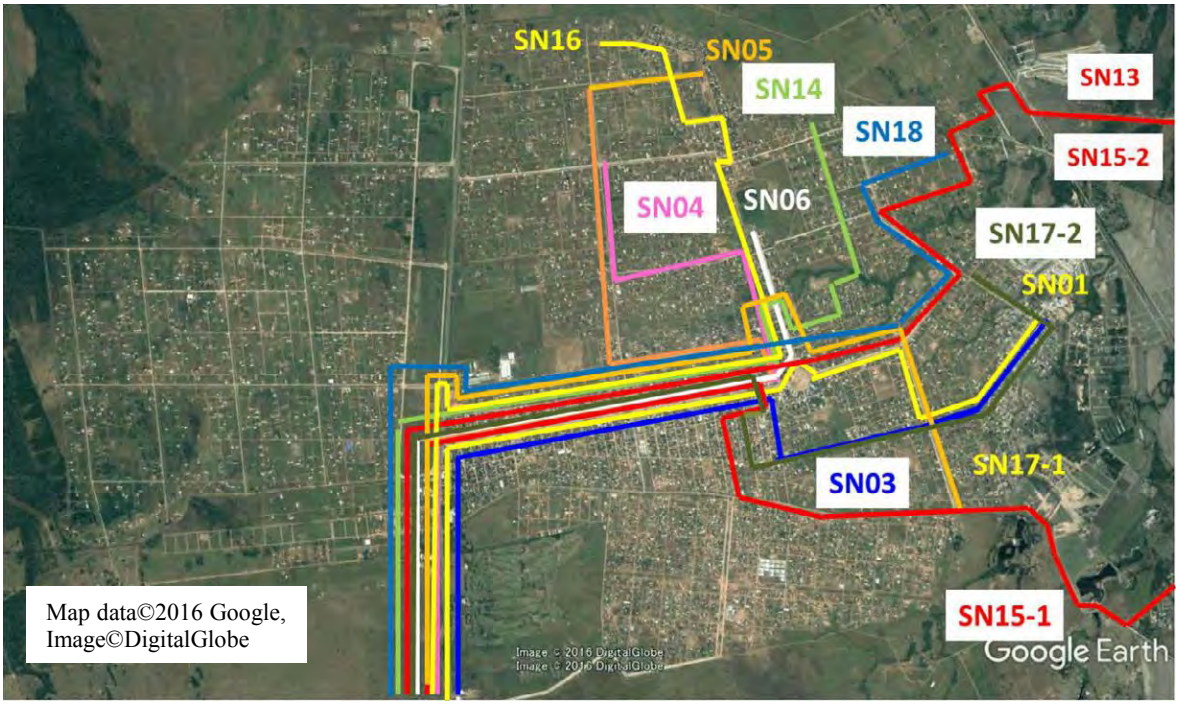
The public transport routes between Satelite Norte and Santa Cruz de la Sierra are illustrated in Figure 2.5-17. Buses collect passengers from different residential districts in Satelite Norte and run on the same national road to reach the city center of Santa Cruz de la Sierra.

Many bus routes are overlapped even in Satelite Norte area as shown in Figure 2.5-18.



Source: Elaborated based on information from Warnes

Figure 2.5-17 Bus Routes Connecting Satelite Norte and City Center of Santa Cruz



Source: Elaborated based on information from Warnes

Figure 2.5-18 Bus Routes in Satelite Norte

(2) Cotoca

Mototaxi is the major mode in the central area of Cotoca, where public transport services fixed routes are not provided. Microbuses and trufis are operated between Cotoca and Santa Cruz de la Sierra as inter-municipal transport services. The most routes from the center of Cotoca enter the area of Los Pozos Market inside the 1st Ring Road. Some routes connect Santa Cruz de la Sierra and local communities of Cotoca directly. The public transport services between Cotoca and local communities, such as Don Lorenzo, Bisito, Campanero, Tajibos, and Guapuru Tarpoe, are provided by trufis.

(3) La Guardia

Trufis and very few combis are the major public transport system in La Guardia, while mototaxi is also a popular mode for trips of short distance. The number of mototaxis is increasing, and there are more than 600 units at present. Mototaxi stands are located along busy streets, which causes the traffic congestion.

Some transport service companies have two terminals, one serving for transport within La Guardia and another for inter-municipal transport to Santa Cruz de la Sierra. The internal transport service is made on dirt roads without any maintenance.

(4) Porongo

Due to the low density of the municipality, the number of public transport routes is very small. Mototaxi is used in the center of Porongo. Since Urubo is developed as a new urbanized area for the relatively high-income group, the private car is the major mode, and public transport services are insufficient. Porongo is completing the construction of a natural gas vehicle (NGV) Service Station near the "Casa del Camba" Restaurant located at the entrance of the district of Urubo.

2.5.9 Present Problems on Public Transport

(1) Overlapped bus routes

The bus routes in the Santa Cruz Metropolitan Area have been extended to newly developed suburban areas from the existing routes based on the requests made by bus operators or the residents. Many bus routes depart or pass the markets in the central area because they can get many bus passengers in these areas. Bus routes are concentrated in the central area, and this concentration of bus routes results in traffic congestion in the city center. The bus route structure could be improved into more efficient and convenient one for bus passengers.

(2) Unstable services

Public transport services are frequently reduced due to worsening of road conditions after heavy rains in the rainy season.

In peak hours, passengers can easily get the bus that goes to their destination because of high frequency, although passengers sometimes need to wait for the next one due to the congestion in the vehicle. In off-peak hours, when the number of operated buses is decreased, the waiting time is not predictable because no information of the bus operation is provided.

(3) Increase in small size public transport

In suburban areas, where the demand for public transport is not high enough for bus operators

to earn profits on the fixed routes, public transport services by small size vehicles are feasible. Public transport services without fixed routes such as mototaxi, torito, taxi, and minibus are the popular modes in areas where population density is low. These modes are also popular in the center of municipalities other than Santa Cruz de la Sierra. Since mototaxi is a convenient mode for short distance trips and popular, the number of mototaxis is increasing. The boarding and alighting of mototaxi take place along roadsides, and the increasing share of motorcycles in road traffic causes road congestion.

Recently, the number of minibuses is increasing in Santa Cruz de la Sierra, where minibuses were once prohibited and replaced with the present microbuses to increase the capacity of public transport. The mixture of minibuses and micros causes a new traffic congestion.

(4) Absence of the public transport authority at the metropolitan level

The urbanized area of Santa Cruz de la Sierra has almost reached the administrative boundary, formulating a big city. Since the traffic demand among municipalities is increasing, the role of the Department of Santa Cruz becomes important because it is responsible for the public transport services between municipalities. At the same time, each municipality needs to consider the increasing intermunicipal and interprovincial public transport within its jurisdiction. Public transport authorities of each jurisdiction need to deal with the public transport under the authorities of other jurisdiction.

(5) Lack of Information on Minibuses and Trufi

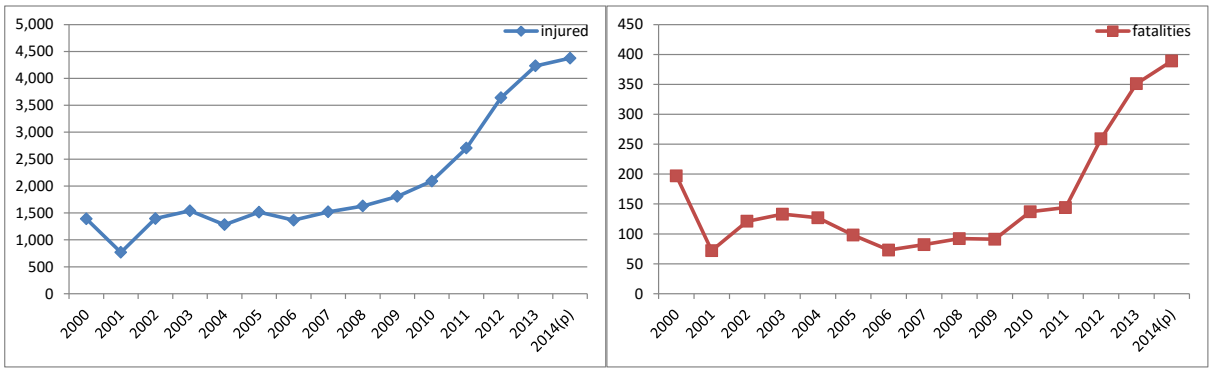
Since minibuses and some of the trufis had not been officially registered by the municipality of Santa Cruz de la Sierra, the municipality does not have basic bus operation data such as bus operator, number of buses operated on a specific route, bus route and so forth. This makes it difficult for the municipality to control and manage the bus operation. Due to the lack of such information, the municipality cannot provide the useful information on the public transport services to people in the Santa Cruz Metropolitan Area.

2.6 Traffic Management

2.6.1 Current Traffic Conditions

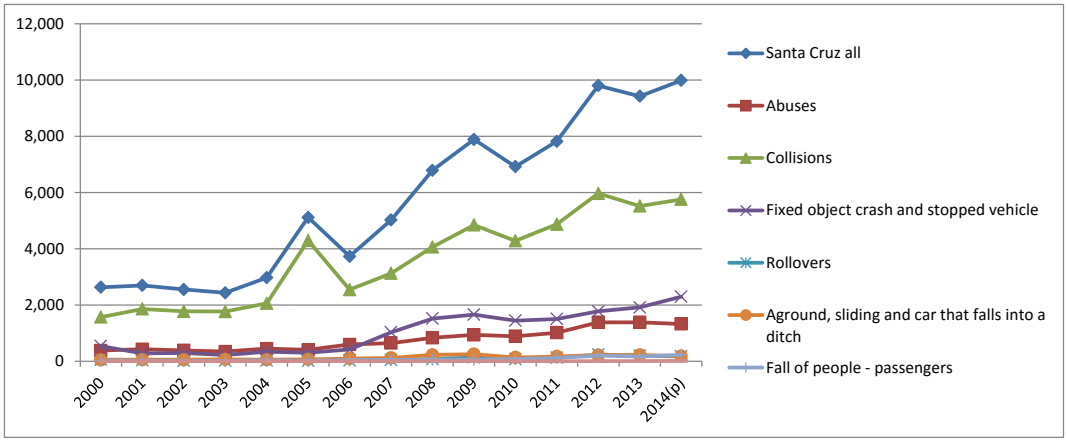
(1) Traffic Safety

According to statistical data from INE, the number of fatalities caused by traffic accidents is 400 people per year and approximately 4,500 injured in the Department of Santa Cruz. This amount continuously increases year after year. In 2014, 31,782 traffic accidents were reported in Bolivia, in which 31.4% (9,985) were recorded in the Department of Santa Cruz. Figure 2.6-2 shows the number of accidents by type. The most common cause of accidents is collisions; the second most common is crashes with fixed objects and stopped vehicles. In Bolivia, 53.5% of road accidents (17,012 cases), are due to recklessness caused by drivers. The second most common cause is speeding with 14.8%; the third, drunkenness or drug use with 11.5%; and the fourth is other causes with 9.8%.



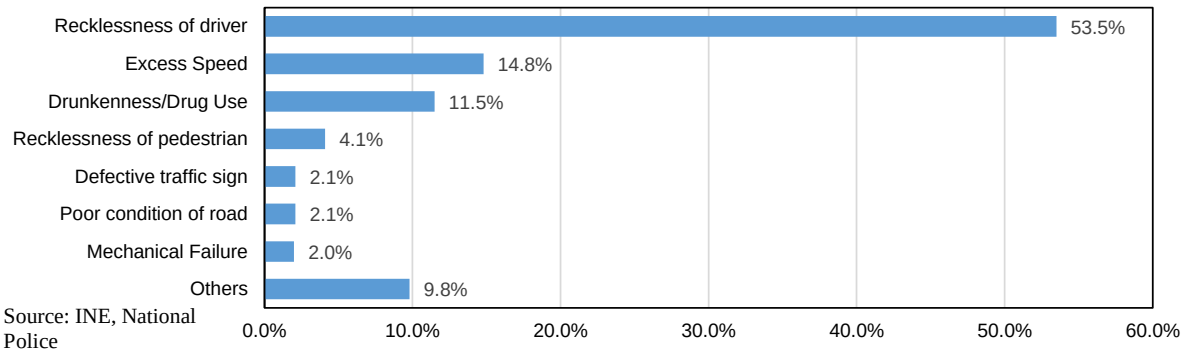
Source: http://www.ine.gob.bo/indice/EstadisticaSocial.aspx?codigo=30903

Figure 2.6-1 Number of Fatalities and Injured persons in Department of Santa Cruz



Source: http://www.ine.gob.bo/indice/EstadisticaSocial.aspx?codigo=30903

Figure 2.6-2 Number of accidents by each type in Department of Santa Cruz



Source: INE, National Police

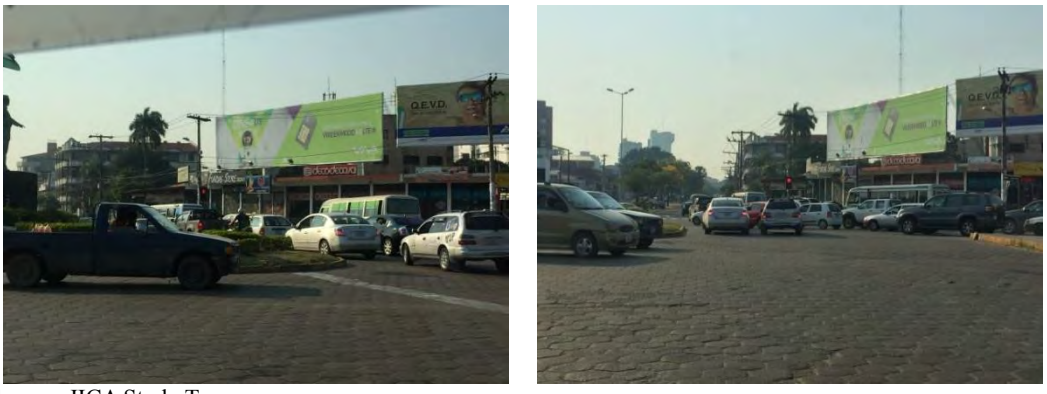
Figure 2.6-3 Causes of accidents in Bolivia

Traffic accidents are one of the major concerns of people in the Metropolitan Area. The news of traffic accidents is frequently reported by media

Source: El Deber

Figure 2.6-4 Traffic accidents reported by media

The configuration of the signaling at intersections affects the traffic safety. For example, the time of all red phase is very short at many intersections, which causes conflicts between vehicles at the signal change time, and forces pedestrian to move out the crossing quickly soon after the green phase finishes.



Source: JICA Study Team

Figure 2.6-5 Picture of traffic conflict at intersection

(2) Traffic Congestion

During the morning peak time, the traffic speed in Santa Cruz de la Sierra begins to reduce at signalized intersections in the radial roads that connect the main cities and then it reduces at the intersections between the ring road and the radial road. These points are called "bottlenecks." Congestion begins in the upstream section of a bottleneck when traffic demand exceeding the traffic capacity of the bottleneck intends to pass through the bottleneck. The

roads that pass through "Mercado Abasto", "Mercado Mutualista" and other roads located near marketplaces experience permanent reductions in traffic speed. After 18:00, congestion occurs near Av. St. Martin. See "5.11 Travel Speed Survey" in Chapter 5.

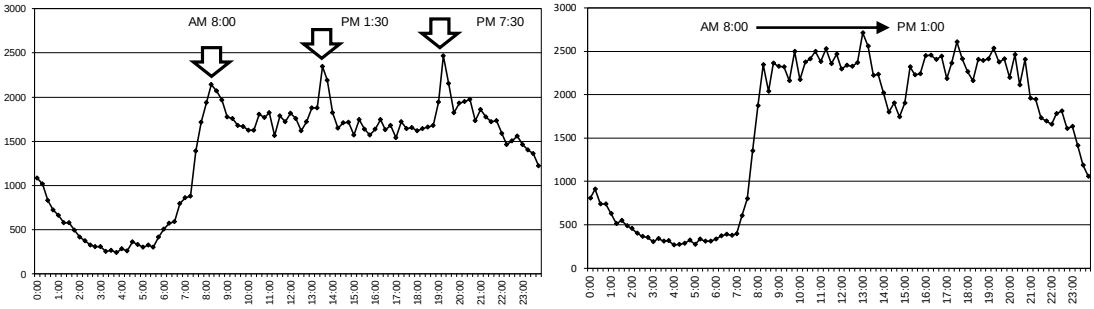

Source: JICA Study Team

Figure 2.6-6 Traffic congestion in Santa Cruz de la Sierra

(3) Traffic Volume

Figure 2.6-7 (Left) shows the traffic volume at a radial road in direction to the city center. The chart has three peak times around 8:00, 13:00 and 19:30 because of the traffic demand increases due to commuter trips to the city center city. Most people in the metropolitan area also goes back home to suburban areas to have lunch with their families, causing an increase in traffic volume before and after lunchtime.

Figure 2.6-7 (Right) shows a chart of traffic volume at 2nd Ring Road. The traffic volume increases rapidly from 7:00 to 8:00, and the heavy traffic continues to 13:00. This indicates that traffic demand is over capacity for a long time.



Source: Elaborated based on the data of D.S.S.

Figure 2.6-7 Traffic volume at radial road (left) and 2nd Ring Road

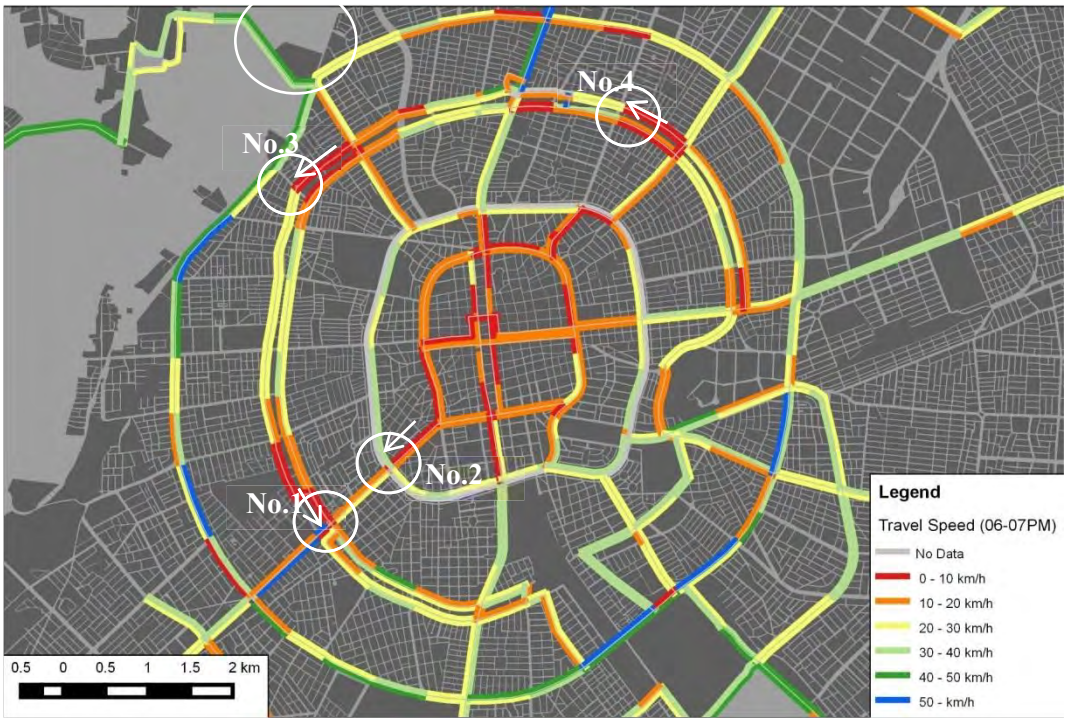
A traffic count survey was conducted in 2016 at 23 locations (See Chapter 5 for the detail). The daily traffic volume on Av. Cristo Redentor near the intersection with the 4th Ring Road was as high as 100,000 vehicles (August 24, 2016), while it was 68,300 vehicles near the intersection with the 2nd Ring Road (August 2, 2016).

The 2nd Ring Road had the traffic volume of 70,700 vehicles (July 26, 2016) per day near the intersection with Av. Grigotá. The traffic volume on the 4th Ring Road near the intersection with Av. Grigotá was 56,500 vehicles (June 30, 2016).

Av. Grigotá had the daily traffic volume of 59,800 (July 26, 2016) and 56,700 (July 28, 2016) near the intersection of 2nd Ring Road and 4th Ring Road, respectively. Av. Grigotá has four lanes per direction, but the traffic volume in the peak hour is only 2,000 vehicles, which is below the capacity. This is due to the saturation of intersections along the road.

The major bottleneck intersections are identified based on the travel speed survey as shown in Figure 2.6-8. The causes of the congestion at these points are:

- Concentration of traffic demand for the radial direction in the morning and evening peak hours (No.1 and No.2)
- Capacity of the roundabout (No 3)
- Parking demand along the market (No.4)



Source: JICA study team

Figure 2.6-8 The Bottle Neck Intersections

2.6.2 Organizations and Institutions

There are various government agencies involved in traffic management in Santa Cruz de la Sierra, which are:

(a) Direction of Traffic and Transport (D.T.T.), Secretariat of Safety and Traffic and Transport

(b) Direction of Road Traffic Sign and Traffic Light (D.S.S.), Secretariat of Public Works

(c) National Police

(d) General Service of Personal Identification (SEGIP)

(e) Direction of Road Infrastructure, Secretariat of Public Works

Table 2.6-1 is a matrix showing the responsibilities of these agencies.

D.T.T. and D.S.S. are the highest policymaking bodies on all matters of traffic management in Santa Cruz de la Sierra. D.T.T.'s powers and functions include reviewing all existing laws, policies, programs, rules, and regulations on land transportation such as traffic direction regulation, traffic regulation of large vehicles, parking management, and the permission of public transportation in Santa Cruz de la Sierra. On the other hand, D.S.S. is mainly in charge of planning and implementation of traffic management measures such as regulatory signage, traffic signals, road marking, bus stop facilities, and equipment. D.S.S. also devises appropriate measures such as the improvement of intersections to relieve traffic congestion.

Table 2.6-1 Matrix of agency responsibility

Agency	Responsibilities	Engineering	Enforcement	Education	Transport
Traffic and Transport (D.T.T.)	• Parking management • Traffic law enforcement (direction regulation) • Public transportation • Intersection improvements • Traffic safety		XX	XX	XX
Road Traffic Sign and Traffic Light (D.S.S.)	• Traffic signals • Traffic signs and markings • Bus stops • Intersection improvements	X	X	X	
National Police	• Driver's licenses • Road accidents • Traffic law enforcement		XX		
General Service of Personal Identification (SEGIP)	• Driver's licenses		XX		
Road Infrastructure	• Flyover bridge • New road construction • Paving	XX			

Legend: XX : Primary responsibility
X : Secondary responsibility
Source: JICA Study Team

2.6.3 Traffic Laws and Regulations

(1) List of laws and ordinances

Table 2.6-2 summarizes the laws and ordinances of the municipality of Santa Cruz de la Sierra.

Table 2.6-2 Laws and ordinances related to traffic management

No.	Content
Ordinance No.040/2000	Regulation for Large Vehicles
Ordinance No.154/2000	Regulation for Large Vehicles supplementation
Ordinance No.019/2007	Authorization of Road Closures for Citizen Activities
Resolution D.T.T. 003/2010	Cancellation related to permission for stop of public transportation at Abasto market and Park of Santa Cruz de las Flores
Ordinance No.086/2011	Regulation for No Parking Areas
Ordinance o.029/2013	Regulation for Public Transportation
Ordinance No.106/2013	Regulation related to registration of taxi driver
Resolution No.008/2014	Regulation for prohibition utilizing minibus as public transportation
Regulation No.022/2015	Regulation of the Use of Public Space

Note. "Ordinance" changed to "Regulation" from 2015 by Revision of the Autonomy Law
Source: D.T.T., Santa Cruz de la Sierra

(2) Penalty on violations of traffic rules

The municipality of Santa Cruz de la Sierra also establishes traffic regulation. Any violation of traffic regulation will be punished as described in the tables below. All administrative fines are payable to the municipality. Bolivia does not have the penalty point system for driving offenses.

Table 2.6-3 Regulations and Fines for Violations

TYPE OF VIOLATION	MINOR	MODERATE	SERIOUS
MAXIMUM SPEED 50 KMH.	**1 to 10 km/h** above the limit (56 - 65 km/h)	**11 to 21 km/h** above the limit (66 -75 km/h)	**MORE 22 to km/h** above the limit (76 or more km/h)
FINES IN Bs.-	**Bs. 451,25:** Equivalent to 1/4 current national minimum wage.	**Bs. 902,50:** Equivalent to 1/2 current national minimum wage.	**Bs. 1805,00:** Equivalent to 100% current national minimum wage.

Type of offense	Fines in Bs.-
Parking in prohibited areas	902,50
Invasion of pedestrian crossing area	902,50
Invasion or abandonment (buses), exclusive of public transport operator	902,50
Phone use while driving	902,50
Not using the seatbelt	902,50
Driving under effects of alcohol and/or drugs	1.805,00
Violation of red light traffic lights	902,50
No license plate or modified plate	902,50
Offence of driving against designated route	902,50

Note: (*1) Equivalent to 1/2 current national minimum wage, (*2) Equivalent to 100% current national minimum wage
Source: Transito Seguro

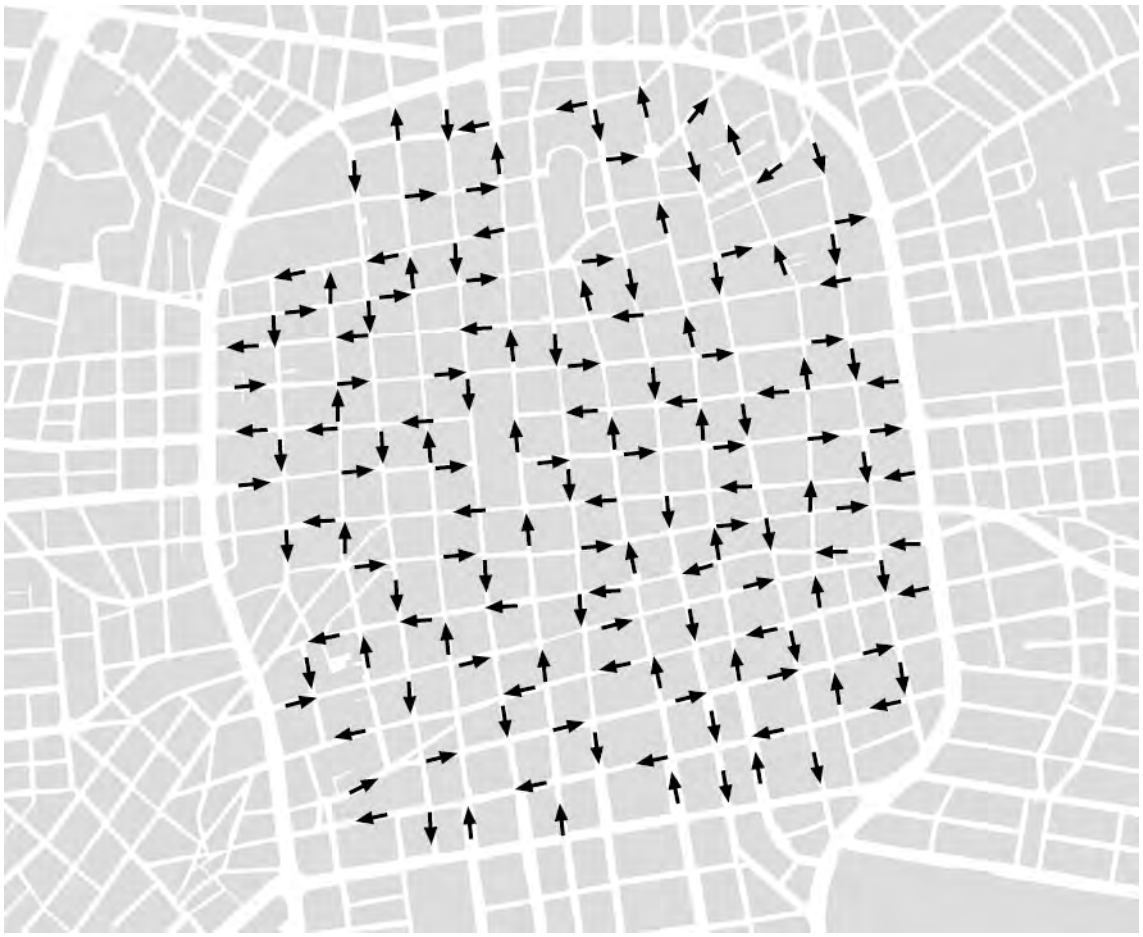
(3) Traffic regulations for large vehicles

Heavy truck traffic is still causing material damage to the streets and avenues among the various neighborhood units and city districts. Therefore, the regulation of large vehicles was established by ordinance No.040/2000 and No.154/2000. Heavy trucks are forbidden from entering the 4th Ring Road except in the case of provided travel permission. Heavy vehicles are also prohibited from parking on the 2nd Ring Road and radials, regardless of whether or not they have permission. The collected fines are deposited into a specific account, which belongs to the municipal government, and the collected funds should exclusively be used for road signs and traffic safety education.

2.6.4 Infrastructure

(1) Urban Streets

The street network inside the 1st Ring Road is operated as a one-way traffic system, where one-way streets, having two or three lanes, are allocated alternately. Exclusive bus lanes are located on some streets. Most of the right lanes on a one-way street are used for on-street parking places.



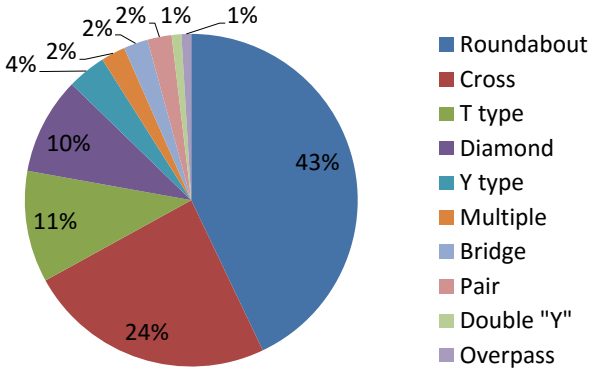
Source: JICA Study Team

Figure 2.6-9 One-way system in the central area

(2) Intersections

Roundabouts are the major type of intersection in Santa Cruz de la Sierra, accounting for 43% of the intersections. There is a grid configuration within the 1st Ring Road with "Cross" type intersections wherein the streets have been oriented as one-way with two lanes and signalized intersections with stop signs and traffic signals on main routes.

The figure below shows the proportion by type of intersections.



Source: JICA study team

Figure 2.6-10 Percentage of intersection type in Santa Cruz de la Sierra

(3) Flyover and Underpass

There are three flyovers, including the intersections of Av. Cristo Redentor and 4th Ring Road, and Av. Cristo Redentor and 6th Ring Road. The intersection of 4th Ring Road has a three-layer structure which includes an overpass, a crossroad, and an underpass. These infrastructures contributed to reducing the traffic congestion.

Source: JICA Study Team

Figure 2.6-11 Flyover

(4) Sidewalk

Some of the sidewalks contain discontinuities as shown Figure 2.6-12. In Santa Cruz de la Sierra, landowners must provide sidewalk in front of their house by themselves. This has resulted in sidewalk sections of various heights and widths, due to the lack of standards. It is difficult for handicapped people to travel on the uneven sidewalks.

Source: JICA Study Team

Figure 2.6-12 Pictures of sidewalk discontinuity

2.6.5 Current Traffic Control and Management

(1) Traffic Signal System

1) Type of Traffic Signal System

At many intersections in Santa Cruz de la Sierra, traffic demand exceeds traffic capacity of the intersections, in particular, during peak hours. Currently, 214 traffic lights have already been installed at intersections in the municipality and are managed by D.S.S. Brazilian companies manufactured these traffic lights. There are different types of signals such as traffic light signals for vehicles, countdown displays, and traffic signals for pedestrians. Figure 2.6-13 and Figure 2.6-14 show some pictures of different types of signal control systems and the locations in which traffic light signal systems have been installed. These signals are connected to a system at the traffic control center at D.S.S. office. D.S.S. manages the signals with the monitoring system by mainly applying a pattern control unit with different phasing parameters based on the day of the week and the hour. However, during peak hours police officers control the traffic flow manually because the traffic volume exceeds throughput.

Traffic signal for vehicles

Traffic signal for pedestrians

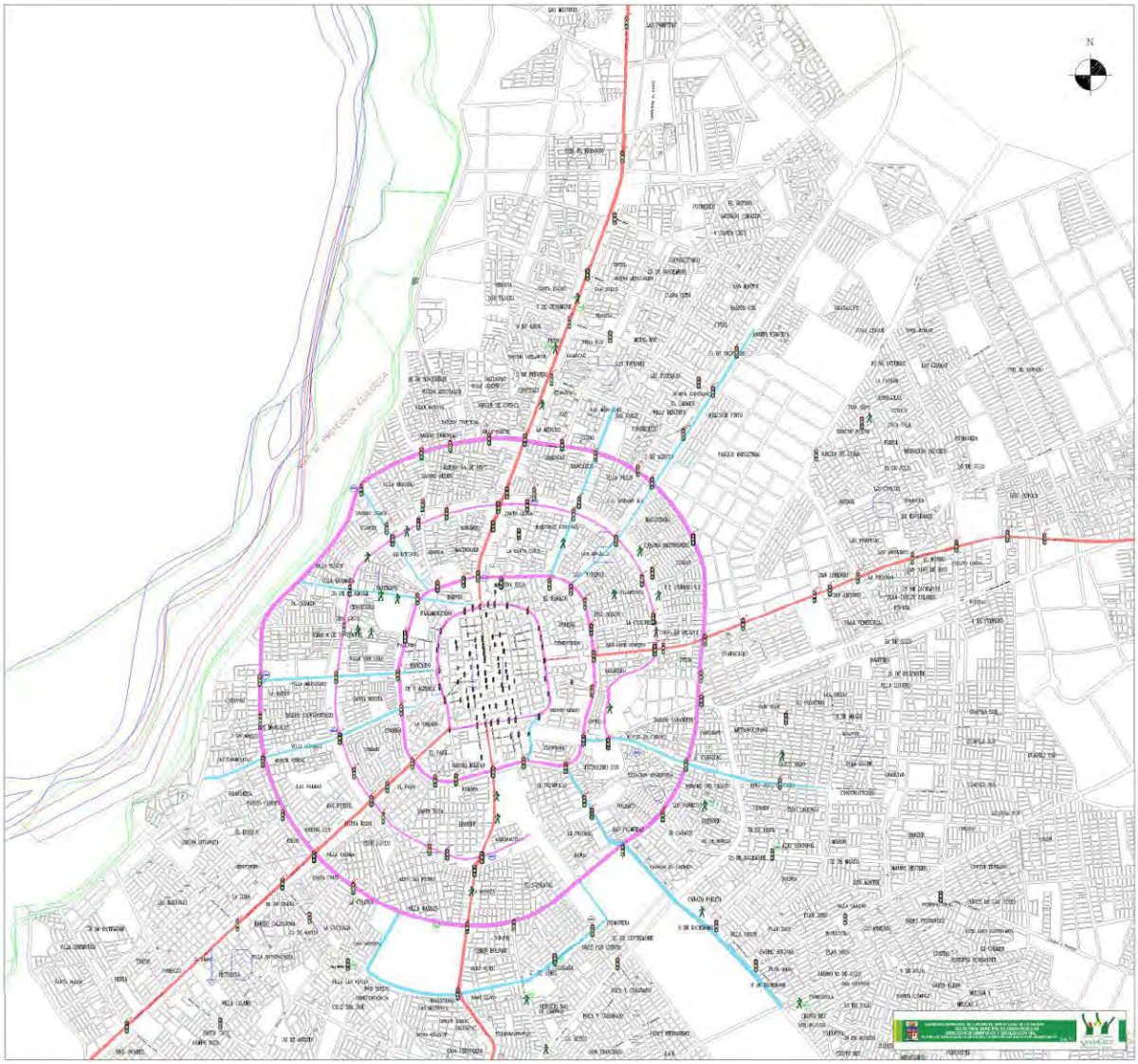
Countdown display

Left turn arrow signal at Av. Virgen De Cotoca

Direction is given by Police officer

Source: JICA study team

Figure 2.6-13 Different type of traffic signals implemented in Santa Cruz de la Sierra



Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-14 Location Map of Traffic Signals

Control monitor

NUEVA ESTRUCTURAS DE TIEMPO 4TO ANILLO – AV SAN AURELIO (4000)
Data: 06-04-2016

PROGRAMACION: SYMART

NRO	PLAN	INTERVALOS HORARIO			TOP1		TOP2		CICLO TOTAL	TIEMPOS DE VERDE: V E (FASE1– 4TO ANILLO) S1 Y S5	TIEMPOS DE VERDE: V E (FASE2– AV. SAN AURELIO)S3 Y S7
	1			NORMAL	6	26	13	15	8	68	35	23
4000	2	6:45	8:15	PICO MAÑANA	6	26	13	32	8	85	35	40
4001	3	11:45	12:45	PICO MEDIO DIA	6	36	13	22	8	85	45	30
4002	4	13:45	14:30	PICO TARDE	6	26	13	27	8	80	35	35
4003	5	18:00	20:30	PICO NOCHE	6	36	13	22	8	85	45	30
4004	6	0:30	5:30	NOCHE	6	16	13	17	8	60	28	26

INSTANTE DE SEÑAL	TOP1	TOP2	Plazo cierre verde s1	Verde s3 anterior top2	plazo cierre verde s3
NORMAL	32	60	3	5	3
PICO MAÑANA	32	77	3	5	3
PICO MEDIO DIA	42	77	3	5	3
PICO TARDE	32	72	3	5	3
PICO NOCHE	42	77	3	5	3
NOCHE	22	52	3	5	3

ESTRUCTURAS DE TIEMPO 4TO ANILLO – AV SAN AURELIO (4000) Data: febrero 2015

PROGRAMACION: SYMART

PLAN	INTERVALOS HORARIO			TOP1		TOP2		CICLO TOTAL	TIEMPOS DE VERDE: V E (FASE1– 4TO ANILLO) S1 Y S5	TIEMPOS DE VERDE: V E (FASE2– AV. SAN AURELIO)S3 Y S7
1			NORMAL	6	26	13	15	8	68	35	23
2	7:00	8:30	PICO MAÑANA	6	31	13	15	8	72	30	32
3	13:45	14:30	PICO TARDE	6	31	13	15	8	72	30	32
4	17:30	19:00	PICO NOCHE	6	31	13	15	8	80	40	30

Example of signal phasing parameters

Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-15 Traffic control center in D.S.S. and signal control program

2) Software-based Signal Control

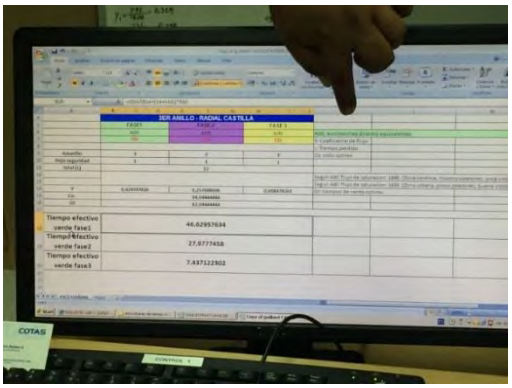
A portion of traffic signals, about 40, which are located at busy intersections are adjusted with signal timing in real time in order to optimize throughput based on traffic volume counted by vehicle detectors such as loop coil (a buried type of traffic detector) and traffic camera. Figure 2.6-16 and Figure 2.6-18 show some pictures of this type of signal control and the locations of the vehicle detectors. A centralized traffic management software called "SYMART", developed by the French company "Aximum", is installed in the control center of D.S.S. SYMART is a software package that enables the control and command of the intersection controllers for traffic regulation.

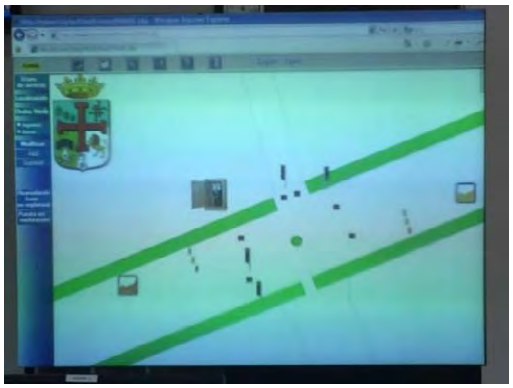
Traffic camera

Loop coil

Source: JICA study team

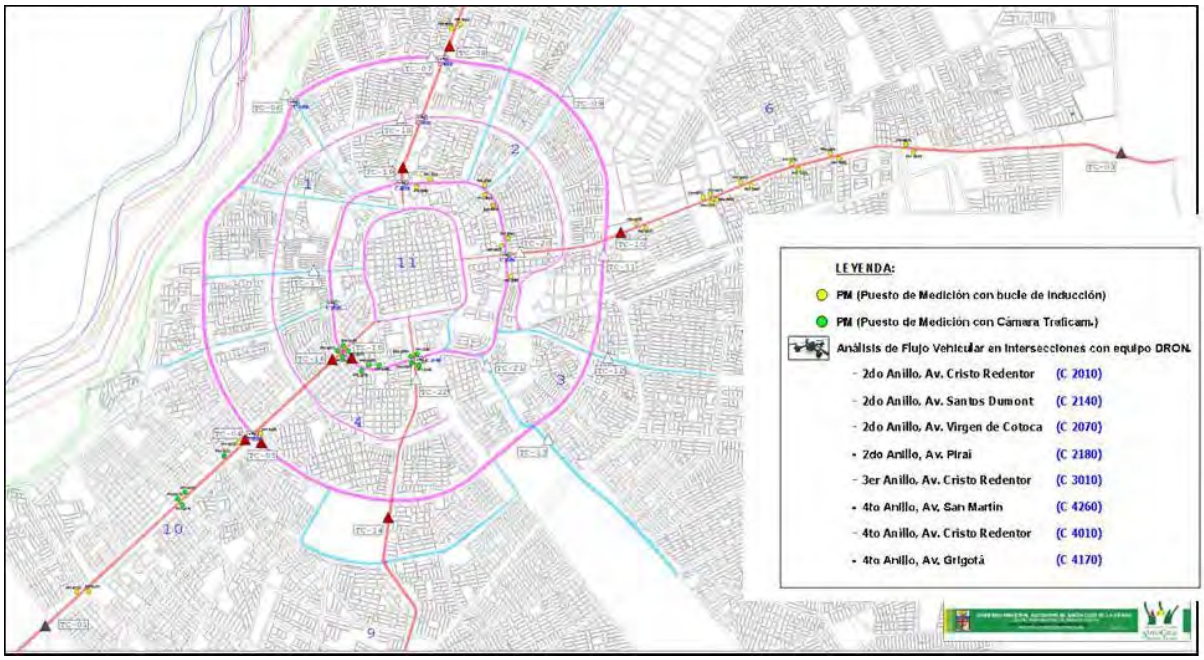
Figure 2.6-16 Traffic detectors to count traffic volume at intersection





Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-17 Traffic control software to adjust signal timing



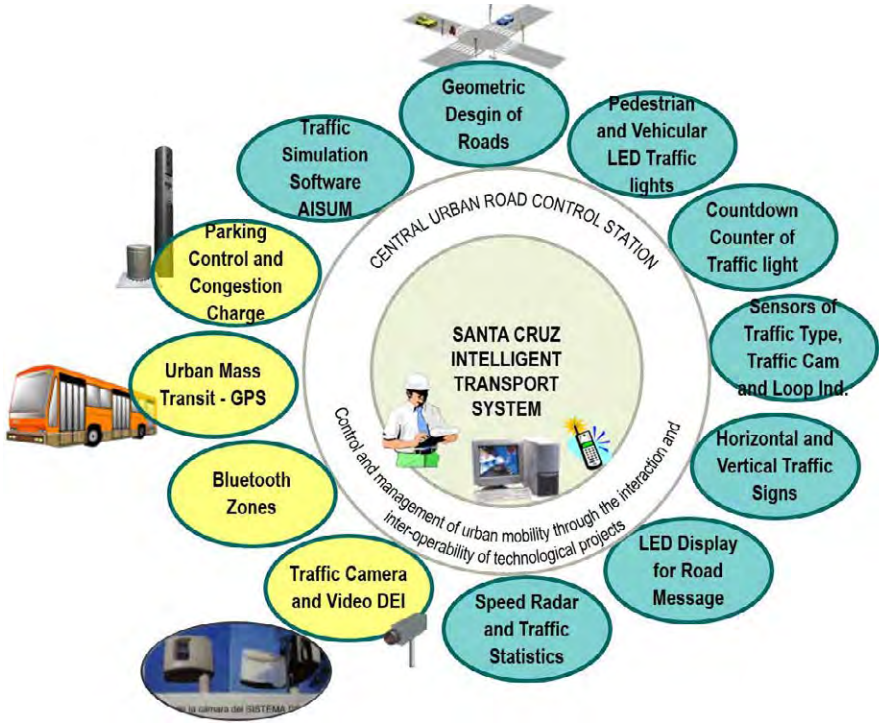
Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-18 Map of location implemented traffic detectors

(2) Intelligent Transport Systems (ITS)

1) Santa Cruz Traffic Intelligent System

D.S.S. has already started to implement some parts of an Intelligent Transport System (ITS), which is called "1) Santa Cruz Traffic Intelligent System". This system consists of 12 components: the projects shown in the blue circles have been already implemented, and the projects described in the yellow circles are under consideration for development.



Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-19 Configuration of Santa Cruz Intelligent Traffic System

2) Variable Message Signs and Speed Limited Information System

D.S.S. has implemented Variable Message Signs (VMS) at four locations. This system is an electronic traffic sign often used on roadways to give travelers information about special events. Such signs warn of traffic congestion, accidents, incidents, roadwork zones or speed limits on a specific highway segment. These signs guide vehicles to take alternative routes, limit travel speed, warn of duration and location of the incidents or just inform of the traffic conditions. The travel time is estimated depending on the result of the time in which one patrol vehicle with a GPS tracking unit drives between the four locations. Therefore, the messages displayed are not always in real time.

Source: D.S.S., Santa Cruz de la Sierra, JICA study team

Figure 2.6-20 Variable message sign in Santa Cruz de la Sierra

In addition, D.S.S. has already implemented radar speed signs with a traffic statistic function at the same locations. As shown in Figure 2.6-21, this system displays vehicle speeds of vehicles passing through the equipment drawing drivers' attention to minor speed infractions to get them to slow down by alerting them to their speed.

Source: D.S.S., Santa Cruz de la Sierra

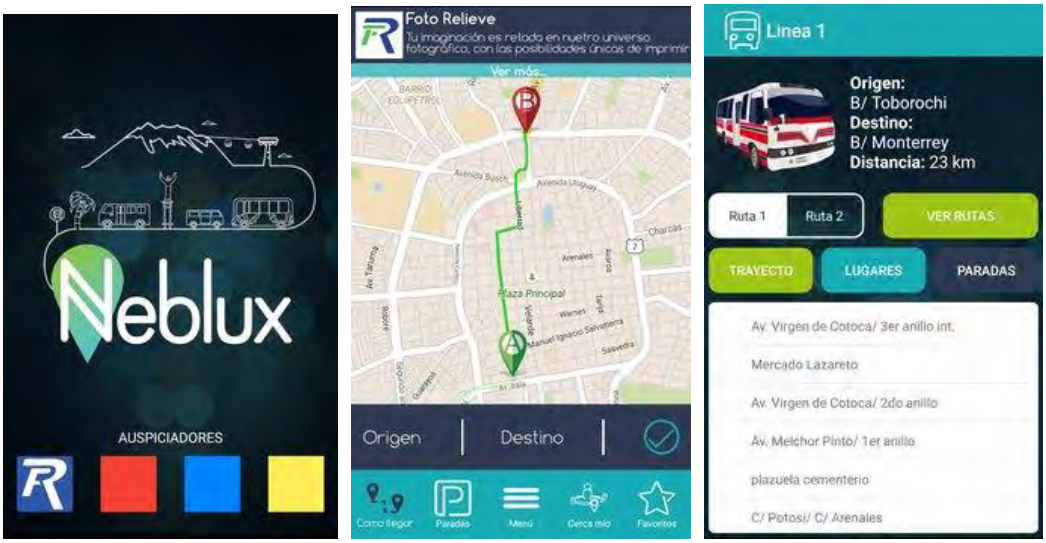
Figure 2.6-21 Radar Speed Sign

3) Public Transportation Information Services from Private Companies

Some companies provide public transportation information service using IT in the Metropolitan Area.

Neblux: Microbus information application for smartphone

There are approximately 120 microbus routes in Santa Cruz de la Sierra. However, when citizens and visitors cannot go to their destination with one route, they have to transfer to other buses. This application can calculate how to reach a destination from their current location and features a map view to allow users to find the most optimal routes to get to the destination.

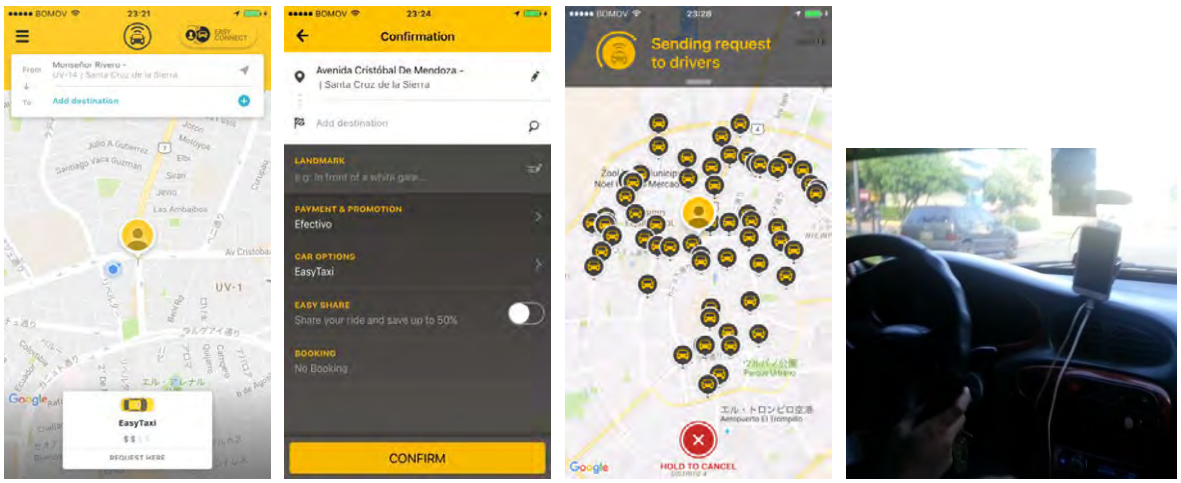


Source: Screenshot of Neblux

Figure 2.6-22 Neblux application

Easy taxi: Taxi information application for smartphone

Approximately 14,000 taxis have registered with this application. Easy Taxi was founded in 2011 in Brazil and is a mobile E-hailing application available in 30 countries. The app allows users to book a taxi and track it in real time. The user can identify the driver and taxi information.



Source: Screenshot of Easy Taxi/ Photo: JICA Study Team

Figure 2.6-23 Easy taxi application

(3) Parking Management

1) Regulation

Ordinance No.086/2011 regulated parking within the jurisdiction of the Municipality of Santa Cruz de la Sierra. Parking is forbidden in the following locations and forms:

a. On the left side of the street, 24 hours a day
b. At 45-degrees, from 7:00 to 21:00
c. Double parking, 24 hours a day
d. In every street lane established as public transport, 24 hours a day.
e. In the Zero Ring Road, i.e., within the 8-block radius ("manzana") surrounding the Plaza 24 de Septiembre, from 7:00 to 21:00
f. On the 1st, 2nd, and 3rd Ring Roads
g. On the crosswalks
h. Blocking fire hydrants
i. Everywhere a signpost indicates that it is forbidden

It is allowed to park vehicles on the right side of the street except where it is explicitly stated that it is a "no parking" area. Traffic congestion is caused not only by illegally parking but also by legally parked vehicles due to the reduction in the traffic capacity of the streets.

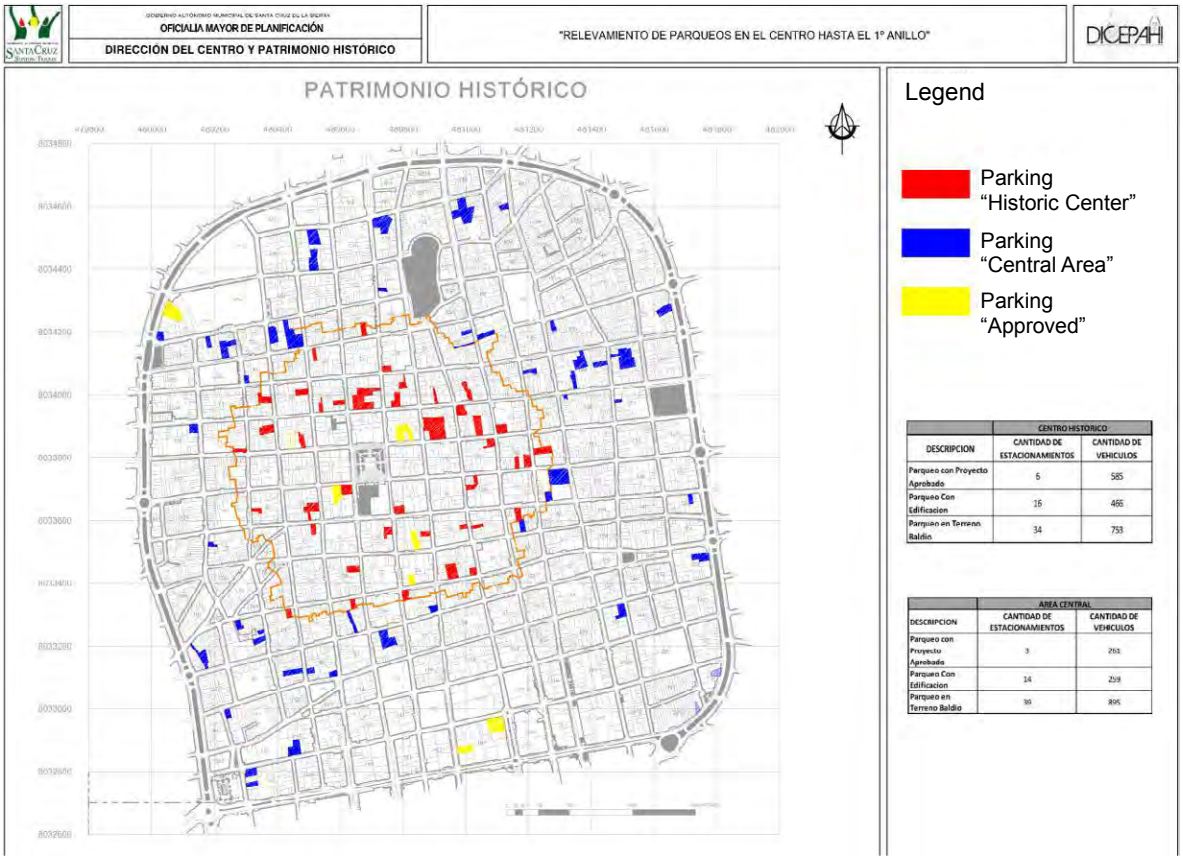
Source: JICA Study Team

Figure 2.6-24 Parking at "No Parking" areas

Source: JICA Study Team

Figure 2.6-25 Legally parked vehicles

In the Historic Center, within the 1st Ring Road, there are many parking lots. According to a study conducted by D.T.T., there are 34 parking lots with a capacity of 753 vehicles in the Historical Center. In the Central Area of Santa Cruz de la Sierra, there are 39 parking lots with a capacity of 895 vehicles excluding the Historical Center.



Source: D.T.T., Santa Cruz de la Sierra

Figure 2.6-26 Location map of parking lots in central area

Source: JICA Study Team

Figure 2.6-27 Pictures of parking lots in central area

Figure 2.6-28 shows the results of the off-street survey inside the Historical Center. This survey was conducted during a weekday, which could be either a Tuesday or Thursday from 15:00 to 18:00. The result shows that there is still space in some of the off-street parking areas, indicating that these parking lots are underutilized. Parking fee of most parking lots is Bs.10. The parking lots that are not used much turned out to be the ones located far from the center and where the parking fee is higher compared to the neighborhood average.

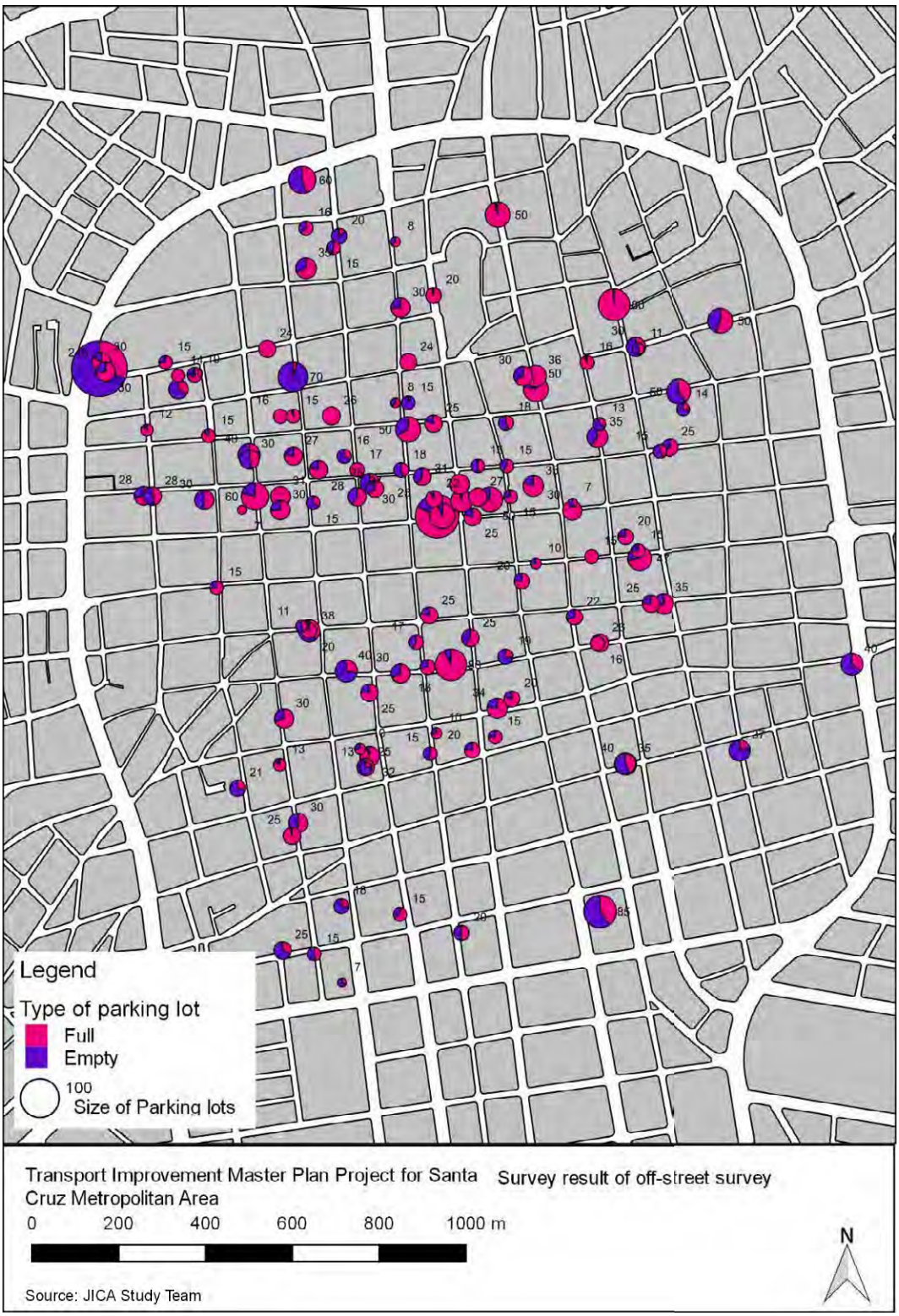
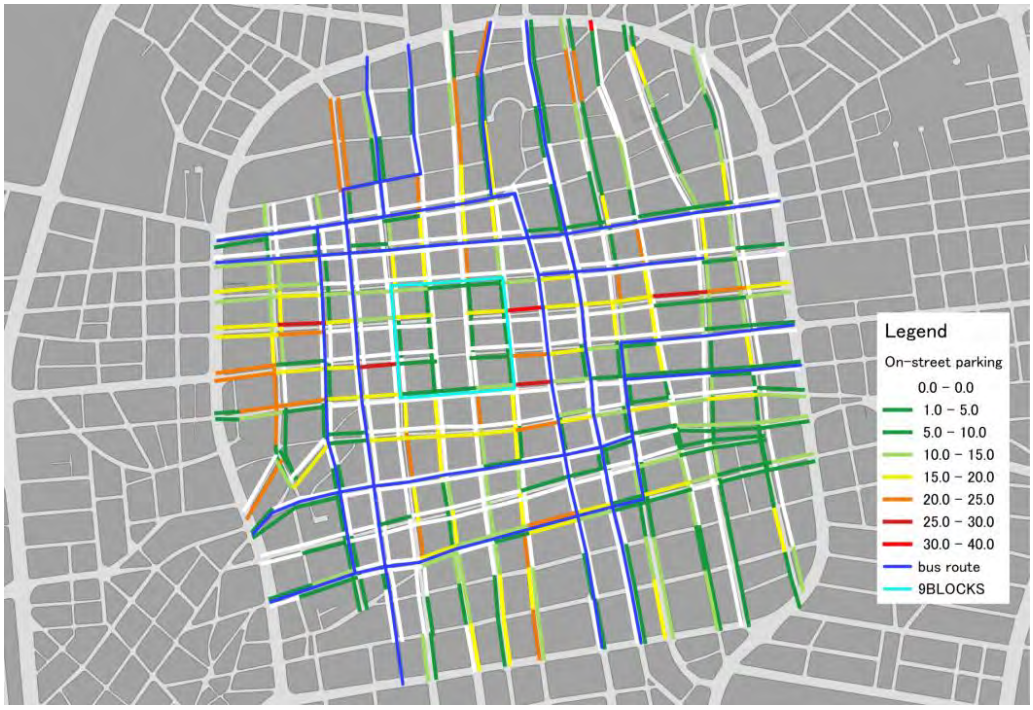


Figure 2.6-28 Survey result of off-street survey

2) On-street parking

Figure 2.6-29 shows the results of the On-Street Parking Survey of the Historical Center. The number of illegally parked cars is small within the eight blocks around the 24 de Septiembre Plaza where on-street parking is prohibited. This contrasts with the areas around the eight blocks, the area around the hospital, and roads connecting to the 24 de Septiembre Plaza where on-street parking is notably common. On-street parking causes traffic congestions by reducing the traffic capacity of the streets.



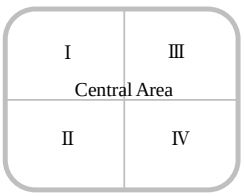
Source: JICA Study Team

Figure 2.6-29 Survey result of on-street survey

Table 2.6-4 shows the supply and demand of parking spaces in the Central Area. As noted previously, some of the parking lots have empty spaces; however overall parking numerical demand exceeds the total capacity of off-street parking space. This means that it is necessary to optimize the existing parking lots by preparing new parking spaces, controlling proper on-street parking and providing the information of empty parking spaces.

Table 2.6-4 Supply and demand of parking space in the Central Area

Block	On-street		Off-street				
	East+West	North+South	Demand	Capacity	Ratio	Parking Demand	Ratio
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
						(a) + (b) + (c)	(f) / (d)
I	505	400	694	1249	56%	1599	128%
II	238	350	264	462	57%	852	184%
III	414	828	1095	1454	75%	2337	161%
IV	470	619	371	635	58%	1460	230%
Total	1627	2197	2424	3800	64%	6248	164%

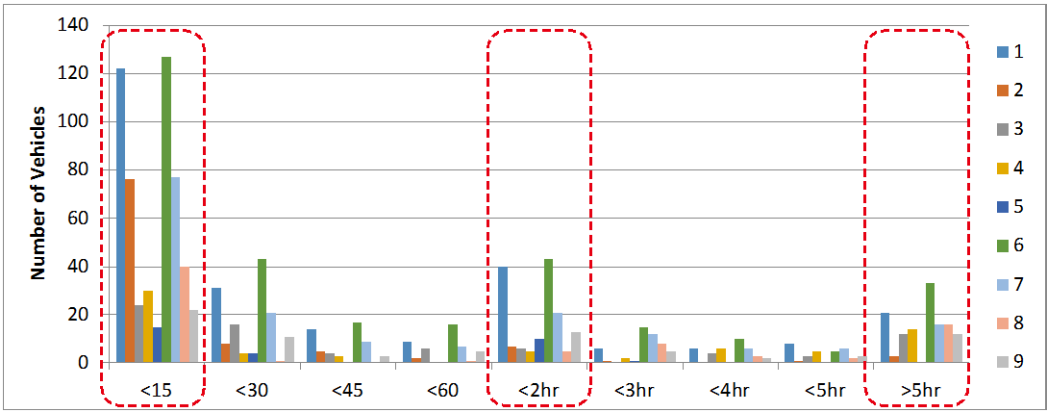


Source: JICA Study Team

According to HIS, as shown in "5.2.6 Household Interview Survey (HIS) Survey result", roughly half of private mode users park their car free of charge in the streets located in the area inside the 1st Ring Road. Paid parking, including on-street parking and parking lots, are less than 10% of the parking usage. This shows that private car users scour for free parking spaces

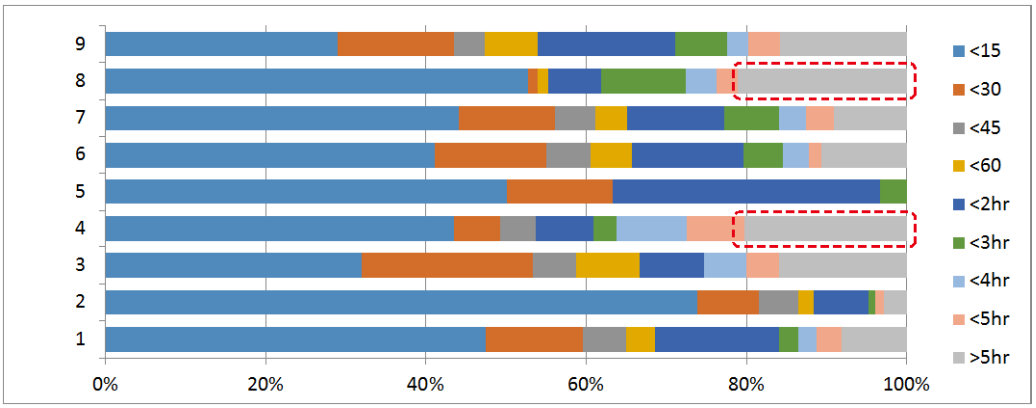
on the street, which leads to aggravation of traffic congestion.

Figure 2.6-30 shows the number of vehicles by each parking time on the streets where the license plate survey was conducted, while Figure 2.6-31 shows the ratio of parking time in each parking lot. According to this survey, the sections of parking time within 15 minutes is the most common. The sections of parking time from 2 hours to 3 hours and over 5 hours can be found in places such as hospital and hotel vicinities. The parking lot No.4 and No.8 have a high percentage of vehicles parked for over 5 hours and are probably located in business areas. The vehicles parked for a long time should be parked on off-street parking facilities.



Source: JICA Study Team

Figure 2.6-30 Number of vehicle each parking time on License plate survey



Source: JICA Study Team

Figure 2.6-31 Raito of parking time each parking lots on License plate survey

3) Enforcement

D.T.T. has enforced the control of parking violation under the ordinance No.086/2011 and No.029/2013. D.T.T. staff controls parking violation at Zero Ring Road and marketplaces every day. They sometimes control parking around shopping malls. Currently, under the latest Local Autonomy Law, the municipality of Santa Cruz de la Sierra has the responsibility for parking control in Santa Cruz de la Sierra.

(4) Traffic safety education

D.T.T. has made some efforts to enhance traffic safety in combination with D.S.S. D.T.T. particularly put effort into safety education for students and the syndicate of public transportation. They also enacted campaigns. In Bolivia awareness of traffic safety is inadequate because the driver's license test does not require detailed knowledge of traffic laws. D.T.T. tried to enhance the awareness of traffic safety for citizens by training children. They made a book and educational tools with illustrations of traffic safety to teach children on the actual roads. D.T.T. also began a campaign of traffic safety and parking education for drivers and pedestrians on the streets adjacent to the main square (Plaza 24 de Septiembre). As part of this initiative, drivers and carriers receive brochures containing safety and accident prevention information to avoid penalties for unlawful parking.

Source: D.S.S., Santa Cruz de la Sierra, and Dirección de Tráfico y Transporte

Figure 2.6-32 Pictures of education for children and training tools

Source: D.T.T., Santa Cruz de la Sierra

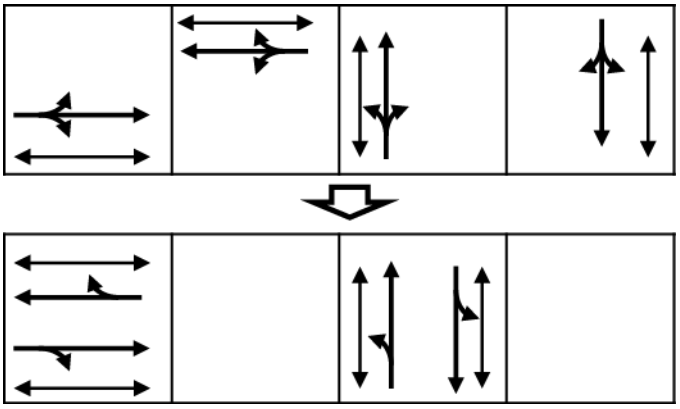
Figure 2.6-33 Pictures of campaigns for traffic safety

2.6.6 Traffic Management Projects

(1) Change of Signal Phase and Signal Control

D.S.S. has already started new projects in which the signal system changes from 4-phase to 2-phase for half of the 2nd Ring Road, and part of the 3rd and 4th Ring Roads. Previously the green signal time was set in each direction. This flow from each approach is set into a single phase, avoiding all conflicts. This type of phasing is ideally suited to urban areas where the *turning movements* are comparable with *through movements* and when *through-traffic* and *turning-traffic* need to share the same lane. However, in cases of heavy traffic, traffic congestion occurred because circle time and queue length become long. Therefore, D.S.S. carried out a change of signal phasing in which left turns are prohibited, and the signal system changed in intersections with heavy traffic, as illustrated in Figure 2.6-34. Figure 2.6-35 shows the pictures before and after the improvement project of signal phase change at the intersection of 3rd Ring Road and Av. Cristo Redentor. A similar effort has also been implemented at the

intersection of 4th Ring Road and Av. San Martin. As shown in these pictures, these projects have been effective in relieving traffic congestion. The flow rate of traffic increased while the queue length decreased because two-way of traffic could flow at the same time and cycle time could be made shorter.



Source: JICA Study Team

Figure 2.6-34 Change of Signal Phases from 4-phase to 2-phase

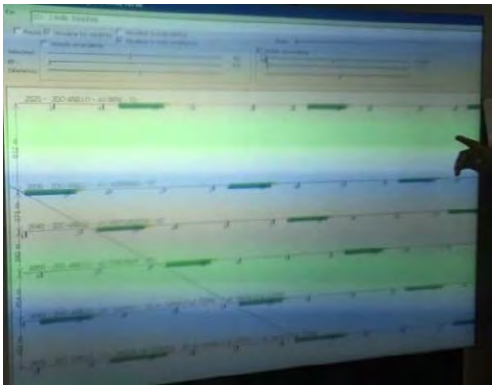
Before

After

Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-35 Before and after Project of Signal Phases Change from 4-phase to 2-phase at intersection of at 3rd Ring Road and Av. Cristo Redentor

D.S.S. has already started to implement "Offset Adjustment," which refers to the time difference between intersections of half of 2nd Ring Road (West Side). When this system is implemented, a vehicle passing on the main road can travel without signal stops between intersections. Figure 2.6-36 shows offset adjustment system implemented at D.S.S.



Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-36 Offset adjustment system

(2) Prohibition of Left Turn and Intersection Improvements

The purpose of these projects is to improve traffic congestion in major intersections. Traffic congestion is caused by conflicts between vehicles making left turns and oncoming vehicles at bottleneck intersections during peak times. Therefore, these plans prohibited left turns in all directions and forced drivers to take detours. Parameters of signals and road markings were also modified. According to D.S.S., in the case of the intersection at the 2nd Ring Road and Av. Santos Dumont, the delay time to pass through was reduced by 2-3 minutes.

Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-37 Intersection improvements

Santa Cruz de la Sierra provides information by distributing leaflets and advertising in various types of media, such as TV and newspaper. D.S.S. had the control of traffic flow for at least ten days since the beginning of the implementation of this modification but after that National Police took over the traffic control.

Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-38 Leaflet providing information on improvement of intersections

Source: JICA Study Team

Figure 2.6-39 Pictures on beginning day of improvement of intersection at 2nd Ring Road and Av. Grigota

Improvement of traffic flow has been observed at main roads such as ring roads. On the other hand, traffic congestion on crossing roads is getting worse due to traffic volume increase.

(3) Parking Management Project

D.T.T. submitted a project profile to the city council regarding a new parking management project within the 1st Ring Road called "Rented Parking and Regulated Routes". The overall objective of this project is to regulate the use of roads for vehicular parking in an organized and orderly manner through a system of tariffed control utilizing parking meters and prohibiting street parking in spaces without parking meters. This system facilitates rotation in the use of public space, creating a permanent and continuous supply, and thus reducing vehicular traffic times in the search for places to park. The specific objectives of the project are:

- Freeing usable spaces on streets and avenues for the circulation of vehicles, increasing the effective capacity of roads in compliance with standards (prohibition of double parking, parking on the left side of the road, and parking at 45-degree angle) by the corresponding control.
- Reducing the car journeys involving prolonged stays of the vehicle in the public space
- Encouraging the transfer of peak hour travel to off-peak hours
- Facilitating short-term parking in congested areas for business, personal business, and other purposes

- Reduce the time spent by moving vehicles in the search for a parking space.

This control will use electronic parking meters which have the following basic characteristics:

- Support for multiple communication networks:
  - Phone: GPRS (General Packet Radio Service) / UMTS (Universal Mobile Telecommunications System)
  - WIFI System (sending data via radio waves)
  - Dedicated network for comprehensive coverage.
- Complete and roman alphanumeric keypad.
- Multiple payment methods:
  - Credit /debit cell
  - e-Cards / Chipcard
- A graphical interface that allows greater clarity in the operation of the user.
- Accessibility for people with disabilities.

D.S.S has also considered introducing a new system of parking guidance and tariffed control utilizing a smartphone app that can provide the information regarding empty parking space, facilitate parking space reservations and payment by credit card. Moreover, violators who park illegally without paying will be identified by monitoring with CCTV camera.

(4) Electronic Violation Detection System

D.S.S. is considering introducing the Electronic Violation Detection System (Sistema de Detección Electrónica de Infracciones: DEI). According to "Transito Seguro: Regulation of the Implementation of an Electronic System for Screening Traffic Violations at Intersections and High-Risk Routes in the City of Santa Cruz de la Sierra", DEI is defined as an electronic system that captures a vehicle at the real-time when committing a traffic violation. This system produces automatic photographs, video or digital images of each vehicle that violates 2 types of traffic rules, which can be either driving through a red traffic light or violating a speed restriction.

The notice of violations recorded by DEI (Electronic Infringement Detection System) will be sent by any of the following methods: text message to a mobile number, Email, printed notification of the vehicle owner and/or information through a consultation portal and citizen information desk.

(5) Pedestrianization Pilot Plan in the Historic Center

The municipality of Santa Cruz de la Sierra carried out a pilot project called "Centro Historicó Plan Piloto de Peatonalización" which prohibited the entry of vehicles into the Historical Center protected area for 180 days starting from September 2014. This project sought to revitalize and restore the Historical Center, giving priority to pedestrians. The streets around "Plaza 24 de Septembre" were closed, during the weekends, seeking to strengthen the area with cultural, recreational, commercial, gastronomic activities, among others. Traffic was restricted, and the only allowed entry was the entry into parking lots or the entry of ambulances. Business owners could put tables on sidewalks (according to standards) for enjoyment with their neighbors but were not allowed to enter the street. Subsequently, this project was stopped due to objections from citizens.

Source: http://hoybolivia.com/Noticia.php?IdNoticia=118996

Figure 2.6-40 Location area of pilot plan at Historic Center pedestrianization

Source: D.S.S., Santa Cruz de la Sierra

Figure 2.6-41 Pictures of Pilot plan at Historic Center pedestrianization

D.T.T. has also made a plan to limit entry within the 1st Ring Road by license plate number. They are considering a plan to manually check license plates at entrances into the 1st Ring Road.

2.6.7 Present Problems on Traffic Management

(1) Traffic Safety

1) Lack of information on traffic accidents

Although there are many traffic accidents, available statistics on the traffic accidents is limited, which makes it difficult to analyze the countermeasures to reduce the traffic accidents. The reason for the lack of the statistics is that the traffic accident data collected by the National Police is not properly shared among municipalities.

2) Inadequate traffic safety education and lack of traffic discipline

The awareness of traffic safety is still inadequate, as is apparent from the frequency of speed limit violations and lack of helmets. Lack of discipline by drivers is a concern for traffic safety.

3) Insufficient traffic infrastructure

D.S.S. has installed traffic signals at major intersections, however not all dangerous sections

are covered, and they are still inadequate. Especially, traffic signals shall be installed at 3rd Ring Road (exterior) and the exclusive bus lane at 1st Ring Road. In addition, sections, where many pedestrians walk such as educational and public facilities should be signalized.

(2) Traffic Congestion

The following 3 areas frequently experience traffic congestion and reduced travel speeds.

- Historical Center
- Bottleneck in road network
- Markets, schools and other facilities which generates a high number of trips

The causes of the traffic congestion are follows.

1) Parking

Parking in the Historic Center, regardless whether it is legal or illegal, is one of the reasons for the congestion.

2) Taxi

Taxis are running around inside the Historic Center to catch passengers, which increase the traffic volume.

3) Bottlenecks

Congestion begins in the upstream section of a bottleneck in the road network when the traffic demand exceeding the traffic capacity of the bottleneck intends to pass through streets with certain physical conditions, such as roundabouts, signal intersections or road with street parking.

4) Congestion around markets, schools, and other facilities

Parking for loading and unloading (including public transportation by modes) around markets, schools and other facilities having high trip generation causes a reduced traffic capacity and congestion.

5) Demand concentration on the peak hours

Currently, all the government or non-government offices open from 8:00 to 9:00 and finish their work at 17:00 to 18:00. The school hours is the same. At lunchtime, most people go back home and return to their offices at the same time.

2.7 Transport Problems

2.7.1 Transport Characteristics

The results of the traffic surveys identified the following transport characteristics which are important information in the problem identification in the Project.

(1) Public transport is the major mode

Public transport (micro, minibus, trufi, large bus, mototaxi, trito) accounts for 51.1% of the trips, followed by private cars at 13.9%. The share of micro is as large as 48.7%. Non-motorized transport (walking and bicycle) accounts for 26.8%.

On the other hand, the share of private car usage to go to workplaces is high in some places within the 4th Ring Road and suburban areas as shown in Figure 2.7-1. The percentage of the car use for go to work from home is low in the area between Santa Cruz de la Sierra and Cotoca.

(2) Public transport passengers travel longer distance than car users

The average travel distance (measured as a straight line) of all trips in the Metropolitan Area is calculated at 4.4km, and that of public transport and private cars is calculated at 6.0km and 5.0km. The trip distances of "go to school" trips and "private" trips are shorter than that of "go to work" trips. In case of the "go to work" trips, the average travel distance of public transport is 7.0km while that of cars is 5.4km.

The average travel distance of suburban area is longer than that of the center of the Metropolitan Area as shown in Figure 2.7-2.

(3) School children use public transport

Walking is the major mode of the trips from home to school for the primary and secondary students accounting for 51% of the transport mode. This is because primary and secondary schools are located within walking distance. On the other hand, public transport also plays an important role for the trips to school, which accounts for 41%. Students of institutes, colleges, and universities rely on public transport, which accounts for 89% of the transport mode.

(4) Distance of walking access to public transport is very short

The average time of walking to bus stops and other locations to take a micro or other public transport system is calculated at 3 minutes and 30 seconds. This number is not accurate because this is the average of the number that people answered in the interview, where the popular answers were 1-2 minutes, 5 minutes, or 0 minutes. The point is that the in most cases, public transport system is available in very short distance. The percentage of the walking access which takes more than 15 minutes is very small (0.2%).

On the other hand, it is necessary to walk 30-60 minutes in the suburban area of Porongo, La Guardia, and El Torno.

The waiting time for public transport is very short at the average of 2 minutes because of the high frequency of microbus services. Some interviewees answered that the waiting time was 20-45 minutes although the percentage is very small. There are some places where people need to stand in a queue during peak hours.

(5) Bicycle accounts for only 1% of the trips

Encouraging bicycle use is one of the major topics which are discussed among urban and transport planners in various opportunities. However, the result of the survey shows that bicycle is not popular as a transport mode.

(6) Feeder transport is not popular

Mototaxis are the major transport mode for short distance in Warnes and Cotoca. The result of the survey shows that the usage of a mototaxi as the feeder mode of microbus or other types of public transport is not common. The combination of mototaxi and other transport mode account for only 9% of the trips relating to mototaxi, while the rest of 91% are the trips of a single use of mototaxi.

Transfer from Trufi to Microbus accounts for 28% of the trips relating to Trufi. However, this is just transfers between routes like the transfers between Microbus, because the route of Trufi is not necessarily designed to supplement the Microbus network.

(7) A trip of public transport consists of one or two modes

The trips consisting of three or more vehicles are very rare, accounting for only 1% of the public transport trips, while 23% of the public transport trips involve two vehicles with one transfer. The rest of 76% of the public transport trips use only one vehicle without transfer of modes.

(8) Workers go back home for lunch

It is common that people go back home to have lunch in the Metropolitan Area, which is one of the causes of the traffic congestion in the noon. The result of the survey shows that 17.5% of the workers go back home for lunch, among which private cars account for 33% of the transport mode.

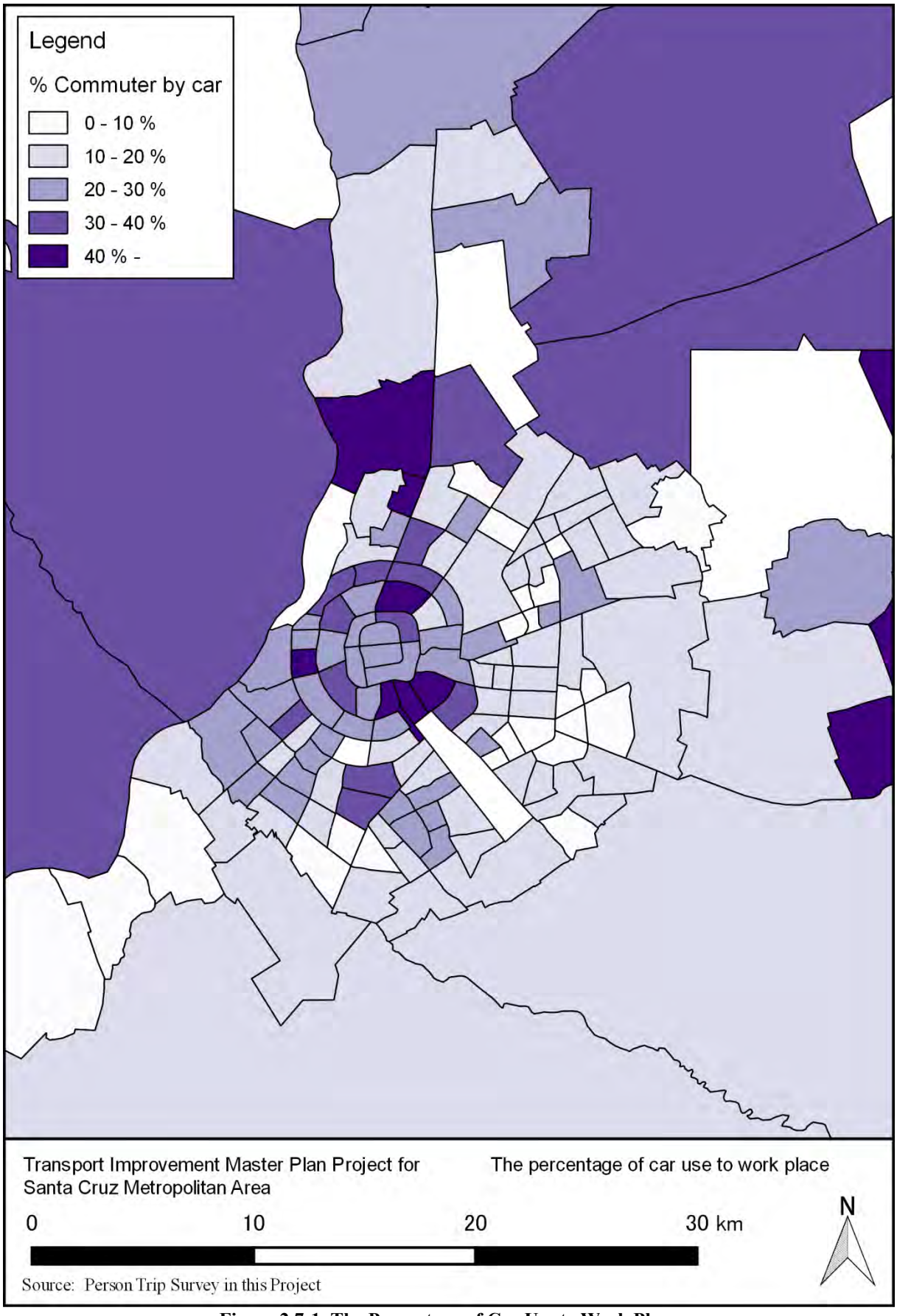


Figure 2.7-1 The Percentage of Car Use to Work Place

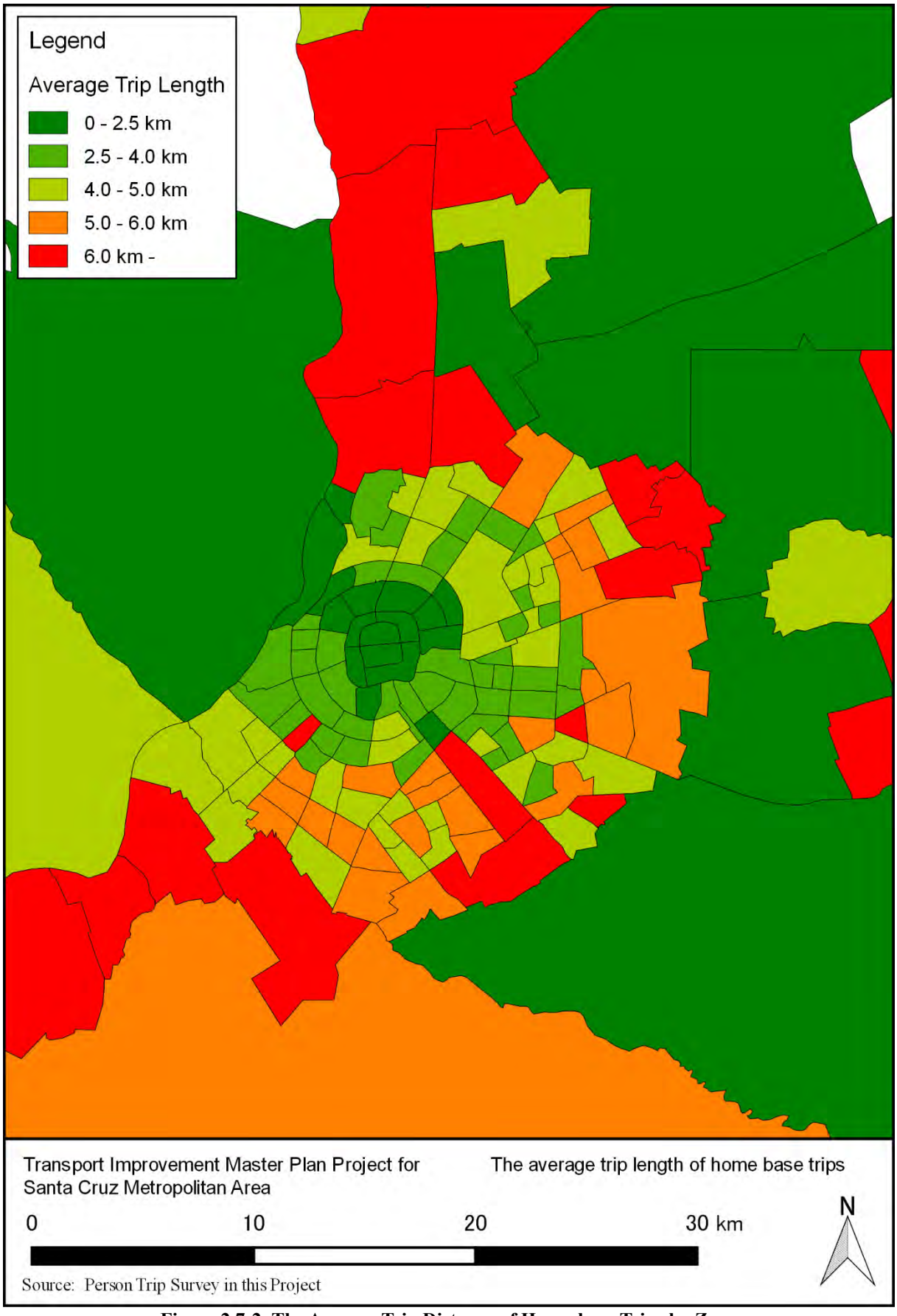


Figure 2.7-2 The Average Trip Distance of Home-base Trips by Zone

2.7.2 Observed Problems

As mentioned in the previous sections, various transport problems are observed and recognized by the people in the Metropolitan Area. The observed problems can be categorized into 1) traffic congestion, 2) public transport services, 3) Infrastructure, 4) traffic safety, and 5) air pollution.

(1) Traffic Congestion

Traffic congestion is observed at various locations and times such as:

- Inside the 1st Ring Road, especially in the historical area in peak hours
- Intersections at the crossings of radial and ring roads in peak hours
- Around large markets when the markets are open
- Arterial roads such as radial and ring roads in peak hours
- Major roads in local communities where the road network is poor

The traffic congestion increases travel times.

(2) Public Transport Services

The following problems are observed in the public transport system in the Metropolitan Area.

- Lack of bus routes in communities in the suburban area
- Low frequency of bus services
- Slow speed in congested areas
- Congestion in vehicles of some routes
- Reduction in the number of bus services in rainy days

(3) Infrastructure

The road infrastructure in the Metropolitan Area is insufficient. The following problems are observed due to the insufficient infrastructure.

- Poor accessibility and mobility in local communities and suburban areas due to unpaved roads
- Long detour is necessary between Porongo and the rest of the Metropolitan Area due to the Pirai River.
- Connections among La Guardia, Cotoca, and Warnes are poor due to lack of direct connection roads.
- Poor highway illumination (lack of street lights) raises the risk of traffic accidents.

(4) Traffic Safety

Recently, traffic-related deaths in Department of Santa Cruz has increased rapidly. Although the statistics at the municipal level is not available, the Metropolitan Area might account for a large part of the deaths in the department. The number of traffic-related deaths per 100,000 inhabitants in Department of Santa Cruz was 31.3 in 2012, which is higher than the national average of 15.5 (calculated from the database of INE). Crossing arterial roads is very

common because the distance between pedestrian crossings in such arterial roads is long. It is observed that pedestrians cross streets between the intersections.

(5) Air Pollution

Owing to the geographic conditions and regular winds, the air pollution is not a serious problem in the Metropolitan Area despite the rapid increase in the number of vehicles. Although the increase in greenhouse gas (GHG) emissions from private and public vehicles in the Metropolitan Area is a global problem, it is not recognized as a local problem because of the blue sky. On the other hand, vehicle emissions from old buses directly affect pedestrians in streets.

2.7.3 Background of the Problems

(1) Urban Growth

The observed problems are the results of the background conditions, some of them are also identified as problems, making a chain of problems and causes. The most apparent cause of these problems is the increase in the number of both private and public vehicles, which is primarily the result of the population increase and the economic growth. These are the socio-economic conditions that are not recognized as problems themselves. On the other hand, the urban expansion with low-density development also contributes to the increase in vehicles as explained in previous sections. This can be identified as a problem, although this might be a result of other problems.

(2) Insufficient Infrastructure

As explained in Chapter 2-7, the intersection project implemented this year to prohibit the left turn has improved the traffic congestion in many intersections. This implies that inappropriate traffic management is one of the reasons for the traffic congestions. Construction of flyovers at intersections of radial and ring roads in recent years also improved the traffic, which is also implied that lack of investment in the road infrastructure is one of the reasons for the problems. Regarding the infrastructure, the rapid increase in urbanized area is one of the reasons for the delay of the pavement.

Pedestrian facilities are also insufficient, which is one of the reasons for the traffic safety problem.

(3) Inadequate Public Transport System

Public transport problems are complex. Congestion in buses is observed in many lines, while many buses carry few passengers in the central area, where many bus lines concentrate. Since bus operators prefer to go through high demand areas, many bus lines concentrate on particular points, which results in the situation that many different lines run along the same streets in the center of the city.

(4) Lack of Urban Planning

Insufficient infrastructure and inadequate public transport system are the results of the lack of urban planning. Municipalities have extended their Urban Areas in response to the pressure of urban developments by the private sector without proper urban planning. The road network has been developed based on the proposal of private sectors.

(5) Absence of the Responsible Authority for the Transport Sector

Each municipality has the responsible section for its land use plan, in which road and street system are established. However, there is no section which makes an integrated transport plan including road infrastructure, public transport, and traffic management. The absence of such authority results in the delay of the integration of the road network and public transport plan into the land use plan.

The dispersal of the responsibility of transport sector among different secretaries is one of the reasons for the absence. In the case of the Municipality of Santa Cruz de la Sierra, the section of traffic sign & traffic light and that of traffic & transport belong to a different secretary, in spite that the traffic control is related to the traffic sign and traffic light. This kind of distribution of the responsibility of the transport sector is observed even in other small municipalities.

(6) Lack of the Institutional System to Protect Planned Areas

Even if municipalities or Department of Santa Cruz have a plan to develop the future road network, it is difficult to keep the lands for the future roads. Once the plan is disclosed, developers, investors, and individual persons will purchase the lands that are determined as the future roads. The Metropolitan Expressway, which was identified in PLOT of the Municipality of Santa Cruz de la Sierra, faces the land acquisition problem because the land along the road has already developed by the private sector. The lack of an institutional system to protect the future road areas, for example, to prohibit construction of buildings in the areas, causes the difficulty of preparing long-term development plans.

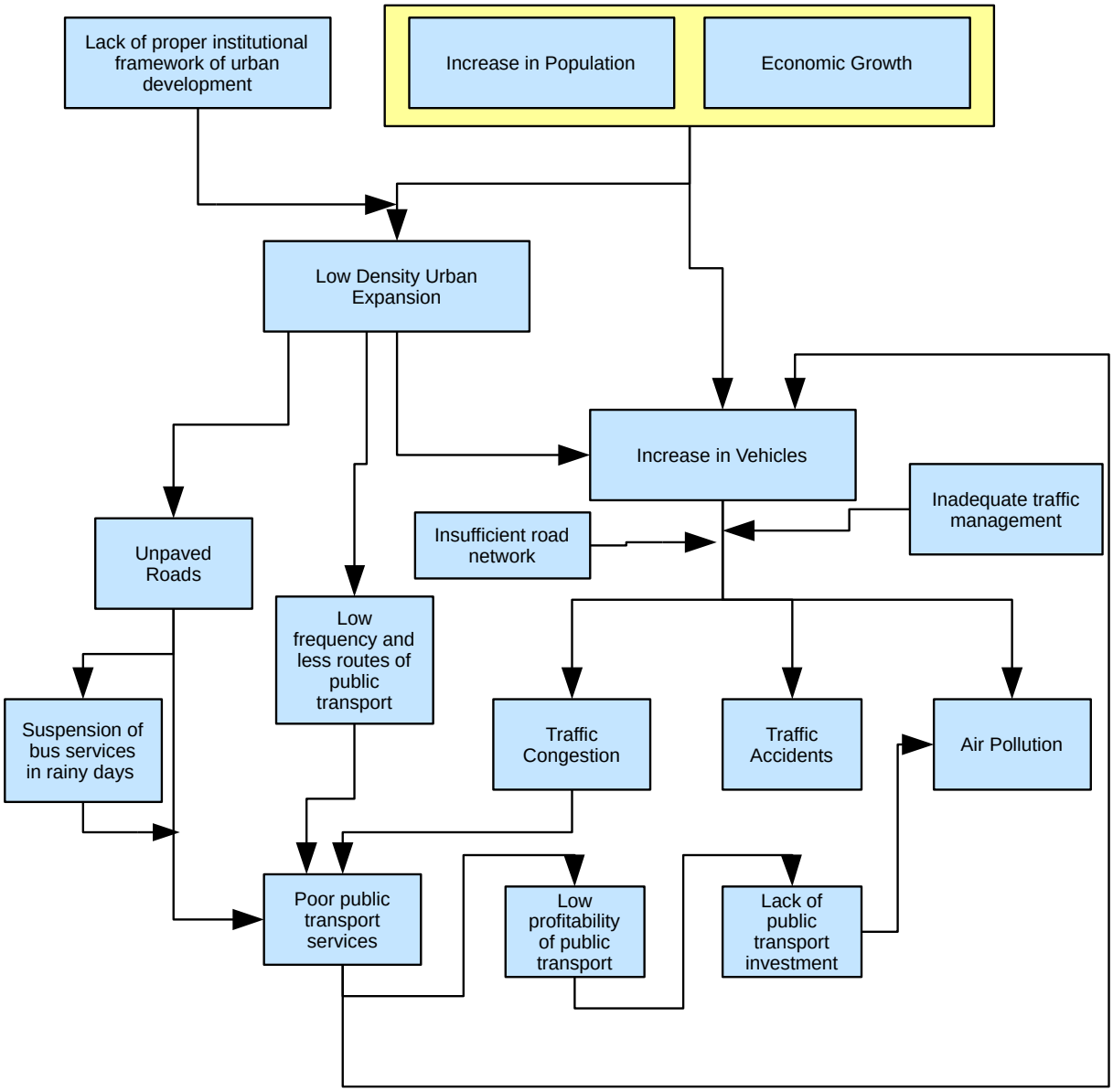
(7) Lack of Institutional Power of the Department to Control Land Use

Previously, the department has some powers in the Rural Areas in each municipality, which enabled the control of the land use for the sustainable development to some extents. Although the department can control developments in the Metropolitan Area through the process of issuing environmental licenses, the department does not have more powers such as the approval of the boundary of Urban Area and Rural Area in the present institutional system. Most municipalities prefer to expand their Urban Area and give permissions to housing developments by the private sector because they expect the development will attract investment and increase the population. This is one of the reasons of the urban sprawl in the Metropolitan Area.

(8) Lack of People's Awareness to Traffic Safety

The traffic safety problem is the result of not only the insufficient traffic facilities but also the lack of people's awareness of traffic safety. The sense of law observance is not necessarily high among drivers, which brings the risk of traffic accidents. Insufficient education to drivers is one of the reasons. Traffic enforcement by traffic police to private cars is relatively proper, but it is observed that the traffic enforcement against buses is insufficient, which causes not only the traffic safety problem but also the traffic congestion.

Figure 2.7-3 illustrates the structure of the major problems. This is simplified structure and not all problems mentioned above are shown.



Source: Elaborated by JICA Study Team

Figure 2.7-3 Structure of Transport Problems in the Metropolitan Area

Chapter 3 Regional and Urban Structure Plan

3.1 Analysis of Development Potential

3.1.1 Characteristics of the Metropolitan Area

(1) Climate

The Metropolitan Area is located in a tropical savanna climate zone in terms of Köppen-Geiger classification. In general, the temperature is hot or warm ranging from 20 to 30 degrees, and sunny days prevail throughout the year. The area has a warm winter season with dry weather for 2-3 months in a year, although the temperature sometimes drops suddenly due to the wind from the south and the cold days continue a few days. In the rainy season, from December to March, sometimes it rains heavily in very short time. As a whole, the area enjoys relatively comfortable weather condition compared to other areas in Bolivia.

(2) Geography

The altitude of the area is approximately 400 above the sea level, and there is no altitude sickness which is observed in the high-altitude areas in Bolivia. The area is almost flat except for the left of Pirai River and El Torno as shown in Figure 3-1. The flat area is very large, spreading between Pirai River and the Rio Grande, which enables the expansion of the urbanized area. Recently, the flood disaster of Pirai River and the Rio Grande has not been observed due to the investment on the river banks.

(3) Water Resource

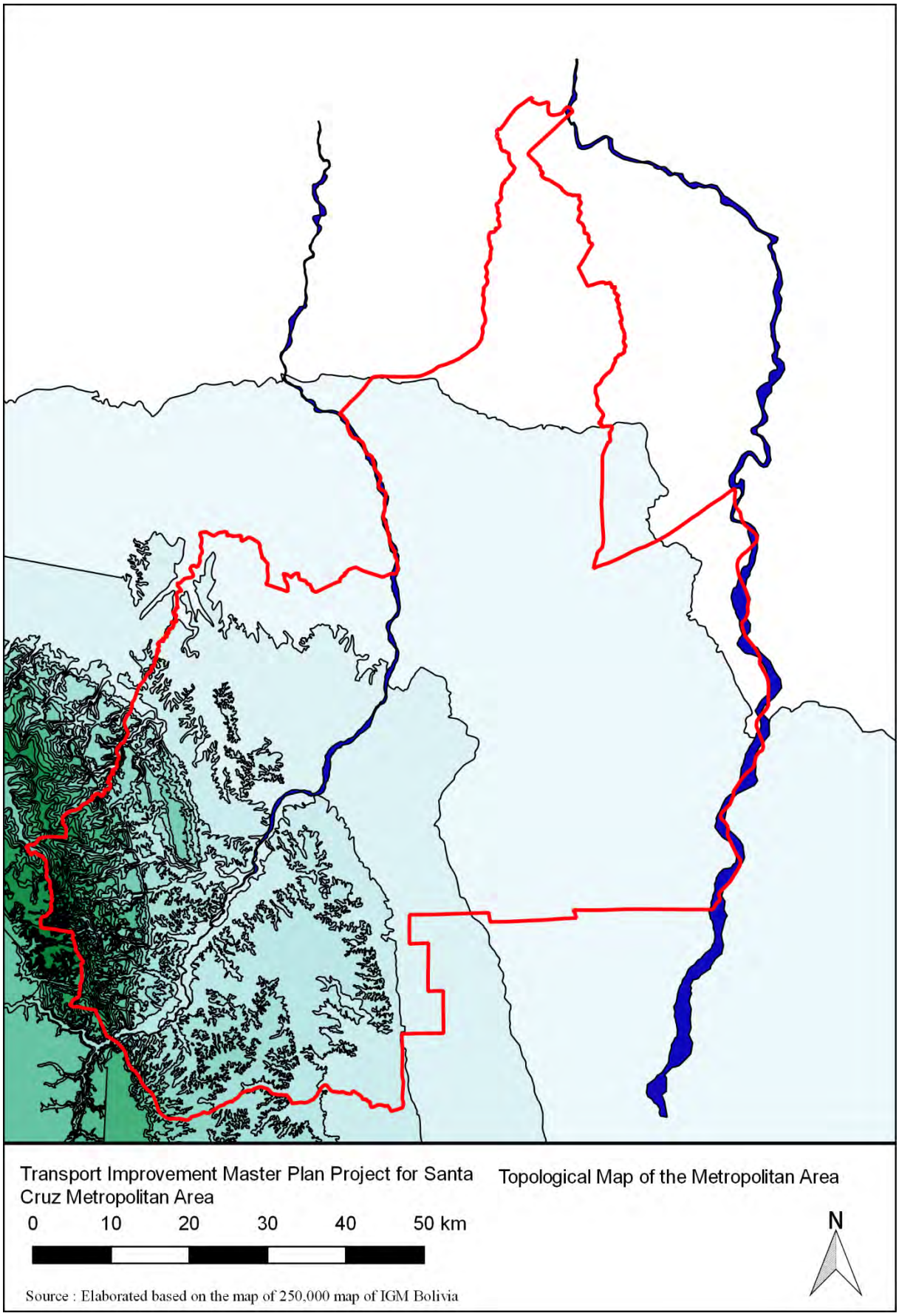
The Metropolitan Area replies on the underground water for not only industrial and agricultural use but also drinking. It is not known whether the water resource is enough to supply increasing water demand in the future or not, although deep groundwater scarcely dries up due to its rich water in general. The short-term risk is the contamination and reduction of water resource due to rapid urban development, which can be or should be controlled by authorities.

(4) Disaster

The natural disaster is very rare in the Metropolitan Area, although there remains a risk of flood and landslide along the Pirai River and the Rio Grande. In March 1983, a flash flood from the Pirai River hit Santa Cruz, which caused a large-scale disaster to the city, killed 250 people and affected 9,500 families. The flood forced 3,000 families to be resettled to the east south of the city, which was named as Plan 3000. In 2007, a flood occurred in Santa Cruz de la Sierra due to El Niño.

(5) Green

Cities in the metropolitan have a rich green environment, even in Santa Cruz de la Sierra, which has a population of 1.6 million. In the 1960s, the city was planned by adopting a concept of the garden city. There are many parks and plazas in the city where many trees are planted.



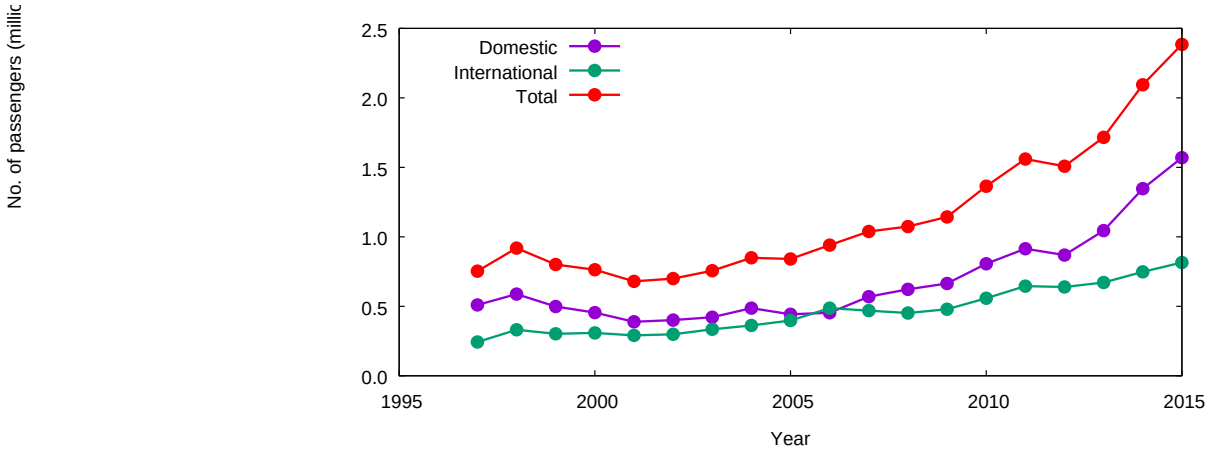
Source: Elaborated based on the map of 250,000-scale of IGM Bolivia

Figure 3-1 Topological Map of the Metropolitan Area

3.1.2 Access

(1) Airport

Viru Viru International Airport has a runway with a length of 3,500m and a width of 45m. The destinations of the international flights from the airport are Buenos Aires, Asuncion, Montevideo, Lima, Sao Paulo, Santiago, Iquique, Quito, Panama City, Miami, and Madrid. It also connects to major airports in Bolivia, and the number of passengers of domestic flights is increasing rapidly in recent years as shown in Figure 3-2. The number of passengers of international flights is increasing gradually. The total number of passengers (departure and arrival) reached 2.34 million passengers per year in 2015.



Source: http://www.sabsa.aero/

Figure 3-2 No of passengers per year at Viru Viru International Airport (departure and arrival)

(2) Railway

There are three railway lines connected to Bimodal Station in Santa Cruz de la Sierra – to the north, east, and south directions. For the north direction, the railway line connects to Montero in a distance of 64km. The railway line to the east connects to Paraguay in a distance of 643km, while the line to the south connects to Argentina in a distance of 359km. Both passenger and freight railway services have been provided by Empresa Ferroviaria Oriental S.A. based on a concession. The railway network in Santa Cruz is not connected to the other railway network in Bolivia due to the Andes mountain range.

The Central Bi-Oceanic Railway Project is initiated by the Government of Bolivia. It is proposed to connect Ilo Port of the Pacific Ocean and Santos Port of the Atlantic Ocean through Bolivia by rail in a length of 4,700 km. Although the feasibility study report has not been disclosed yet, the route probably run through the Metropolitan Area. If this project is implemented, the Metropolitan Area can access both ports by rail, which enhances the role of the area as the strategic logistic hub in Bolivia.

(3) Road

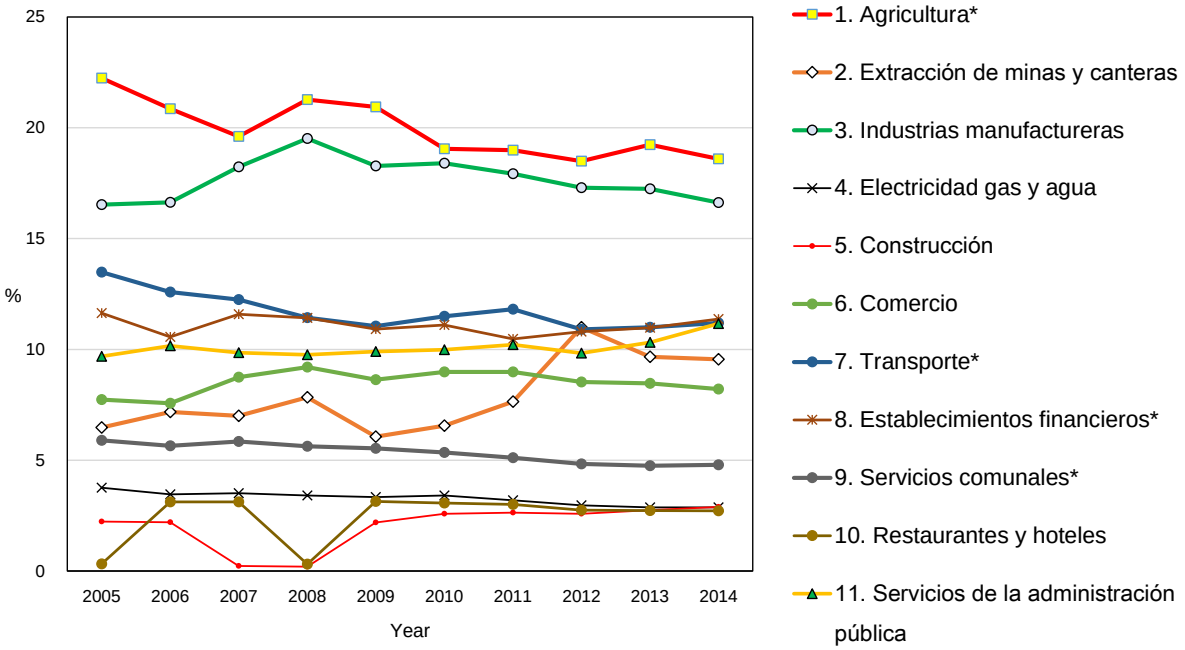
The Metropolitan Area is located at the strategic point of the national road network as shown in Chapter 2. The Fundamental Road 4 (F4) connects the Metropolitan Area and Brazil as the Bi-oceanic Corridor in the east section and connects the Metropolitan Area and Cochabamba in the west section. F4 is connected to F1 in Oruro, which goes to La Paz. F7 is an alternative route for F4 connecting the Metropolitan Area and Cochabamba. F9 runs from La Guardia to the south, connecting to the national road network and reaching the border with Paraguay and Argentine.

The urban road network in Santa Cruz de la Sierra is unique with radial and ring roads, which form the shape of the city as concentric circles.

3.1.3 Industry

(1) Overview

The agriculture and the manufacture are the main and important industry of the Department of Santa Cruz, accounting for 18.6 and 16.6% of the regional GDP of the department in 2014. Recently, the proportions of the agriculture and the manufacture are slightly decreasing, while that of the mining industry has increased as shown in Figure 3-3. Although the regional GDP of the Metropolitan Area is not estimated, the agriculture and the manufacture are also the most important economic sector in the Metropolitan Area.



Source: Elaborated based on a data of INE

Figure 3-3 Proportion of GDP by Economic Activity of the Department of Santa Cruz, 2005-2014

(2) Agriculture

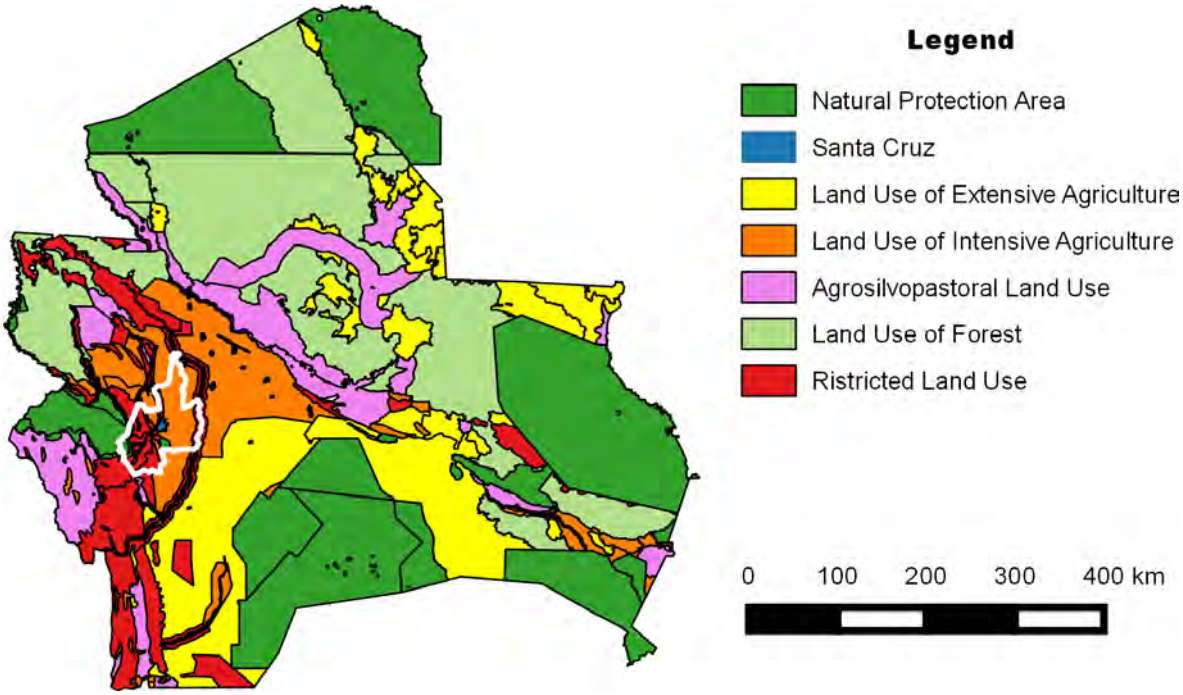
The production of the agricultural sector of the Department of Santa Cruz accounts for 42.5% of the sector in the national GDP, followed by La Paz at 16.8% and Cochabamba at 12.7% in 2014[1]. The industrial agriculture (intensive farming) accounts for 42.4% of the gross value of the agricultural sector in Santa Cruz, followed by livestock at 28.4% and cereals at 16.4%[2]. Soybean is the dominant product in the industrial agriculture, followed by sorghum and corn. Other major products in the industrial agriculture are wheat, rice, sesame, and sunflower. Beef cattle are major in the livestock sector. Soybean cake is the major agricultural product for export to foreign countries.

The area of the industrial agriculture stretches between the Pirai River and the Rio Grande in the Metropolitan Area, while the west side of the Pirai River is categorized as the restricted area in the land use plan of the Department of Santa Cruz as shown in Figure 3-4.

[1] INE: GDP of Agriculture, Forestry, Hunting and Fishing in current prices

[2] http://www.cao.org.bo/, CAO (Eastern Agricultural Chamber)

Because of the rich agricultural products, many food processing factories are located in the Metropolitan Area.



Source: Elaborated based on GIS data provided by SOPOT in 2014

Figure 3-4 Land Use Plan of the Department of Santa Cruz

(3) Manufacture

In addition to the agricultural sector, manufacture is an important sector in the Metropolitan Area. The agricultural processing is the major part of the manufacturing industry.

There are four industrial parks in the Metropolitan Area. The Industrial Park in Santa Cruz de la Sierra is the first industrial park in Bolivia having 40 years history. The area is as large as 962 ha. One of the advantages of the industrial area is that it is located just outside of the 4th Ring Road and surrounded by populated area, which means that the accessibility to workers is good. There are many related factories around the Industrial Park.

There is a private industrial park in Warnes-the Latin America Industrial Park (PILAT). The area is as large as 1,200ha. This is a new industrial park, and there remain many empty lots. The industrial park in La Guardia has an area of 500ha.

The existence of various industries is also the advantage to establish factories in the Metropolitan Area.

(4) Logistics

The Metropolitan Area is the logistics hub not only in the department but also in the country, owing to freight transport infrastructures such as road, rail, airport, and warehouses. The agricultural industry contributes to the logistics hub.

The Metropolitan Area has three inland depots: One is located along Av. Virgen de Cotoca which is operated by ALBO, a public enterprise. A private inland depot (Winnel) is located near the ALBO. The other is also a private inland depot (Soficruz) located in Warnes along the National Highway 4 near PILAT. There is a plan to construct logistics facilities for air

cargo near Viru Viru International Airport. In addition to the bonded area, there are many warehouses along arterial roads.

(5) Services

The Metropolitan Area is the center of financial, commercial and business in the department and the country, concentrating many shops, offices, banks, hotels, and restaurants, especially in Santa Cruz de la Sierra. It is also the center of the public sector as the capital of Department of Santa Cruz. The city has an exposition center (Fexpocruz) which attracts many events. G77 Avenue has a linear space for various events. There are three soccer teams in the Metropolitan Area, two in Santa Cruz de la Sierra, and one in Warnes.

(6) Tourism

Unlike La Paz and other areas in Bolivia, the Metropolitan Area lacks famous tourist attractions in the international tourism market. However, the potential of tourism development is high because of the rich natural and historical resources. Since it is located in the center of the Santa Cruz, the area can be the base for eco-tourism. In addition to the natural resources located outside the Metropolitan Area, the area has the following resources.

Table 3-1 Resources of Tourism Development

City	Tourism Resource
Santa Cruz de la Sierra	Cathedral Basilica of "San Lorenzo" Museums, cultural centers, galleries Municipal Zoo Carnival Fest "Las Cabañas" of Piray´s river "Plaza 24 de Septiembre" the center of the city. Central Urban Park whit fount of dancing water Fexpocruz
Cotoca	Santuario de la Virgen de Cotoca Día de la tradición Cotoqueña Aniversario de la Virgen Romería a Cotoca, 7 y 15 de Diciembre Artesanos y Alfareros de Cotoca
Porongo	Colonial Temple Jesuítico Colonial architecture of the village of Porongo Water Falls Espejillos El Amboró Park The Resort Lagos Eco-tourism complex "Santa Lidia" Eco tourism Recreation Center "Laguna capiguara Biocentro Guembé "La rinconada"
El Torno	Parish Church "Santa Trinidad" Limoncito Lemon City "Palmira" Lagoon Waterfalls "El jardín de la Delicias" Alto Espejos "Le Mayen" Holiday Resort
La Guardia	Ivaga Guazu Ecological Park Eco Resort Laguna Azul Natural Reserve Las Garzas Laguna Tom Hackett Lomas de Arena Park. "Ivagua Guazú" Ecological Park
Warnes	Amusement Play Land Aqualand Waterpark Resort Las Lagunas Rise Festival Milk Fest

Source Elaborated based on information of each municipality

3.1.3 Market Plan

(1) Status of Supply Chain and Market Plan

Santa Cruz de la Sierra has a plan to develop the supply chain and market plan by the guidelines of the Municipal Development Plan and PLOT. Functional, sustainable and definitive municipal policies are required to solve the problems of the services and supply center. Regarding the supply chain, Municipality of Santa Cruz de la Sierra Secretariat of Planning has classified the markets into four categories; Wholesaler, District, Vicinal, and Barrios or Itinerant.

Table 3-2 Market Categorization

Categorization	Description
4th Level - Wholesaler (MAYORISTA)	The Markets which has the supply with a level of attention for all the city, and facility which is permanently authorized for the wholesale commercialization of products. One wholesale market has been built, and construction of two new wholesale markets in the north area and east area of the city is proposed. These markets are located near the arterial roads which are the entrance to the city and close to producer's towns or agroindustrial zones. Required area for a wholesale market is equal or larger than 10 ha.
3rd Level- District (DISTRITAL)	The market is established by a joint effort of the public and private sector. It is authorized for commercialization at the retail level. Decentralization of the markets in a smaller scale is proposed to serve populations of 65,000 to 70,000. These markets are located on the main road in the central part of each district, and provide their service to one or more district(s). The market will be built in 2 to 4 ha of land depending on the land availability.
2nd Level - Vicinal (VECINAL)	The market is established by a joint effort of the public and private sector. It is authorized for the commercialization at the retail level such as groceries, household furnishings, consumer goods, meals, and services. The markets cover one or more neighborhood units which have 8,000 to 10,000 inhabitants in lands of 1 ha. Currently, there are 11 neighborhood markets built in the different districts which must be technically and administratively reviewed.
1st Level - Barrios or Itinerant (BARRIAL / ITINERANTE)	Temporary market supply services to their neighborhood are called Itinerant Fair. Itinerant Fairs widespread and scattered without plans. The location of this type of fair should be difined technicaly to avoid worsening the pedestrian traffic and the access to residential areas. The markets cover 1,000 to 1,500 inhabitants and will be located within the UVs.

Source: Municipality of Santa Cruz de la Sierra

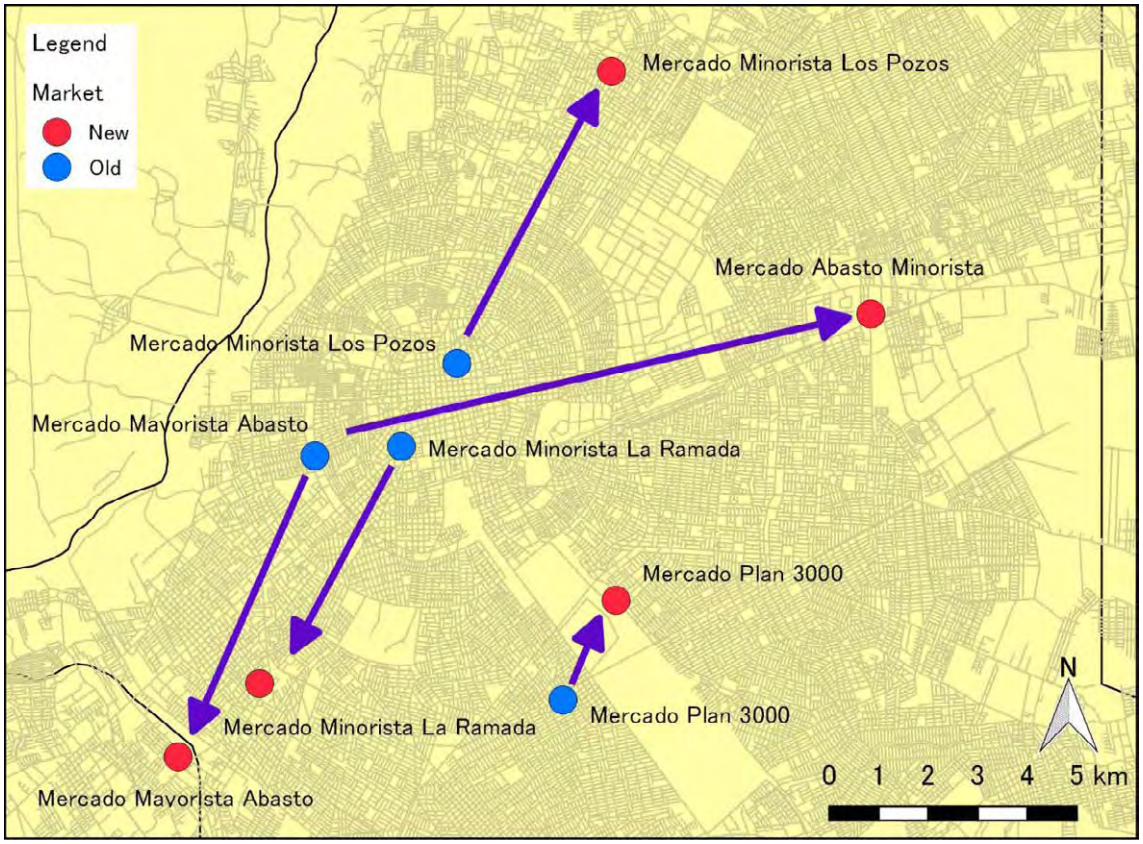
Every market exists individually, and there is no relation between them. Demand is the main factor for the market development and the location. The lack of the registration of the sellers is the weak point for controlling the market operation. The regulations at the market are only for the products, but not for building, installation, security, infrastructure, and operation. The lack of the law and the rule for the marketing operation create these situations. Some of the sellers who locate their stores in the market facility are not registered, and tax is not paid for their space and commercial activities.

(2) Market Relocation Plan

According to the Market Relocation Plan (Plan de ordenamiento y traslado de meracdos) of Municipality of Santa Cruz de la Sierra, Mercado Los Pozos, Mercad La Ramada, Mercad Plan 3000 and Mercado Adasto have a relocation plan.

Regarding Mercado Los Pozos and La Ramada, new markets provide a space temporarily or permanently to street vendors who irregularly settled their store in public spaces adjacent to the existing markets. As for Mercado Plan 3000, the new market is proposed to have a function

as a district market. Mercado Abasto will be divided into two markets; one is the wholesale market, Mercado Mavorista Abasto, which keeps the current function of the market and the other is the retail market, Mercado Abasto Minorista.



Source: Prepared by JICA Study Team based on information from Municipality of Santa Cruz de la Sierra

Figure 3-5 Market Relocation Plan

Following Figures shows the current situation of each market and location of the new markets.

Current Situation

New Location

Source: Municipality of Santa Cruz de la Sierra

Figure 3-6 Mercado Plan 3000

Current Situation

New Location (Mercado Mavorista Abasto)

Image of Mercado Abasto Minorista

New Location (Mercado Abasto Minorista)

Source: Municipality of Santa Cruz de la Sierra

Figure 3-7 Mercado Abasto

Current Situation

New Location

Source: Municipality of Santa Cruz de la Sierra

Figure 3-8 Mercado Los Pozos

Current Situation

New Location

Source: Municipality of Santa Cruz de la Sierra

Figure 3-9 Mercado La Ramada

Following items are considered for the planning of the new markets.

- Avoid traffic from a high number of buses that pass the same course by managing bus route. Traveling patterns of citizens should be considered for enables consumers to select

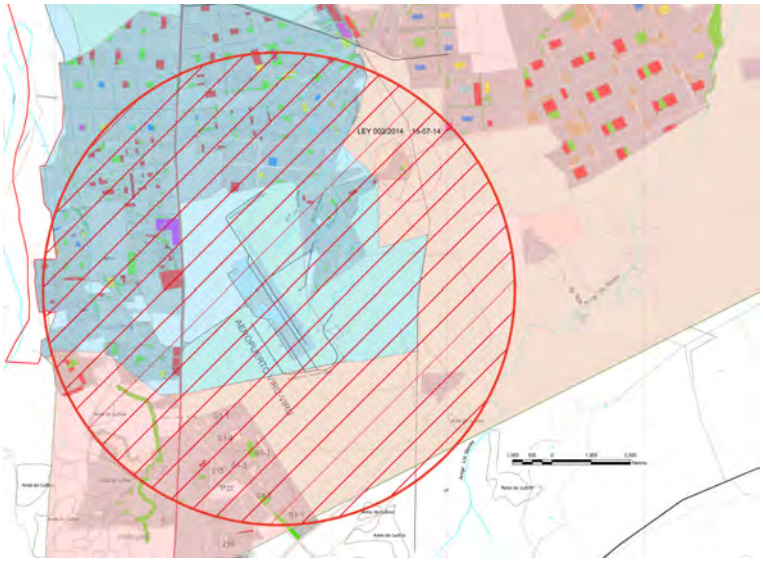
various transportation.

- Decentralization of functions to provide better services to the citizen, and create a regional supply network which is located by matching the needs of the residents' in the area and commercial qualifications.
- Regulate products offloading hours
- Prohibit both selling and retailing to the citizens at wholesale markets.
- Municipality government can make an agreement with legally established seller association, go through any procedures for supply center construction and implement the construction.
- Updated the technical standards for supply service center and service center for both private and public.

3.1.4 Other Conditions

(1) Obstacle Limitation Surfaces of Viru Viru International Airport

Viru Viru International Airport is located at 16km north of the center of Santa Cruz de la Sierra and 15km south of the center of Warnes. Although the area around the airport has not been urbanized yet, it is necessary to consider the restriction of the development in the area. Since the airport is an international airport, construction of buildings that exceed 45m is restricted within a circle of 4,000m radius. The affected area is shown in the figure below.



Note: The red circle with the red hatch is the circle with the radius of 4,000m.
Source: Elaborated on the map of Director Plan of Warnes

Figure 3-10 Circle of 4000m Radius of Viru Viru International Airport

(2) Natural Protection Area – Lomas de Arena

The Lomas de Arena is a large natural park (14,075ha) located in La Guardia near the boundary of Santa Cruz de la Sierra. The park is one of the famous tourist attraction with the rich natural environment including a desert. Department of Santa Cruz is responsible for the administration of the park. The park was established in 1991 through D.S. No. 22911 and protected from development. Recently, the urbanized area of Santa Cruz de la Sierra is expanding to the south direction close to the park.

(3) Bridge Construction over the Rio Grande near Okinawa Uno

Presently, Banegas Bridge, which is located on NH10 at the Rio Grande, is under construction with the financing of the Korean Government. The bridge will open the direct connection to Montero from the east area of Department of Santa Cruz, and provide the detour route to the center of the Metropolitan Area thorough Okinawa Uno. The improvement project of Okinawa Road will contribute to the change in the traffic movement.

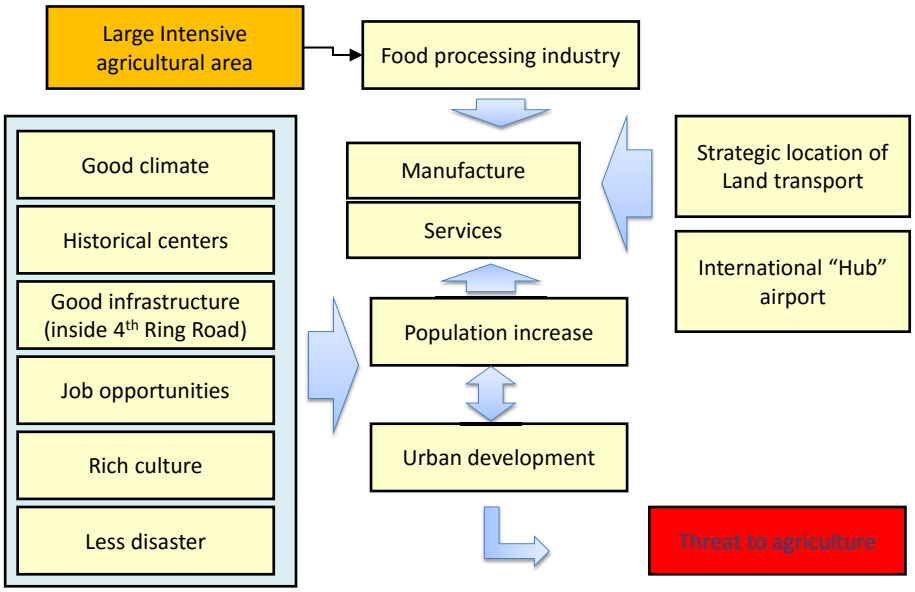
3.1.5 Summary of the Development Potential

The economy of the Metropolitan Area relies on the intensive agriculture, which promotes the food processing industry, transport services, and other economic activities to support the agricultural industry. Other than the agriculture, the Metropolitan Area has many advantages such as good climate, history, infrastructure, job opportunity, culture, and less disaster. From this, the population is increasing, and the economy is growing in the Metropolitan Area. The strategic location contributes to the growth of the Metropolitan Area. The national level projects such as bi-oceanic corridor and the hub airport project will also raise the economic position of the Metropolitan Area. Housing and industrial development are very active.

There are few negative aspects. The problem of the flood of the Pirai River and the Rio Grande has been managed recent years, and the capacity of underground water would be increased by additional investment. The public security has been improved, and the poverty problem can be solved with the economic development.

However, the threat exists because of the high development potential itself. The growth of the city will accelerate the change in land use pattern. The need for the urban activity will transform agricultural lands to urbanized areas, which will reduce the most important factor of the development potential.

Figure 3-11 illustrates this relation of the development potential and the threat.



Source: JICA Study Team

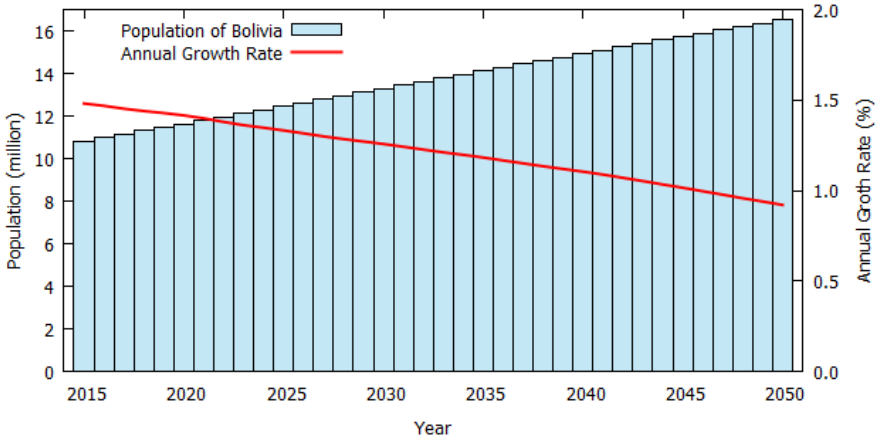
Figure 3-11 Summary of Development Potential in the Metropolitan Area

3.2 Socio-economic Framework

3.2.1 Population

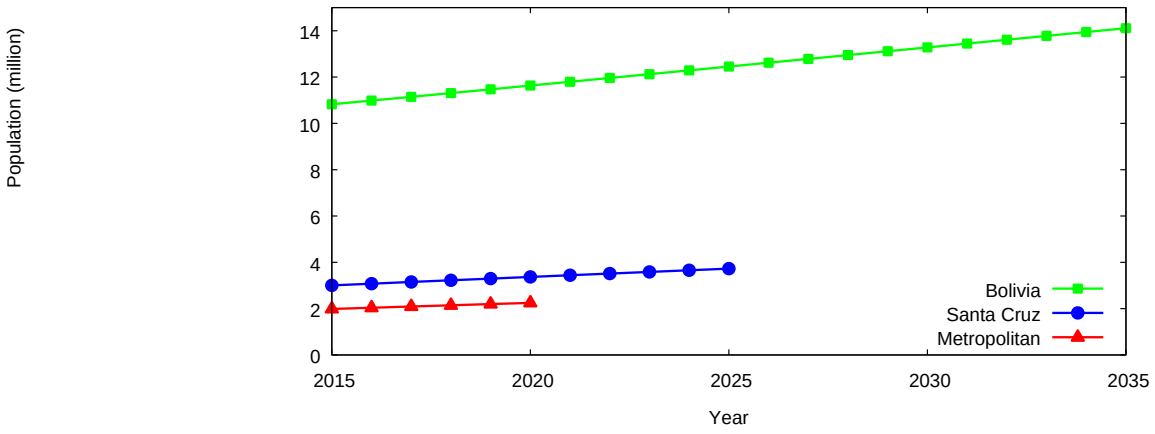
(1) Review of Projection by INE

The National Institute of Statistics of Bolivia (INE) projected future population of Bolivia up to 2050, in which the population in 2025 and 2035 is projected at 12.5 million and 14.1 million, respectively. INE also projects future population by department, but the projection is up to 2025, in which the population of the Department of Santa Cruz in 2025 is projected at 3.73 million. For the population projection at the municipal level, INE provides the projection only up to 2020.



Source: Elaborated based on the data of INE

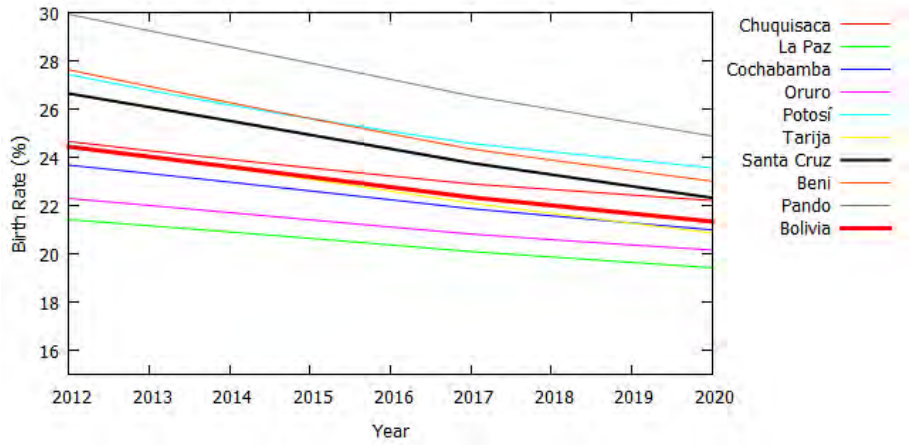
Figure 3-12 Projection of Population of Bolivia up to 2050 by INE



Source: Elaborated based on the data of INE

Figure 3-13 Population Projections by INE

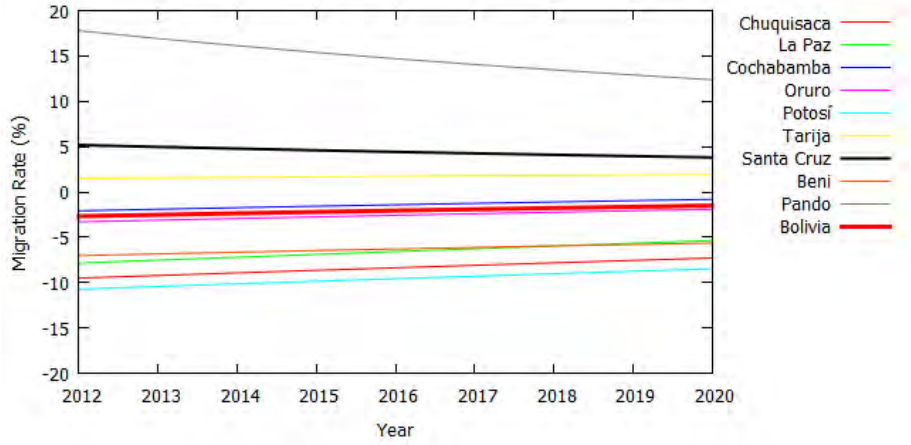
The projection of the birth rate in the Department of Santa Cruz is slightly higher than that of Bolivia as shown the table below. The Pando Department, which shows the highest birth rate, is a small department with the lowest population of 110,436 (2012 Census).



Source: Elaborated based on the data of INE

Figure 3-14 Birth Rate Projection by Department

The Department of Santa Cruz attracts migration from other departments and countries (the migration rates of both domestic and international are positive). As shown in the figure, it is projected that migration rate of Bolivia continues to be negative at least 2020 (the number of migration from Bolivia is larger than the number of migration to Bolivia from foreign countries). On the other hand, it is projected that the Department of Santa Cruz will have positive migration rates.

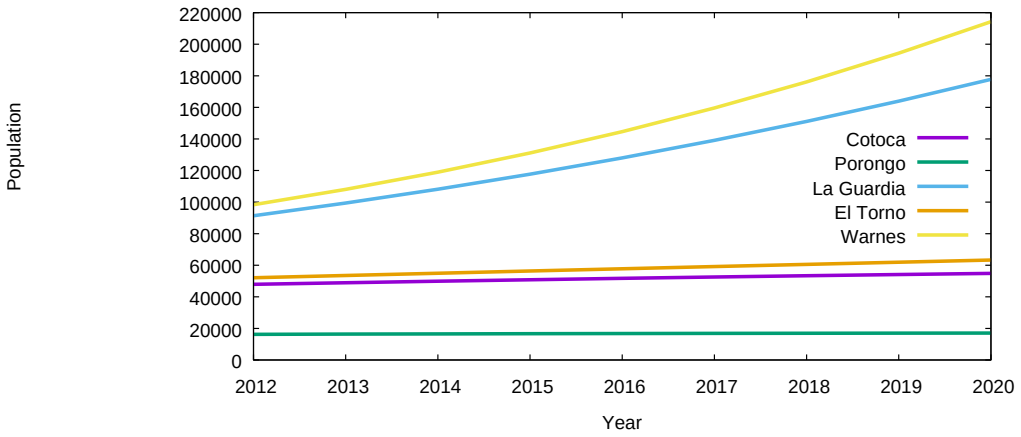


Note: "Migration" = Incoming migration – outgoing migration. It includes both domestic and international migrations.

Source: Elaborated based on the data of INE

Figure 3-15 Migration Rate Projection by Department

INE estimated the future population by municipality only up to 2020 as shown in Figure 3-16. The increase rate of the population of Warnes and La Guardia is higher than other municipalities. Although the methodology of the projection is not known, this might reflect the rapid increase in the population of Warnes and La Guardia from 2001 (previous census) to 2012. The projection might be just based on some polynomial functions because the curve matches the functions very well. Since many urbanizations are observed in Cotoca and Porongo recently, the population of municipalities in 2020 would be different from the projection by INE.



Source: Elaborated based on the data of INE

Figure 3-16 Projection of Population by Municipality from 2012 to 2020 (INE)

(2) Projection

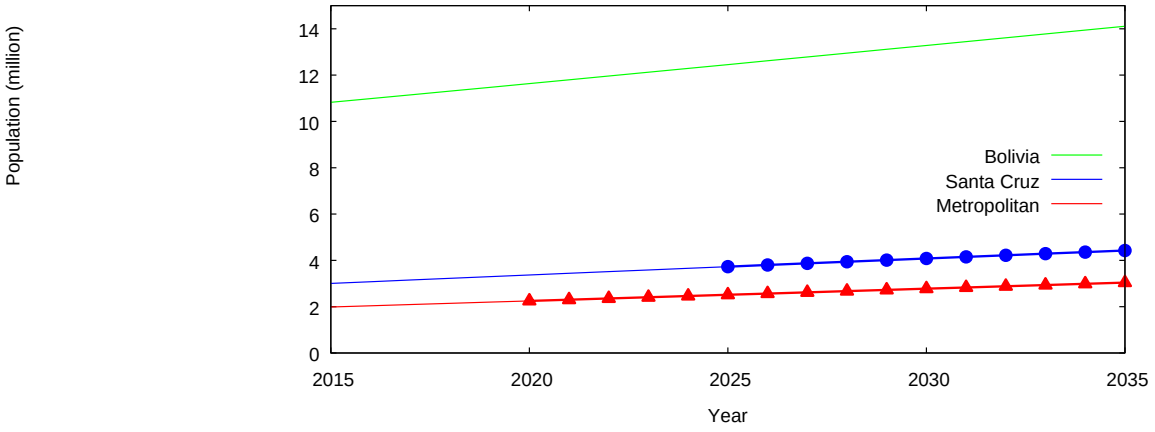
As analyzed above, the population projection by INE is very conservative and rational except for the projection of each municipality, although it does not consider the possibility of strong economic development in the Metropolitan Area. The Project applies the projection of the population of the Department of Santa Cruz by INE up to 2025. Also, it is assumed that the increase continue the same trend as the projection by INE. Table 3-3 shows the result of the projection. The population in the Metropolitan Area is estimated to increase by approximately 1 million by 2035.

Table 3-3 Population Projection of the Metropolitan Area

Year	2015	2020	2025	2030	2035
Bolivia	10,825,013	11,633,371	12,454,178	13,280,632	14,110,019
Santa Cruz Department	3,004,951	3,370,059	3,729,404	4,097,063	4,480,610
%to Bolivia	27.8	29.0	29.9	30.8	31.8
Metropolitan	1,986,855	2,249,657	2,513,800	2,788,055	3,077,969
%to Department	66.1	66.8	67.4	68.1	68.7

Source: INE (Bolivia, Department of Santa Cruz up to 2025, and Metropolitan up to 2020) and the projection by JICA Study Team

Figure 3-17 shows the chart of the population projection.



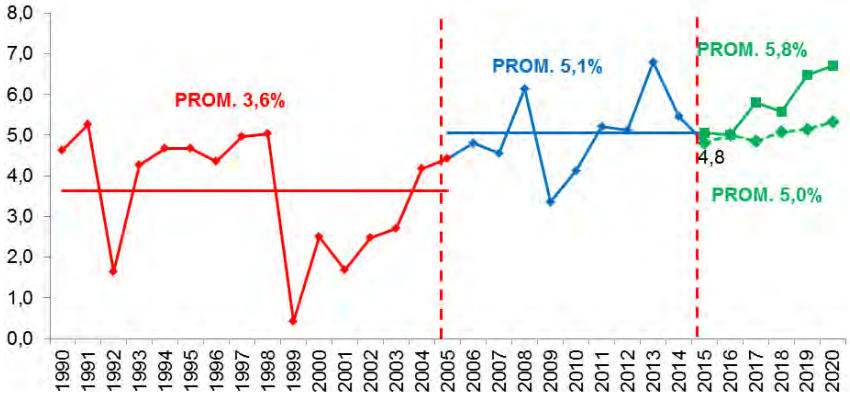
Source: JICA Study Team

Figure 3-17 Population Projection

3.2.2 GDP

(1) GDP Growth Rate

The Economic and Social Development Plan 2016-2020 (PDES) assumed that the GDP growth rates during the period of 2016-2020 as 5.8% in average. It also considers the lower case of the annual GDP growth rate at 5.0%. There is no official assumption on the GDP growth rates for the long-term period until 2035. As shown in Figure 3-18, Bolivia has experienced high economic growth in last ten years, although it was not as high as those recorded in Asian counties in the same periods. Expecting such high growth rate, 7% for example, for 15 years (2020-2035) is optimistic considering unpredictable economic conditions in the world. From this, the GDP growth rate for the project period is assumed at 5% per year. Although the GDP growth rate in the Metropolitan Area would be higher than the growth rate in Bolivia, the same growth rate is assumed due to unpredictable nature of the economy.

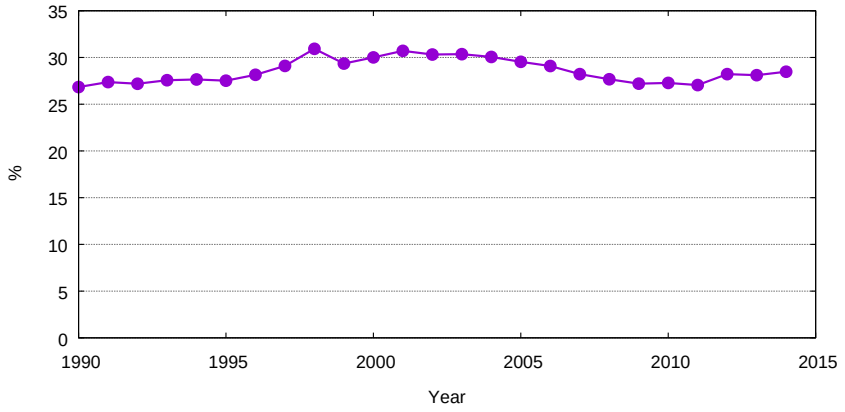


Source: Economic and Social Development Plan 2016-2020

Figure 3-18 GDP Growth Rates of Bolivia

(2) Regional GDP

The proportion of the regional GDP of the Department of Santa Cruz is approximately 30% for long years as shown in Figure 3-19, although there have been fluctuations. The proportion decreased gradually in the 2000s and dropped to 27.05% in 2011, although the proportion increased slightly from 2011. The proportion in 2014 is estimated at 28.48% by INE. From the past trend of the proportion, it is assumed that the proportion of GDP of the Department of Santa Cruz continue to be 30% until 2033.



Source: Elaborated based on the data of INE

Figure 3-19 Proportion of GDP of the Department of Santa Cruz to Bolivia

(3) GDP per Capita

Bolivia's GDP per Capita in 2014 was USD 3,124. Applying the assumption on the GDP growth rate of 5% and the future population in Bolivia, GDP per Capita of Bolivia in future was estimated as shown in Table 3-4.

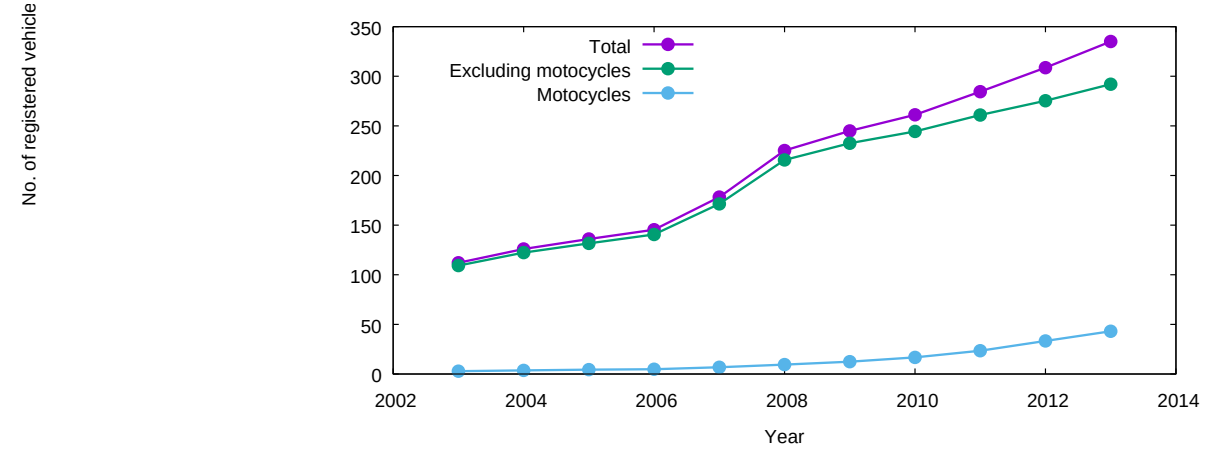
Table 3-4 Projection of GDP per Capita

		2014	2020	2025	2030	2035
GDP	(2014=1.0)	1.00	1.34	1.71	2.18	2.79
Population	(2014=1.0)	1.00	1.09	1.17	1.25	1.32
GDP per Capita	(2014=1.0)	1.00	1.23	1.46	1.75	2.11
	(USD)	3,124	3,838	4,576	5,477	6,579

Source: JICA Study Team

3.2.3 Vehicles

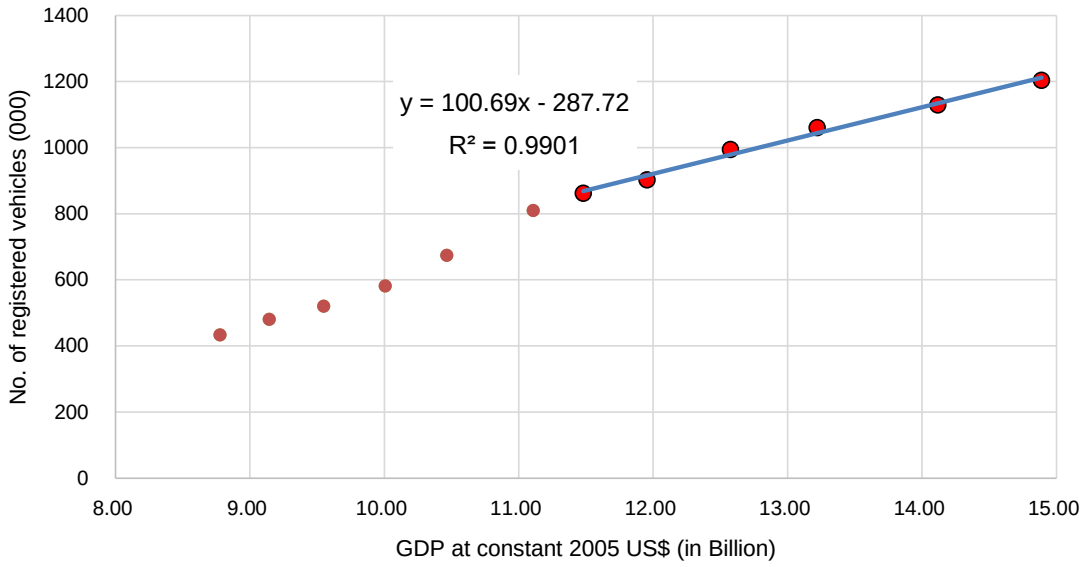
The number of motor vehicles per 1000 people of the Metropolitan Area in 2012 is calculated at 150.5 based on the statistics of INE. Motorcycles are excluded in this calculation. This is higher than the rate of Bolivia (102.5) and the Department of Santa Cruz (113.2). Figure 3-20 shows the number of registered vehicles in the Metropolitan Area from 2003. There was a sharp increase from 2006 to 2008, and the number has increased at an average growth rate of 8.27% per year. Recently, the number of motorcycles is increasing higher rate than other vehicles.



Source: Elaborated by the JICA Study Team based on the statistics of INE

Figure 3-20 No. of Registered Vehicles in the Metropolitan Area

If this rate continues until 2035, the number will reach 1,678,100 vehicles, which means 545 vehicles per 1,000 population. This is not an unrealistic number because it is still lower than that of many developed countries. Since the number of registered vehicles in Bolivia has a good correlation with GDP at constant prices as shown in Figure 3-21, its projection was made by using the regression analysis.



Note: Motorcycles are excluded.
Source: JICA Study Team (GDP: Worldbank database, No. of registered vehicles: INE)

Figure 3-21 Correlation between No. of Registered Vehicles (Bolivia) and GDP

The number of registered vehicles in the Metropolitan Area in future was estimated from that of Bolivia, assuming that the increase rate is the same as shown Table 3-5.

Table 3-5 Projection of No. of Registered Vehicles

	2012	2015	2020	2025	2030	2035
Boliva (000)	1,061	1,268	1,721	2,276	2,985	3,889
(per 1000 persons)	102	117	148	183	225	276
Metropolitan (000)	275	328	445	589	772	1,006
(per 1000 persons)	151	165	198	234	277	327

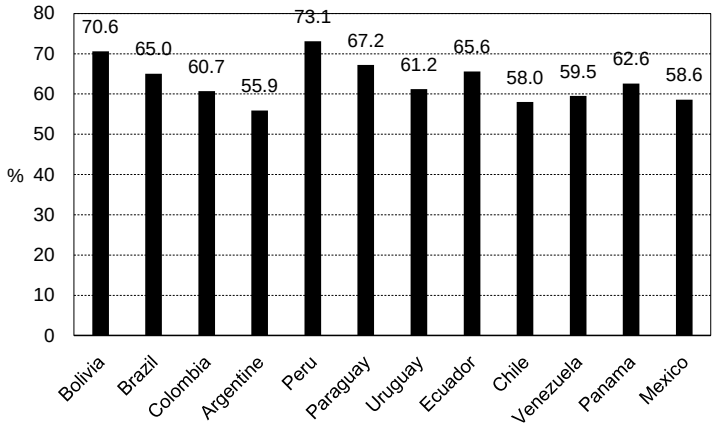
Note: Motorcycles are excluded.
Source: Estimated by JICA Study Team

3.2.4 Employment

The economically active population of Bolivia accounts for 59.5% of the population of work age[3] (Población en Edad de Trabajar: PET), while that of Department of Santa Cruz is 59.2% in the 2012 census. In case of the Metropolitan Area, it is calculated at 59.4%. According to the definition of INE, the population of non-work age (Población en Edad de No Trabajar: PENT) means the population under ten years old. The percentage of the economically active population to the total population changes based on various factors. If enrolment rate increases or income level becomes higher than the present level, the proportion of workers in the age group of children will decrease. As the proportion of old age group such as over 65 increases, it also decreases. On the other hand, the reduction in the unemployment rate will increase the percentage.

Figure 3-22 shows a comparison of the percentages of employment of countries in Latin America. Although the definition of the percentage (population of 15 years and more) is different from that mentioned above, Bolivia shows the high percentage of the employment rate.

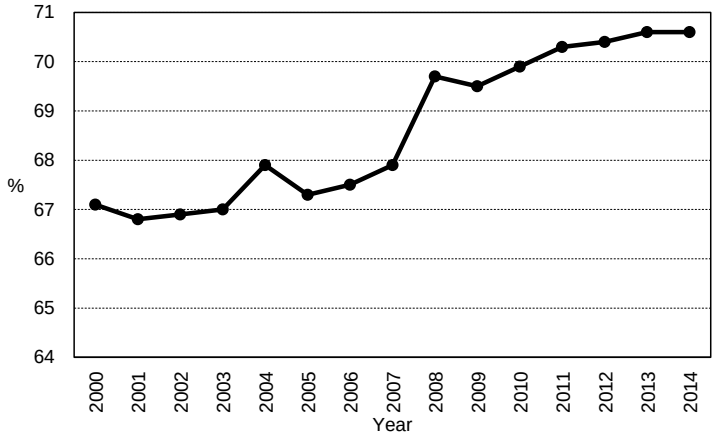
[3] This excludes population living in foreign countries



Source: Elaborated based on the World Bank database

Figure 3-22 % of Employment to Population (>15 years) in Latin America (2014)

The employment rate had increased in Bolivia as shown in Figure 3-23 in the 2000s, but the increase has been small in 2010s. The high level of the employment rate will continue owing to the improvement of the national economy. However, as the retired population increases, the rate will decrease as other countries in future, and the increase in enrollment to school in young ages will also contribute to the decrease. From these circumstances, the percentage of the economically active population is assumed to be the same as that of the 2012 census. Since the population projection by age group is not made, it is also assumed that the economically active population to the total population would be the same.



Source: Elaborated based on the World Bank database

Figure 3-23 % of Employment to Population (>15 years) of Bolivia, 2000-2014

Table 3-6 shows the projection of the economically active population in the Metropolitan Area. It is assumed that the proportion of the number of the economically active population to the total population is the same in future.

Table 3-6 Projection of Economically Active Population in the Metropolitan Area

	2012	2015	2020	2025	2030	2035
Employment	825,954	897,023	1,015,672	1,134,927	1,258,747	1,389,637
Population	1,829,442	1,986,855	2,249,657	2,513,800	2,788,055	3,077,969

Source: JICA Study Team (Population of 2012-2020 is INE's projection.)

3.3 Development Scenarios

3.3.1 Scenario Setting

(1) Objective

The Strategic Environment Analysis (SEA) requires analyses of alternatives including "zero option" to minimize the negative impact on the environment. On the other hand, the analysis of several scenarios is one of the fundamental tasks in a transportation planning process. Before to proceed the analysis on options of transport policy, a development scenario, which represents the regional structure in future and the strategic way to achieve it, was selected.

It is necessary to establish the objective of the analysis to prepare the alternatives. The analysis of the present conditions in Chapter 2 clarified that the following problems would occur in future if no actions are taken place for the urban expansion with low-density developments.

- Lack of arterial roads and difficulty of construction of new roads
- Poor accessibility to local community due to lack of proper road network
- Delay of pavement due to many local streets
- Poor transport services due to low-density urban structure
- Increase in energy consumption due to many private cars and small public transport vehicles

The objective of the alternative analysis was established based on the problems as:

- To reduce the negative impacts caused by the expansion of low-density urbanized areas.
- To protect and promote the agricultural industry in the Metropolitan Area.

The contents of "the negative impacts" are described above as the problems. Although there might be other approaches to the alternative analysis, it was concluded that solving the urban development problems caused by the low-density development would be the most important issue in the Metropolitan Area.

(2) Background

As shown in Chapter 2-3, the urbanized area has expanded to the suburban area at low density. This trend continues. Recently, many urban developments have been approved, and most of the plots are sold out quickly even if the lands have not been fully developed. The success of the real estate sector has induced larger developments in the Metropolitan Area. Figure 3-25 shows existing urbanized areas (orange color) and the future development areas (yellow) that were already approved. Almost all the plots in the yellow areas are empty at the moment. It is calculated the total area amounts to 316km^2, which can accommodate 1.1 million population with a density of 3,480 inhabitants/km^2. Since the population in the Metropolitan Area is projected to increase 1.1 million until 2035, it can be concluded that there is no need to develop the residential areas. However, due to the strong appetite of the private sector for the investment on urbanizations, the approved areas would further expand in future.

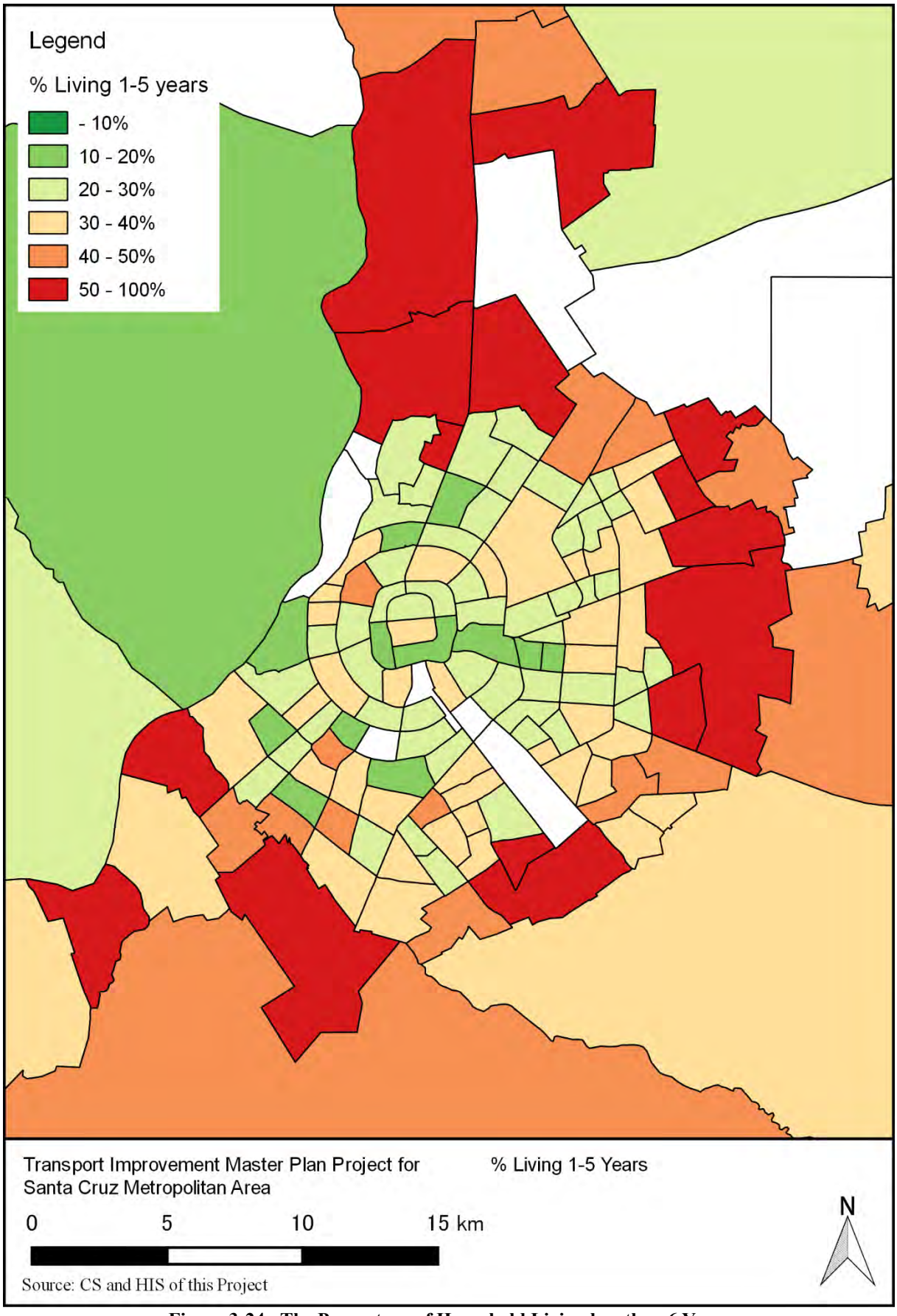
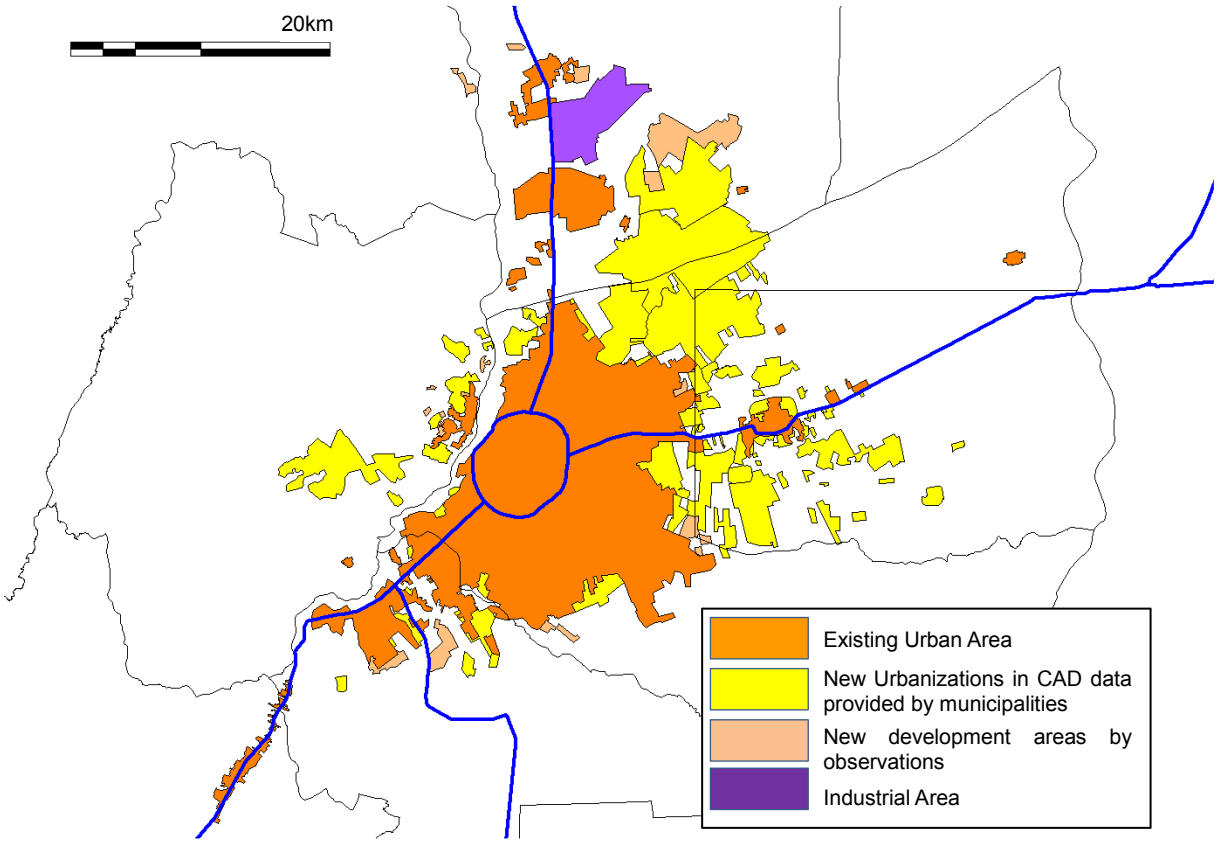


Figure 3-24 The Percentage of Household Living less than 6 Years



Source: Elaborated based on CAD data provided by municipalities

Figure 3-25 Suburban Development

(3) Possible Alternatives

Several alternatives will satisfy the objective, including unrealistic ones. For example, stopping immigration to the Metropolitan Area can contribute to stagnating the urban expansion, but this is an unrealistic alternative. Possible alternatives should accept the increase in population. From this, densification is necessary, and the following scenarios are considered as the possible alternatives to achieve the objective.

- To restrict new urbanizations
- To discourage developments in approved urbanizations that have not been populated, by not providing public services and infrastructure
- To develop or redevelop existing urbanized area in Santa Cruz de la Sierra
- To densify the centers of municipalities
- To develop a new town(s) with the proper density
- To cancel the approval of existing urbanizations that have not been developed

In addition to the alternatives of the land use, the following alternatives can contribute to the objective.

- Construction of arterial roads and improvement of streets in existing urbanized area to encourage the densification and discourage the development in suburban area
- Development of public transport system to encourage the modal shift from private to public mode

Development scenarios are prepared based on the alternatives above.

(4) Preparation of Development Scenario

The development scenarios by the alternatives of the urban structure were prepared as:

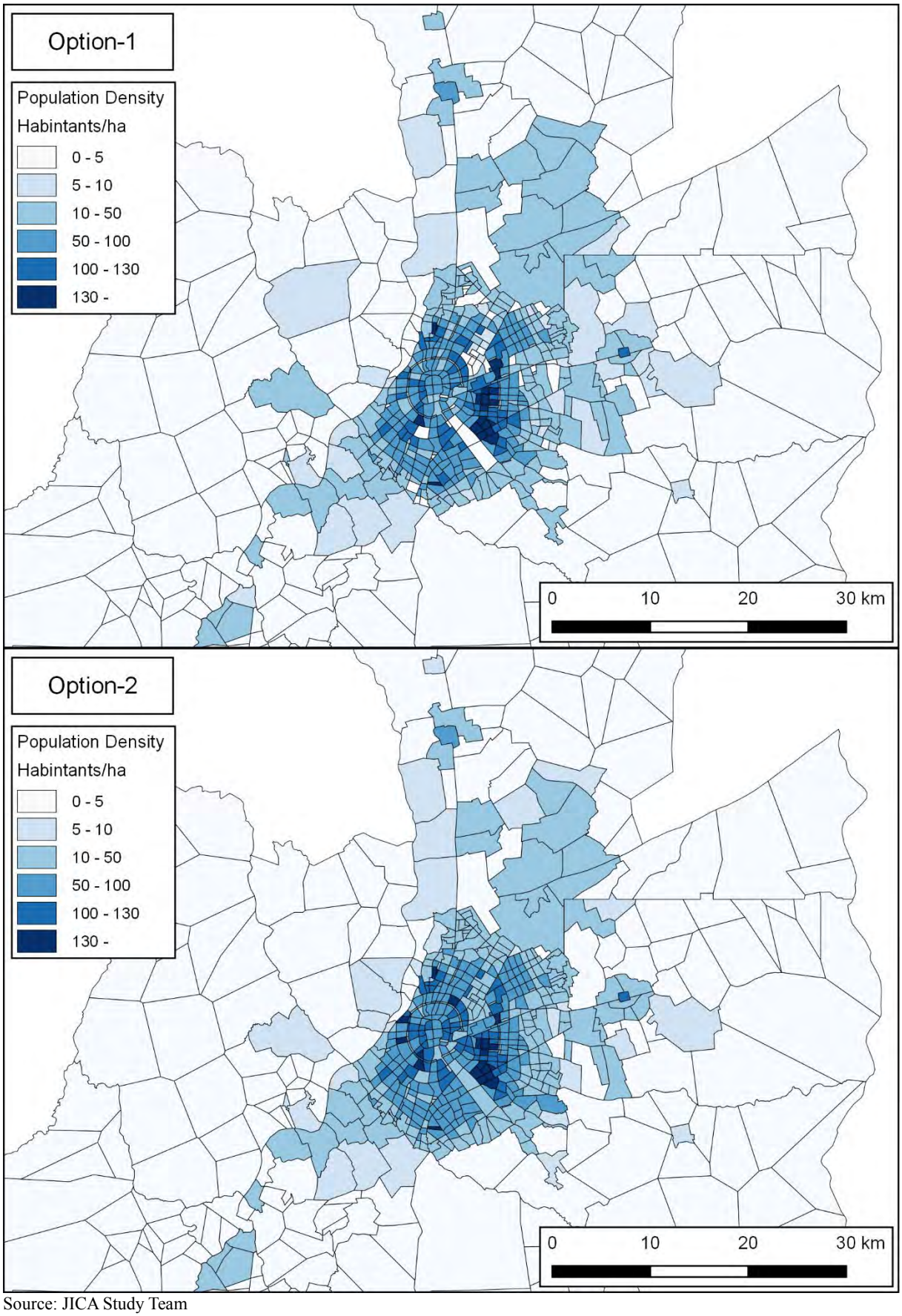
- Trend Expansion
- Controlled Expansion
- Densification of the Existing Urbanized Area
- Subcenter Development

The characteristics of these alternatives are summarized in Table 3-7.

Table 3-7 Alternatives of Urban Structure

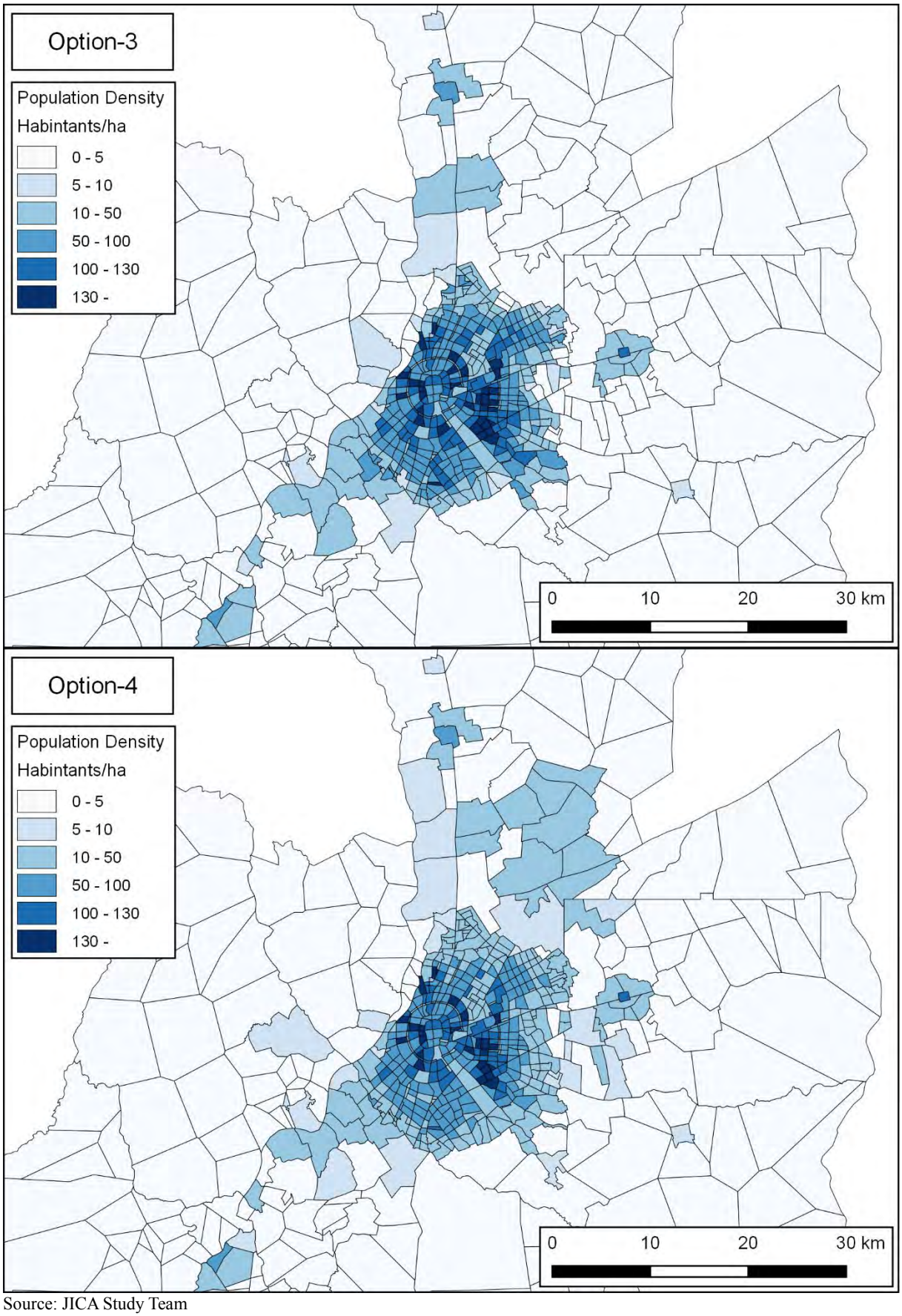
Alternatives	Characteristics
Trend Expansion	• The present trend of sprawl development will continue. • The urban expansion with low-density development will continue. • Urbanizations will be approved as far as the plan satisfies regulations. • Municipal land use plans will be formulated taking into account of private sector development.
Controlled Expansion	• The further expansion of urbanized area is restricted to already developed areas. • New urbanizations will be restricted in principle. Construction will be only allowed in existing urbanizations. • Public services and infrastructure in some parts of urbanizations will be suspended to discourage housing. • Municipal land use plans will be formulated to control the urban development.
Densification of the Existing Urbanized Area	• The urban area will be shrunk to the area of already urbanized area • Existing urbanized area will be densified to accommodate the future population.
Subcenter Development	• The urban area of the center of the Metropolitan Area will be shrunk to the area of already urbanized area • Subcenters will be developed to accommodate the future population.

Source: JICA Study Team



Source: JICA Study Team

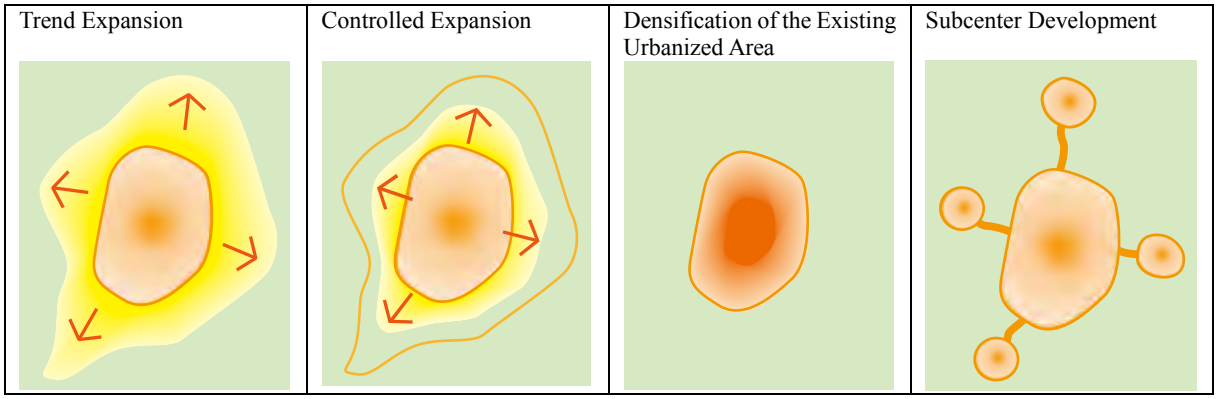
Figure 3-26 Population Density of Option-1 & Option-2



Source: JICA Study Team

Figure 3-27 Population Density of Option-3 & Option-4

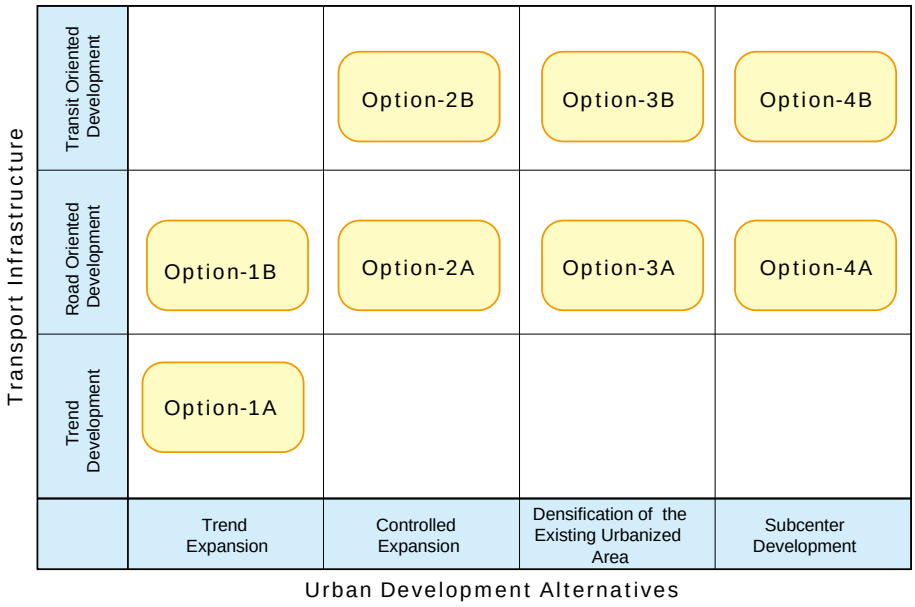
The image of these alternatives is shown in Figure 3-28.



Source: JICA Study Team

Figure 3-28 Image of Alternatives

For each alternative, two options were prepared such as road oriented development and transit-oriented development, except for the Trend Expansion, which has trend development option as the "Zero Option" and road oriented development option. In case of Trend Expansion, the transit-oriented development option is not considered because the option aims to change the urban structure. The trend development option means that there would be no policy change in the development of transport infrastructure.



The contents of each option are summarized as following tables.

Table 3-8 Development Scenario - Optoin-1A

Option Name	Zero option
Urban development policy	Urban developments by the private sector will be approved as far as they satisfy the existing regulations.
Urban structure	Low-density area will expand, and the urban sprawl will continue. The urbanized area of Santa Cruz de la Sierra expands beyond the boundary of the municipality.
Public Transport	Continue the present status. Public transport routes are proposed by local communities or private sectors, and the authorities approve as far as the proposal satisfies the existing regulations.
Road Infrastructure	The pavement in existing communities and new development area is the major infrastructure development. Improvements to intersections and signalization will continue.
Forecast	Private cars will be major transport modes in new urbanized areas, and small size transit systems such as motorbikes continue to play an important role as the public transport system in low-density development areas.
Environment	Increase in the urbanized area will cause negative environmental impacts such as loss of forest and green areas. Also, increase in private vehicles and small size public transport system will increase air pollution.

Source: JICA Study Team

Table 3-9 Development Scenario - Option-1B

Option name	Trend development with arterial roads
Urban development policy	[same as option-1A]
Urban structure	[same as option-1A]
Public Transport	Although the policy is as same as Option-1A, more public transport services connecting urbanizations in suburban areas and the center of the Metropolitan Area will be provided because of the arterial road development. However, public transport services in local streets will remain poor due to the delay of pavement.
Road Infrastructure	Arterial roads are constructed to improve the accessibility to new urbanized areas and existing communities where the arterial road network is insufficient.
Forecast	Construction of arterial roads will improve traffic accessibility except for unpaved area. However, other conditions will be the same as Option-1A (Zero Option)
Environment	Increase in urbanized areas will cause negative environmental impacts. Also, increase in private vehicles and small size public transport system will increase air pollution. Land acquisition problem will occur.

Source: JICA Study Team

Table 3-10 Development Scenario - Option-2A

Option name	Controlled urban development
Urban development policy	The urban expansion will be managed to avoid urban sprawl problem. New urbanization will be restricted, but the development in present urbanizations will continue as far as they are the part of the desirable urban area.
Urban structure	The urbanized area will expand, but the area will be smaller than that of Option-1. The population density will be higher than that of Option-1, but it will be still low.
Public transport	Public transport routes are proposed by local communities or private sectors, and the authorities approve as far as the proposals satisfy the existing regulations. However, the public transport system in the urbanizations that are not included in the controlled area will not be allowed. The level of public transport services in communities will be better than that of Option-1.
Infrastructure	Arterial roads are constructed to improve the accessibility to new urbanized areas and existing communities where the arterial road network is insufficient. Also, pavement in existing communities and new development area will continue to attract people to the controlled area. Improvements to intersections and signalization will continue. Road conditions in communities are better than Option-1.
Forecast	The decrease in population density will be avoided, but the present low density will continue even if the population will increase because the already developed or approved urbanization is large enough to accommodate the future population. Traffic situation will be deteriorated with more heavy congestions and poor public transport services.
Environment	The further loss of forest, agricultural area, and the green area can be avoided. Air

	contamination caused by vehicles will be the same as Option-1.

Source: JICA Study Team

Table 3-11 Development Scenario - Option-2B

Option-2B	Controlled urban development with transit development
Urban development policy	The urban expansion will be managed to avoid urban sprawl problem. New urbanization will be restricted, but the development in present urbanizations will continue as far as they are the part of the desirable urban area. Some urbanizations will be abandoned.
Urban structure	The urbanized area will expand, but the area will be smaller than that of Option-1. The population density will be higher than that of Option-1, but it will be still low.
Public transport	Modal shift from private cars to public transport systems will be enhanced. Public transport system will be improved by replacing vehicles, reorganizing routes, and increasing the capacity. As a variation of this option, an introduction of mass transit systems can be considered.
Infrastructure	The pavement in existing communities and new development area is the major infrastructure development. Improvements to intersections and signalization will continue.
Forecast	The decrease in population density will be avoided, but the present low density will continue even if the population will increase. However, there will be densified areas where public transport services are improved. Traffic situation will be improved by public transport development, although congestion will remain due to increase in private vehicles.
Environment	The further loss of forest, agricultural area, and the green area can be avoided. Air pollution caused by transport sector will be reduced compared to Option-2A. Workers in public transport sector will be affected.

Source: JICA Study Team

Table 3-12 Development Scenario - Option-3A

Option name	Densification of the existing urbanized area
Urban development policy	The urban expansion will be suspended. New urbanized development will be restricted, and new development will be constrained whiting existing urbanized area. Some urbanizations will be abandoned.
Urban structure	The present urban structure will continue by shrinking new developed areas which have not been populated yet.
Public transport	The policy on the public transport is as same as Option-1A (Zero Option). However, public transport routes to some urbanizations which should be abandoned are not allowed.
Infrastructure	Road infrastructure will concentrate on existing urbanized area. Pavement, widening, improvement of intersection and construction of flyovers will be the major investment on transport infrastructure.
Forecast	Population density will increase in existing urbanized area. Car ownership will increase according to the economic growth, although the frequency of public transport will increase which will improve public transport service but cause more congestion in the center of the city. Strong regulation of the urban development will be necessary.
Environment	The further loss of forest, agricultural area, and the green area can be avoided. The scenario requires restriction of the right of landowners who have purchased the area which is defined as the non-urbanized area in this scenario. Air contamination will concentrate on existing urbanized area, although the decrease in air pollution from private cars is expected.

Source: JICA Study Team

Table 3-13 Development Scenario - Option-3B

Option name	Densification of the existing urbanized area with transit development
Urban development policy	[same as option-3A]
Urban structure	The size of the urbanized area will be the same as the present one. Some public transport corridor will be formed.
Transport policy	Modal shift from private cars to public transport systems will be enhanced. Public transport system will be improved by replacing vehicles, reorganizing routes, and increasing the capacity.
Infrastructure	Road infrastructure will concentrate on existing urbanized area. Pavement, widening, improvement of intersections, and construction of flyovers will be done although the investment will focus on the improvement of the public transport system.

Forecast	Population density will increase in existing urbanized area. Car ownership will increase according to the economic growth, although the share of public transport will increase because of the improvement of the public transport system. High population density will improve transit public transport business.
Environment	The further loss of forest, agricultural area, and the green area can be avoided. The scenario requires restriction of the right of landowners who have purchased the area which is defined as the non-urbanized area in this scenario. Air pollution will decrease.

Source: JICA Study Team

Table 3-14 Development Scenario - Optoin-4A

Option-4A	Sub center development
Urban development policy	Instead of expanding the urbanized area, subcenters will be developed. New urbanizations will be restricted, and most urbanizations which have not been urbanized will be abandoned.
Urban structure	The subcenters will be connected with the urban area of Santa Cruz de la Sierra.
Public transport	Inter-municipal bus routes will connect the subcenters and the center of the city, although the institutional mechanism at present will continue.
Infrastructure	Road infrastructure will concentrate on existing urbanized area and the subcenters.
Forecast	Urban sprawl problems such as poor infrastructure will not take place, although strong urban regulations will be required. The concentration of bus routes in the center of the city will cause the traffic congestion like the present situation.
Environment	The further loss of forest, agricultural area, and the green area can be avoided. The scenario requires restriction of the right of landowners who have purchased the area which is defined as the non-urbanized area in this scenario. Air pollution will be less than Option 2A.

Source: JICA Study Team

Table 3-15 Development Scenario - Option-4B

Option-4B	Subcenter development with transit corridors
Urban development policy	Instead of expanding the urbanized area, subcenters will be developed. New urbanizations will be restricted, and most urbanizations which have not been urbanized will be abandoned.
Urban structure	The subcenters will be connected with the urban area of Santa Cruz de la Sierra.
Public transport	Subcenters will be connected to the center of the city with mass transit systems, and urban transit systems will serve the central area.
Infrastructure	Road infrastructure will concentrate on existing urbanized area and the subcenters.
Forecast	Urban sprawl problems such as poor infrastructure will not take place, although strong urban regulations will be required. Mass transit systems and urban transport systems will cause the modal shift from private cars to public transport systems. Also, the introduction of large transport systems will reduce the traffic congestion in the center of the city.
Environment	The further loss of forest, agricultural area, and the green area can be avoided. The scenario requires restriction of the right of landowners who have purchased the area which is defined as the non-urbanized area in this scenario. Air condition will be improved.

Source: JICA Study Team

3.3.2 Comparison of Development Scenarios

(1) Environmental Impacts

Since the analysis is a strategic stage and detail plan is not formulated for each scenario, measurable indicators are not calculated. Instead, each option is evaluated by five ranks from 1 to 5. The rank 5 means the worst impact among the options. The rank 1 is the least negative impact, although this does not necessarily mean "the most positive". Table 3-16 shows the comparison of the environmental impacts.

Table 3-16 Comparison of Environmental Impacts

	Loss of green	Water contamination	Green House Gas/ Air pollution	Social Impacts
Option-1A	■■■■■ 5	■■■■■ 5	■■■■■ 5	■■ 2
Option-1B	■■■■■ 5	■■■■■ 5	■■■■■ 5	■■ 2
Option-2A	■■■■ 4	■■■■ 4	■■■■ 4	■■■ 3
Option-2B	■■■■ 4	■■■■ 4	■■■ 3	■■■■ 4
Option-3A	■■ 2	■■■ 3	■■■■ 4	■■■■ 4
Option-3B	■■ 2	■■■ 3	■■ 2	■■■■■ 5
Option-4A	■■■ 3	■■■ 3	■■■■ 4	■■■■ 4
Option-4B	■■■ 3	■■■ 3	■■ 2	■■■■■ 5

Source: JICA Study Team

The more compact, the less negative impact on the natural environment. It is assumed that the more compact the populated area becomes, the less the vehicle kilometers become. Since the development of public transport system often causes employment problems of existing bus operators, higher scores are given to the options of the transit-oriented development. Option-3 and Option-4 would bring social problem because of the concentration of infrastructure investment in exiting areas.

(2) Traffic Impacts

Each option would bring different traffic impacts such as traffic congestion, safety, accessibility, mobility, and so on. In case of traffic safety, the difference by option is very small. Each option was evaluated by five ranks whose definition is the same as mentioned above. Table 3-17 shows the result of the evaluation.

Table 3-17 Comparison of Traffic Impacts

	Congestion in the center of the Metropolitan Area	Accessibility to local communities	Mobility on arterial roads	Traffic Safety
Option-1A	■■■■■ 5	■■■■■ 5	■■■■■ 5	■■■■■ 5
Option-1B	■■■■■ 5	■■■■■ 5	■■■■■ 5	■■■■■ 5
Option-2A	■■■■■ 5	■■■■ 4	■■■■■ 5	■■■■■ 5
Option-2B	■■■■ 4	■■■■ 4	■■■■ 4	■■■■■ 5
Option-3A	■■■■■ 5	■■■ 3	■■■■ 4	■■■■ 4
Option-3B	■■■■ 4	■■■ 3	■■■ 3	■■■■■ 5
Option-4A	■■■■ 4	■■■ 3	■■■■ 4	■■■■ 4
Option-4B	■■■ 3	■■■ 3	■■■ 3	■■■■■ 5

Source: JICA Study Team

The negative traffic impacts are caused by vehicles. The more the number of vehicles, the more the traffic congestion. It is assumed that the car ownership in compact cases is lower than that of low-density cases, although the congestion in the center of the Metropolitan Area

would be almost the same in most cases unless the policy of the modal share is applied. The compact urban structure enables the concentration of the investment on road development and pavement, which improves the accessibility to local communities.

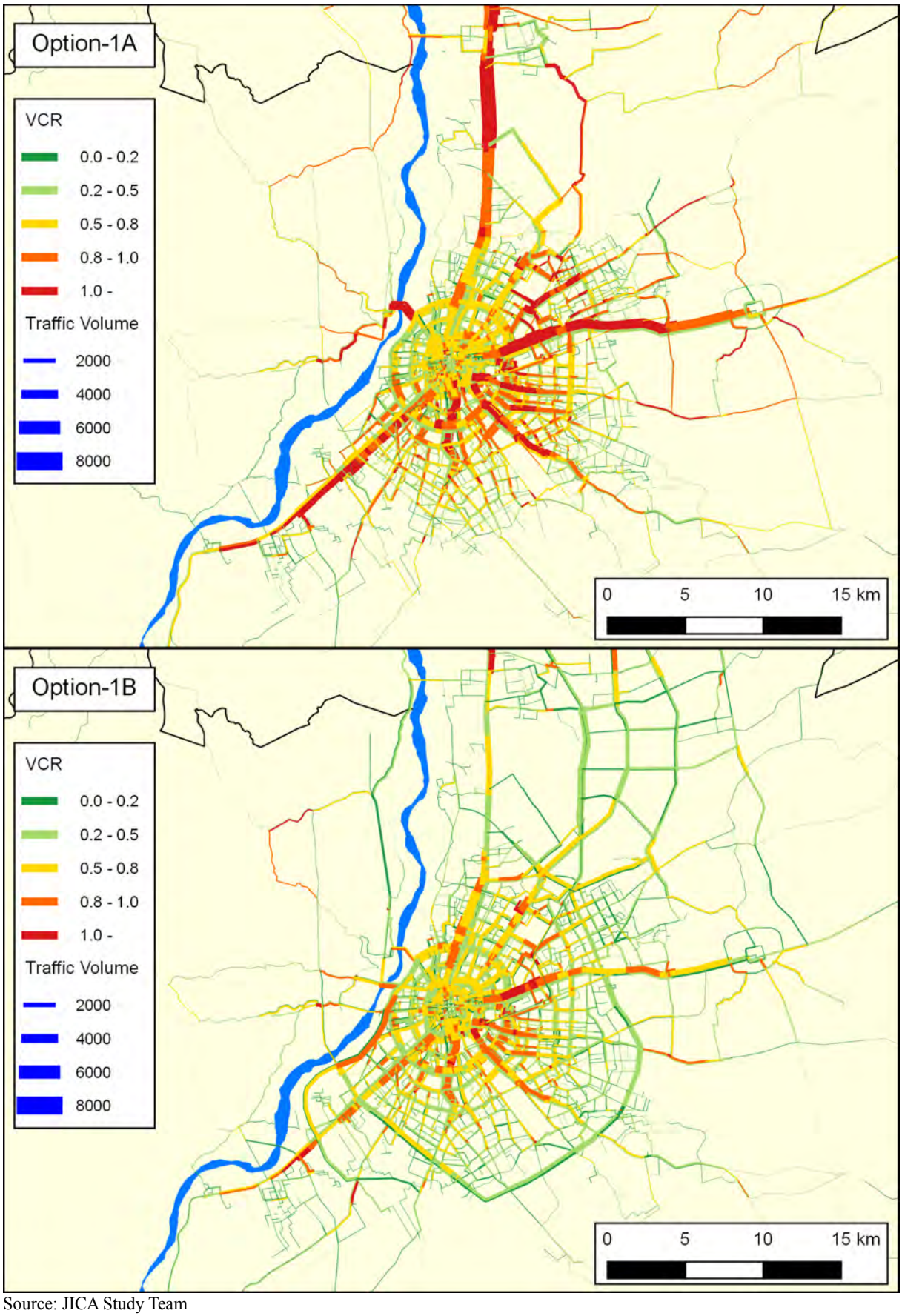
(3) Public Transport Services

Public transport services are provided to the area where passenger demand is high to ensure the profitability. In low-density areas, the frequency of bus services is smaller than high-density corridors. Buses in the low-density area need to run a long distance to collect passengers, which results in low profitability of the bus services. Although the tariff is one of the important criteria of public transport, it is uncertain whether the fare is affected by option, because it depends on the transport policy, then the tariff is excluded from the evaluation item. Table 3-18 shows the comparison of options about public transport services. The definition of the rank is the same as above.

Table 3-18 Comparison of Public Transport Services

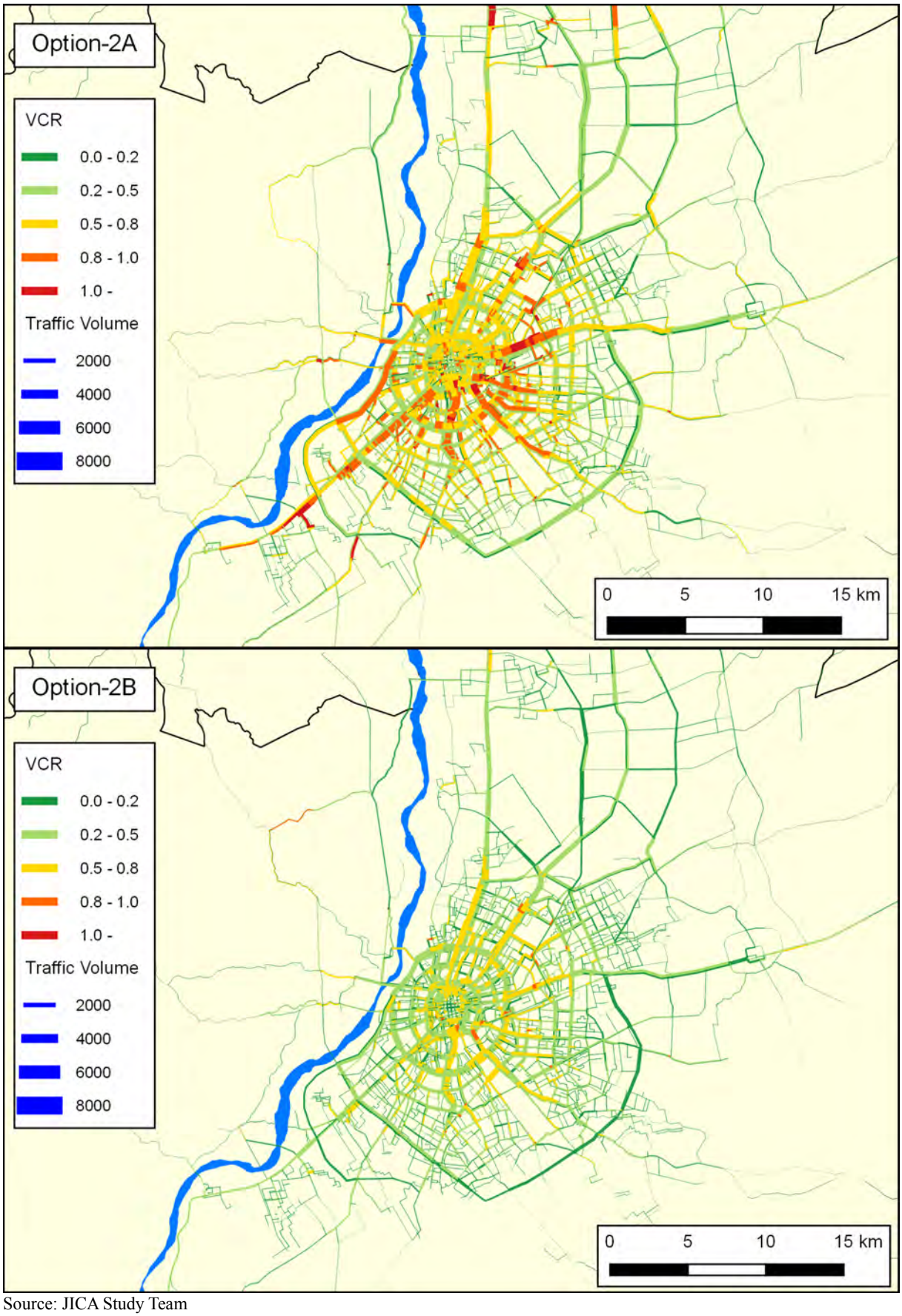
	Frequency	Service area	In vehicle congestion	Travel time
Option-1A	■■■■■ 5	■■■■■ 5	■■■■■ 5	■■■■■ 5
Option-1B	■■■■■ 5	■■■■■ 5	■■■■■ 5	■■■■■ 5
Option-2A	■■■■ 4	■■■■ 4	■■■■■ 5	■■■■ 4
Option-2B	■■■ 3	■■■ 3	■■■■ 4	■■■ 3
Option-3A	■■■ 3	■■■ 3	■■■■■ 5	■■■ 3
Option-3B	■■ 2	■■ 2	■■■■ 4	■■ 2
Option-4A	■■■ 3	■■■ 3	■■■■■ 5	■■■ 3
Option-4B	■■ 2	■■ 2	■■■■ 4	■■ 2

Source: JICA Study Team



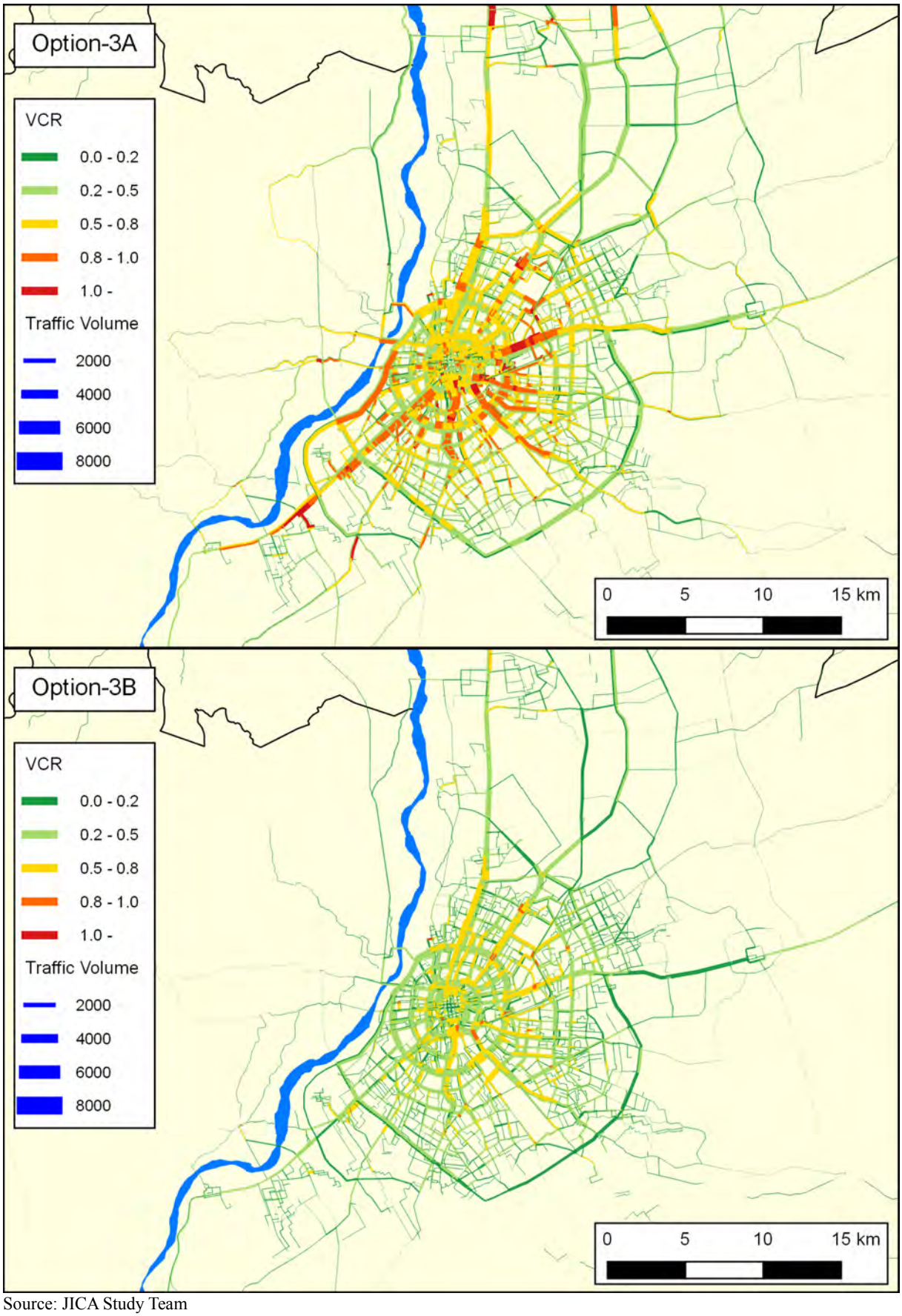
Source: JICA Study Team

Figure 3-29 Traffic Assignment of Option-1 (AM Peak)



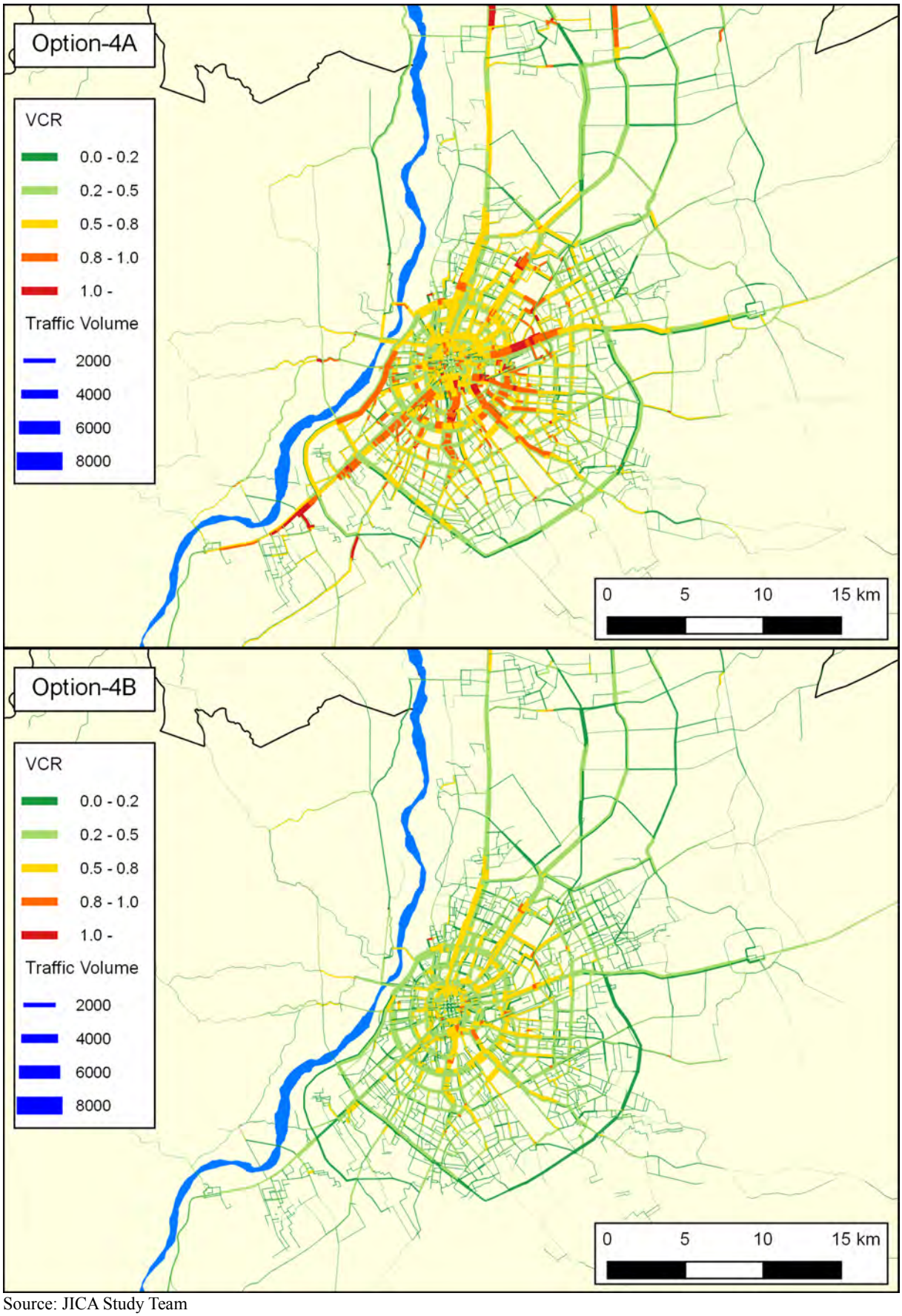
Source: JICA Study Team

Figure 3-30 Traffic Assignment of Option-2 (AM Peak)



Source: JICA Study Team

Figure 3-31 Traffic Assignment of Option-3 (AM Peak)



Source: JICA Study Team

Figure 3-32 Traffic Assignment of Option-4 (AM Peak)

3.3.3 Selection of Development Scenario

Based on the alternative analysis, Option 2B was selected considering the less negative impacts on the environment than Option 1A, 1B, and 2A, and the difficulty to implement the alternatives of Option 3A/B and 4A/B.

The characteristics of Option 2B is the urban expansion with the already approved urban developments and the modal shift from the private mode to the public mode by the public transport development. Although the densification of existing urbanized area is a very attractive scenario to minimize the negative impacts caused by low-density development, it is very difficult to abandon the already approved urbanization under the present legal framework. Instead of the restriction on the suburban development, encouraging the densification by various preferential measures is one of the strategies to achieve the densification scenario – Option 3A/B. However, such measures require several years to work, while the construction of houses in the already approved area continues.

The subcenter scenario – Option 4A/B – is also difficult to achieve because of the same reason. The idea of the scenario is to develop the center of municipalities other than Santa Cruz de la Sierra. For example, the area inside the 2nd Ring Road of Cotoca has not been developed fully developed, while there are many urbanizations in the suburban area. The situation would be the same as Option 3A/B. Even if the priority is given to developments inside the 2nd Ring Road of Cotoca, the construction of houses in the suburban area near Santa Cruz de la Sierra will continue. In fact, the development potential in urbanizations near the center of the Metropolitan Area is higher than that in the center and around Cotoca.

Option 2B also faces the similar problem, because it needs to suspend new approvals of urban developments, which causes a political problem. However, this issue can be handled if all municipalities agree that further low-density development should be avoided. The large Urban Area of Cotoca is one of the institutional problems of this scenario, but it would be possible to control the approval of the new development by introducing some guidelines for the approval process.

In the case of Option 2, the urban structure of low population density remains, although it is higher than "zero option" of Option 1A and Option 1B. This makes it difficult to introduce high capacity public transport systems, because of the low passenger demand by route. Option 2B intends to introduce public transport corridors with the concept of Transit Oriented Development (TOD). The public transport mode does not necessarily a high capacity system such as an urban railway system. Even if the capacity of a vehicle of the public transport system is not high, Option 2B forms public transport corridors by attractive transport systems to promote the modal shift from the private mode to the public mode.

3.4 Regional and Urban Structure

As analyzed in the development scenario, the control expansion scenario was selected as the best alternative for the regional development. This scenario discourages further urban development other than those which have been already approved and planned.

The Urban Area of Santa Cruz de la Sierra is the center of the Santa Cruz Metropolitan Area, as is the same as the present situation. Subcenters are located around the center, such as Cotoca, Warnes, Satelite Norte, Urubo, Porongo, La Guardia, and El Torno. This is the same as the present structure. The difference is new centers located in the east of Viru Viru International Airport. The new center is connected to the center of the metropolitan with a new corridor. Each subcenter is connected each other with corridors.

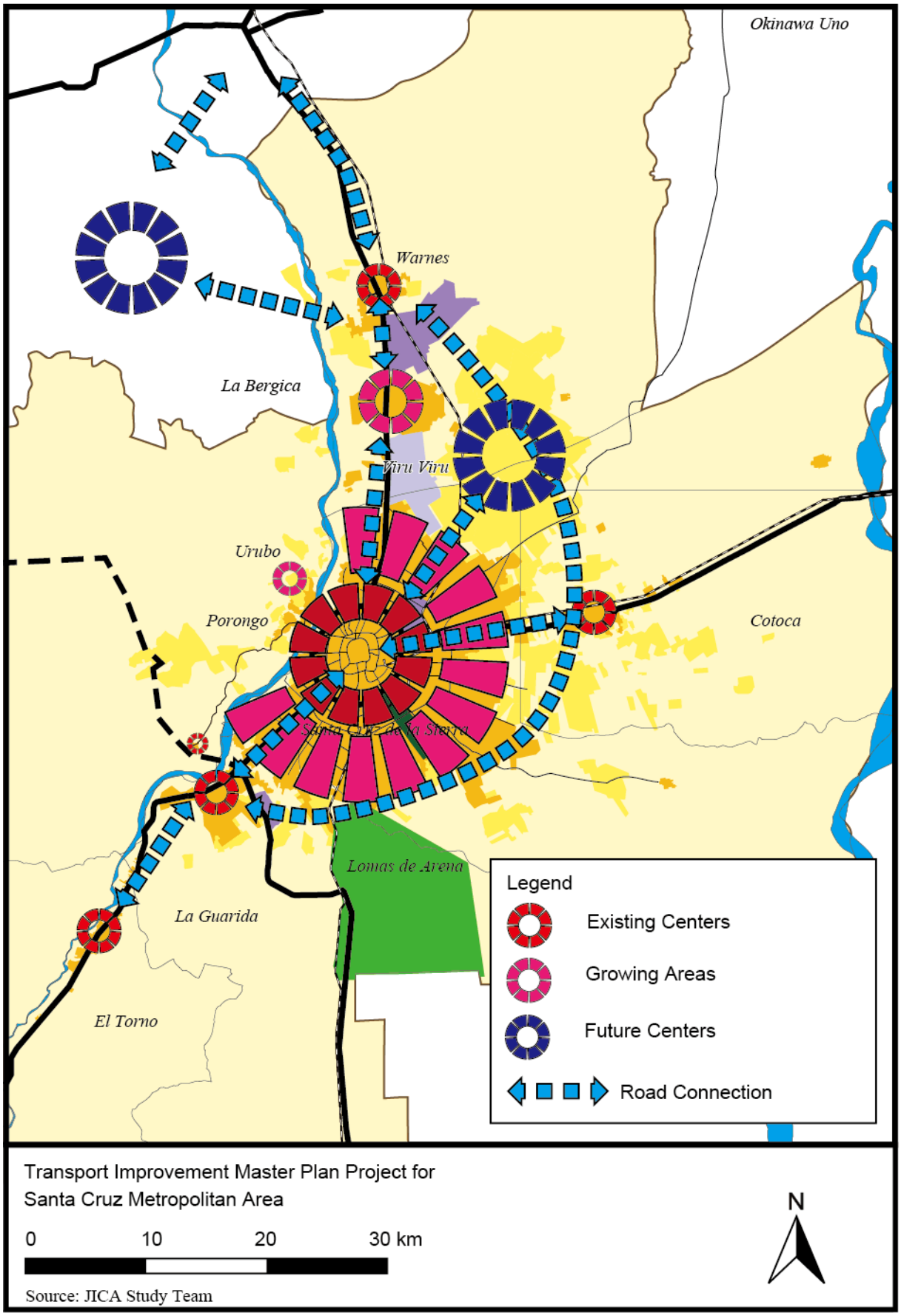


Figure 3-33 Regional Structure

3.5 Socioeconomic Projection by Zone

The future population of the Santa Cruz Metropolitan Area is projected in 3.2.1 based on the projection by INE. The future population is allocated to medium zones based on the following assumptions.

- Population in existing urbanized areas would be almost the same as the present population. The population growth rate in these areas is assumed to be 1% per year.
- The rest of the future population is allocated to new urbanized areas. The population density of urbanizations in Porongo is assumed to be 15 inhabitants per hectare. The population density of other urbanizations is calculated at 22.3 inhabitants per hectare.

After this allocation, the population by medium zone is aggregated into that by municipality. Table 3-19 shows the results of the population projection by municipality.

Table 3-19 Population Projection by Municipality

Municipality	2020	2025	2030	2035
Santa Cruz de la Sierra	1,681,032	1,796,606	1,917,180	2,044,558
Cotoca	113,376	160,452	209,200	260,968
Porongo	53,746	79,197	105,377	132,891
La Guardia	126,093	139,944	154,374	169,632
El Torno	65,012	69,599	74,217	78,851
Warnes	210,404	268,010	327,722	391,088
Total	2,249,663	2,513,808	2,788,070	3,077,988

Source: JICA Study Team

Figure 3-34 illustrates the population projection in 2035 by medium zone. The population growth is significant in the ease of the Urban Area of Santa Cruz de la Sierra, where the urbanizations stretch north and south.

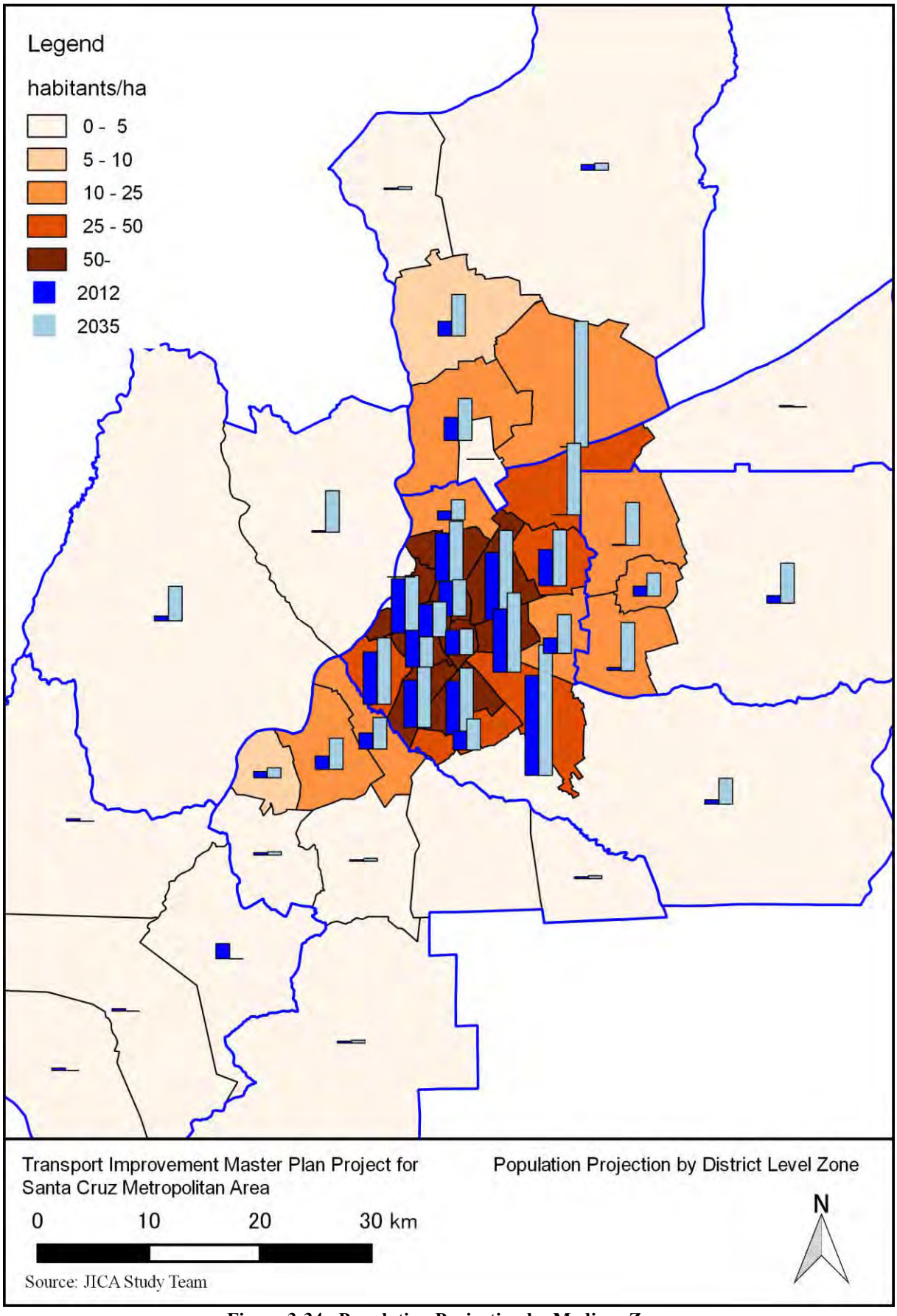


Figure 3-34 Population Projection by Medium Zone