Republic of Peru
Ministry of Transport and Communications

DATA COLLECTION SURVEY
ON
URBAN TRANSPORT
FOR
LIMA AND CALLAO METROPOLITAN AREA

FINAL REPORT (SUMMARY)

JANUARY, 2013

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA - CARIBBEAN CO., LTD.

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Exchange Rate (As of April 2012)

1 Nuevo Sol (S/.)	= 30.988 Japanese Yen (Yen)
1 Yen	= 0.03227 Nuevo Sol
1 US dollar (US$)	= 82.5 Yen
1 US$	= 2.662 Nuevo Sol

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Abbreviations

AATE	Electric Train Autonomous Authority
AC	Alternating Current
APEIM	Peruvian Association of Market Investigation Companies
APM	Automated People Mover
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Stop
BPR	Bureau of Public Roads
BRT	Bus Rapid Transit
BTN	Backbone Transmission Network
CBTC	Communication Based Train Control
CCTV	Closed Circuit television
CEPLAN	National Strategic Planning Center
CETPRO	Productive Technical Educational Center
CL	Cordon Line
CNG	Compressed Natural Gas
COSAC	High Capacity Segregated Corridor
CTLC	Lima and Callao Transport Committee
DC	Direct Current
EMU	Electric Multiple Unit
FORNAM	Peru National Environment Funding
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
HB	Home Base
HBO	Home Base Others
HBS	Home Base School
HBW	Home Base Work
HSST	High Speed Surface Transport
IMP	Metropolitan Institute of Planning
INEI	National Institute for Statistics and Information
IT	Information Technology
JICA	Japan International Cooperation Agency
KV	Kilo Volt
LRT	Light Rail Transit
MML	Metropolitan Municipality of Lima
MRT	Mass Rapid Transit
MTC	Ministry of Transport and Communications

NHB	Non Home Base
NSE	Socio-economic Level
OA	Office Automation
OCC	Operation Control Center
OD	Origin Destination
ONPU	National Office of Planning and Urban Development
O&M	Operation and Maintenance
PEA	Economically Active Population
PHPDT	Peak Hour Peak Direction Trip
PIS	Passenger Information System
PLAM de Lima	Metropolitan Territorial Plan and Urban Development Plan for Lima 2006-2021
PLANDEMET	Metropolitan Development Plan, Lima and Callao 1967-1980
PLANMET	Metropolitan Development Plan for Lima and Callao 1990-2010
PMTU	Master Plan for Lima and Callao Metropolitan Area Urban Transportation in the Republic of Peru
SL	Screen Line
STCTLC	Technical Secretary of Lima and Callao Transport Committee
TDM	Traffic Demand Management
TSAS	Traffic Safety Audit System
VOC	Vehicle Operating Cost
VOT	Value of Time
VVVF	Variable Voltage Variable Frequency

Chapter 1 Introduction

1.1 Background

In 2004, Japan International Corporation Agency (JICA) conducted a series of traffic surveys including a Person Trip Surveys covering interview of 38,000 households in the Lima and Callao Metropolitan Area. The Master Plan for Lima and Callao Metropolitan Area Urban Transportation (PMTU-2025) with target year of 2025 was formulated in 2005 based on the traffic surveys.

PMTU-2025 proposed the future public transport network consisting of four railway lines and 15 trunk bus lines. A Trunk Bus System for East-West Corridor along Venezuela Ave. and Nicolas Allyon Ave. was studied in the F/S in 2007.

After the master plan and feasibility studies, the environment of the transport system in Lime and Callao Metropolitan Area has been changed to a large extent. A Bus Rapid Transit (BRT) System was opened in 2010 with a total length of 27km along Republic Road. On December 23rd, 2010, the basic metro network of Lima and Callao, having five routes, was formulated by the Ministry of Transport and Communications (MTC) and approved by the Presidential Decree (D.S. 059-2010-MTC) as shown in Figure 1.1. In January 2012, Electrical Train Autonomous Authority of Lima and Callao (AATE) inaugurated the fist metro line in Lima.

Source: MTC

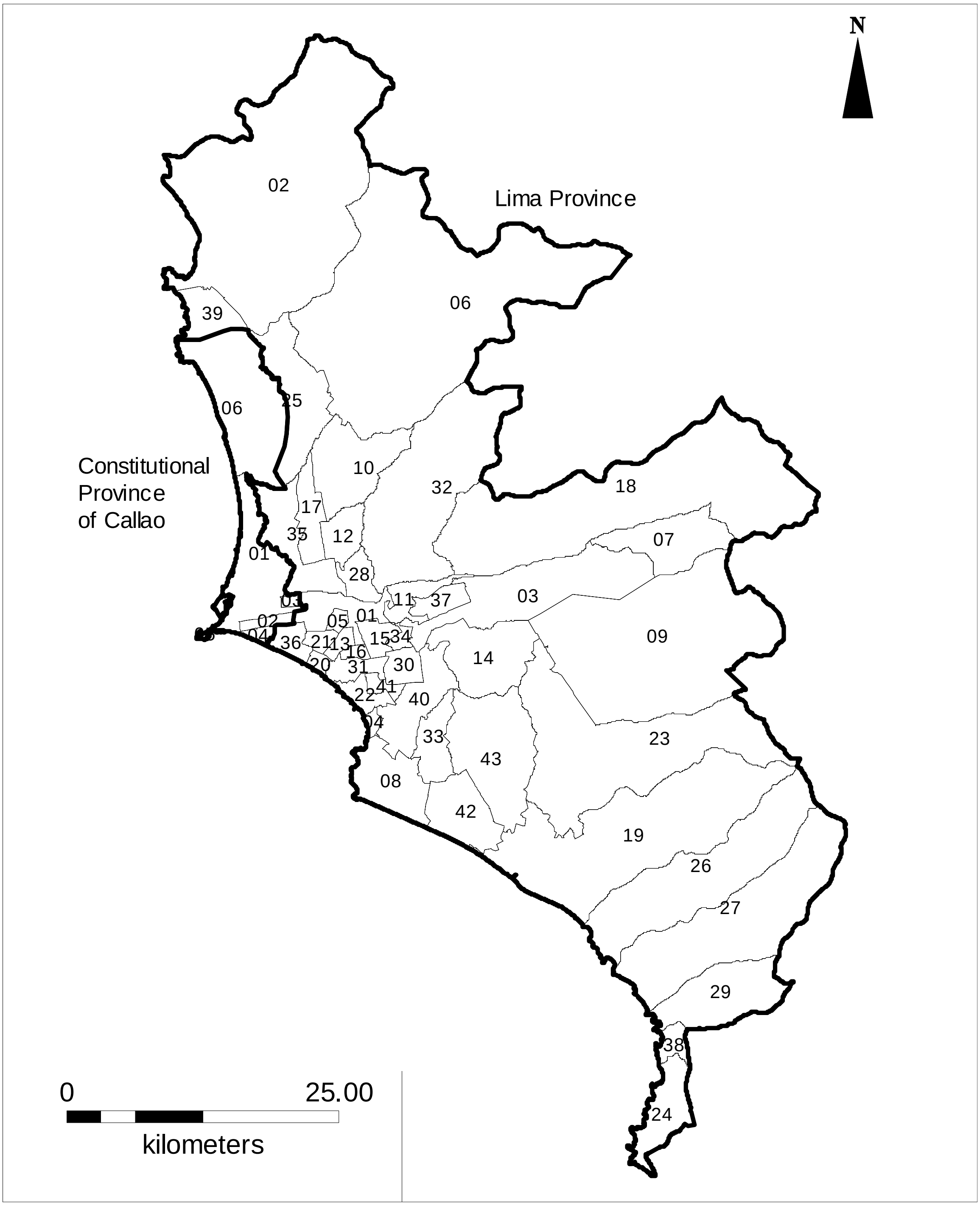
Figure 1.1 Metro Network Plan by MTC

In this connection, JICA proposed to review PMTU-2025 by updating the data in the previous study including the Origin-Destination (O/D) matrices by conducting a new Parson Trip Survey, and has employed a Japanese consultant consortium consisting of Nippon Koei Co., Ltd and Nippon Koei Latin America (hereinafter referred as the JICA Study Team) to conduct the Study.

In PMTU-2025, the public transport plan was analyzed based on two modes such as Trunk Bus System and Railway System (elevated and surface), while this study considers three modes such as Trunk Bus System, Medium Capacity Transit System, and Railway System (elevated and underground).

1.2 Study Area

The Study Area covers the Lima and Callao Metropolitan Area. This area is the same as that in the study of PMTU-2025, consisting of Lima Province and Constitutional Province of Callao. Lima Province is one of 10 provinces in Lima Department. The Study Area has 2,800 km^2 of land and a population of 945 million in 2012. There are 49 Districts, 43 in Lima Province, and 6 in Constitutional Province of Callao, in the Study Area as shown in Figure 1.2.



Source: JICA Study Team

Figure 1.2 Study Area

1.3 Purpose

The Study's purpose is to contribute to identify urban transport issues and develop the traffic database for stakeholders' decision making on the future development directions in the urban transport sector in the Lima and Callao Metropolitan Area by updating the transport data in 2004 and conducting the demand forecast in the Year 2030.

1.4 Schedule

The Study was conducted from the middle of March, 2012 to the end of December, 2012. Traffic surveys including the Person Trip Survey for 20,000 households were conducted from May to August. The Interim Report was submitted at the end of September. There were two seminars cosponsored by JICA and MTC on August 29th, 2012 and December 6th, 2012.

Chapter 2 Traffic Surveys

2.1 Contents of Traffic Surveys

The Study Team carried out several traffic surveys to determine the existing transportation characteristics as shown in Table 2.1.

Table 2.1 Traffic Surveys

No.	Survey	Objective	Coverage	Method
1	Person Trip Survey	Socio-economic profile and information on resident trips	23,040 households surveyed in the Study Area (sampling rate 1.0%)	Direct interviews of all selected family members
2	Cordon Line Survey	Traffic volume and information on non-resident trips	7 stations on the Study Area boundary, including the Jorge Chávez International Airport	- 24-hour traffic counts - Direct interviews of passengers and drivers (14-hours)
3	Screen Line Survey	Traffic volume and vehicle occupancy in the Screen Line	15 stations along the Rímac River, and 7 stations along the Panamericana Sur (Southern Panamerican) Highway	- 24-hour traffic counts, - Observation of vehicle occupancy (14-hours).
4	Passenger Interview Survey	Stated preference with regard to selected modes	Interviews of 2,415 passengers	Direct interview at stations, bus stops, and parking area
5	Travel Speed Survey	Travel speed on major road sections	Monitoring during peak hours and off-peak hours along 22 major corridors.	3 round trips per route, by the floating vehicle method.
6	Freight Transportation Survey	Goods and freight flow characteristics	- Traffic counts & interviews at 7 stations - Interviews at 3 stations - Interviews of 5 major freight companies	- 24-hour traffic counts - Direct interviews of drivers (12-hours) - Direct interviews of selected freight companies.

Source: JICA Study Team

2.2 Person Trip Survey

The Person Trip Survey is the most important of all surveys. The objective of “Person Trip Survey” is to gather information of socioeconomic profile and trip behavior of household members on a particular day. Note that this chapter describes the contents of the survey, while the results are described in Chapter 3.

2.2.1 Coverage

The Study Area covers the Lima and Callao Metropolitan area, including 49 districts. Initially, the Study Area was divided into 427 traffic zones; blocks were selected in each traffic zone in proportion to their population. The interviews include all selected household members, but the information on trips was gathered only for people 6 years old and over.

2.2.2 Sampling Method

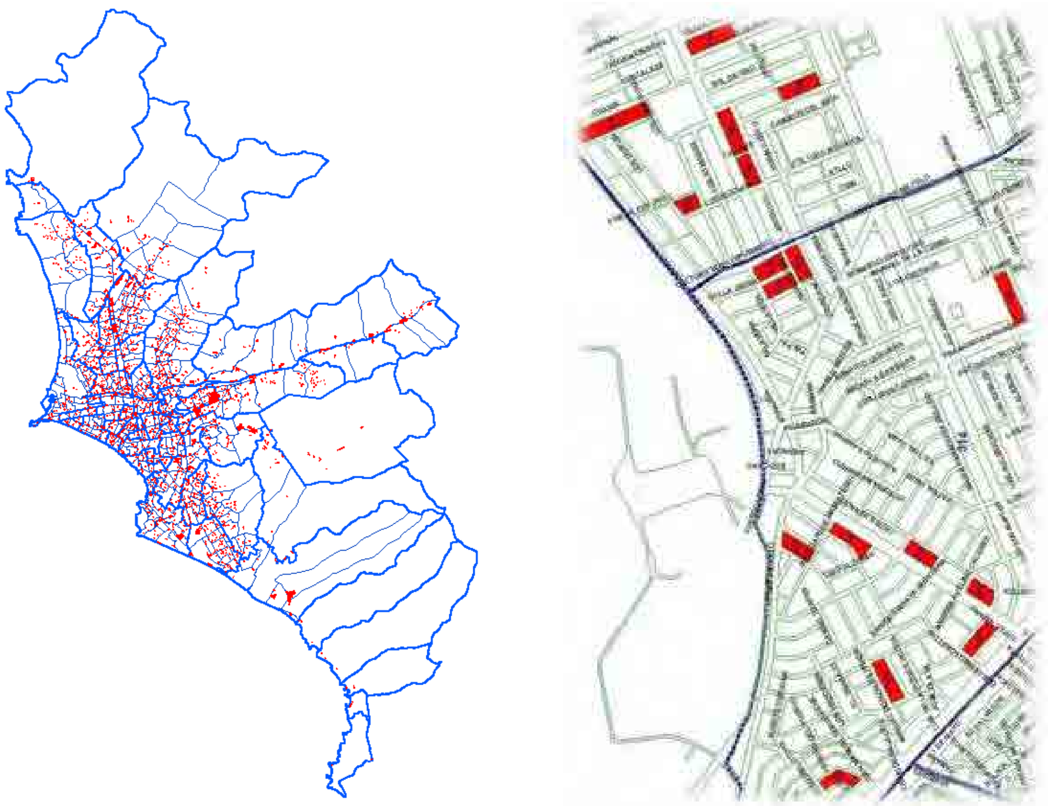
The target number of households by traffic zone was determined based on information from the 2007 National Census and the population projection for the year 2012 (Chapter 4).

The households to be surveyed were selected in the following manner.

First, survey blocks are selected randomly by traffic zone. Secondly, the households to be surveyed are selected at a certain interval of houses in each block until the target number is met.

Randomness can be assured by this method because it can be assumed that the socio-economic profile is very similar in the same block.

Direct interviews are carried out to all household members of 6 years old and more, and their answers are registered by the interviewers in their corresponding questionnaires. If not all household members are present during the visit, a new appointment for a later visit is requested. The left map in Figure 1.2 shows the selected blocks while the right map shows an example of selected blocks.



Source: Person Trip Survey, 2012

Figure 2.1 Location of selected blocks for Survey collection

2.2.3 Traffic Zone

For updating the study in PMTU-2025, the Study Team retained all 427 traffic zones.

Sample proportions were initially established by population, but there were locations with very small population, especially in the southern districts (beach resorts); therefore, a minimum sample of 32 households was applied for these districts.

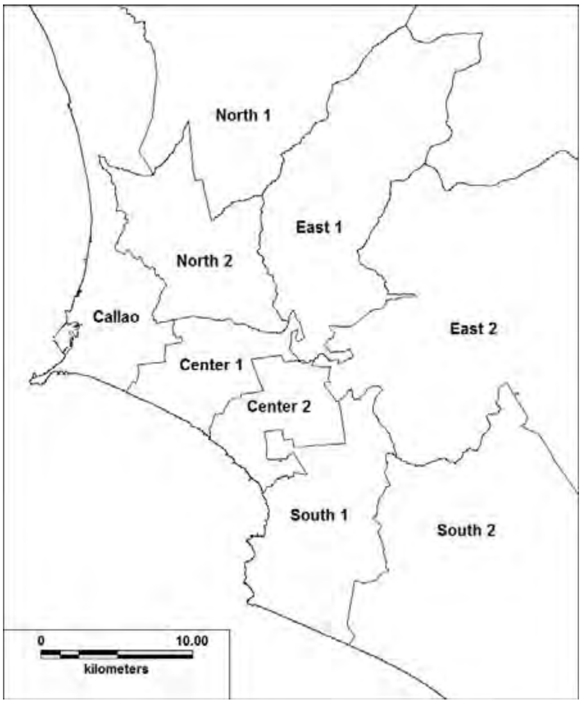
Some traffic zones were not included in the surveys, due to their small or none population. For this reason, interviews were conducted for 410 traffic zones.

The zoning system consists of several layers as shown in Table 2.2. The survey was carried out by 9 survey teams in each survey area as shown in Figure 2.2.

Table 2.2 Zoning

Name	Size
Traffic Zone	427 internal traffic zones (17 zones as trip attractors only) 19 external traffic zones
District	49 districts In Lima: 43 In Callao: 6
Survey Areas (Figure 2.2)	9 Areas: North 1, North 2, Center 1, Center 2, East 1, East 2, South 1, South 2, and Callao

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2 Survey Areas

2.2.4 Survey Items

The information to be gathered from the survey is listed below:

a) **Household Information** covering socio-economic characteristics of household members, household structure, vehicle ownership, income level, dwelling location, dwelling characteristics, house equipment ownership, etc.

b) **Personal Information** covering socio-economic characteristics of household members, including age, sex, job or work, activities, disabilities, address of working place and / or school, etc.

c) **Trip information** covering characteristics of the trips made by the selected household members, including origin and destination, trip purpose, trip mode, transfers, fares, time of departure, time of arrival, etc.

d) **Information on the chosen mode** covering the perception characteristics with regard to the chosen mode, including the reasons for its selection.

2.2.5 Selected Samples

Table 2.3 shows the number of sampled households for the Person Trip Survey and the effective samples after their revision.

Table 2.3 Effective Samples

Survey Area	Population in 2012	No. of Households (000)	No. of Surveyed Households	No. of Valid Households	Productivity (%)	Sampling Rate (%)	No. of Effective Individuals
	A	B	C	D	E=D/C	F=D/B	G
North 1	1,146,547	266.43	2,756	2,722	99%	1.02%	10577
North 2	1,403,138	337.82	3,356	3,327	99%	1.98%	12925
East 1	1,215,853	281.91	2,840	2,812	99%	1.00%	11962
East 2	1,227,903	297.87	2,904	2,863	99%	0.96%	11184
Center 1	704,179	188.52	1,752	1,677	96%	0.89%	5754
Center 2	545,492	154.02	1,604	1,599	100%	1.04%	5185
South 1	1,159,543	286.14	2,812	2,787	99%	0.97%	9587
South 2	1,078,760	257.72	2,652	2,637	99%	1.02%	10577
Callao	969,170	240.81	2,364	2,280	96%	0.95%	9075
Total	9,450,585	2,311	23,040	22,704	99%	0.98%	86,826

Source: INEI and Person Trip Survey

The sample size was 22,704 households, but 1% of which were not valid. The sample included a population of 86,826 (estimated from the number of household members), which showed a miniaturization of the average household size as compared to that in 2004. The number of trips made by the samples is 117,244.

The gross trip rate obtained from the Person Trip Survey was low in comparison with the rate in the study of PMTU-2025. This may be due to the biased samples of lower income groups.

2.3 Cordon Line Survey

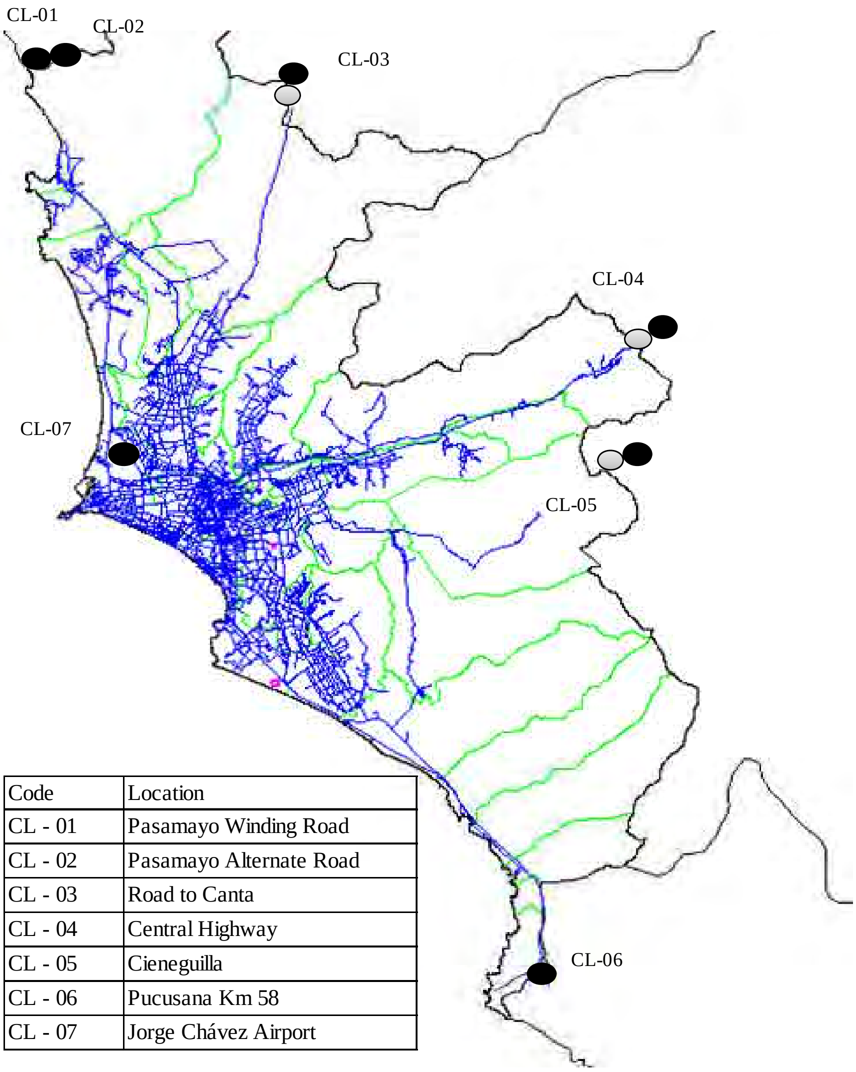
2.3.1 Survey Methodology

The Cordon Line is the borders of the Study Area. The Cordon Line Survey consists of the following two subcomponents.

1) Interview Survey: this survey is to interview car drivers on roadsides to collect information about the origin and destination of passengers in vehicles. Vehicles are flagged down for an interview, and drivers are asked some questions in the survey. Since the survey forces drivers to stop on the road, cooperation of police is essential.

2) Traffic Count Survey: the number of vehicles at the same locations is counted by vehicle type.

The Cordon Line Survey was conducted at the locations shown in Figure 2.3.



Code	Location
CL - 01	Pasamayo Winding Road
CL - 02	Pasamayo Alternate Road
CL - 03	Road to Canta
CL - 04	Central Highway
CL - 05	Cieneguilla
CL - 06	Pucusana Km 58
CL - 07	Jorge Chávez Airport

Source: JICA Study Team

Figure 2.3 Location of the Counting Points along the Cordon Line

2.3.2 Results of Cordon Line Survey

(1) Survey Summary

Table 2.4 shows the result of the traffic count in the Cordon Line Survey. A considerable increase was observed at CL-6 in comparison with the data of 2004. In the southern area of the Study Area, there was a rapid expansion trend, including the southern districts which have been considered as summer resort beaches in the past.

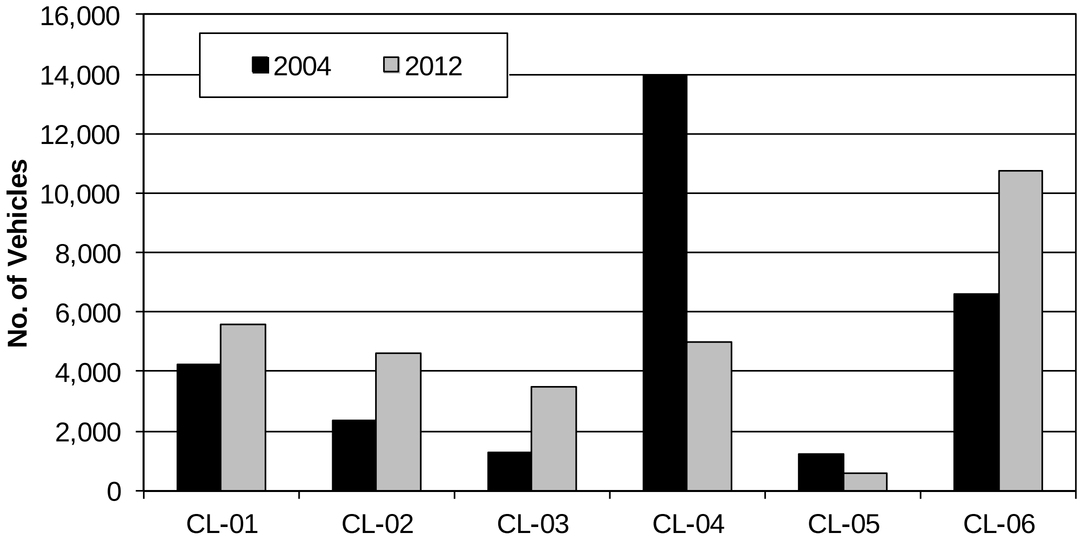
Decreases in the number of vehicles were observed in comparison with the study of PMTU-2025 for the areas of Central Highway (CL-04) and Cieneguilla (CL-05). The survey points were shifted away from small bus terminals to avoid counting of internal traffic at these CL locations. It is judged that numbers in 2004 included considerable volume of internal traffic.

Table 2.4 Counted Traffic Volume (Vehicles / Day)

Code	M/C		Automobile / Taxi		Public Traffic		Truck		Total	
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012
CL - 01	1	2	1	33	1,590	2,244	2,632	3,293	4,224	5,572
CL - 02	7	27	1,593	3,776	92	719	691	85	2,383	4,607
CL - 03	57	225	333	1,554	317	1,476	555	239	1,262	3,494
CL - 04	460	61	6,230	1,952	4,514	1,227	2,762	1,729	13,966	4,969
CL - 05	61	50	612	387	429	96	116	36	1,218	569
CL - 06	54	408	2,280	5,178	1,579	2,283	2,692	2,890	6,605	10,759
Total	680	773	25,084	12,880	10,172	8,045	9,946	8,929	45,882	30,627

Source: Cordon Line Survey, 2012

The bar chart of Figure 2.8 shows the comparison of the traffic count survey between 2004 and 2012.



Source: PMTU-2025 and Cordon Line Survey, 2012

Figure 2.4 Comparison of Traffic Volume Cordon Line

2.4 Screen Line Survey

2.4.1 Methodology

The Screen Line Survey consists of the traffic count survey and the passenger occupancy survey. The obtained data is used for the calibration of the transport model.

The traffic count survey and the passenger occupancy survey were carried out for 24 hours and 14 hours, respectively, on 15 locations along Rimac River and on 7 locations of Panamericana Sur highway.

(1) Traffic Count

The number of vehicle by type and direction was counted for every hour. The same 17 vehicle types as those used for the Cordon Line Survey were also used in the traffic count of the Screen Line Survey.

(2) Passenger Occupancy

The number of passengers per vehicle was estimated by visual observation from roadsides. Classified occupancy rates such as empty, 1/4 seated, 1/2 seated, 100% seated, 1/2 standings, and full loading were observed for coletivos, combis, microbuses, and buses. The survey period was 14 hours (7:00- 21:00).

Table 2.5 shows the conversion factors to be used to estimate the number of passengers from the classified occupancy rates. The factors are different from those used in the study of PMTU-2025, reflecting the increase in seating capacity of vehicles.

Table 2.5 Factors for Passenger Occupancy

Mode	Full	100% seated 50% standing	100% seated	50% seated	Almost empty	Empty
Omnibus	80	57	33	17	8	0
Microbus	50	37	23	12	4	0
Rural Wagon	24	20	15	8	2	0

Source: JICA Study Team

(3) Preparation and Schedule of Survey

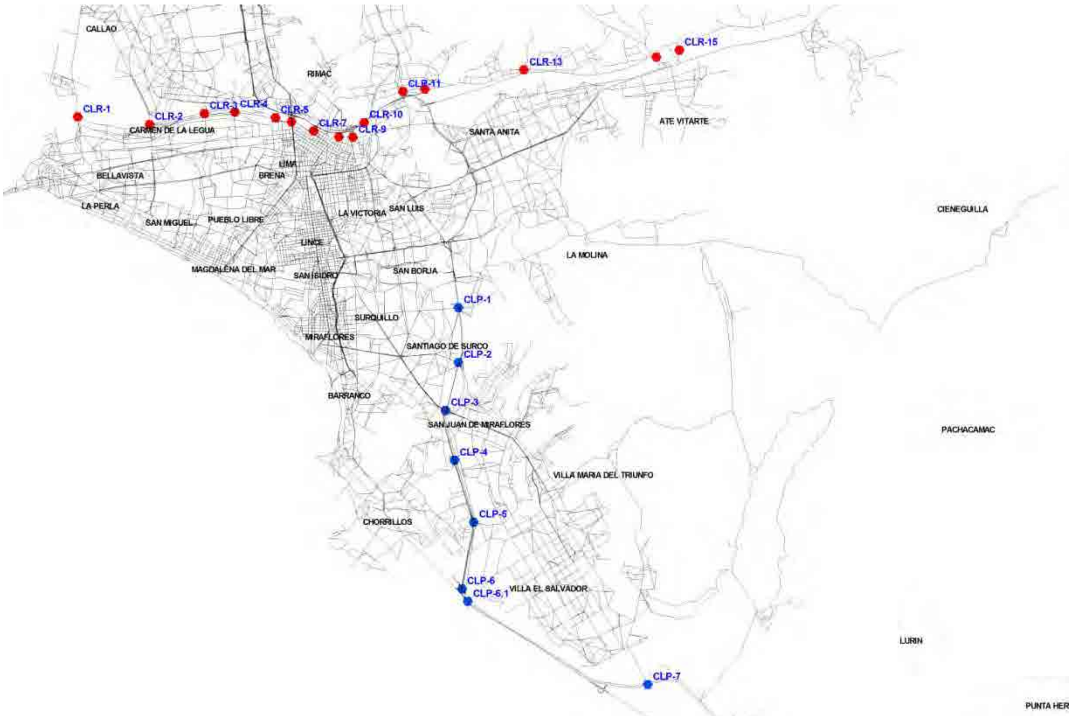
The survey was done simultaneously for each Screen Line. The surveys were conducted at 15 bridges along the Rimac River and 8 points along Panamericana Sur highway as shown in Table 2.6.

Table 2.6 Screen Survey Locations

CODE	Name (Rimac River Screen)
CLR1	Puente Gambeta
CLR2	Puente Faucet
CLR3	Puente Universitaria
CLR4	Puente Dueñas
CLR5	Puente Santa María
CLR6	Puente Ejercito
CLR8	Puente Ricardo Palma
CLR7	Puente Santa Rosa
CLR9	Puente Huánuco
CLR10	Puente Huáscar
CLR11-1	Puente Nuevo (Av. Chinchaysuyo)
CLR11-2	Puente Nuevo (Av. Pirámide del Sol)
CLR12	Puente Las Lomas
CLR13	Puente Prialé
CLR14	Puente Huachipa
CLR15	Puente Bayles Santa Clara

CODE	Name (Panamericana Sur Screen)
CLP1	Angamos
CLP2	Benavides
CLP3	Tomas Marsano (Tren Eléctrico)
CLP4	Alipio (Panamericana y Salida)
CLP5	Mateo Pumacahua
CLP6	Huaylas (Rampa)
CLP6-1	El Sol
CLP7	Dv. Lurín (Carretera)

Source: JICA Study Team



Source: JICA Study Team

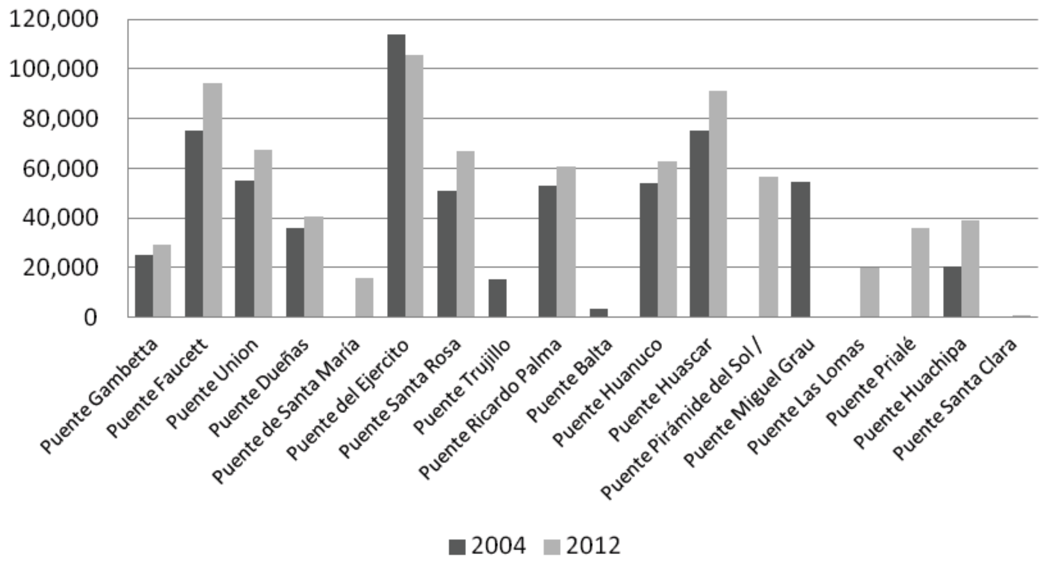
Figure 2.5 Screen Survey Locations

2.4.2 Result of Screen Line Survey

The total numbers of vehicle trips along the Rímac River and the Panamericana Sur (Southern Panamericana Highway) Avenue were 785,614 and 280,973 vehicles/day, respectively, running on both directions. These volumes have increased by 24.4 % and 68 %, respectively from 2004.

Figure 2.6 and Figure 2.6 show the traffic volume on each station along the Screen Lines. On the Screen Line along the Rímac River, traffic volume on the Del Ejército Bridge was the highest with 105,494 vehicles, followed by the traffic volume on the Faucett Bridge with 92,696 vehicles, and Huáscar Bridge on the Vía de Evitamiento (the beltway) with 91,222 vehicles. In comparison with those recorded in 2004, the order of traffic volume from highest to lowest remained the same but and in general terms, the traffic volumes have increased.

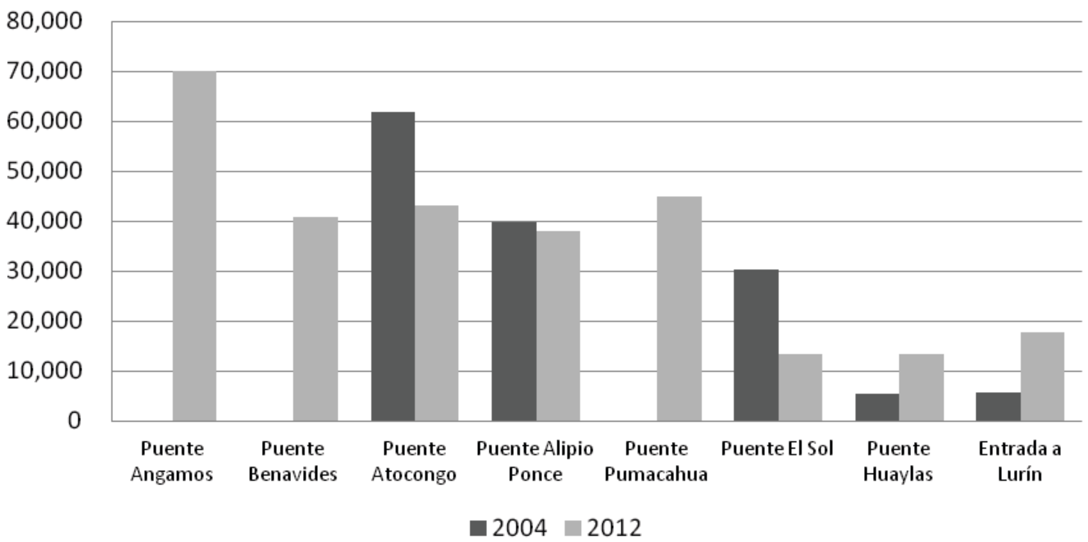
However, the order of passenger volume has changed. It was found that the passenger volume on the Santa Rosa Bridge was the highest with 453,040 passengers/day, followed the new bridge (Piramide and Chinchaysuyo) with 452,815 passengers/day and Ricardo Palma Bridge with 402,215 passengers/day.



Unit: Vehicles per day
Source: Screen Line Survey, 2012

Figure 2.6 Traffic Volume Change on the Rímac River Screen Line

Figure 2.7 shows the traffic volume on the Screen Line along the Panamericana Sur (Southern Panamerican Highway) Avenue. The highest traffic volume was observed on the Primavera Bridge (Angamos Avenue, with 69,924 vehicles/ day) followed by the Mateo Pumacahua Bridge with 44,782 vehicles/day, and the Atocongo Bridge with 43,144 vehicles/day. The observed volume in 2004 at the Atocongo Bridge seems to be absorbed by the newly constructed Metro Line-1 at this point. With regard to the number of passengers, the Atocongo Bridge had the largest number with 336,857 passengers/day followed by the Mateo Pumacahua Bridge with 222,503 passengers/day.



Unit: Vehicles per day
Source: Screen Line Survey, 2012

Figure 2.7 Traffic Volume on the Southern Panamerican Highway Screen Line

2.5 Passenger Interview Survey

The Passenger interview (PI) survey was carried out to collect information on passengers' willingness to change their transportation mode to mass transit system.

2.5.1 Methodology

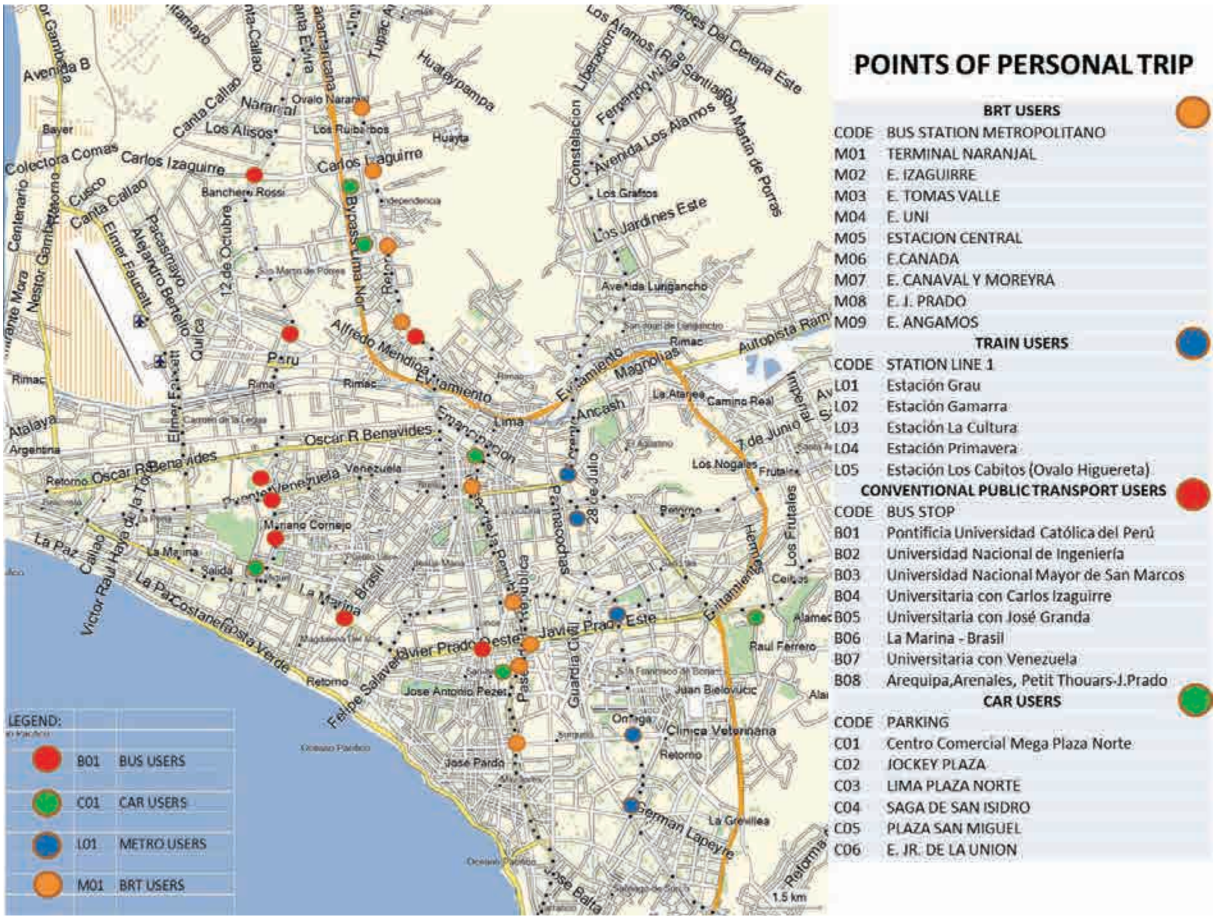
Interviews of the users of private and public passenger transport were carried out. Interview items include 1) personal attributes, 2) trip information, 3) opinion on public transport, 4) willingness-to-pay for modern type mass transit system.

The locations of interviews are mainly at the stops on public transportation routes, the stations of Metropolitano (BRT) and Metro Line 1, and private parking lots for car users.

The target sample number was set at 2,000. A pilot survey was done in June 2012 prior to the main interviews.

2.5.2 Preparation and Schedule of the Survey

Passenger Interview Survey was conducted at locations shown in Figure 2.8.



Source: JICA Study Team

Figure 2.8 Location of Passenger Interviews

2.5.3 Result of the Survey

Among the surveyed public transport users, only 11% of interviewees had cars. Traffic congestion and fuel cost were the main reasons that people did not use cars. Eighty six percent of public transport users used taxi at least once a week.

More than half of bus users were using also Metropolitano, but only one-fifth used the Metro line.

Metropolitano (BRT) users mainly walked to the BRT stations. Four percent of car users and 2 % of taxi users changed to BRT. The travel speed of BRT was evaluated first, followed by its frequency, vicinity and comfort. More than half of BRT users qualified its services as good or very good.

Over 60% of Metro Line-1 users evaluated its services as good or very good. Comfort was evaluated as the worst, but it still considered acceptable by 80% of users.

2.6 Travel Speed Survey

2.6.1 Methodology

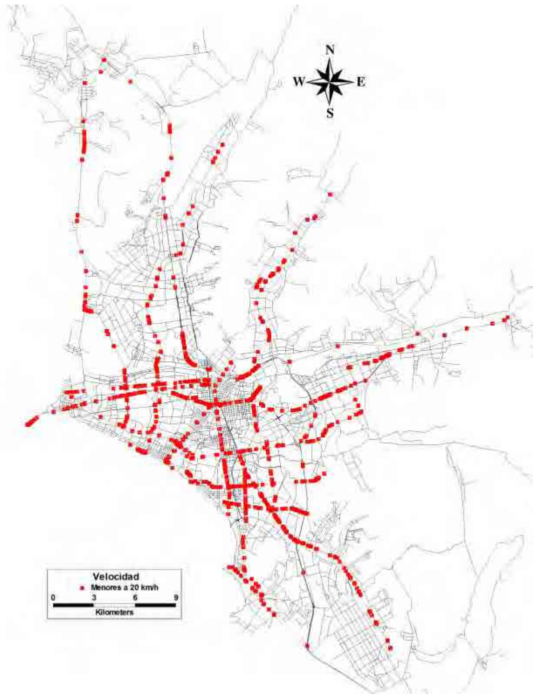
The objective of the survey is to identify bottlenecks on the road network during peak hours and establish a function of volume-speed relation for each route in combination with the results of the traffic counts.

The survey routes were 22 arterial roads with the total length of approximately 400km.

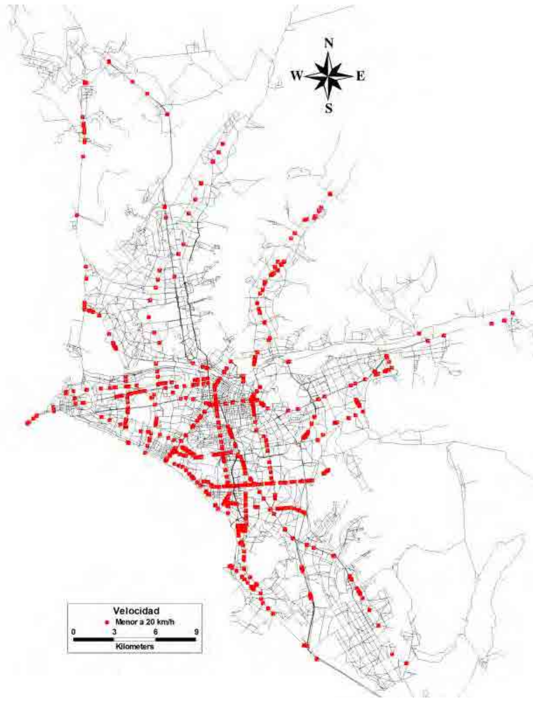
The survey was carried out during peak hours and off-peak hours using GPS devices. The peak and off-peak periods for each route are established based on the existing reports, and the results of traffic counts carried out prior to the travel speed survey.

2.6.2 Survey Results

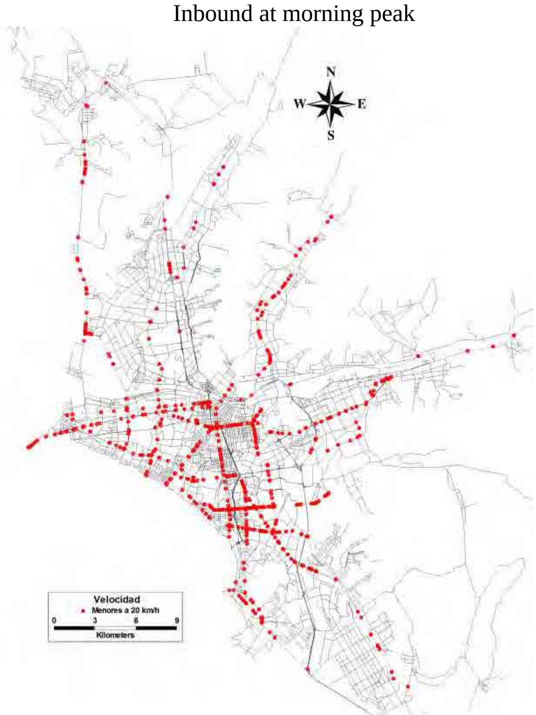
Figure 2.9 shows the traveling speed at morning peak hours for incoming and outgoing traffics. For the incoming direction (entrance), the average travel speed was under 20 km/h on the following sections.



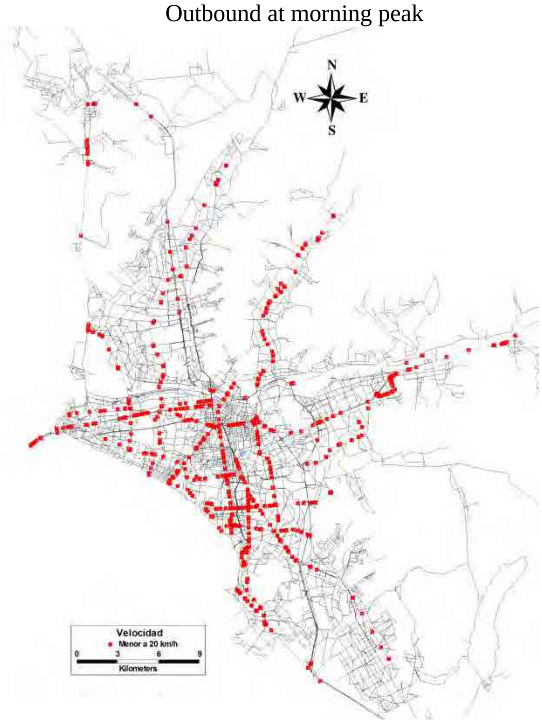
Inbound at morning peak



Outbound at morning peak



Inbound at afternoon peak



Outbound at afternoon peak

Source: JICA Study Team

Figure 2.9 Main Roads with Traveling Speed Less than 20km/h

2.7 Freight Transport Survey

2.7.1 Freight Vehicle Volume at Cordon Line

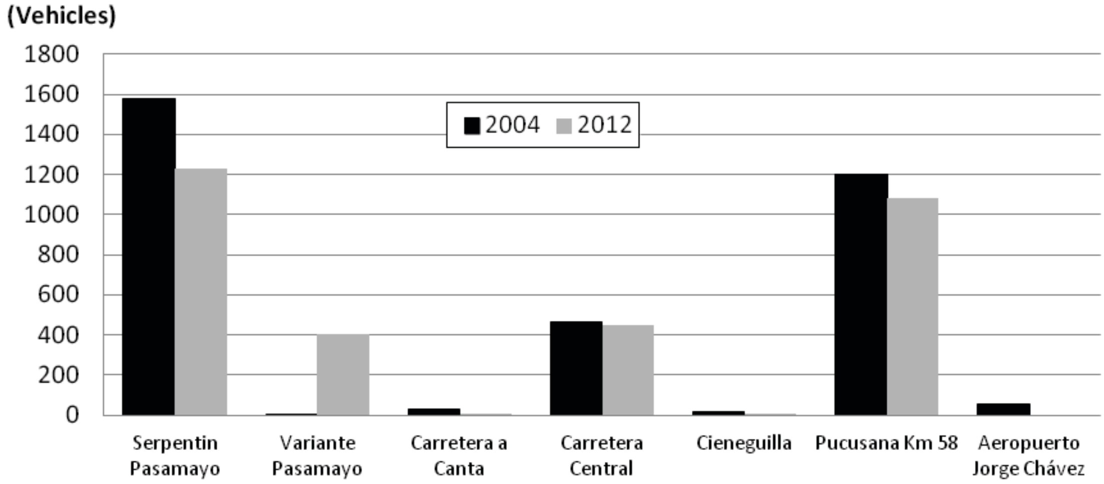
Table 2.7 shows the summary of the number of freight vehicles at each survey location while Figure 2.10 shows the comparison of the traffic volumes between the survey result in 2004 and 2012.

Table 2.7 Freight Traffic Volume by Survey Location

No. of freight vehicles per day

	CL-01	CL-02	CL-03	CL-04	CL-05	CL-06	CL-07
Incoming	2,076	176	749	1,277	40	1,893	313
Outgoing	2,220	170	729	887	45	1,656	344
Total	4,296	346	1,478	2,164	85	3,549	657

Source: Freight Traffic Survey, 2012



Source: PMTU-2025 and Freight Traffic Survey, 2012

Figure 2.10 Freight Traffic on the Cordon Line

According to the counting results at Stations CL-1 (Lima - Huaral) and CL-6 (Lima - Cañete), the freight vehicle volume at each point has increased in comparison with PMTU-2025, with the following volume counts: 4,296 on Pasamayo Serpentín (Winding Road), 3,549 on Southern Panamerican. The freight traffic volumes at CL-4 (Lima- Huarochirí) were: 2,164 on Central Highway (there has been a decrease here in comparison to PMTU2025). The remaining points such as CL-2 (Lima – Huaral), CL-3 (Lima -Canta), and CL-5 (Lima - Huarochirí) also showed a decrease. Canta showed an increase of 1,478 freight vehicles. The freight traffic volumes on Pasamayo Variante (Alternate Road) and Cineguilla decreased to 346 and 85 vehicles/day, respectively.

2.8 Traffic Count

Information on traffic volume is used for the calibration of the O-D matrix. In this Study, the data was gathered by following ways:

a) Counts on Screen Line and Cordon Line in this Study (May 2012) and
b) Traffic counts on principal roads (from existing studies)

Table 2.8 summarizes the information from traffic counts.

Table 2.8 Summary of Traffic Counts

Type of survey	No. of stations of count	Count	
		Traffic counting	Passenger occupancy
Screen line traffic counts	16 stations on bridges along Rimac River	24 hours	14 Hours (7:00 a 21:00)
	8 stations along Panamericana Sur highway	24 hours	14 Hours (7:00 a 21:00)
Cordon line traffic counts	6 stations on principal highways going out Lima	24 hours	
Traffic counts in previous studies	120 stations (Traffic study 2009 – STCTLC)	4 hours (6:00 – 10:00)	
	28 stations (Traffic study 2011 – STCTLC)	12 hours (7:00-11:00; 12:00 -16:00; 17:00 - 21:00)	
	12 stations (Traffic study 2011 – STCTLC)	4 hours (7:00-11:00)	
	52 Stations (Traffic study of Faucett road 2011– AATE)	6 hours (07:00– 10:00; 17:00– 20:00)	
	38 stations (Study of rationalization of Route of Metro Line 1 2011-AATE)	16 hours (06:00- 22:00)	
	7 stations (Traffic study of Faucett road 2012– AATE)	6 hours (07:00– 10:00; 17:00– 20:00)	
	28 stations (EMU 2012 – AATE)	16 hours (06:00 – 22:00)	16 hours (06:00 – 22:00)

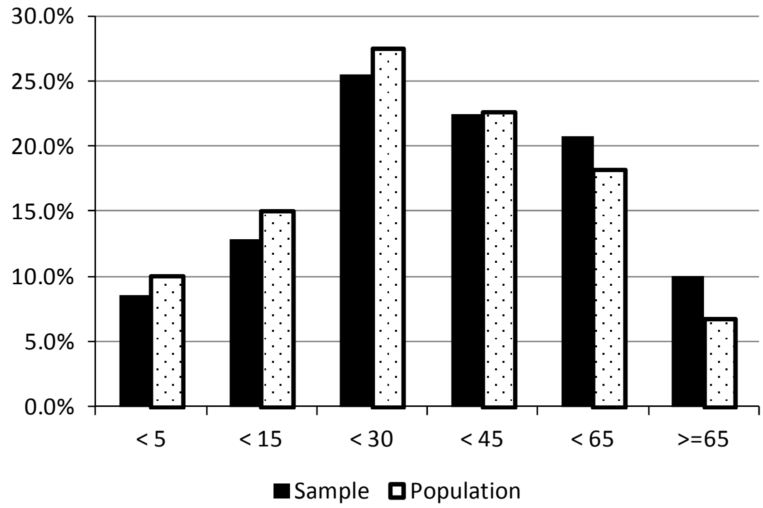
Source: JICA Study Team

Chapter 3 Person Trip Analysis

3.1 Making OD matrices

3.1.1 Sample Expansion

The Person Trip Survey conducted in this Study was a sampling survey with a sampling rate of 0.83%. Although the sampling rate of households was 0.92% as explained in Chapter 2, the sampling rate of the population was 0.83% because there were members who were absent in the interview survey. The numbers of various data are estimated by applying the expansion factor that is calculated as the inverse of the sampling rate. If the sample members were selected randomly, the distribution of gender and age group would fit the population. Figure 3.1 shows proportions of population and samples by age group. Although the proportion of the two data groups is similar, the proportion of the sample does not match the population statistically, and it was concluded that the sampling rates are different by age group.



Source: JICA Study Team (Chapter 4 and Person Trip Survey)

Figure 3.1 Proportion of Age Group

The sample size was different by district. The JICA Study Team applied different expansion factors by age group by district.

3.1.2 Cordon Line OD

Trips by residents in the Study Area were captured in the Person Trip Survey while that of visitors were not recorded. The Cordon Line Survey was conducted to estimate the number of visitors' trips. The OD matrices of visitors were developed from the result of the highway cordon line survey at 6 locations and the airport cordon line survey.

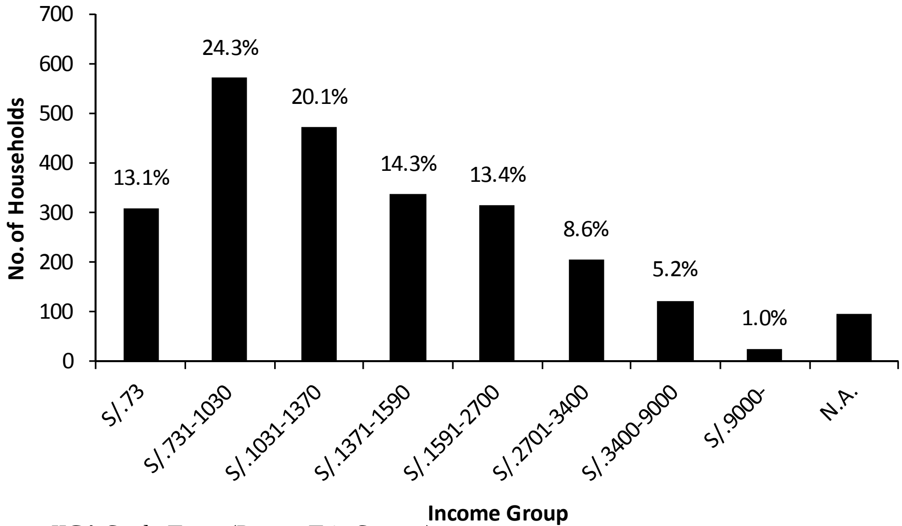
3.1.3 Calibration of OD

The estimated OD matrices were calibrated by the result of the Screen Line Survey. The numbers of trips were adjusted by multiplying the numbers by 1.29 for walk, bicycle, and motorcycle; 1.0 for mototaxi; 1.91 for taxi and car; 1.44 for combi, minibus, bus and metropolitan; and 1.29 for Metro Line-1.

3.2 Trip Characteristics

3.2.1 Households

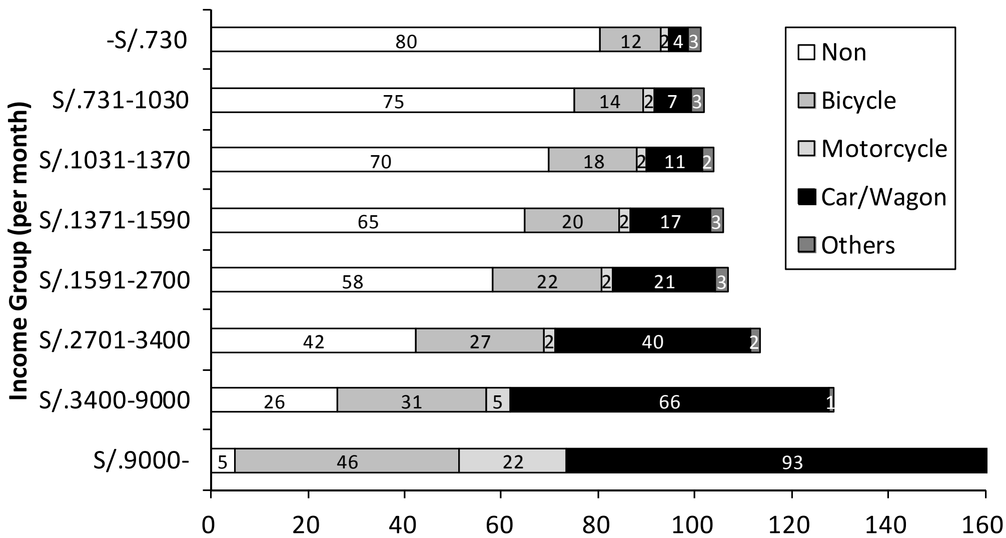
Figure 3.2 shows the number of households and the ratio by income group. "No response" households are excluded from the ratio calculation. The most common income group is S/.731 – 1,030 per month, accounting for 24.3% of the households. The households with the income of less than S/.2700 per month account for 85%.



Source: JICA Study Team (Person Trip Survey)

Figure 3.2 Income Distribution

Figure 3.3 illustrates the ratio of vehicle ownership by income group. Since some households own more than two types of vehicles (for example, motorcycle and cars), the total of the percentage exceeds 100. The bar chart shows that vehicle ownership is related to the income level. Car ownership of the households with the monthly income of more than S/. 9000 is as high as 93%.



Source: JICA Study Team (Person Trip Survey)

Figure 3.3 Vehicle Ownership by Income Group

3.2.2 Trip Rate

The number of trips after calibration was estimated at 22.3 million in the Study Area, of which 16.9 million trips are produced by vehicles as shown in Table 3.1. The trip rate of the Study Area is 2.4 trips per person per day while that of the central area and other area is 2.7 and 2.3, respectively.

Table 3.1 Number of Trips and Trip Rate of the Study Area

	Central	Other Area	Study Area Total
Population (1,000)	1,873	7,578	9,451
No. of Trips (1,000)	5,012	17,296	22,308
Trip Rate (per day)	2.7	2.3	2.4
No. of Trips excluding Walk Trips	4,091	12,787	16,878
Trip Rate	2.2	1.7	1.8

Source: JICA Study Team

3.2.3 Modal Share

The modal share in the Study Area was calculated based on the primary mode as shown in Table 3.2. The modal share in 2012 is similar to that of 2004. Walk trip accounts for 24%, private mode accounts for 16%, para transit mode accounts for 9%, and public transport mode accounts for 51% of the total modes.

Table 3.2 Modal Share of All Modes

	2012		2004	
Mode	No. of Trips (000)	Modal Share	No. of Trips (000)	Modal Share
Walk	5,416	24.3%	4,208	25.4%
Bicycle	77	0.3%	84	0.5%
Motorcycle	107	0.5%	30	0.2%
Private car	3,401	15.2%	1,856	11.2%
Mototaxi	1,325	5.9%	600	3.6%
Taxi	591	2.6%	902	5.5%
Colectivo	333	1.5%	181	1.1%
Combi	3,880	17.4%	3,791	22.9%
Minibus	5,536	24.8%	3,072	18.6%
Bus	1,248	5.6%	1,661	10.0%
BRT	274	1.2%	0	0.0%
Train	74	0.3%	0	0.0%
Truck&Others	44	0.2%	152	0.9%
Total	22,308	100.0%	16,537	100.0%

Source: JICA Study Team (Person Trip Survey)

3.2.4 Trip Purpose

Table 3.3 shows the composition of trips by purpose. Commuter trips (“To Work”, “To School”, and their returning home trips) are the major trips in the Study Area. “To Work” and “To School” trips account for 16.7% and 14.0% of all mode trips, respectively. The proportions of these trips are slightly larger than those in 2004 (16.2 and 13.9%). Private trips and Business trips account for 19.5% and 2.5%, respectively. These percentages are lower than those in 2004 (3.1%). If walk trips are excluded, the proportion of “To School” trips drops to 11.0%.

Table 3.3 Trip Purpose

Purpose	All Modes			Excluding Walk Trips		
	No. of Trips (1,000)	%	Excluding "To Home"	No. of Trips (1,000)	%	Excluding "To Home"
To Work	3,733	16.7	32.2	3,052	18.1	33.8
To School	3,122	14.0	26.9	1,861	11.0	20.6
Business	557	2.5	4.8	538	3.2	6.0
Private	4,191	19.5	36.1	3,579	21.2	39.6
To Home	10,549	47.3	-	7,849	46.5	-

Source: JICA Study Team (Person Trip Survey)

3.2.5 Trip Generation and Attraction

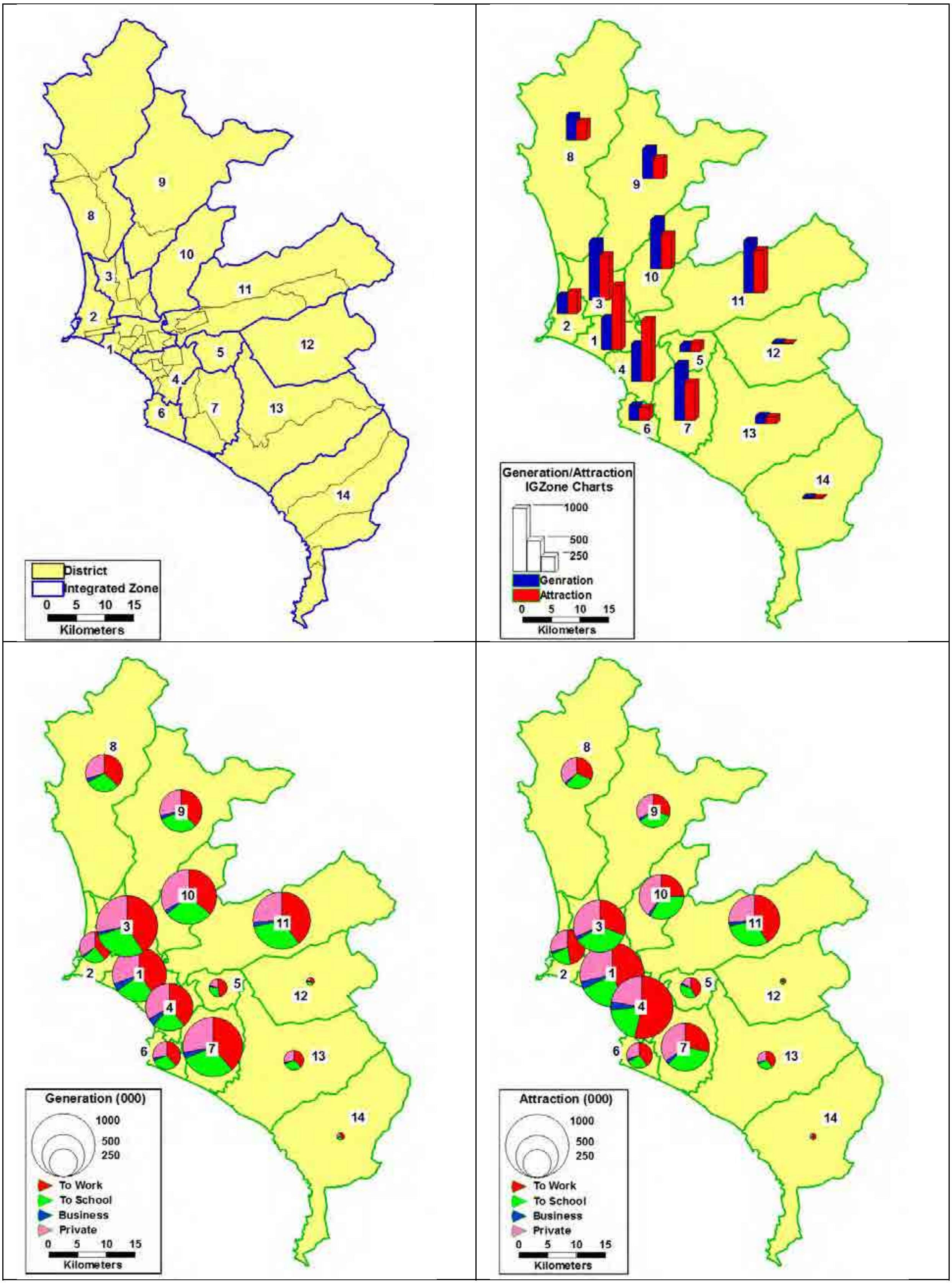
The trip generation is the demand of trips based on the departure place while the trip attraction is that of arrival place. They are calculated based on Traffic Analysis Zone (TAZ), District, Integrated Zone, and the Study Area. The study of PMTU-2025 used 14 integrated zones to present the results of the analysis instead of using 49 districts. To compare the results with the previous study in 2004, the results of this Study are presented based on the 14 integrated zones. The top-left map in Figure 3.4 illustrates the boundaries of the integrated zones with those of 49 districts.

The top-right map in Figure 3.4 shows the trip generation and attraction in the Study Area. "To home" trips are excluded. Blue and red bars show the trip generation and attraction, respectively. As can be seen, the central areas such as integrated zones 1 and 4 are the major destinations of the daily trips in the Study Area while the trip generation demand is high in suburban areas.

The largest difference in the transport system in the Study Area between the year 2004 and 2012 is the existence of mass transit systems such as Metropolitano and Metro Line-1. Figure 3.5 shows the distribution of origins and destinations of mass transit passengers. "To home" trips are excluded. Traffic Analysis Zones (TAZs) are classified by the trip density (the number of trips divided by the area of the zone). Trip origins and destinations are distributed along Metro Line-1 and Metropolitano. As can be seen, trip origins of Metro Line-1 are distributed in the south of the line while trip destinations are concentrated in the center of the city. Metropolitano has a large area of trip origins in the north of the line, and the destinations cover a large area in the center of the city.

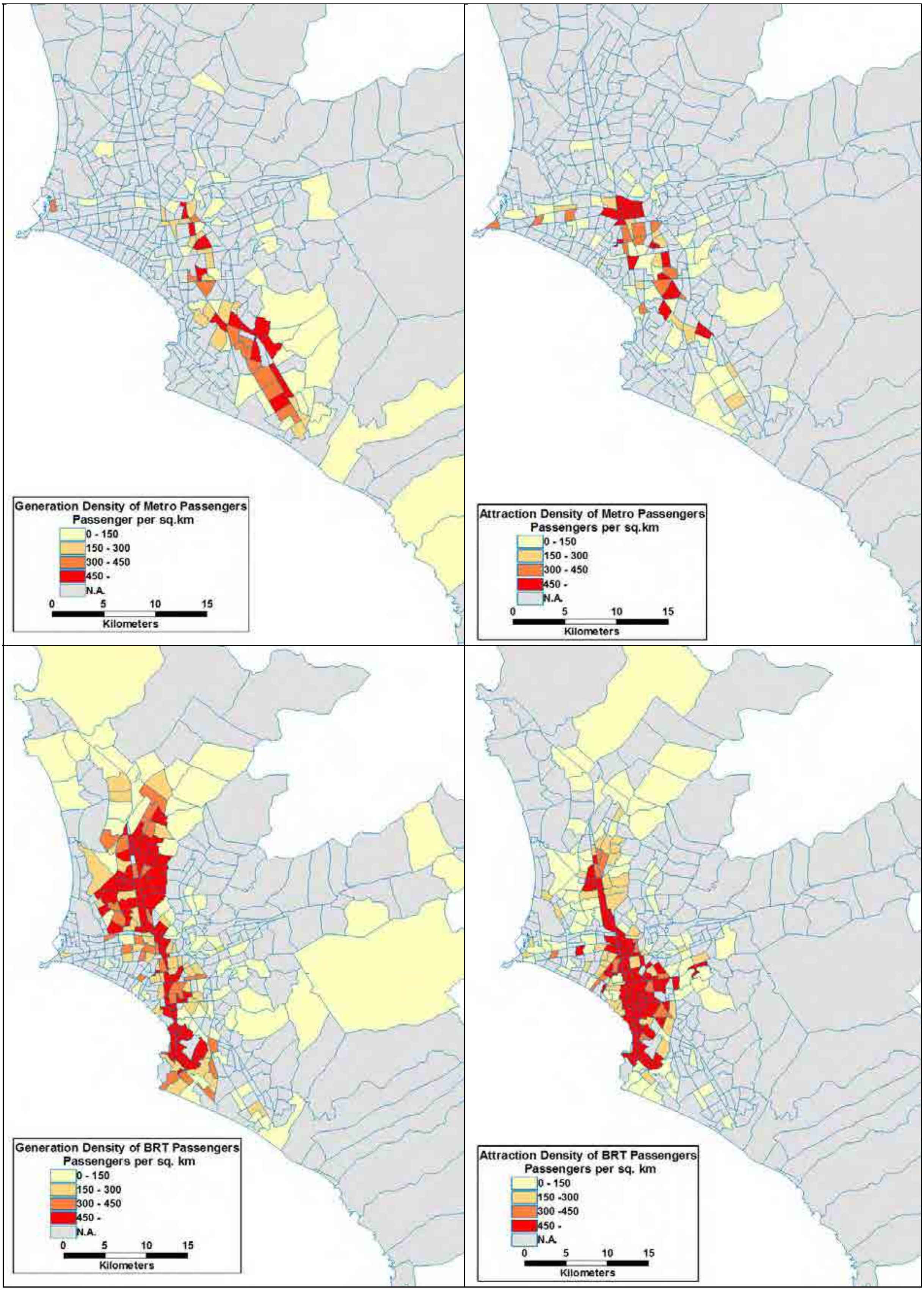
3.2.6 Trip Distribution

A desired line diagram is used to visualize an OD matrix by showing the traffic flow among areas with lines whose width represent the traffic volume. Figure 3.6 shows the desired lines based on the integrated zones. As can be seen from the figure, traffic demand is concentrated in the integrated zone -1. Since the modal share of public transport is large, the desired line of public transport passengers seems to be almost the same as that of total passengers. The scale of the desired lines of private and para transit modes is enlarged so that the difference of the volume among zones becomes clear. High demand for the private mode is observed in the center of the city such as between zones 1 and 4, and between zones 4 and 5. The distribution pattern of para transit mode is similar to that of public mode.



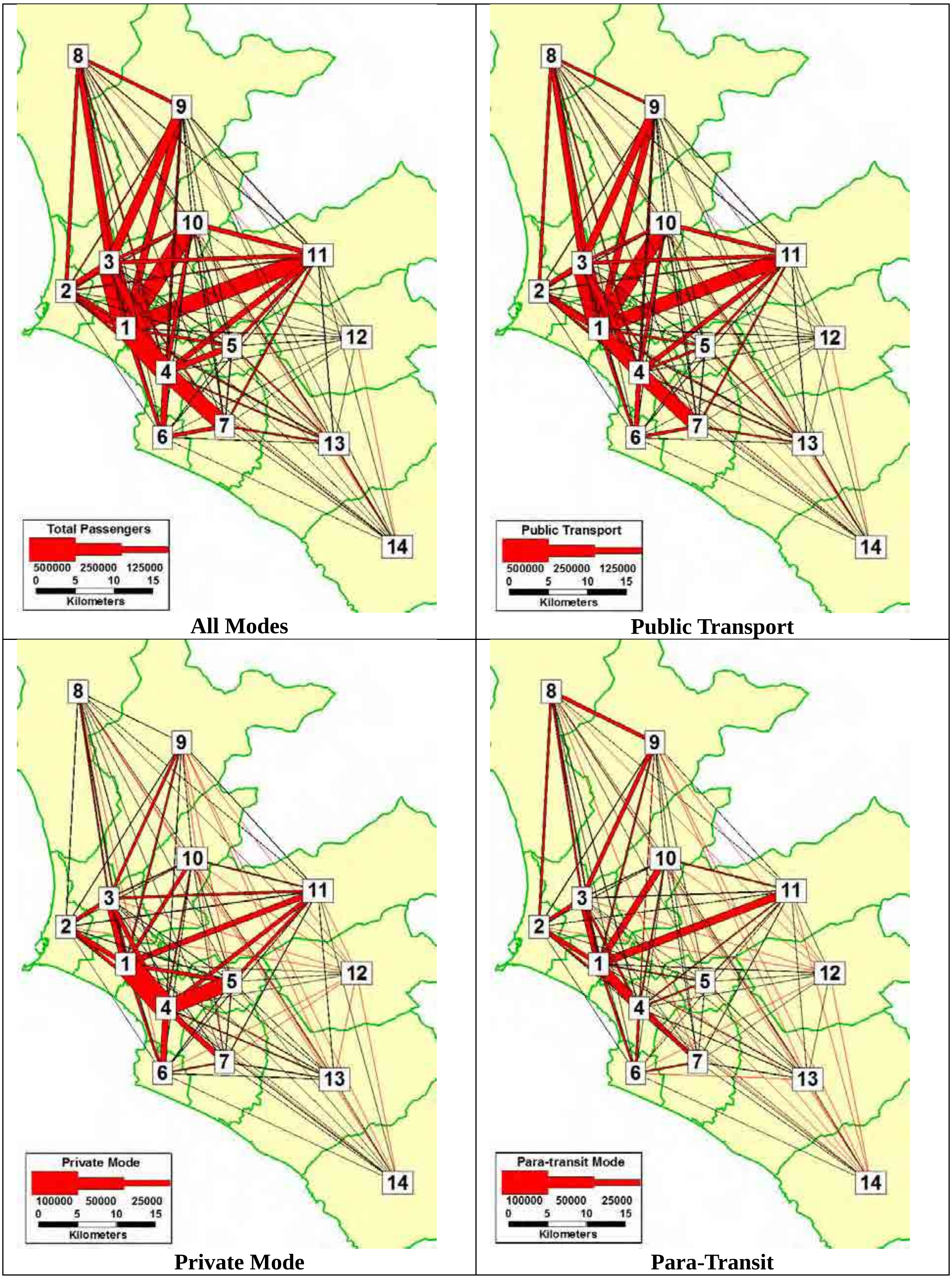
Source: JICA Study Team (Person Trip Survey)

Figure 3.4 Trip Generation and Attraction by Integrated Zone



Source: JICA Study Team (Person Trip Survey)

Figure 3.5 Generation and Attraction Density of Mass Transit Passengers



Source: JICA Study Team (Person Trip Survey)

Figure 3.6 Desired Line

Chapter 4 Socio-economic Framework

4.1 Economic Framework

4.1.1 GDP Projection

There is a projection of the future GDP growth rates up to 2021 in a report published by the National Strategic Planning Center (CEPLAN) in 2010. The projection in the report was employed in the Study for the projection up to 2020. The GDP growth rates after 2020 were assumed as 4.3% and 4.2% for the period of 2020-2025 and 2025-2030, respectively. The growth rates of per capita GDP were projected from the future GDP and the population projection described in the following section.

Table 4.1 Projection of National GDP and Per Capita GDP, 2012-2030

(constant prices in 1994)

Year	National GDP		Per Capita GDP	
	(million nuevos soles)	Average annual growth rate (period)	(million nuevos soles)	Average annual growth rate (period)
2012	235,605		7,818	
2015	286,023	6.7% (2012-2015)	9,182	5.5% (2012-2015)
2020	373,861	5.5% (2015-2020)	11,390	4.4% (2015-2020)
2025	461,170	4.3% (2020-2025)	13,401	3.3% (2020-2025)
2030	566,305	4.2% (2025-2030)	15,775	3.3% (2025-2030)

Source: JICA Study Team

4.1.2 GRDP Projection

There are no official data available regarding projection of the GRDP and per capita GRDP in Department of Lima. Based on the projection of National GDP and the percentage share trend of GRDP in Department of Lima in Peru, the study team estimates the GRDP in Department of Lima as shown in Table 4.2 while Table 4.3 shows the projection of per capita GRDP in Department of Lima estimated from the GRDP and population projection in Department of Lima.

Table 4.2 Projection of GRDP in Department of Lima, 2012-2030

(constant prices in 1994)

Year	National GDP	GRDP in Department of Lima		
	(million nuevos soles)	(million nuevos soles)	Average annual growth rate (period)	% share in Peru
2012	235,605	113,558		48.2%
2015	286,023	139,949	7.2% (2012-2015)	48.9%
2020	373,861	185,998	5.9% (2015-2020)	49.8%
2025	461,170	231,761	4.5% (2020-2025)	50.3%
2030	566,305	287,195	4.4% (2025-2030)	50.7%

Source: JICA Study Team

Table 4.3 Projection of Per Capita GRDP in Department of Lima

(constant prices in 1994)

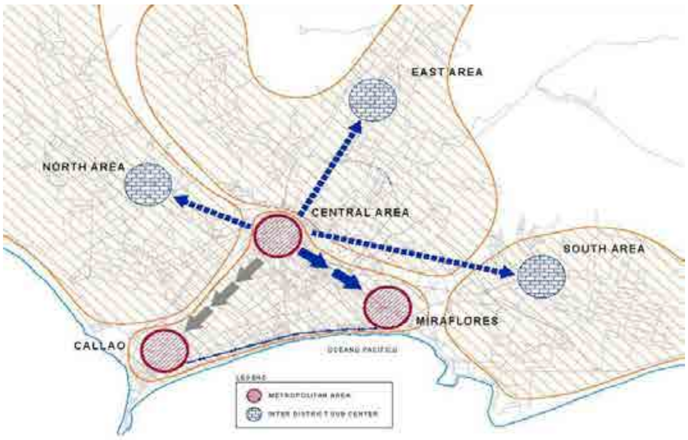
Year	Per Capita GRDP (million nuevos soles)	Average Annual Growth Rate (period)
2012	10,957	
2015	12,900	5.6% (2012-2015)
2020	15,910	4.3% (2015-2020)
2025	18,486	3.0% (2020-2025)
2030	21,631	3.2% (2025-2030)

Source: JICA Study Team

4.2 Land Use Plan

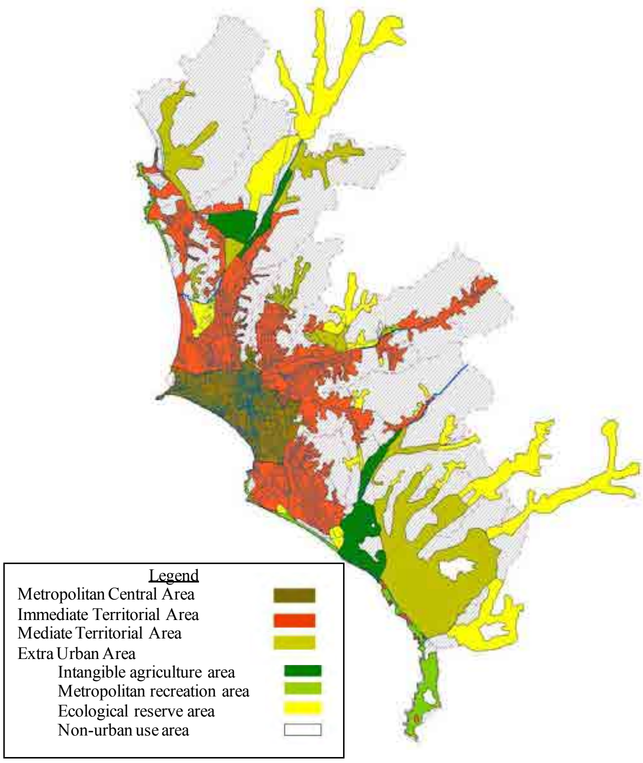
4.2.1 Metropolitan Development Plan for Lima and Callao 1990-2010 (PLANMET)

The latest official development plan for Lima and Callao Metropolitan Area is "Metropolitan Development Plan for Lima and Callao 1990-2010" (PLANMET) formulated by MML in 1989. The PLANMET introduced the concept of "4 major urban centers" with existing metropolitan center and 3 new sub-centers (Figure 4.1), and "Territorial Unites of Metropolitan Planning" with 4 categorizations of the area according to the target of urbanization (Figure 4.2).



Source: PMTU-2025

Figure 4.1 Concept of 4 Major Urban Centers of PLANMET

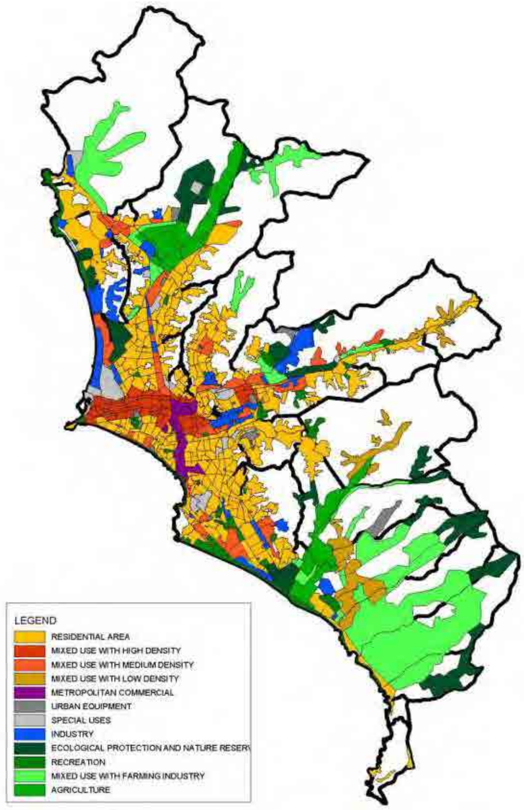


Source: PMTU-2025

Figure 4.2 Territorial Unites of Metropolitan Planning of PLANMET

4.2.2 Land Use Plan of PMTU-2025

Figure 4.3 shows the Land use plan for 2025 from PMTU-2025. The Study Team follows the concepts of the metropolitan structure in PMTU-2025 and adopts its land use plan for the future projection.



Source: PMTU-2025

Figure 4.3 Land Use Plan of PMTU-2025

4.3 Population

4.3.1 Population by District

Table 4.4 summarizes recent and future population from the national level to province level. Percentage share of the population in Lima and Callao Metropolitan Area was gradually increased from 30% to 34% in Peru.

Table 4.4 Summary of Recent and Future Population

Year	Peru	Lima and Callao Metropolitan Area		Lima Province	Callao Province
	Population	Population	% share in Peru	Population	Population
2000	25,983,588	7,757,300	29.9%	6,968,339	788,961
2005	27,810,540	8,489,668	30.5%	7,622,791	866,877
2012	30,135,875	9,450,585	31.4%	8,481,415	969,170
2020	32,824,358	10,690,877	32.6%	9,609,386	1,081,491
2030	35,898,422	12,175,250	33.9%	10,963,461	1,211,789

Source: 1), 2), 3) and JICA Study Team

Table 4.5 shows results of future population projection and population density in Lima and Callao Metropolitan Area combining 427 traffic zones into 49 districts level. Consequently, as mentioned in the urban structure of PMTU-2025 in section 4-2, Central Lima Area shows population decrease trend and neighboring area of North, South and East Lima Area show the population growth.

Table 4.5 Future Population Projection, 2012-2030

Area	District Name	Area (ha)	2012		2020		2030	
			Population	Population Density	Population	Population Density	Population	Population Density
Total [Lima Area]		267,040	8,481,415	31.8	9,609,386	36.0	10,963,461	41.1
Central Lima Area	Lima	2,198	286,849	130.5	250,769	114.1	204,312	93.0
	Barranco	333	31,959	96.0	27,037	81.2	20,677	62.1
	Breña	322	79,456	246.8	71,214	221.2	60,605	188.2
	Jesús Maria	457	71,364	156.2	71,964	157.5	72,714	159.1
	La Victoria	874	182,552	208.9	156,044	178.5	121,838	139.4
	Lince	303	52,961	174.8	46,379	153.1	37,894	125.1
	Magdalena del Mar	361	54,386	150.7	55,111	152.7	56,016	155.2
	Magdalena Vieja	438	77,038	175.9	75,281	171.9	73,025	166.7
	Miraflores	962	84,473	87.8	79,092	82.2	72,168	75.0
	Rimac	1,187	171,921	144.8	155,885	131.3	135,257	113.9
	San Borja	996	111,568	112.0	112,970	113.4	114,595	115.1
	San Isidro	1,110	56,570	51.0	51,124	46.1	44,117	39.7
	San Luis	349	57,368	164.4	58,593	167.9	60,066	172.1
	San Miguel	1,072	135,086	126.0	137,470	128.2	140,124	130.7
	Santiago de Surco	3,475	326,928	94.1	375,355	108.0	434,720	125.1
	Surquillo	346	92,328	266.8	90,386	261.2	87,852	253.9
Total [Central Lima Area]		14,783	1,872,807	126.7	1,814,674	122.8	1,735,983	117.4
North Lima Area	Ancón	29,864	39,769	1.3	49,178	1.6	60,555	2.0
	Carabayllo	34,688	267,961	7.7	353,520	10.2	455,939	13.1
	Comas	4,875	517,881	106.2	544,326	111.7	576,884	118.3
	Independencia	1,456	216,503	148.7	220,608	151.5	225,398	154.8
	Los Olivos	1,825	355,101	194.6	401,239	219.9	457,906	250.9
	Puente Piedra	7,118	305,537	42.9	423,069	59.4	562,386	79.0
	San Martín de Porres	3,691	659,613	178.7	772,050	209.2	909,235	246.3
	Santa Rosa	2,150	15,399	7.2	23,344	10.9	32,537	15.1
Total [North Lima Area]		85,667	2,377,764	27.8	2,787,336	32.5	3,280,840	38.3
South Lima Area	Chorrillos	3,894	314,835	80.9	346,955	89.1	386,483	99.3
	Cieneguilla	24,033	38,328	1.6	58,998	2.5	82,870	3.4
	Lurin	18,026	76,874	4.3	98,024	5.4	123,497	6.9
	Pachacamac	16,023	102,691	6.4	165,546	10.3	237,453	14.8
	Pucusana	3,739	14,403	3.9	20,786	5.6	28,273	7.6
	Punta Hermosa	11,950	6,935	0.6	8,681	0.7	10,791	0.9
	Punta Negra	13,050	6,878	0.5	9,478	0.7	12,560	1.0
	San Bartolo	4,501	7,008	1.6	8,792	2.0	10,946	2.4
	San Juan de Miraflores	2,398	393,493	164.1	426,560	177.9	467,313	194.9
	Santa Maria del Mar	981	1,220	1.2	2,108	2.1	3,107	3.2
	Villa El Salvador	3,546	436,289	123.0	509,576	143.7	599,201	169.0
	Villa Maria del Triunfo	7,057	426,462	60.4	488,430	69.2	564,414	80.0
Total [South Lima Area]		109,198	1,825,416	16.7	2,143,934	19.6	2,526,907	23.1
East Lima Area	Ate	7,772	573,948	73.8	720,347	92.7	897,166	115.4
	Chaclacayo	3,950	43,180	10.9	44,417	11.2	45,897	11.6
	El Agustino	1,254	189,924	151.5	196,726	156.9	205,050	163.5
	La Molina	6,575	157,638	24.0	194,308	29.6	238,757	36.3
	Lurigancho	23,647	201,248	8.5	247,707	10.5	304,039	12.9
	San Juan de Lurigancho	13,125	1,025,929	78.2	1,206,300	91.9	1,426,300	108.7
	Santa Anita	1,069	213,561	199.8	253,639	237.3	302,521	283.0
Total [East Lima Area]		57,392	2,405,428	41.9	2,863,442	49.9	3,419,731	59.6
Callao Area	Callao	4,565	417,622	91.5	394,834	86.5	339,742	74.4
	Bellavista	456	74,287	162.9	68,485	150.2	57,308	125.7
	Carmen de La Legua-Reynoso	212	42,065	198.4	39,944	188.4	35,092	165.5
	La Perla	275	60,886	221.4	55,966	203.5	46,625	169.5
	La Punta	75	3,793	50.6	2,655	35.4	1,396	18.6
	Ventanilla	7,352	370,517	50.4	519,606	70.7	731,626	99.5
Total [Callao Area]		12,935	969,170	74.9	1,081,491	83.6	1,211,789	93.7
Grand Total [Lima and Callao Metropolitan Area]		279,975	9,450,585	33.8	10,690,877	38.2	12,175,250	43.5

Source: JICA Study Team

4.3.2 Population by Socioeconomic Level

Based on the data published by INEI and APEIM, and followed to the future development scenario in PMTU-2025, the study team estimates the future population distribution by socio-economic levels as shown in Table 4.6. According to the estimation, the socio-economic levels A and B will significantly concentrate in Central Lima Area while the following socio-economic levels C to E will spread from central to suburban areas.

Table 4.6 Future Population by Socio-economic Level in the Study Area

Year	Population by Socio-economic Level (% share)				
	A and B	C	D	E	Total
2012	2,006,351 (21.2%)	3,298,800 (34.9%)	2,957,358 (31.3%)	1,188,076 (12.6%)	9,450,585 (100.0%)
2020	3,152,225 (29.5%)	3,682,967 (34.4%)	2,737,926 (25.6%)	1,117,759 (10.5%)	10,690,877 (100.0%)
2030	4,217,054 (34.6%)	4,154,220 (34.1%)	2,687,412 (22.1%)	1,116,565 (9.2%)	12,175,250 (100.0%)

Source: JICA Study Team

4.3.3 Number of Workers

The future number of workers at resident zones was projected based on the results of the national census 2007, and corresponding to the historical trend of the working population by job categories. Table 4.7 shows the result of the projection. The number of workers at workplace zones was estimated based on the projection in PMTU-2025.

Table 4.7 Future Number of Workers by Industrial Category

Year	Primary Industry	Secondary Industry	Tertiary Industry	Total
2012	42,261	1,137,967	3,298,095	4,478,324
2020	33,666	1,292,977	3,686,811	5,013,454
2030	32,893	1,505,890	4,292,035	5,830,818

Source: JICA Study Team

4.3.4 Number of Students

The number of students at resident zones was projected based on the results of the national census 2007 and corresponding to the growth rate of relevant age group by 3 categories. Table 4.8 shows the summary of future number of students in the Study Area.

Table 4.8 Future Number of Students at Resident Place

Year	Primary / Secondary School Student	Superior School Student	Occupational School Student	Total
2012	1,550,395	551,426	67,137	2,168,958
2020	1,716,645	607,003	75,461	2,399,108
2030	1,886,629	656,943	83,209	2,626,781

Source: JICA Study Team

The number of students at school locations was also projected by applying the population growth rates by age group. The Ministry of Education is publishing the web-based GIS database regarding the number of students with school location. This database is based on the results of educational census (Censo Escolar), and the latest census was implemented in 2011. The number of students at school location in Lima and Callao Metropolitan Area in 2011 is aggregated from this database and divided into 427 traffic zones with the 3 categories mentioned above. As for the university and graduate school, the number of students was published by INEI in national university census (Censo Nacional Universitario 2010).

Chapter 5 Demand Forecast

5.1 Methodology of Demand Forecast

The traditional four step model was applied for the demand forecast, which consists of 1) trip generation model, 2) trip distribution model, 3) modal split model, and 4) traffic assignment model. These models were developed based on the result of Person Trip Survey. Since the traffic congestion in peak hours and the capacity of mass transit systems are the issue in Lima and Callao Metropolitan Area, these models were developed for the peak hour traffic.

Figure 5.1 shows the Traffic Analysis Zone of the Study. The Study Area is divided into 427 traffic zones as has been applied in previous studies. Lima has 401 zones and 26 are located in Callao.

Source: Database of PMTU-2025, illustrated by the JICA Study Team

Figure 5.1 Traffic Analysis Zone

The network data was prepared in TransCAD format because transit route data was already available in that format. The network consists of approximately 14,400 links and 8,600 nodes while the transit network consists of 590 routes.

5.2 Transport Models

5.2.1 Trip Generation Model

Trip Generation Model, consisting of Trip Production and Trip Attraction Models, was developed by multi linear regression analysis for the following three categories:

- Home-based Work purpose trip - HBW: a work purpose trip from or to the home of the trip maker;
- Home-based School purpose trip - HBS: a study purpose trip from or to the home of the trip maker;
- Other purpose trip (OP) compound by:
  - Home-based Other purpose trip - HBO: another purpose trip from or to the home of the trip maker; and
  - Non home-based trip - NHB: a trip of which the origin and destination are not the home of the trip maker.

5.2.2 Trip Distribution Model

The Trip Distribution Model was also developed as a gravity model for the same three categories as the Trip Generation Model. The impedance for the gravity model is calculated from travel time and travel cost.

5.2.3 Modal Split Model

The Modal Split Model was developed as a binary logit model between private and public mode for the three categories. .

5.2.4 Traffic Assignment

Traffic assignment of the Study consists of two steps: 1) private mode assignment, and 2) transit assignment. User Equilibrium Method was applied for both cases. For private mode assignment, BPR function is used for the delay function of each link. Discomfort effects due to congestion are considered for the route cost function of the transit assignment.

5.3 Network Scenario

The JICA Study Team updated the road network data which was prepared in TransCAD format based on information of recent road projects. The future road projects in PMTU-2025 and new projects that are not included in PMTU-2025 were added to the future road network.

For the transit network, the railway lines of MTC Plan were added to the network because it is realistic to consider the government decision (059-2010-MTC), although the scenario when Line-3 and Line-5 are not implemented was prepared because these lines overlap with Metropolitano. In addition to the existing plan, the monorail route proposed in Chapter 6 was added to the network data with three alternatives.

5.4 Future Demand

5.4.1 Peak Hour Demand and Modal Share

The results of the future matrices for the public and private mode for the morning peak are presented in Table 5.1. It indicates that the despite the large investments expected in public transport the private mode increases its participation on the modal split. This tendency is explained for the strong increasing in the motorization rate of the population and for investments also expected in the road network.

Table 5.1 Future demand estimated for 2020 and 2030

Year	Public	Private	Total	Public	Private
2012	999,972	303,114	1,303,086	76.7%	23.3%
2020	1,090,237	346,943	1,437,180	75.9%	24.1%
2030	1,215,816	390,897	1,606,713	75.7%	24.3%
Evolution 20-12	9.0%	14.5%	10.3%		
Evolution 30-20	11.5%	12.7%	11.8%		

Source: JICA Study Team

5.4.2 Demand of Public Transport System

The results of the demand forecast of the public transport system are shown in the tables below. This is the result of the case when the new route, which is studied in Chapter 6, is added to the metro network plan in 2010. The demand of Line-3 is the largest, followed by Line-1. Railway system would be suitable for Line-2 because the capacity of medium capacity transit systems would be less than the demand. For Line-4, medium capacity transit systems can deal with the estimated demand. The demand of the new route is not large enough to introduce a railway system, and then introduction of a medium capacity transit system is worth studying.

Table 5.2 Projection of Passenger Boarding of Railway System

	2020			2030		
	Line-1, 2, 4	MTC Plan	MTC Plan & New Route	Line-1, 2, 4	MTC Plan	MTC Plan & New Route
Line 1	436,000	428,000	530,000	574,000	672,000	697,000
Line 2	304,000	379,000	421,000	368,000	498,000	518,000
Line 3	0	569,000	582,000	0	716,000	699,000
Line 4	235,000	333,000	367,000	300,000	434,000	452,000
Line 5	0	104,000	109,000	0	117,000	122,000
New Route	0	0	175,000	0	0	202,000
Metropolitano	341,000	186,000	251,000	414,000	214,000	315,000

Source: JICA Study Team

Table 5.3 Projection of Peak Hour Peak Direction Passenger Volume of Railway System

	2020			2030		
	Line-1, 2, 4	MTC Plan	MTC Plan & New Route	Line-1, 2, 4	MTC Plan	MTC Plan & New Route
Line 1	25,000	24,000	28,000	35,000	38,000	40,000
Line 2	22,000	24,000	27,000	27,000	34,000	35,000
Line 3	0	39,000	39,000	0	53,000	49,000
Line 4	12,000	16,000	18,000	16,000	20,000	20,000
Line 5	0	8,000	9,000	0	9,000	10,000
New Route	0	0	15,000	0	0	17,000
Metropolitano	29,000	15,000	14,000	39,000	19,000	18,000

Source: JICA Study Team

5.4.3 Findings of the Demand Forecast

The followings are major findings of the demand forecast.

1) The road congestion of arterial roads connecting the suburban areas and the center of the city in peak hours will become heavier. Therefore, construction of the road projects proposed in PMTU-2025 is necessary. Especially, the implementation of Vía de Periférica, Av. Paseo de la República Sur, and Autopista Ramiro Prialé are very important.

2) The road capacity of arterial roads in the center of the city, excluding Centro, still has a margin against the commuter traffic demand. Therefore, there is a possibility to solve the congestion problem to some extents by introducing intersection improvements and traffic managements proposed in PMTU-2025.

3) Since passenger demand in the north south direction is very high, Metro Line-1 and Line-3 should be developed as a high capacity system such as railway. Although Line-3 uses Tupac Amaru as same as the BRT (Metropolitano), the capacity of Metropolitano is not high enough to cope with the demand.

4) Metro Line-2 and Line-4 are planned for the east west direction. As far as the demand concerned, there is a possibility that a medium capacity transit system can cope with the demand for these lines. This is further analyzed in Chapter 6.

5) Although Metro Line-5 has the demand of approximately 10,000 PHPDT, the line overlaps with Metropolitano. From this, the construction of Line-5 would be overinvestment.

6) Since the metro lines in the government's metro plan in 2010 cross each other, transfer demand is very high. Therefore, changes of a line will affect the passenger demand of other lines to a large extent. It is necessary to develop transfer stations so that the transfer is very convenient.

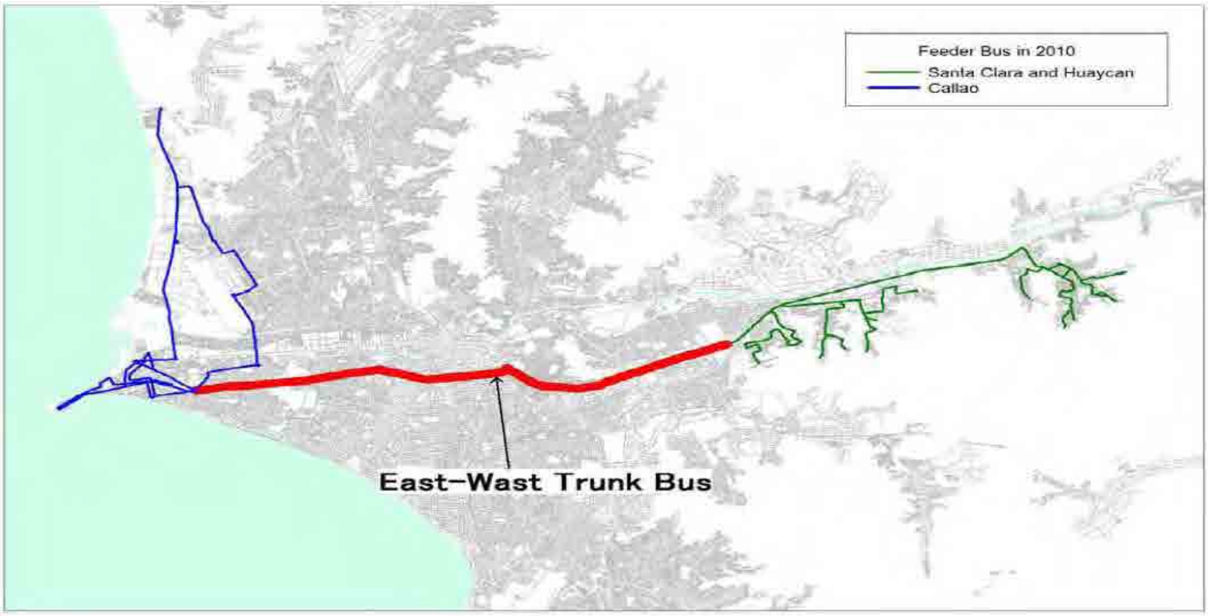
7) Passenger demand in the suburban direction of the metro lines in the plan is also high. It is desirable to study feeder bus systems at the time of the railway development.

Chapter 6 Concept Study of Medium Capacity Transit System

6.1 Background of the Study

6.1.1 Medium Capacity Transit System as an Alternative of Urban Transit System

In the urban transport planning in Peru, the choice of the urban transit system has been discussed between BRT and railway systems. The mass transit plan in PMTU-2025 was also formulated based on Trunk Bus System and Railway System. A trunk bus (BRT) project along Av. Venezuela – Carretera Central (East-West Corridor) was studied in the feasibility study by JICA in 2007 based on the conclusion of the study of PMTU-2025. The corridor was identified as the second Metropolitano by Protransporte.



Source: JICA F/S in 2007

Figure 6.1 East-West Trunk Bus Corridor in JICA F/S

On the other hand, the corridor was identified as Line-2 of the railway network in the Presidential Decree in 2010 (DS 059-2010-MTC). Since the two plans use the same roads for their routes, it was necessary to select one of them for the proper system along the corridor. Generally, the choice between BRT and Light Rail Transit (LRT) involves controversy because the two systems can be applied to routes of similar conditions. Since the characteristics of a BRT and a railway system are quite different, especially in the case of capacity, another alternative – medium transit capacity system – can be considered.

In this connection, this study evaluated the urban transit system based on the updated demand forecast by adding medium capacity transit systems as a new alternative.

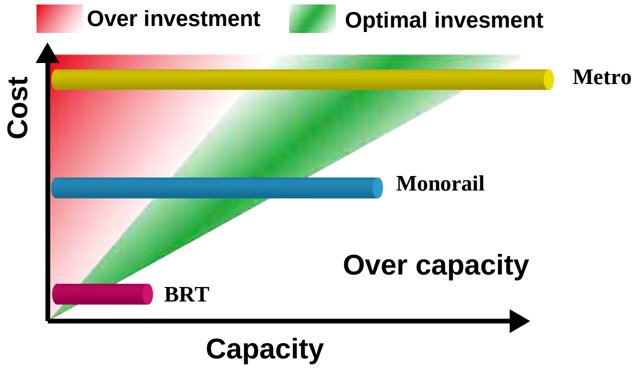
6.1.2 System Selection

In the study of PMTU-2025, only BRT and railway system were considered in developing the public transport network. The study prepared 16 scenarios of the combination of BRT and railway system and evaluated them. The criteria of the evaluation are: total cost, covered population, benefit to cost ratio, speed on road, distance of congested section, and reduction of CO_2.

Although the approach is proper in the master plan stage, it is necessary to consider various criteria for the system selection of each route. The followings items affect the system selection.

- Traffic Demand
- Route Condition
- System Integration
- Sustainability
- Development Timing

Figure 6.2 illustrates the concept of the optimal investment in view of traffic demand and capacity. In case that the demand is low, introduction of a high capacity system will be overinvestment while the introduction of a low capacity system to a high demand corridor will bring about over saturation. Medium transit capacity systems fill in the gap between railway system and BRT.



Source: JICA Study Team

Figure 6.2 Range of Optimal Investment

6.1.3 Evaluation of Present Plan

(1) Candidate System based on Demand Forecast

Table 6.1 shows the candidate system of each line of the government's metro plan in 2010 based on the results of the demand forecast in Chapter 5. The criteria are: 1) BRT or LRT in case of the maximum passenger demand in the peak hour for peak direction (PHPDT) is less than 10,000; 2) medium capacity transit system in case of PHPDT is between 10,000 and 20,000; 3) railway in case of PHPDT is larger than 35,000. If PHPDT is between 20,000 and 35,000, the suitable system should be selected based on route conditions and other factors.

Table 6.1 Candidate System by Demand and Route Conditions

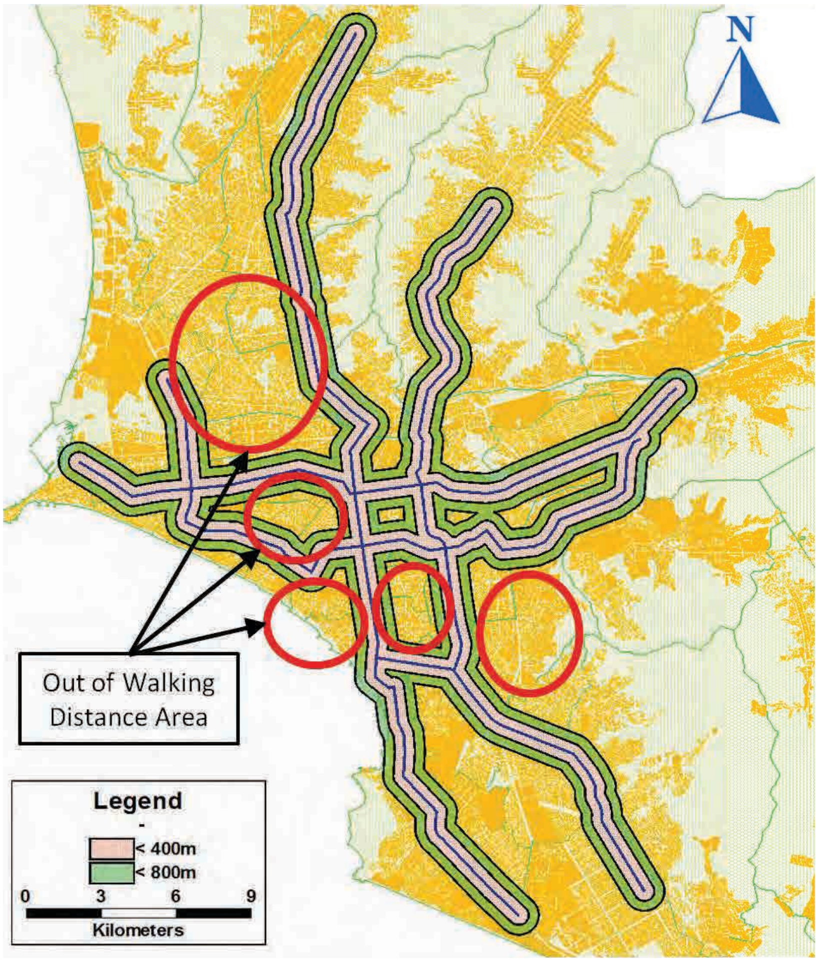
Line	PHPDT	Route Condition	Candidate System
Line-1	38,000	Under construction as elevated railway	Elevated railway
Line-2	34,000	Elevated structure for entire sections is difficult.	Underground railway
Line-3	53,000	Elevated structure for entire sections is difficult.	Underground railway
Line-4	20,000	Elevated structure is possible, although the curve condition is harsh for conventional railway.	Railway or medium capacity transit system
Line-5	9,000	Elevated structure is possible, although the line duplicates with Metropolitano	Medium capacity transit system

Source: JICA Study Team

(2) Service Area of Railway Network

Figure 6.3 shows the area of influence of the railway network in the Metro Plan. The bands in the figure show the area within a distance of 400m and 800m from each line. The distance of 800m would be the maximum walking distance in general. The access to the areas which are not covered with the bands is provided by feeder services. There is a blank area along Av. Universidad in the north of Rimac River (San Martin de Porres, Los Olivos). This is a populated area, and the traffic demand is very high. Presently, this area is served by the feeder services of Metropolitano. It is necessary to provide a mass transit system for the area.

Major high demand corridors are served with the railway network in the Metro Plan. However, there are some corridors where railway service will not be provided. For example, traffic demand along Av. Universitaria is high, but no mass transit system is planned for the corridor.



Source: Elaborated by JICA Study Team

Figure 6.3 Walking Distance Area of Railway System in Lima

6.2 Study of Medium Capacity Transit System

6.2.1 Target Routes and System

As described in the preceding section, medium capacity transit systems will probably be the most appropriate systems for Metro Line-4, judging from the result of the demand forecast. Line-1 is under construction as an elevated railway while railway is the only system to satisfy the demand of Line-3. Although a medium capacity transit system can carry the demand of Line-2, the route condition should be evaluated because railway will be more preferable considering the economy. Since the demand on Line-5 is small, the existing BRT will probably be able to cope with the future demand.

Besides, a corridor consisting of the Trunk Bus routes in PMTU-2025 was identified as the route where medium capacity transit systems will be preferable, based on the analysis of the service area of the present metro plan and the potential demand.

The medium capacity transit systems include LRT, AGT, and monorail. With its small, medium, and large types, the monorail can cope with a wide range of demand. Monorails are preferable system in view of the urban environment in Lima.

From these, the concept of the monorail system on Line-4 and the new route was studied.

6.2.2 Advantages and Features of Monorail

Figure 6.4 illustrates the bogie and track of monorail.

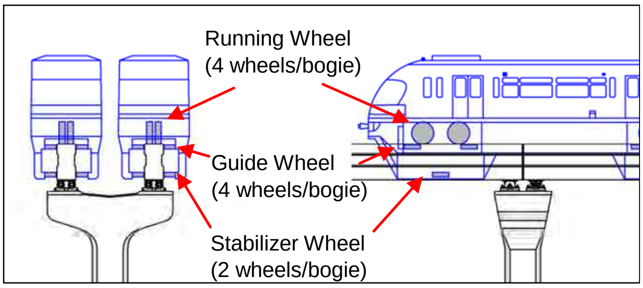


Figure 6.4 Bogie and Track of Monorail

The advantages of monorail are summarized as follows:

- High Flexibility in Route Alignment Condition
- Environmental Friendly
- Wide Rage Transport Capacity

As can be seen in the map of the MTC plan, the proposed routes require curves with a small radius. In elevated sections, it is necessary to make the route plan in such a way to keep the minimum radius of the system. Since the minimum radius of monorail is 70m, more flexible alignment will be possible compared to conventional railway system which requires the minimum radius of 250m.

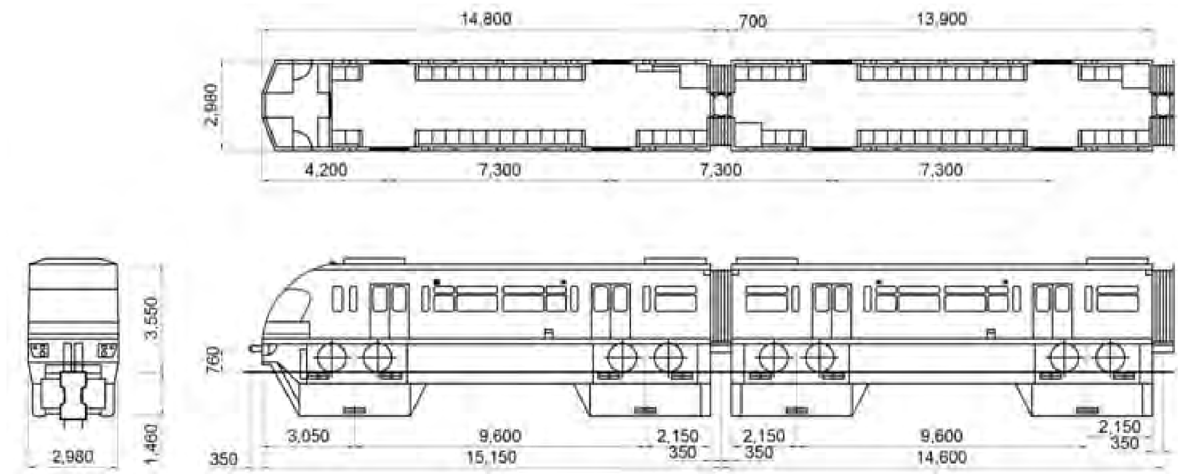
The structure of monorail is slender as shown in Figure 6.5 compared to the slab structure that is used by most transit systems.

Source: JICA Study Team

Figure 6.5 Monorail's superstructure and Conventional Slab Structure

6.2.3 Preliminary Design of Monorail Car

Figure 6.6 shows an example of the seat arrangement of the monorail. Longitudinal seat will be applied same as Metro Line-1. Wheelchair spaces and the emergency equipment such as spiral chutes shall be positioned, accordingly.



Source: JICA Study Team

Figure 6.6 Dimension and Seat Arrangement of Monorail

Since the length of bogie is shorter than conventional railway systems, the capacity of a train is smaller than that of railway systems. However, a monorail train can carry more than 900 passengers in case of 6-car composition. Table 6.2 shows the train capacity.

Table 6.2 Train Capacity

	2 car-train	3 car-train	4 car-train	6 car-train
Train capacity (passengers)	302	463	624	946
Train length	30.0m	44.9m	59.5m	88.7m

Note) Standees: 6 passengers per square meter

Source: JICA Study Team

6.3 Route Study

The Study was planned to conduct a concept study of the medium capacity transit system for Line 2 and Line 4 in the beginning of the Study when the plan of BRT for the East-West Corridor by Protransporte still existed while MTC had the plan of Line 2 as underground railway system. Although the railway system was finally selected for the corridor, the JICA Study Team conducted a field survey of Line 2 for the monorail system.

6.3.1 Line-4

From the demand forecast, medium capacity transit systems would be suitable for Line-4. Since the number of necessary rolling stock is larger than that of railway, there is a possibility that railway systems are more reasonable than medium capacity transit systems if the reduction in the infrastructure cost of medium capacity transit systems is not so large.

The monorail system has an advantage about the route condition of Line 4 because small radius curves are necessary for this line in case of elevated structure. In addition, steeper slope can be applied to cross over Line 1, which will reduce the construction cost.

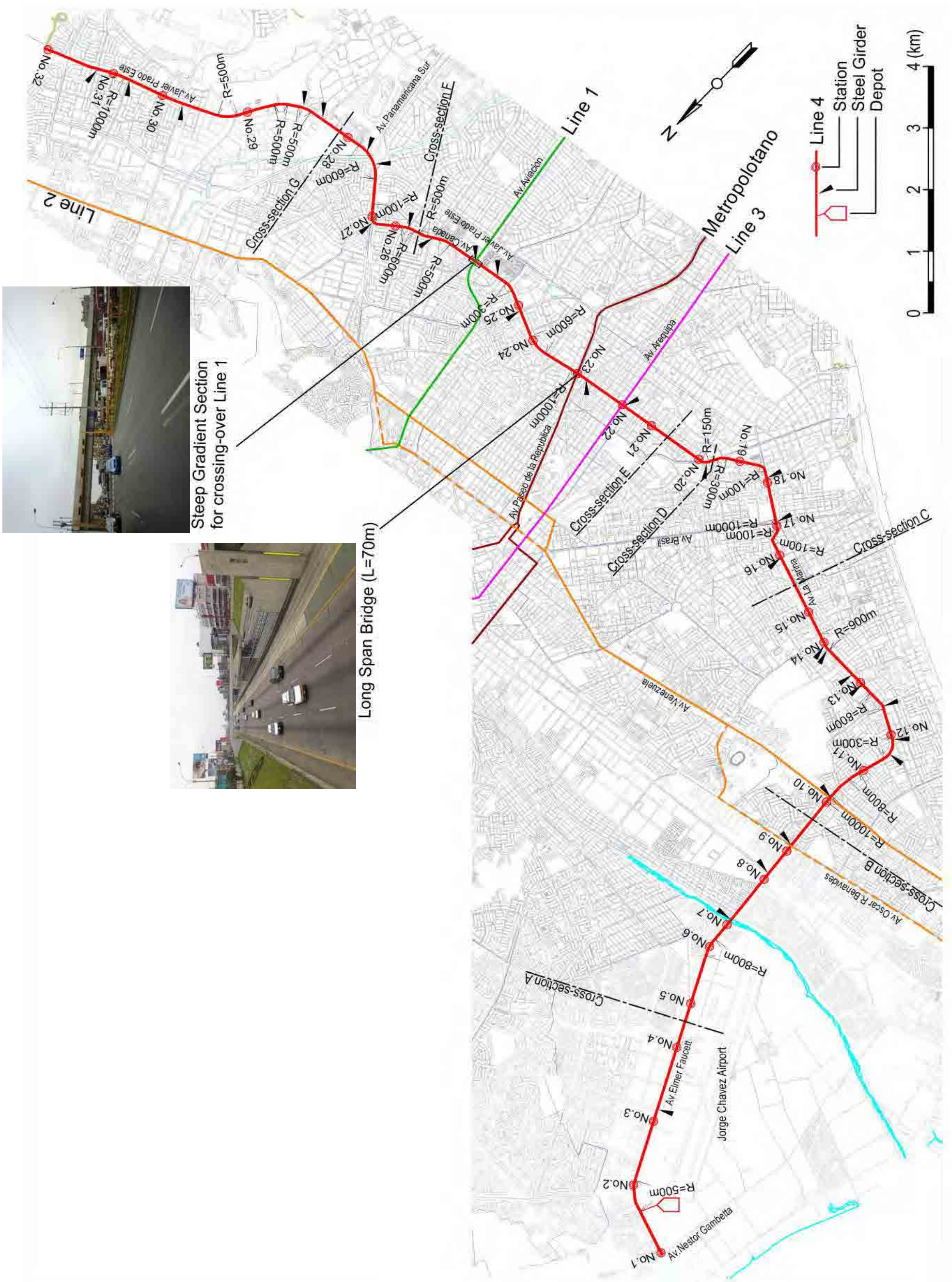
The demand forecast shows that the monorail system will be able to cope with the passenger demand of Line 4 in the future.

Table 6.3 shows the outline of the monorail system on Line 4, and the route is shown in Figure 6.7.

Table 6.3 Outline and Assumption of Line 4 Monorail

Item	Description
Route Alignment	
Route Length	29k500m
Number of Stations	32 stations
Small curve radius section (less than 300m)	100m: 3 sections 150m: 1 section 300m: 3 sections
Steep gradients section (i=6%)	1 section
Steel girder section	31 sections
Long span bridge	1 bridge
Service	
Estimated demand	35,000 PHPDT
Schedule speed	35km/h
Train configuration	8-car train
Headway	2 minutes
Transport capacity	38,000 PHPDT

Source: JICA Study Team



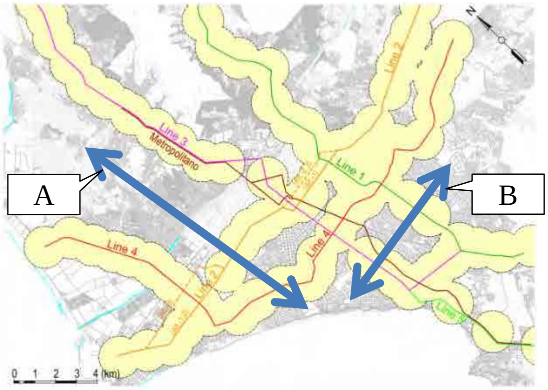
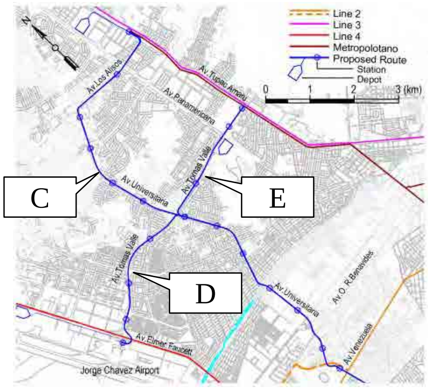
Source: JICA Study Team

Figure 6.7 Line-4 Monorail Route

6.3.2 New Route

The railway plan in PMTU-2025 includes a route along Av. Universitaria, where passenger demand is very high. As shown in Figure 6.3, the present metro plan cannot cover the area along this avenue. There is another corridor where the railway service will not be available in the metro plan. That is Av. Angamos Este, which runs between Line 4 and the south part of Line 3. Based on the discussion with MTC, the study route of the monorail was proposed along Av. Universitaria and Av. Angamos Este. With regard to the terminal point of the north part, three alternative routes were studied. Table 6.4 summarizes the process of the route selection and the alternative setting.

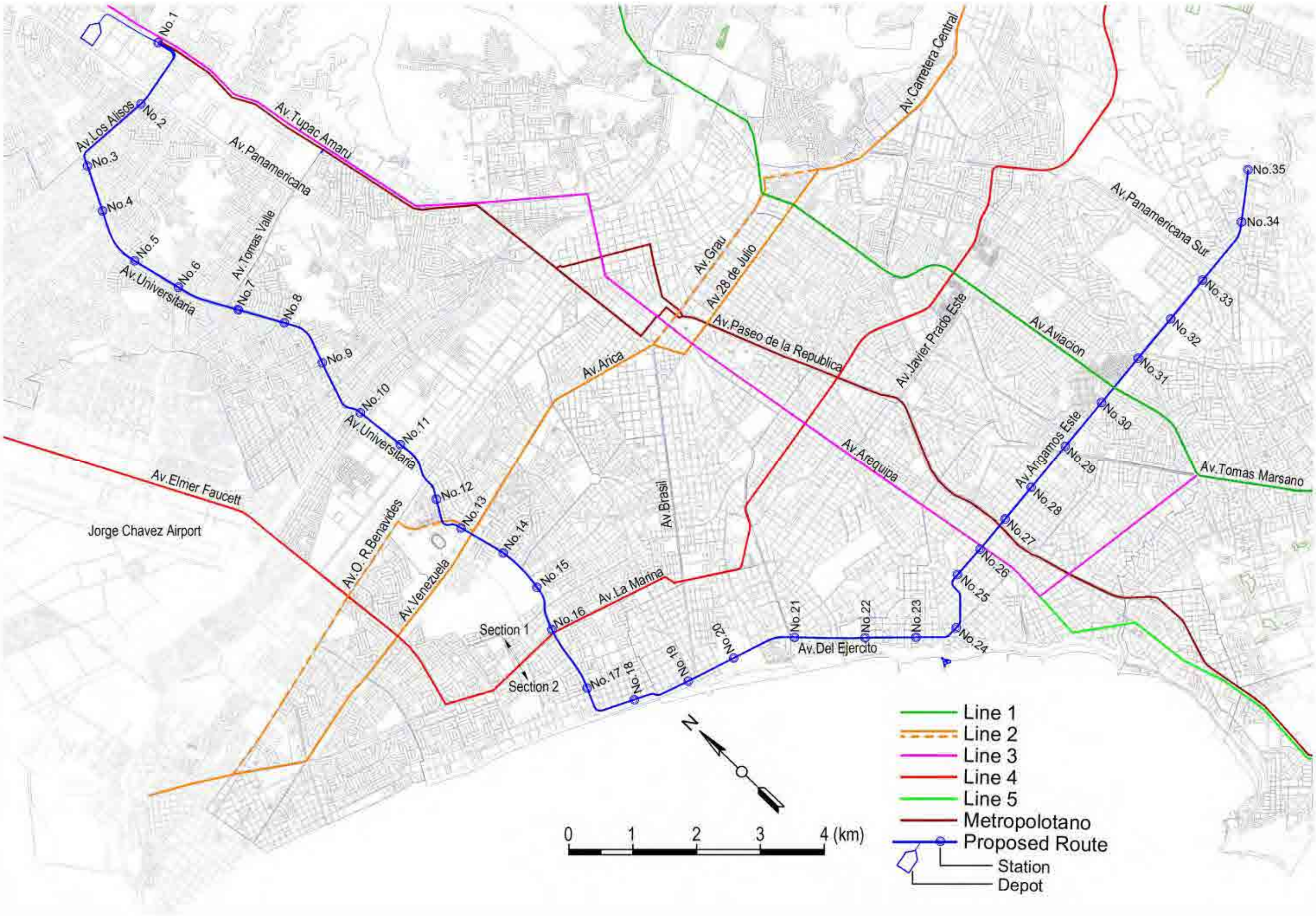
Table 6.4 Procedure of Proposed Route Selection

	Upon checking the blank areas of the public transport which are not covered with the effective area of Metro lines, the following 2 blank areas were found. A) area along Av. Universitaria (North-South axis) B) area along Av.Angamos Este (East-West axis) Therefore, a proposed route was set on Av. Universitaria and Av. Angamos Este. (In this figure, the effective area was assumed as 1km from each station.)
	As alternatives of the northern end of the route, following 3 routes were considered. C) Approach to Naranjal station on Metropolitano. D) Approach to Airport Jorge Chavez E) Long distance bus terminal (Gran Terminal Terrestre) Based on the evaluation of passenger demand forecast, alternative C was selected.

Source: JICA Study Team

The demand forecast shows that the demand along Av. Universitaria is very high while that of Av. Angamos is relatively low. Therefore, the project is divided into two phases. Phase-1 is the section between Naranjal station and the crossing with Line-2, and Phase-2 is the remaining part of the route.

The outline of the route is shown in Table 6.5, and the route is shown in Figure 6.8.



Source: JICA Study Team

Figure 6.8 Proposed Route (Ultimate)

Table 6.5 Outline of Proposed Route

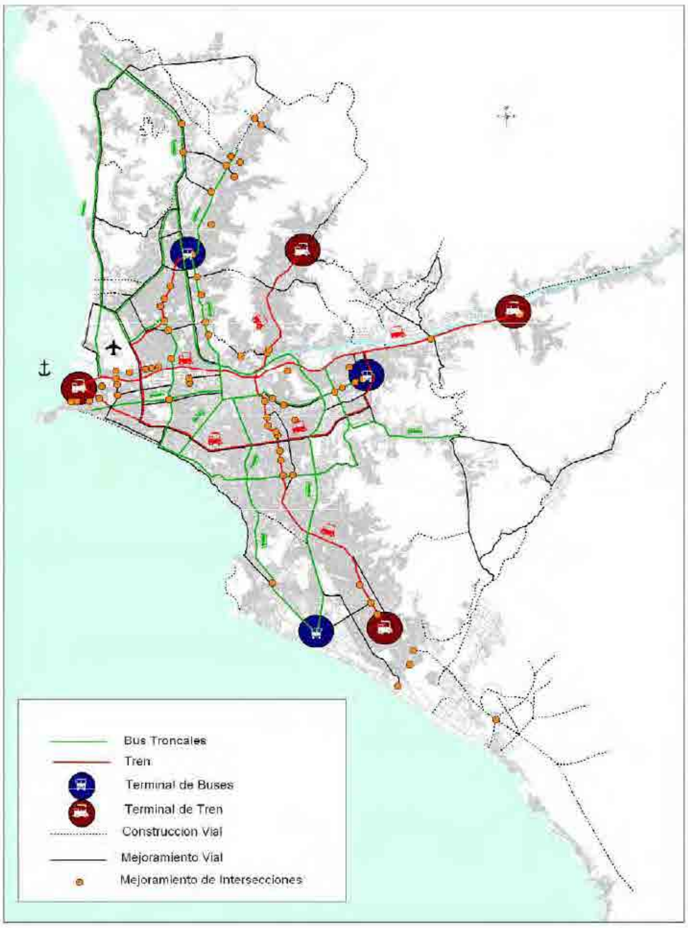
Item	Phase 1	Ultimate (Phase 1+2)
Route Alignment		
Route Length	13k690m	30k150m
Number of Stations	16 stations	35 stations
Small curve radius section (less than 300m)	100m: 5 sections 150m: 2 section 300m: 4 sections	100m: 12 sections 150m: 2 sections 300m: 4 sections
Steep Gradients section (i=6%)	3 sections	5 sections
Steel girder section	10 sections	22 sections
Long span bridge 1 bridge	None	1 bridge
Service		
Estimated demand	10,000 PHPDT	22,000 PHPDT
Schedule speed	35km/h	35km/h
Train configuration	6-car train	6-car train
Headway	5 minutes	2.5 minutes
Transport capacity	11,300 PHPDT	22,700 PHPDT

Source: JICA Study Team

Chapter 7 Review of PMTU-2025

7.1 Summary of PMTU-2025

The Urban Transport Master Plan for the Lima and Callao Metropolitan Area (PMTU) 2025 was formulated in 2005 by JICA in collaboration with Transport Council of Lima and Callao (CTLC). In the study, a Person Trip Survey in which more than 34,000 households were interviewed was conducted for the analysis of the present condition and the future scenarios. The master plan was formulated for four sectors, namely, 1) Road Facilities, 2) Railway, 3) Trunk Bus System, and 4) Traffic Management. Figure 7.1 shows the project map of the master plan.



Source: PMTU-2025

Figure 7.1 PMTU-2025

PMTU-2025 proposed 68 projects with the investment cost of USD 5,535 million as shown in Table 6.1.3. The proposed project consists of road facilities, railways, trunk bus lines, and traffic management programs.

Table 7.1 No. of Projects and Cost by Sector

	Road Facilities	Railways	Trunk Bus lines	Traffic management programs	Total
No. of projects	33	7	18	10	68
Cost USD Million	2,374	2,024	981	156	5,535

Source: PMTU-2025

7.2 Socio-economic Framework

The study of PMTU-2025 estimated the future population of Lima and Callao Metropolitan Area. The population in 2004 was 8.0 million according to PMTU-2025, and the study estimated the population at 8.85 million for the year 2010 and 10.6 million for 2025. The actual population in 2010 was 9.16 million. The population projection was revised in this study. The revised population is larger than the previous projection. This difference is attributed to the projection of the population in 2004. Although the study estimated the population in 2004 at 8.0 million, the actual population was 8.5 million in 2005.

Table 7.2 Population Projection in PMTU-2025

(million)

	2010	2015	2020	2025
Population	8.85	9.48	10.06	10.57
Revised in this study	9.16	9.90	10.69	11.48

Source: PMTU-2025 and JICA Study Team

The master plan assumed that the population in the central area would increase, but the population in the central area has decreased from 2004. The actual population growth was higher than the projection in suburban areas and lower than the projection in the central areas.

Peru achieved high economic growth recently. PMTU-2025 estimated the annual growth rate of the real GDP from 2005 to 2010 at 4% while the growth rate of the five years was 7.2% per year. The growth rate of GDP per capita was estimated at 2.0% per year, although it was 6.0%.

7.3 Demand Analysis

The results of the demand forecast in the study of PMTU-2025 showed that the traffic demand in 2025 would be 1.48 times the demand in 2004 (from 12.1 to 18.0 million trips per day). The change in the modal share was estimated as shown in Table 7.3.

Table 7.3 Projection of Modal Share

	2004	2025
Car	15.3%	22.5%
Taxi	7.4%	7.0%
Public Transport	77.3%	70.5%

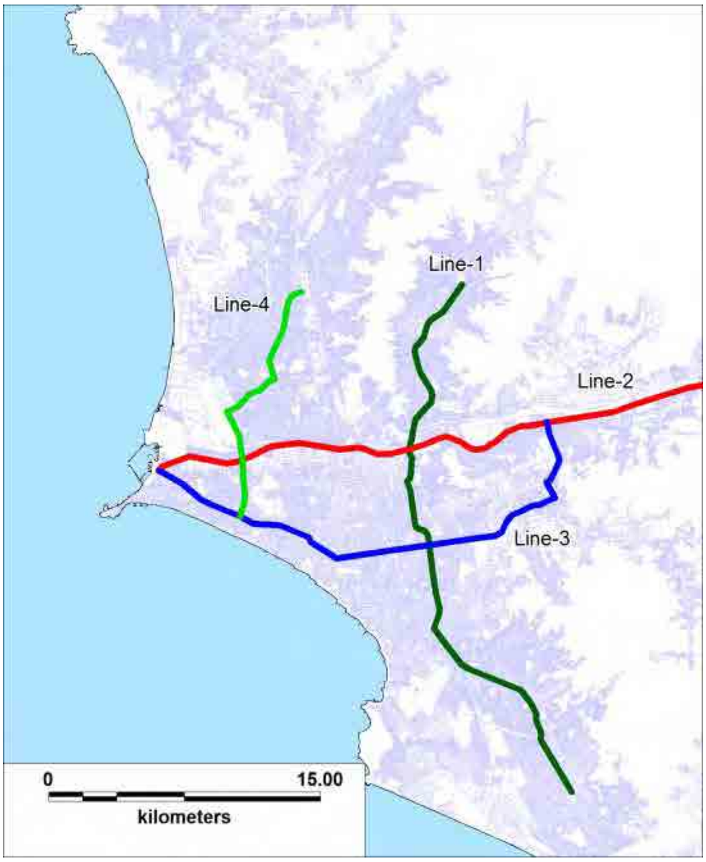
Source: PMTU-2025

The master plan study analyzed the future situation in case of no action would be taken place, in which the average travel speed was projected to decrease from 16.8km/h to 7.5km/h, and the average commuting time was projected to increase from 44.9 minutes to 64.8 minutes.

7.4 Public Transport Planning

7.4.1 Railway

After comparing the heavy rail and the light rail transit, the previous study concluded that light rail transit would not satisfy the demand due to its capacity. However, the proposed railway system was surface type railway system, which has a lower capacity than the elevated or underground system. Figure 7.2 shows the railway network in the master plan. Only Line-1, whose structure was already constructed as an elevated type at the time of the master plan study, was proposed as an elevated system. The reason for applying at-grade structure instead of elevated type is not clear because it is not mentioned in the master plan reports. Since "utilization of existing railway infrastructure and facilities" was one of the major concepts for the planning of the railway network in the master plan, reduction in the project cost was probably an important consideration in the master plan.



Source: PMTU-2025 (Illustrated by JICA Study Team)

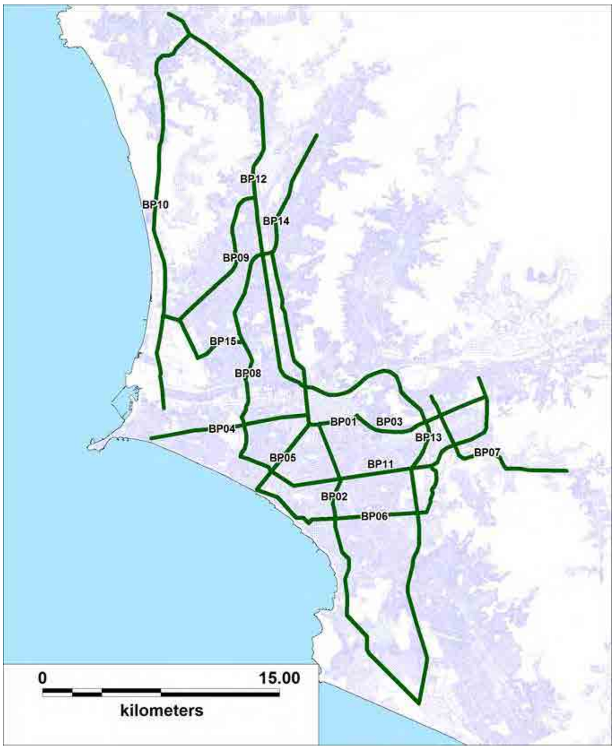
Figure 7.2 Railway Plan in PMTU-2025

7.4.2 Trunk Bus

The master plan study identified 17 trunk bus lines, although the type of the busway was not identified in the plan. The master plan proposed three types: 1) Trunk busway, 2) Exclusive bus lane, and 3) Bus priority lane. A trunk busway is partially or fully segregated from other traffic while an exclusive bus lane is separated from other lanes with paint marking on roads. The articulated bus with 150-200 passengers per bus was proposed for these lanes. On the other hand, a bus priority lane is used for buses only at peak hours. The single unit bus with a capacity of 80-100 passengers was proposed for the bus priority lanes.

The capacity of a trunk busway was designed at 25,000 passengers per hour per direction. After the alternative analysis with the demand forecast, 15 trunk bus lines were selected. Among the 15 trunk bus lines, only the COSAC Project was implemented as the BRT system, which was opened in 2010.

In 2007, JICA conducted the feasibility study for the East-West Corridor (Av. Venezuela Trunk Busway, Av.Grau Trunk Busway, and Carretera Central Trunk Busway). However, this corridor was identified as a railway system (Line-2) in the notification by the Government in 2010.



Source: PMTU-2025 (Illustrated by JICA Study Team)

Figure 7.3 Trunk Bus Plan in PMTU-2025

7.4.3 Evaluation of Public Transport Plan

Although railway lines are planned as an at-grade type except for Line-1 in PMTU-2025, they should be elevated or underground systems in order to cope with the future traffic demand. It is recommended that the railway and the trunk bus network should be reorganized based on the metro plan in 2010 (D.S. 059-2010-MTC) to respond to the demand on north-south and east-west corridors. Introduction of medium capacity transit systems should be considered for the review in addition to the analysis of the project costs. This Study proposes Metro Line-6 by combining several trunk bus routes.

7.5 Road and Traffic Management

7.5.1 Road Plan

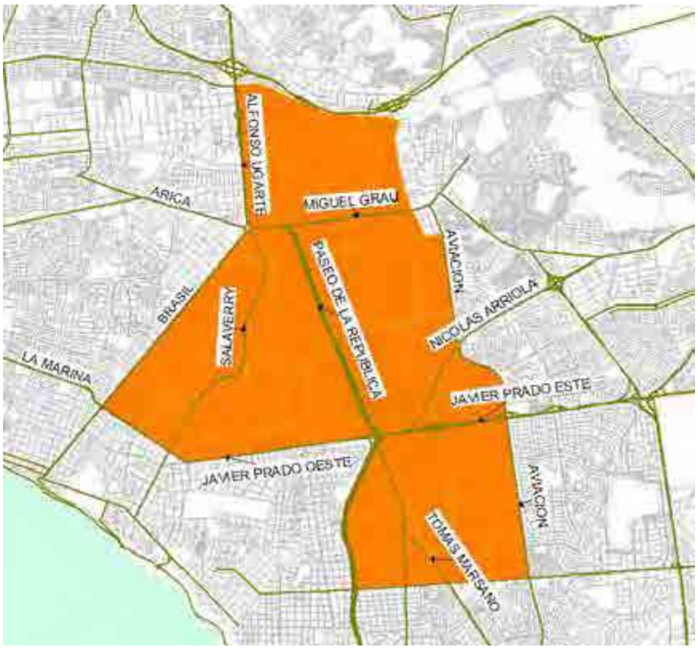
In PMTU-2025, road a network plan was formulated for three (3) road categories: 1) National and Regional Expressway Network, 2) Metropolitan Expressway Network, and 3) Arterial and Collector Road Network. The network development plan consists of 1) road construction and improvement, 2) road widening, and 3) construction of new roads in new housing areas. In addition, improvement of 62 intersections is proposed Figure 7.5.1 shows the road network plan in 2025.

Source: PMTU-2025

Figure 7.4　Road Network Plan in PMTU-2025

7.5.2　Traffic Management

In the TDM Plan, the study of PMTU-2025 evaluated 12 typical TDM measures and concluded that the license-plate numbering system would be the most applicable measure for the metropolitan area, although the area licensing system (ALS) was finally selected as the TDM project in response to the technical committee of the study. Figure 7.6.1 shows the proposed control area of the ALS. Vehicles entering the area need to pay an entrance charge in ALS. The ALS has not been implemented, although it was proposed as a short-term project. Since the ALS discourage people to use their cars, an alternative public transport system is essential.



Source: PMTU-2025

Figure 7.5 Control Area of the Area Licensing System

7.5.3 Evaluation of Road and Traffic Management Plan

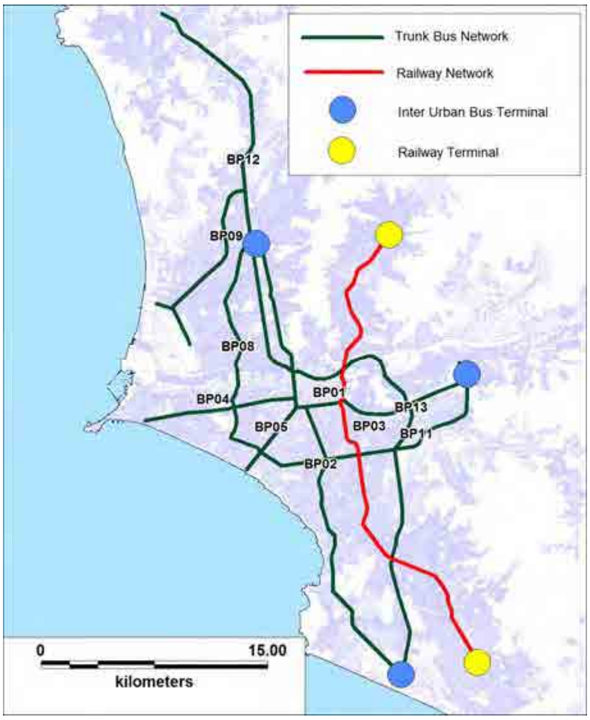
Av. La Costa Verde, which was planned in PMTU-2025 and has already been implemented, will play an important role in the future according to the result of the demand forecast. This Study has estimated higher growth rate of the population in suburban areas than PMTU-2025, which results in larger demand forecast on arterial roads connecting the central area and the suburban areas. From this, these roads are more important than in PMTU-2025. The important roads based on the demand forecast are Vía de Periférical, Av. Paseo de la República Sur, and Autopista Ramiro Prialé. Linea Amarilla, which was not included in PMTU-2025, will be an important project to release traffic congestion along Rimac River.

The result of the demand forecast shows that the capacity of arterial roads in the central area does not necessarily insufficient against the traffic demand in peak hours. Since the traffic congestion is observed in the central area nevertheless, probably because bottlenecks at intersections and on small streets cause the congestion, proper traffic management measures will be necessary. On the other hand, the present mass transit system is sufficient to introduce the measures proposed in PMTU-2025 to discourage the use of private cars in the central area. In addition to develop bicycle lanes for the alternative of the car use, it is necessary to review the timing of introducing such method.

7.6 Short-term Plan

7.6.1 Short-term Projects in PMTU-2025

The study of PMTU-2025 formulated a short-term plan consisting of 33 projects for the period of 2005-2010, by identifying priority projects based on six criteria of the master plan projects. The criteria are (1) transport planning policy, (2) economic effect, (3) traffic improvement effect, (4) characteristics and conditions of the project, (5) progress of the on-going projects, and (6) balance of investment cost every year. The total project cost was estimated at US$ 1,295 million, accounting for 24% of the master plan cost by 2025.



Source: PMTU-2025 (illustrated by JICA Study Team)

Figure 7.6 Short-term Railway and Trunk Bus Projects in PMTU-2025

7.6.2 Implementation of Short-term Projects

Figure 7.6 shows the locations of implemented projects of the short-term plan. There are six projects that have been implemented out of 33 projects as follows.

1) Construction of Metro Line-1

2) Construction of Metropolitano (COSAC Project)

3) Improvement of Av. Elmer Faucett

4) Improvement of Av. Universitaria

5) Synchronized Traffic Control System

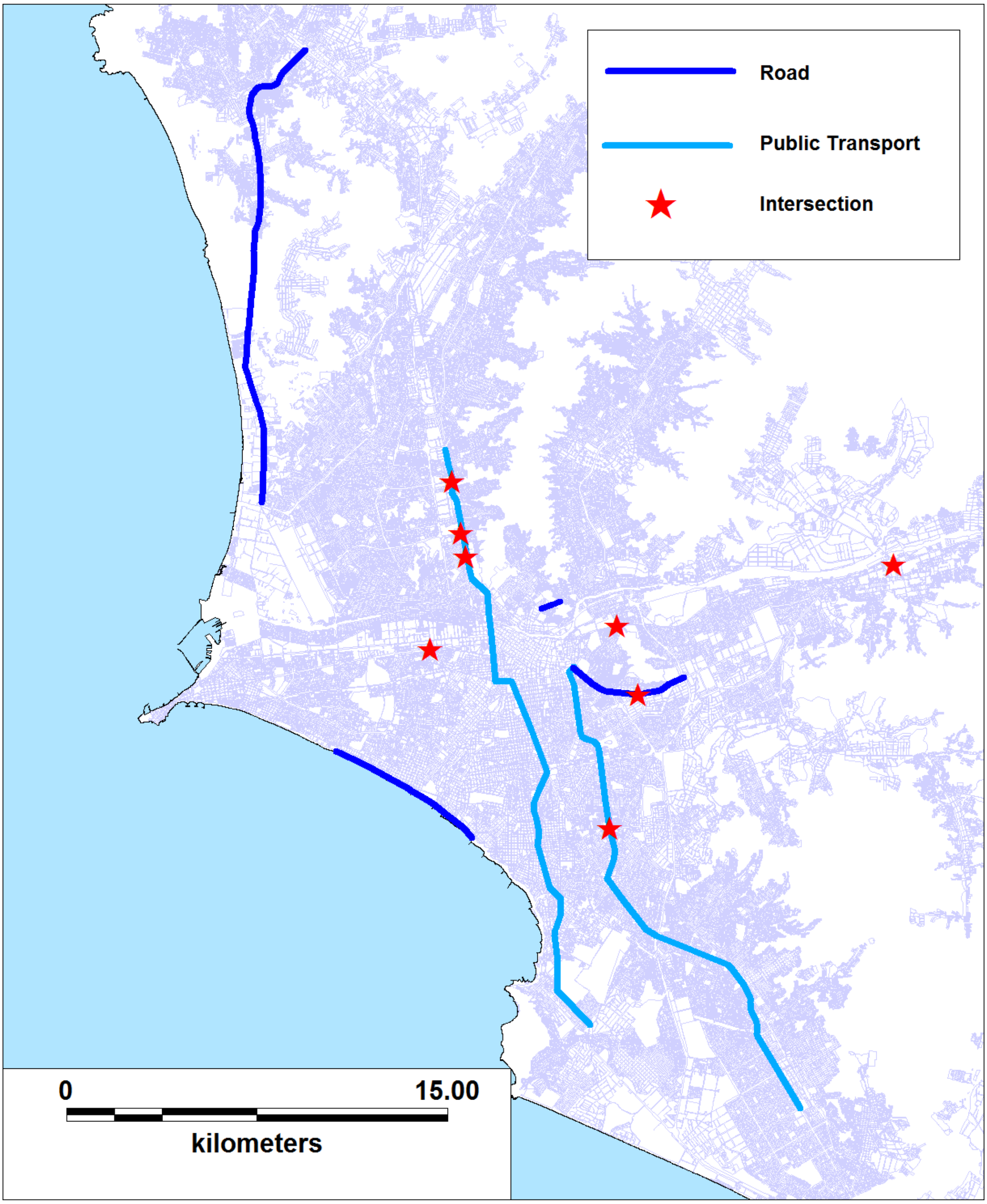
6) Intersection Improvement (Partially)

Note that the construction of Costa Verde has been implemented although it was planned as a mid-term project in PMTU-2025. In addition, “Planning” was the content of some traffic management projects, and the plan of traffic management projects was proposed in the subsequent JICA F/S in 2007.

The result can be explained by the following reasons:

- Too many trunk bus projects were included. Although a trunk bus project can be implemented in a shorter period than railway system, the period of five years is too short to implement the all the projects.
- There were other priority projects. Some mid-term projects in PMTU-2025 were implemented in the short-term period. Development of the bicycle lane network has

been a priority project.



Source: JICA Study Team based on PMTU-2025

Figure 7.7 Implemented Projects in PMTU-2025

7.7 Urban Transport Issues

7.7.1 Urban Expansion

PMTU-2025 was formulated based on the distribution of the future population which was estimated from the future land use plan, but the real urban development trend has been different from the plan. The JICA Study has reviewed the population projection and revised the distribution of the future population reflecting the actual trend of the urban development. From this, infrastructure development in suburban areas, especially in the north area, is more important than in PMTU-2025. In addition to developing the transport infrastructure to respond to the demand, the efficient public transport system should be developed by controlling the urban development. Furthermore, population recovery in the central area, which was assumed in PMTU-2025, is effective to reduce long distance travel demand, so the actions for the population recovery will be necessary.

7.7.2 Increase in Commuter Time

According to the Person Trip Survey, the average commuter time ("To Work") of all modes is approximately 45 minutes. The average travel time by bus is approximately 50 minutes. It is expected that the travel time will be longer according to the expansion of urbanized area. Since travel time reduction is an important issue for bus passengers as shown in the passenger interview survey, it is necessary to provide high speed transit system especially for people living in suburban areas.

7.7.3 Increase in Passenger Car

Presently, modal share of public transport in motorized transport is as high as 70% in Lima. Although the number of cars will increase in the future as estimated in Chapter 4, the JICA Study Team estimated that the modal share in peak hours will not change because the mass transit network in the future will improve public transport services while the congestion on arterial roads will remain. However, there is a possibility that the car share will be higher than the estimation due to the rapid expansion of the urban area. Presently, car ownership in the suburban areas is lower than in the central area, but the car usage will increase unless proper public transport system is provided because the income level is increasing.

7.7.4 Capacity Limit of Metropolitano

After the inauguration in 2010, Metropolitano has greatly improved the urban mobility in Lima, running through high demand corridor. Presently, its service area is larger than that of Metro Line-1. According to the demand forecast, the future demand will exceed the capacity of Metropolitano unless other mass transit system is implemented.

7.7.5 Modal Shift

According to the passenger interview survey, 95% of passengers of Metropolitano and Metro Line-1 shifted from public transport modes such as bus and combi to the mass transit systems. Passenger car users concentrate on the central area of the city, where cars are more convenient than public transport. Public transport network should form a dense network to attract passenger car users. The demand forecast shows that congestion on arterial roads will remain in the future even if all lines in the metro plan in 2010 are implemented. Promoting modal shift from private mode to public mode is necessary to improve the road congestion. Park and ride facilities should be considered in the planning of metro lines.

7.7.6 Intermodal Transportation

Metropolitano attracts many passengers by the feeder bus system with large scale terminal stations. In the demand forecast, transfer between bus and railway lines (or monorail) is assumed to be convenient. Since boarding demand from feeder buses at the terminal station of metro lines of the metro plan is expected to be very large, proper development of the intermodal facilities is an important issue. In addition, fare integration with feeder bus systems and metro lines should be considered because the additional payment to metro lines is one of the reasons that bus demand will remain high in the future.

7.7.7 Station Transfer

The demand forecast shows that transfer demand between metro lines at the crossing stations will be very high. Reduction in walking time and distance between the stations is an important issue as well as the capacity of the stations.

7.7.8 New Transit Corridor

This study proposed Metro “Line-6” along the corridors which were identified as parts of Bus Truck System routes in PMTU-2025. The concept study shows a monorail system will be the best system for the route. It is recommended to include the new route in the metro plan.