社会開発調査部報告書

No. 32

REPUBLIC OF GUATEMALA

MASTER PLAN STUDY ON THE COMPREHENSIVE URBAN TRANSPORTATION SYSTEM IN GUATEMALA METROPOLITAN AREA

FINAL REPORT

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF GUATEMALA

MASTER PLAN STUDY
ON
THE COMPREHENSIVE URBAN TRANSPORTATION SYSTEM
IN
GUATEMALA METROPOLITAN AREA

FINAL REPORT

MARCH 1992

JAPAN INTERNATIONAL
COOPERATION AGENCY

Preface

In response to a request from the Government of the Republic of Guatemala, the Government of Japan decided to conduct a master plan study on the Comprehensive Urban Transportation System in Guatemala Metropolitan Area and entrusted the study to the Japan International Cooperation Agency (JICA).

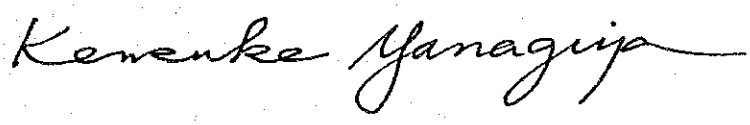
JICA sent to Guatemala a study team headed by Mr.Takeshi Yoshida, Yachiyo Engineering Co.,Ltd., three times between March 1990 and December 1991.

The team held discussions with the officials concerned of the Government of the Republic of Guatemala, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

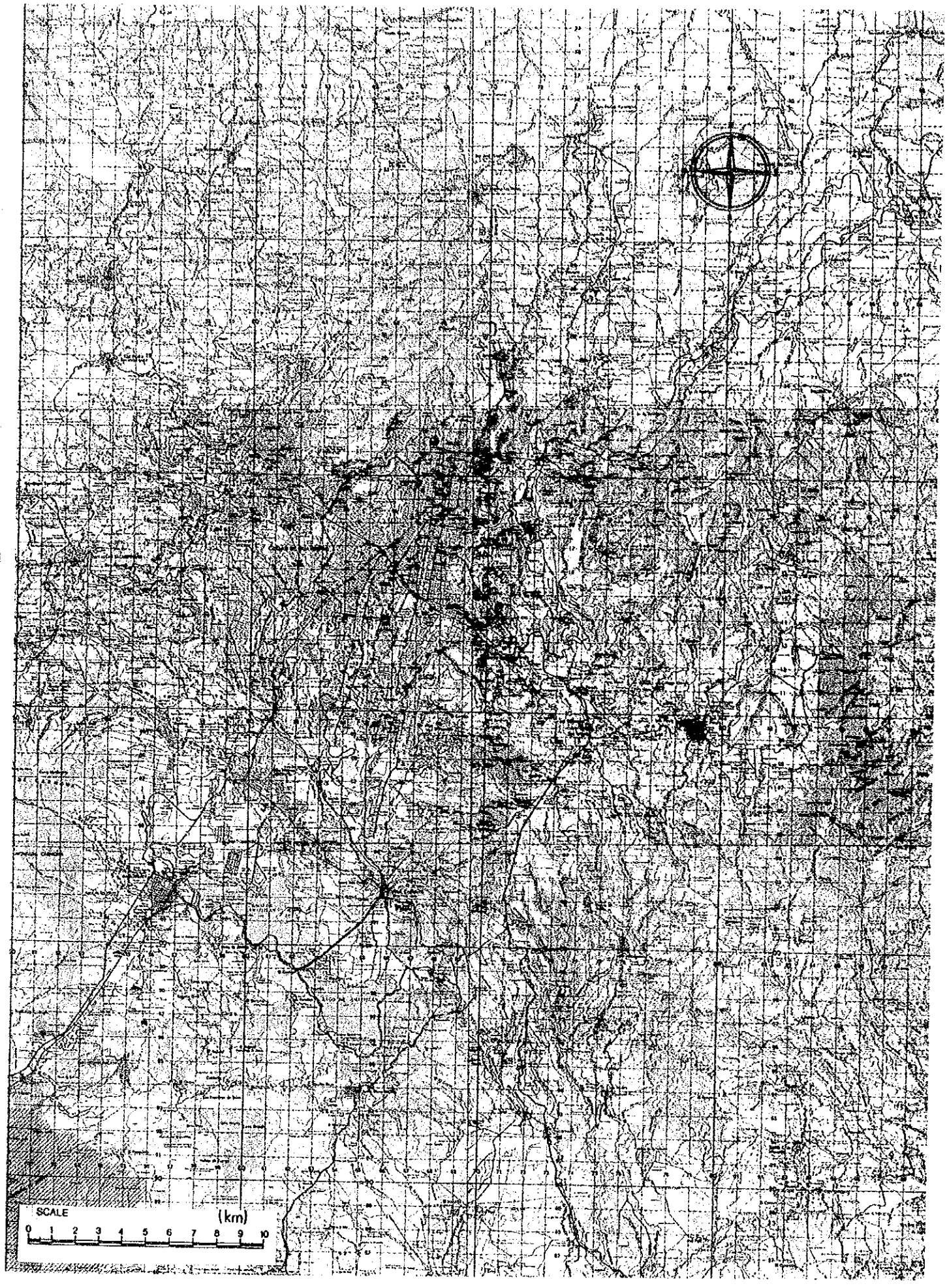
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Guatemala for their close cooperation extended to the team.

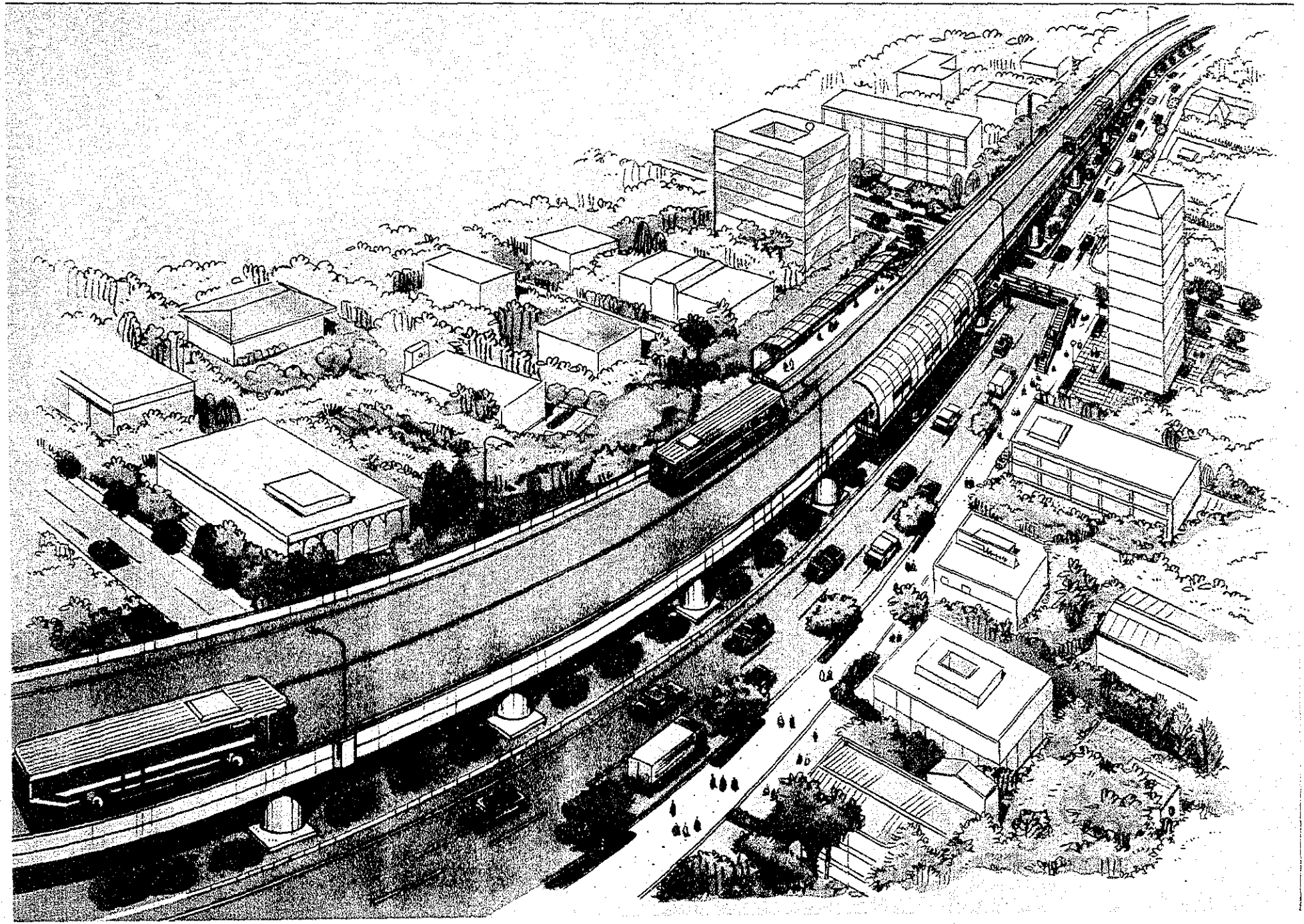
March, 1992



Kensuke Yanagiya
President
Japan International Cooperation Agency



Guatemala Metropolitan Area



Perspective of Recommended Busway (Viaduct)

TABLE OF CONTENTS

1. INTRODUCTION

1. INTRODUCTION

(1) Study Development

In response to the request of the Government of the Republic of Guatemala, the Government of Japan, through the Japan International Cooperation Agency (JICA), initiated a Master Plan Study on the Comprehensive Urban Transportation System in Guatemala Metropolitan Area (called ESTUAM).

The preliminary study team, headed by Dr. Hisao Uchiyama, was dispatched by JICA to Guatemala and the Scope of Work for the Study was agreed on November 1989. The full-scale site study in Guatemala began on July 1990 and continues upto December 1991.

(2) Study Purpose

The objectives of the study are as follows;

1) To formulated a Master Plan on the Comprehensive Urban Transportation System in Guatemala Metropolitan Area (hereinafter referred to as GMA)

2) To recommend an Urgent/Short Term Development Plan to be formulated within the framework of the Master Plan.

3) To transfer relevant technology to Guatemala counterpart personnel in the course of the Study.

(3) Scope of the Study

1) Target Year

The year 2010 is defined as the target year for the Master Plan Study, and the year 1995 is adopted as the target year for the Short Term Development Plan.

2) Study Area

The Study Area covers Guatemala City and the area it influences, such as Mixco, Villa Nueva, San Miguel Petapa, Sta. Catarina Pinula, Chinautla, Amatitlan, Villa Canales, Fraijanes and San Jose Pinula.

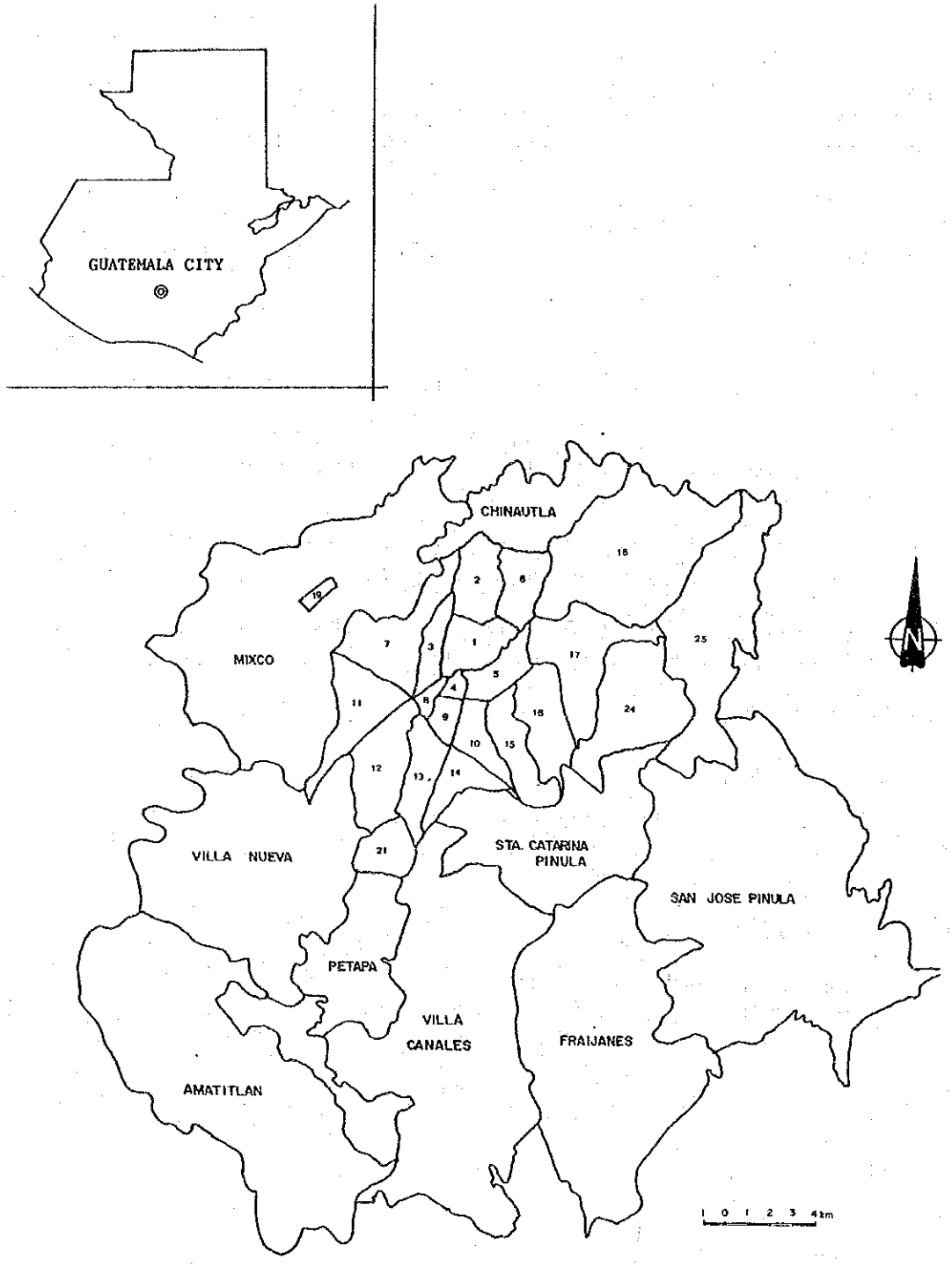


Figure 1.1 Study Area

(4) Study Organization

To conduct the Study, JICA has organized both the Study Team, headed by Mr. Takeshi Yoshida and the Advisory Committee, chaired by Dr. Hisao Uchiyama, to receive the advice for the Study. The government of Guatemala has formed the Counterpart Team, headed by Mr. Edgar De Leon under Guatemala Municipality. Guatemala Municipality, Ministry of Planning, Ministry of Communication, Transport and Public Works, National Police, Housing Bank and Guatemala Railway.

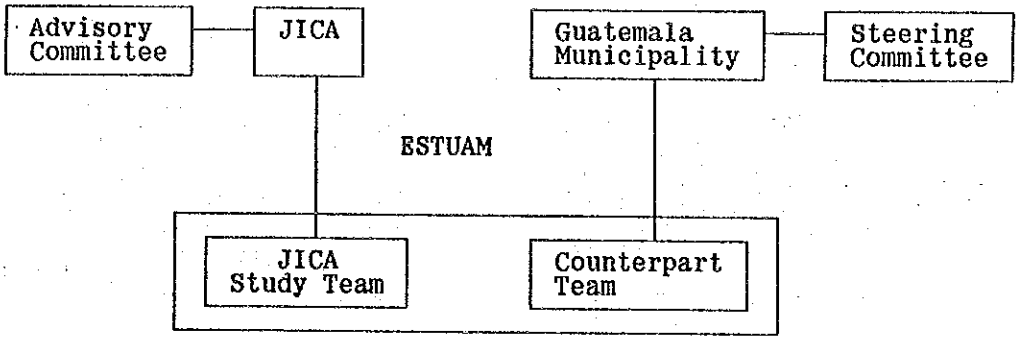


Figure 1.2 Study Organization

Study Organization Members

JICA STUDY TEAM

Ing. Takeshi Yoshida	Project Manager
Ing. Koichi Tsuzuki	Road Planner (Deputy Manager)
Ing. Hikaru Nishimura	Transportation Planner
Ing. Shinsuke Tsuruta	Public Transportation Planner
Ing. Masayuki Ishiya	Demand Forecast Analyst
Ing. Hiroaki Sugawara	Transportation Survey Analist
Lic. Shigeru Okutsu	Transportation Survey Supervisor
Arq. Iwane Mizuno	Land Use/Urban Development Planner
Arq. Naoyuki Minami	Street and Parking Planner
Ing. Keiichi Ichikawa	Traffic Planner
Lic. Takao Yamane	Economic and Financial Analyst

JICA ADVISORY COMMITTEE

Chairman	: Dr. Hisao Uchiyama	Science University of Tokyo
Member	: Dr. Mitsuyuki Asano	Ministry of Construction
Member	: Ing. Shinji Mizuno	Ministry of Construction
Member	: Lic. Kozo Fujita	Ministry of Transport
‡Member	: Lic. Hiroyuki Sumita	Ministry of Transport

JICA PROJECT COORDINATORS

Lic. Hiroshi Uchiyama	Japan International Cooperation Agency
‡Lic. Shoichi Okumura	Japan International Cooperation Agency

GUATEMALA COUNTER PART TEAM

Ing. Edgar de León Maldonado, Coordinador ESTUAM	
Ing. Carlos Barillas	
Arq. Claudio Piedrasanta	
Ing. Jorge Chavarría	
Ing. Ruldy Cuéllar	
‡Ing. Melecio Recinos	
‡Ing. Rolando Figueroa	

CONSULTING COMMITTEE

Ing. Edgar de León Maldonado, Coordinador ESTUAM
Ing. Marco Antonio Arango, D.G Transportes Extraurbanos/MINISCOPT
Ing. José Santos Monzón, Dirección General de Caminos/MINISCOPT
Ing. Roberto Martínez Okrassa, SEGEPLAN
Ing. Miguel Angel Oquendo, BANVI
Arq. Edna de Figueroa, Municipalidad de Guatemala
Lic. Alejandro Porras, Municipalidad de Guatemala
Lic. José Francisco Ramírez Valenzuela, Policía Nacional
Ing. Carlos Moino, FEGUA
‡Arq. Fernando Masaya, BANVI

‡:Predecessor

Figure 1.3 Study Organization Members

PART I EXISTING CONDITIONS

2. SOCIO-ECONOMIC CONDITIONS AND LAND USE

2.1 Existing Socio-Economic Conditions

(1) Location of Study Area and Physical Conditions

The Study Area is located on a plateau in Guatemala 1,500m above sea level, at a latitude of 14°N, and a longitude of approximately 90°W, and covers and area of 937 sq.km. A watershed runs from the area in the northwest of Guatemala City's urban district to the southeast, and the distinguishing topographical feature is a downward gradient from the watershed to the northeast direction and to the southwest. In the southern part of the Study Area there is Lake Amatitlan at a height of 1,200m above sea level.

The geological features of the area are composed of volcanic diluvial rock susceptible to erosion, which have created many deep valleys cutting into the hilly area.

The region has a mild climate, with an average temperature throughout the year of about 20°C. There are two seasons, a dry season from November through April, and a rainy season from May to October.

(2) Historical Background

Present-Day Guatemala City was established in 1776, as the old city located in Antigua was destroyed by earthquake in 1773. Until 1870 the tempo of urban growth was retarded by the drive for independence and the social instability from the subsequent civil war, in addition to other factors such as the isolationist policy pursued by the Conservative Party following the civil war. Guatemala City began to expand both in terms of its social economy and physically pattern in 1871 after the Liberal Party seized power. Incorporation of the surrounding communities, subdivisions and the introduction of urban facilities such as roads, street lighting, horse trolleys, railroads, telephone service, and electrical service, were carried out. In 1900, the population reached 100,000.

The first half of the 20th century was the period which saw the formation of the framework for the present-day Guatemala City urban area. Trunk roads linking north and south were constructed, and the present Zona 9, 10, 13, 14, and the Central District were directly linked. Also, suburbanization progressed through the construction by the upper class of Northern European-style single family villa type residences with gardens. Meanwhile, middle and lower-class residential districts were formed stretching from the city's northeastern area to the southwestern district. The population in 1950 reached 300,000.

After 1950, the population influx from the rural areas to the capital rapidly increased. There was an expansion in the amount of urban land, and, concurrent with the formation of a new commercial core district in Zona 9 and 10, industrial belts developed along the trunk roads under the economic expansion of the 1960s and 70s. Guatemala City's sphere of influence expanded, reaching Mixco and Villa Nueva. The population of the Study Area reached 1 million in 1970, and 1.8 million, in 1990.

(3) Population

The population of the Study Area increased from 1.35 million in 1981, to 1.8 million by 1990, at an average annual rate of 3.3%. Guatemala City's population of 1,030,000 in 1990 accounted for 47% of the Study Area's total population, but its rate of increase was lower compared to the surrounding communities, and its share continues to gradually decrease. In recent years, the area showing a particularly sharp population increase was Villa Nueva, whose population increased at an average annual rate of 12%. From population of 82,000 in 1981, the population increased by a factor of 2.7 by 1990, to 225,000.

Table 2.1.1 Population Change in Study Area

Area	Population		Annual Increase Rate(%)
	1981[1)]	1990[2)]	
Guatemala City	865,200 (64.3)	1,034,400 (57.4)	2.00
Mixco	226,800 (16.8)	335,000 (18.6)	4.43
Villa Nueva	81,500 (6.1)	225,400 (12.5)	11.97
Others	171,800 (12.8)	206,100 (11.5)	2.04
Total	1,345,300 (100.0)	1,800,900 (100.0)	3.29

Note:
1) Corrected Population of 1981 Census
2) Study Team Estimation

(4) Economic Conditions

Guatemala's economy met with a series of difficulties in the 80's: while the negative growth which had continued throughout the first half of the decade had shifted to positive growth after 1987, the average growth figure of 0.9% for the decade indicated there was almost no real growth during the period. For this reason, per capita GDP has declined to 82% of its 1980 level.

The primary sector can be almost totally ignored in the Study Area, while the secondary and tertiary sectors account for over half of the national economy. Using the estimated share for the capital region from the Guatemala Central Bank's economic activity analysis broken down by sector, the Study Area's gross regional product (GRP) as of 1990 was 1.827 million quetzales at 1958 prices. The resident's per capita GRP was estimated at 1,014 quetzales in 1958 terms, or 2,018 US dollars.

Table 2.1.2 Economic Activities in the Study Area

Gross Regional Product (GRP)	(million quetzal[1])	1,827
Population	(thousand persons)	1,801
GRP per capita	(quetzal[2])	1,014
	(US dollars)	2,018

Note: 1) In 1958 constant prices
2) In 1990 prices (US$1.00=Q5.00)
Source: Study Team Estimation

The working population totaled 637,000; 16,000 in the primary sector; 150,000 in the secondary sector, and 471,000 in the tertiary sector, a figure which accounted for 73.9% of the total number.

Table 2.1.3 Employment by Sector

Sector	Employment	Percentage
Primary	16,300	2.6
Secondary	149,800	23.5
Tertiary	470,800	73.9
Total	636,900	100.0

Source: Person Trip Survey

2.2 Existing Land Use and Urban Structure

Of the total area of 93,725.5 ha in the Study Area, an area of 45,935.5 ha (49%) lies on a gradient of 30% or more. The greater part of this land is currently forest land for which urbanization is deemed not possible. That land which is not on a 30% gradient, and thus has the potential for future urbanization, occupies 51% of the total, or 47,752 ha.

The total area of the urban area is 24,916.2 ha, which includes land which has been prepared but is not yet being used; and the semi-urbanized districts of the surrounding communities. This accounts for 52% of the land which has the potential for urbanization. Occupying 37% of this total are 17,760.3 ha of farmland.

Table 2.2.1 Land Use in the Study Area

Classification	Area (ha) Whole Study Area	(%)	Percentage Under 30% Slope Degree
Area with less than 30% Slope Degree	47,752.0	50.9	100.0
Urban Area	24,916.2		52.2
Farm	17,760.3		37.2
Forest	3,530.5		7.4
Water Area	1,352.5		2.8
Others	192.5		0.4
Area with more than 30% Slope Degree (Forest)	45,973.5	49.1	
Total	93,725.5	100.0	

Source : Study Team

Table 2.2.2 Urban Land Use Composition

Classification	Area (ha)	Percentage
Residential	13,279.3	53.3
Business/Commercial	538.2	2.2
Industry	1,134.2	4.6
Public	998.7	4.0
Mixed	631.4	2.5
Green Area	394.8	1.6
Semi-urban	7,939.5	31.8
Total	24,916.2	100.0

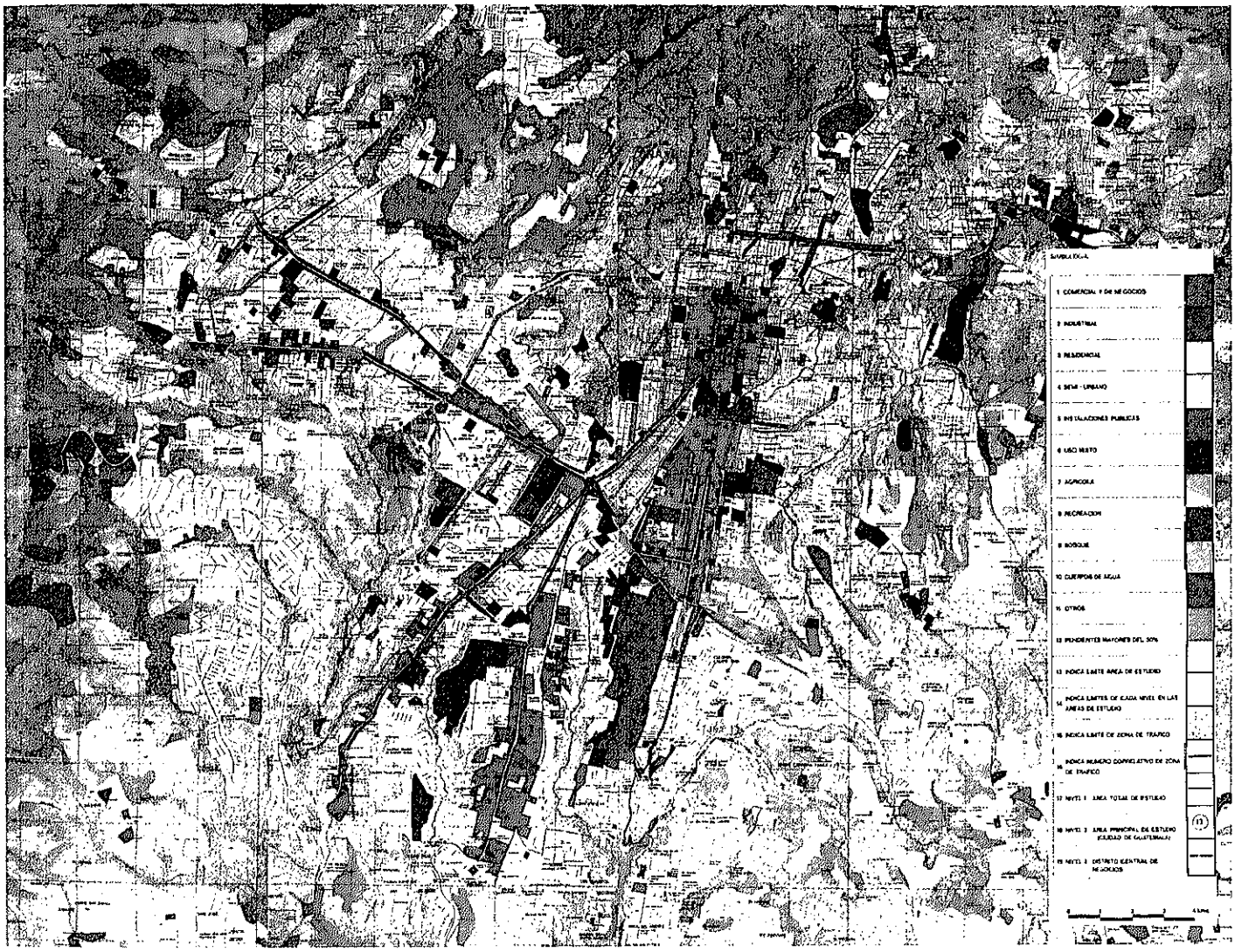


Figure 2.2.2 Present Land Use of the Central Area

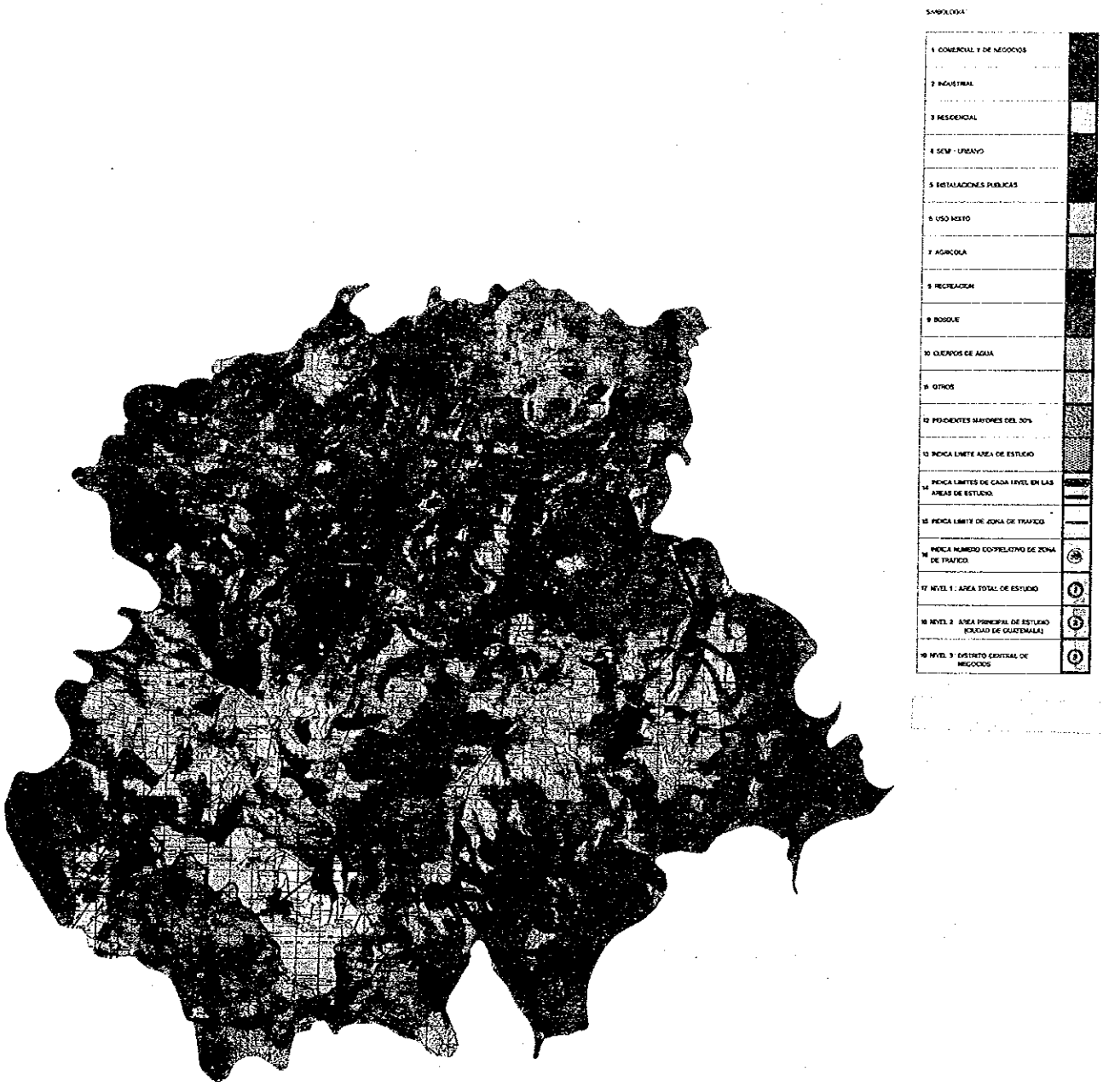


Figure 2.2.1 Present Land Use of the Study Area

3. PERSON TRIP CHARACTERISTICS

3.1 Person Trip Survey

3.1.1 Outline of Field Survey

The purpose of the person trip (herein after referred to as "PT") survey is to obtain the detailed information of the existing individual trip behavior of residents in the Study area. The survey covers the travel of persons in terms of trip purpose, choice of transport mode, origin and destination of the trip, travel time, etc. The results of the PT survey shall be the fundamental information for the future traffic forecast and the planning of urban transport facilities.

The survey was conducted on weekdays in September of 1990 by visiting and interviewing to households which were randomly sampled in advance. Trained surveyors sent to the house, asked items to each member aged five years and over, of the household according to the survey sheet.

(1) Survey Items

The survey items are divided into the three categories shown in the following table, such as a) household information, b) individual information and c) trip information.

Table 3.1.1 Person Trip Survey Items

Categories	Survey Items
Household Information	Number of members in family Number of persons aged 5 years and over Car ownership Walking time to the nearest bus stop Living year in the present house
Individual Information	Sex and Age Employment Occupation and Industry Place of work or study Monthly income
Trip Information	Origin of the trip Departure time Destination of the trip Arrival time Trip purpose Transport mode Bus route Bus stops to be used Whether drive or not Number of passengers Parking place

(2) Sampling

A total number of 15,500 households were selected according to the consumer list of the Guatemala Electric Company (EEG).

The number of households supplied with electric power according to the EEG list as of July 1990 is 291,344 households in the Study Area. Compared with the number of households randomly sampled, a sample rate can be calculated as 5.3% in the Study Area.

(3) Zoning System

In the PT survey, origin and destination of trips are investigated. These information will be codified according to the zoning system in order to handle it in a computer.

Taking into account municipality boundaries, road network, land use and topography, the following zoning system for the PT survey were determined.

	Number of zones
Guatemala City	37
Other municipalities	21
Study Area Total	58
Outside Study Area	9
Total Zones	67

Detailed information about the zoning system is shown in Appendix.

(4) Related Surveys

1) Cordon Line Survey

The PT survey covers the movements only of residents in the Study Area. Therefore, to get the information about trips traveled by residents outside the Study Area, a supplementary survey named a cordon line survey, was made of the vehicles and passengers crossing a cordon line surrounding the Study Area.

A traffic count and interviews of sampled passengers were done at seven points on trunk roads crossing the cordon line. At the interview, passengers' OD and trip purposes were inquired. The field works were conducted during the same period as the PT survey.

2) Screen Line Survey

A screen line survey aims at verification and adjustment, when necessary, of the PT survey results.

The screen line is an imaginary line drawn so as to divide the Study Area into two parts. To verify the OD structure of the PT survey, the estimated volume of traffic crossing the screen line as base on the PT survey is compared to the actual traffic volume counted on the screen line. For this purpose, traffic and passenger counts were carried out at seventeen points crossing the screen line.

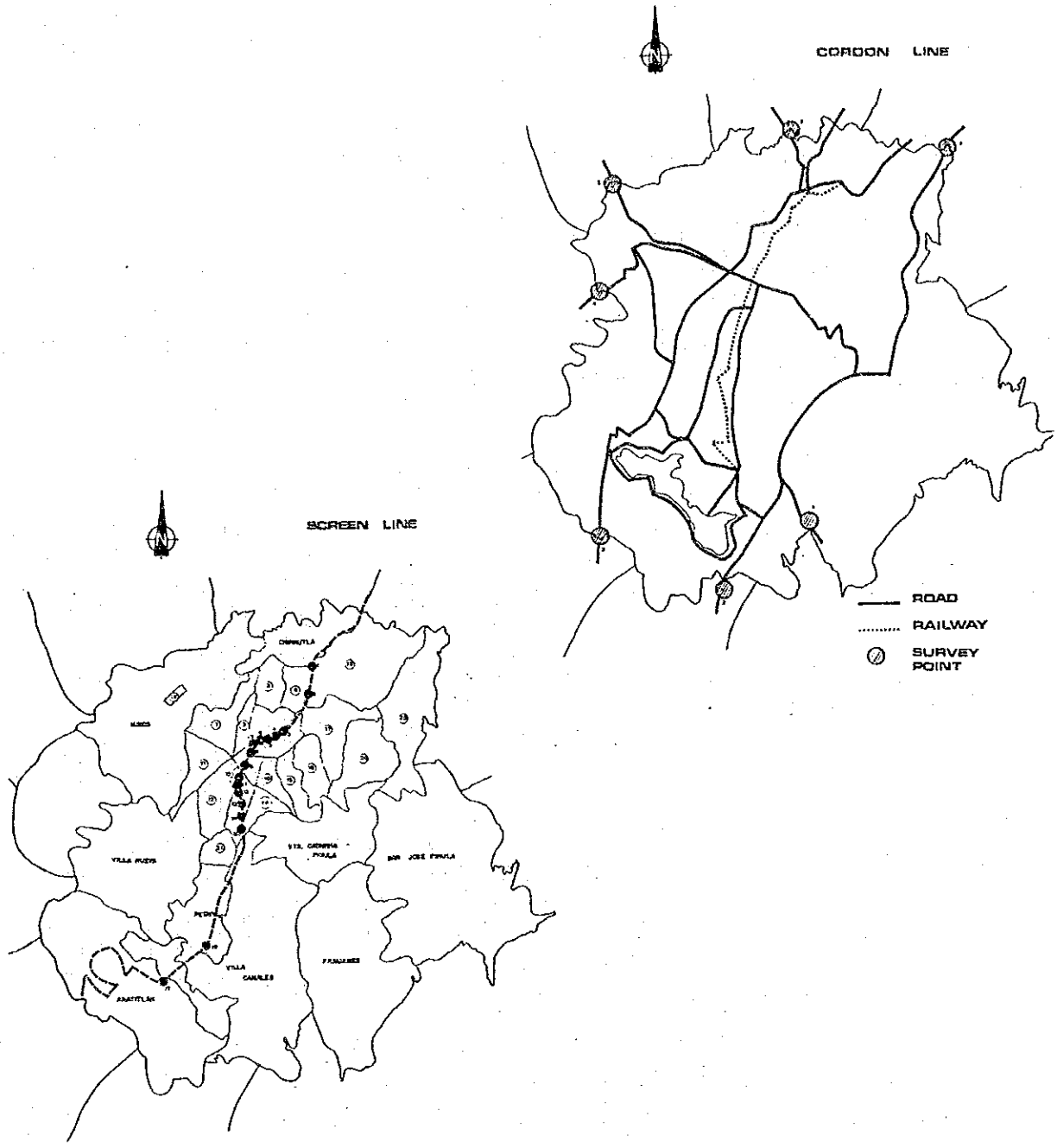


Figure 3.1.1 Cordon Line and Screen Line Survey Location

3.1.2 Data Processing for Person Trip Data

(1) Outline

The data processing of PT data consists of the following five major items;

- Checking and Correcting process of PT data
- Establishment of present population index and expansion of PT personal data
- Screen Line adjustment for PT data
- Analysis of Cordon Line survey results
- Production of Data base and assembling of present Origin and Destination (hereinafter referred as "OD") tables

In addition, the following figure describes the relation between surveys carried out and these five items of the procedure.

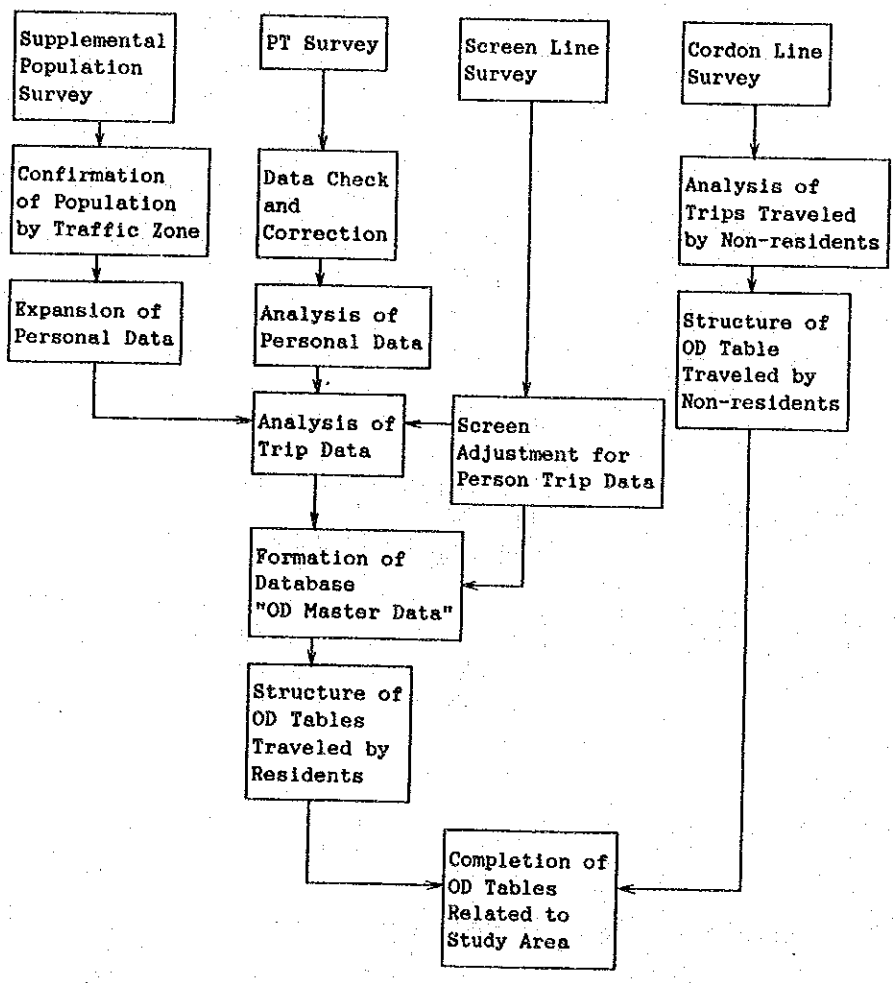


Figure 3.1.2 Data Processing for PT Data

(2) Confirmation of Present Population

The PT survey was undertaken to interview all members belonging to the families selected as a sample in each traffic zone. Therefore, the results should be expanded to provide complete information reflecting the activity of the whole Study Area. Hence, the population is the target to expand it.

By using the base data of the Population Census conducted in 1981 and the result of supplementary population survey conducted by JICA team, the total population of Guatemala City, other Municipality and the Study Area were estimated as 1,034,000, 767,000, and 1,801,000, respectively.

(3) Expansion of Personal Data

In order to determine the expansion factor, sample distribution of individual attributes such as sex, age group and car ownership, were compared with the actual distribution. The distribution by age group and sex were adopted as an expansion factor, the sample data was expanded in order to provide the complete information.

(4) Screen Line Adjustment for Person Trip Data

The OD table obtained from the person trip survey can be checked for accuracy by comparing it with the results of the screen line survey. If the traffic volume calculated from the OD table are significantly different from the present traffic flow, the OD table should be adjusted to represent the existing situation.

(5) Processing of Cordon Line Survey Data

The Cordon Line survey was conducted by counting traffic volumes by types of vehicles, and a sample of drivers were simultaneously interviewed to obtain detail of trips such as origin and destination of the trips, and purposes.

The results of the interview survey were expanded in accordance with the traffic volumes for each type of vehicles at each survey location. The OD tables were divided into that of residents and of non-residents. The former table was abandoned because it can be obtained from the PT survey, and the latter table is then added to the OD tables for which were calculated by processing the PT data.

3.2 Summary of Person Trips

(1) Number of Person Trips

The total numbers of person trips per day in 1990 in the Study Area are 3,423,142 trips. Within those trips, 98.9% of them, 3,386,252 trips, are traveled by residents in the Study Area, while the remaining 36,889 trips are traveled by outside residents. For trips traveled by outside residents, only 1,262 trips are external-external trips and the remaining majority of trips are related to the Study Area. On the other hand, the external-external trips traveled by residents in the Study Area are very few. Hence, the Study Area can be considered to be closed from the traffic point of view.

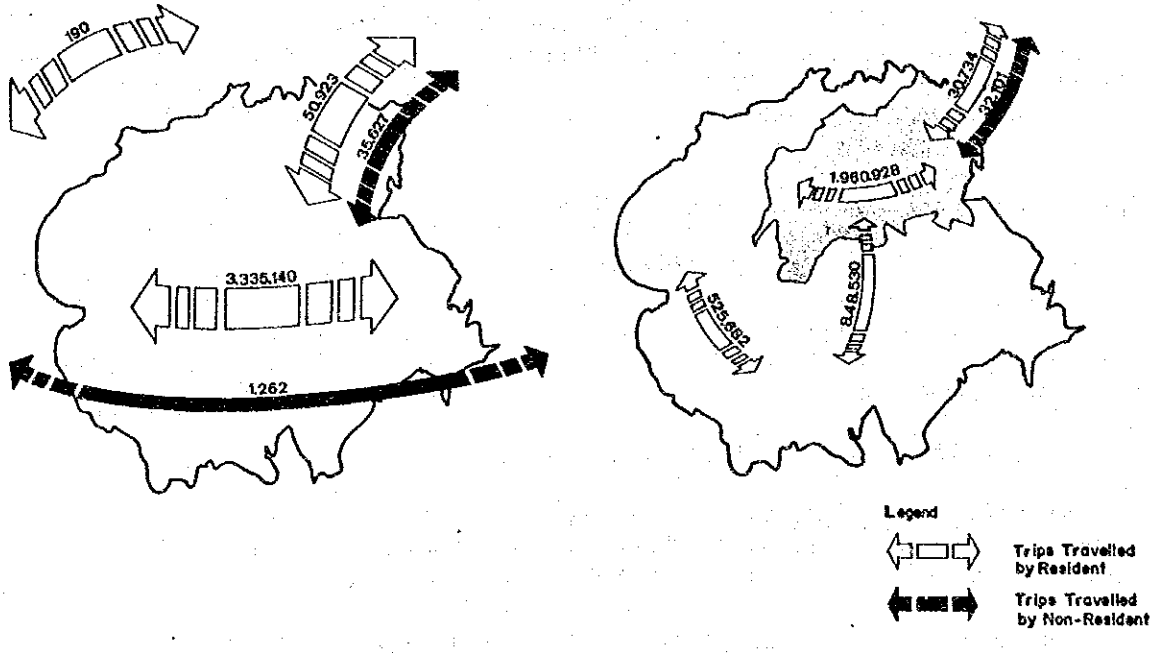


Figure 3.2.1 Outline of Person Trips

(2) Composition of Purpose

As shown in Figure 3.2.2, the composition of trip purpose are "to home" (47.7%), "to work" (22.5%), "to school" (14.6%), "others" (6.7%), "shopping" (4.5%), "business" (2.3%) and "to office" (1.5%).

It is remarkable that trips of "to home" purpose occupy almost a half of the total trips.

In considering together the results of analysis for the trip patterns, majority of persons made home based trips and after reaching destination, they simply returned homes, without moving to another destination. Another words, it is considered that the trip structure in the Study Area is quite simple.

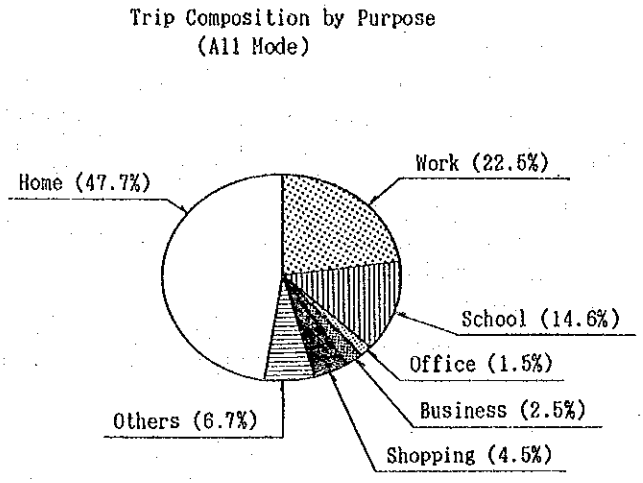


Figure 3.2.2 Composition of Trip Purpose

(3) Trip Composition by Mode

For the modal split, bus (large bus system) is the highest as 35.9%, followed by passenger car (18.7%), microbus (17.1%) and walking (16.3%). It is understood that buses (bus and microbus), which are the most important public transportation system, contribute to more than a half of the total trips.

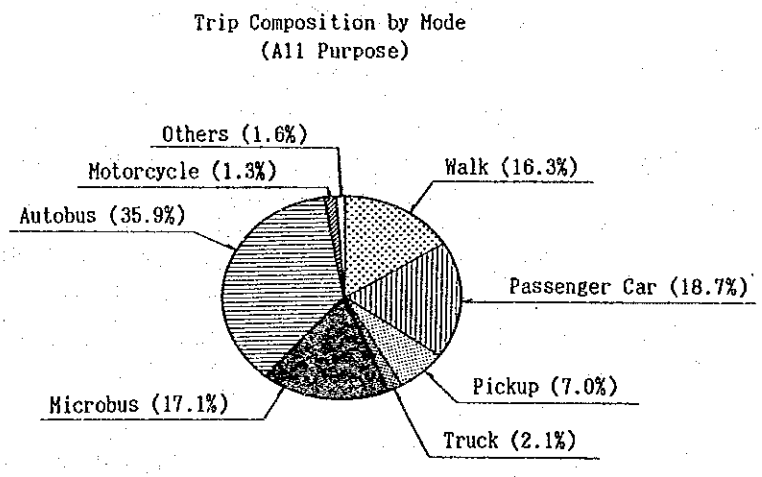


Figure 3.2.3 Trip Composition by Mode

3.3 Trip Production

There are the following 2 types of trip production rate. However, the gross trip production rate is called as the trip production rate in this chapter, unless a special note is written.

Gross trip production rate
: Number of trips by individual attributes is divided by the total number of 5 years and over population.

Net trip production rate
: Number of trips by individual attributes is divided by the total number of 5 years and over population, who made trips.

(1) Trip Production by Sex and Age Group

The trip production rate is much higher by males as 2.76 compared with 1.68 by females. This tendency can clearly be found out in Figure 3.3.1, which illustrates the trip production rate by age group and trip purpose.

For instance, trip generation rates up to 14 years old are not different between males and females, and their main purposes are "to school" and "to home". However, for age group over 14 years old or over 20 years old, the trip generation rate of males drastically increased, while trip generation rate is decreasing in the case of females. For the trip purpose, there are many "to work" purpose by males, while there are many "others" including "shopping" purpose by females. These facts indicate higher mobility by males than females.

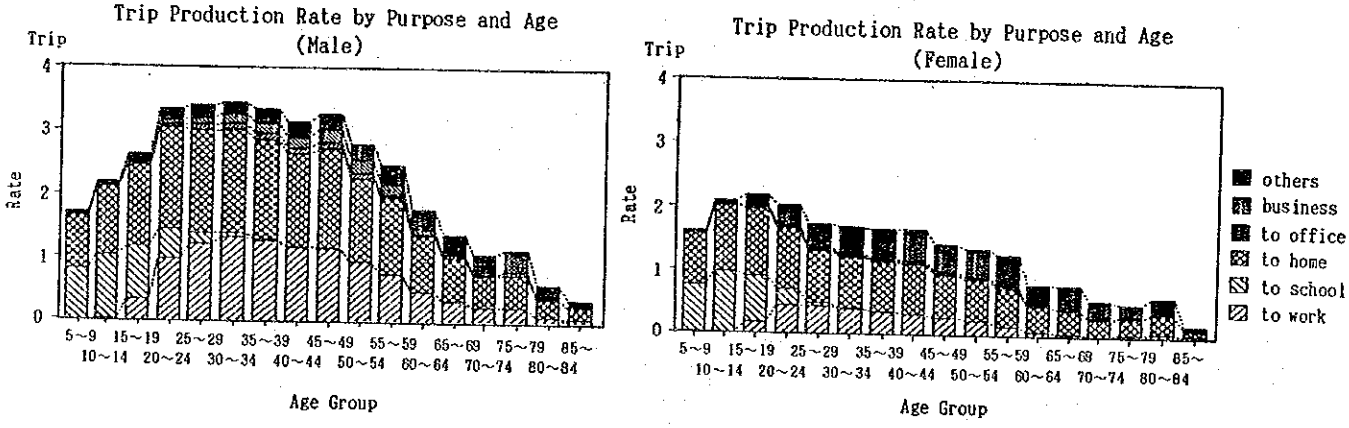


Figure 3.3.1 Trip Production by Sex and Age Group

(2) Trip Production by Work Status

For the trip production rate by work status, the rate is extremely high as 5.27 for business students, followed by workers as 3.12. In the case of business students, it can be supposed that directly go to a school from a work place or they make an additional return trip to a school after they go back home from a work place.

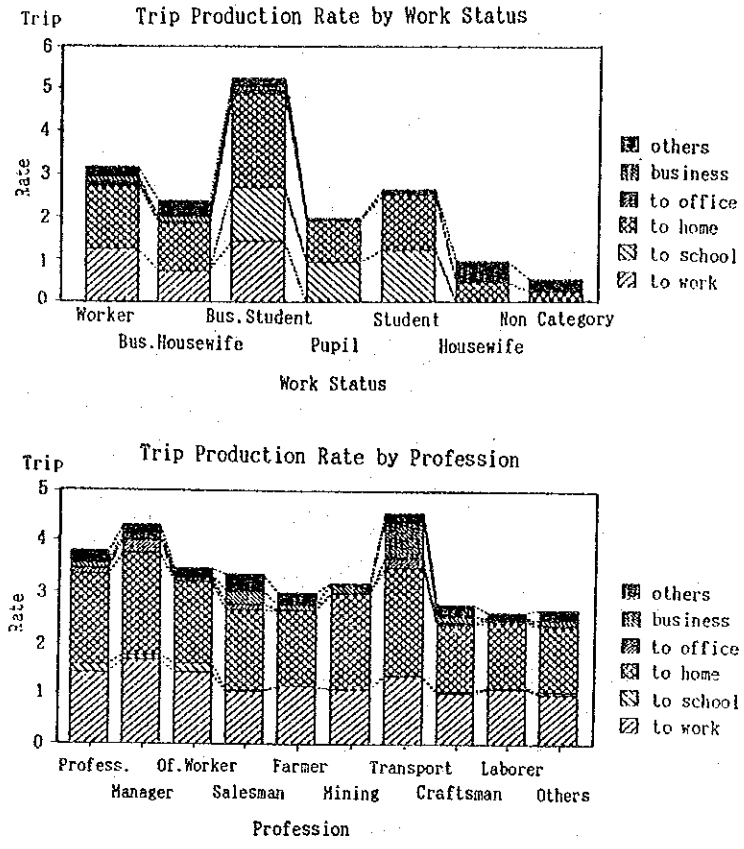


Figure 3.3.2 Trip Production by Work Status

(3) Trip Production by Industry

There is no big difference between trip productions by industrial sectors. However, the production rate of the tertiary industry is higher than those of the primary and the secondary industries. Among the tertiary industry, that of workers for transport business and bank insurance business are high as about 4.0 trips.

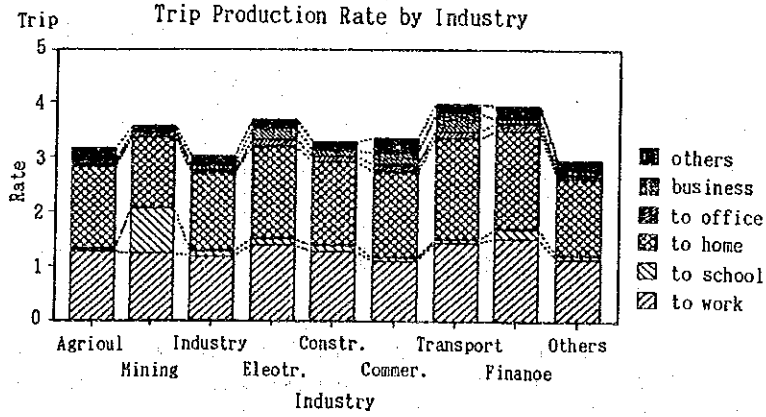


Figure 3.3.3 Trip Production by Industry

(4) Trip Production by Income Level

Referring to the trip production rate by income level shown in Figure 3.3.4, it is prominent that the higher income level results the larger trip production rate.

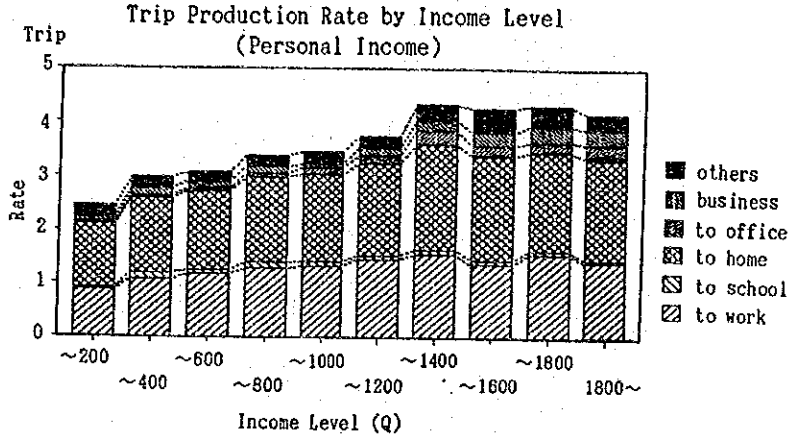


Figure 3.3.4 Trip Production by Income Level

(5) Trip Production by Car Owning

The trip production rate is obviously different between the car owning household and the non-car owning household as shown in Figure 3.3.5. The difference is about 1.0 trip according to the actual data. In addition, the trip production rate slightly increases if number of owing cars by a household increases.

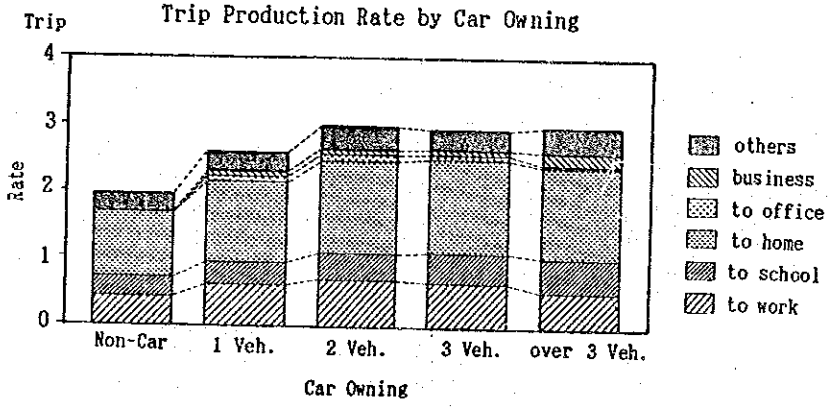


Figure 3.3.5 Trip Production Rate by Car Owning

It is, therefore, clear that the availability of cars greatly effects the characteristics of trip generation. Another words, car owing/non-car owing is very important factor for the trip generation.

3.4. Trip Generation and Attraction

(1) Trip Generation and Attraction by Purpose

Figure 3.4.1 shows the distribution of trip generation and attraction excluding "to home" purpose trips.

Trip generation volume are large in residential areas, such as zone 7 and Mixco along CA-1, and zone 18 and Villa Nueva along CA-9. On the contrary, large trip attracts into zone 1 where is the business center, and trip attraction volume are small in Municipalities outside Guatemala Municipality in south-eastern areas, such as Sta. C. Pinula, San Jose Pinula, Fraijanes, etc., where population are small.

The comparison of trip generation and attraction volumes by purpose in postal zone with heavy volume are as follows.

a) Trip generation volume

- The share of "to work" and "to school" purposes is high in Villa Nueva, Mixco and zone 18.
- The share of "to work", "to school" and "others" purposes is high in zone 7.
- The share of "others" purpose is high in zone 1.

b) Trip attraction volume

- The share of "to work", "to school", "shopping" and "others" purposes is high in zone 1.
- The share of "to work" and "to school" purposes is high in zone 12.

It is easily understood that many trips generated from residential areas with "to work" and "to school" purposes have their destination in zone 1. In addition, many trips are attracted to zone 7 as the destination of commuting and going to school. As a reference, the San Carlos University, which is the national university in Guatemala, is located in zone 12. Therefore, many trips are attracted to zone 12 as the destination of going to school.

Table 3.4.1 describes the both generation and attraction volumes by trip purpose and traffic zone.

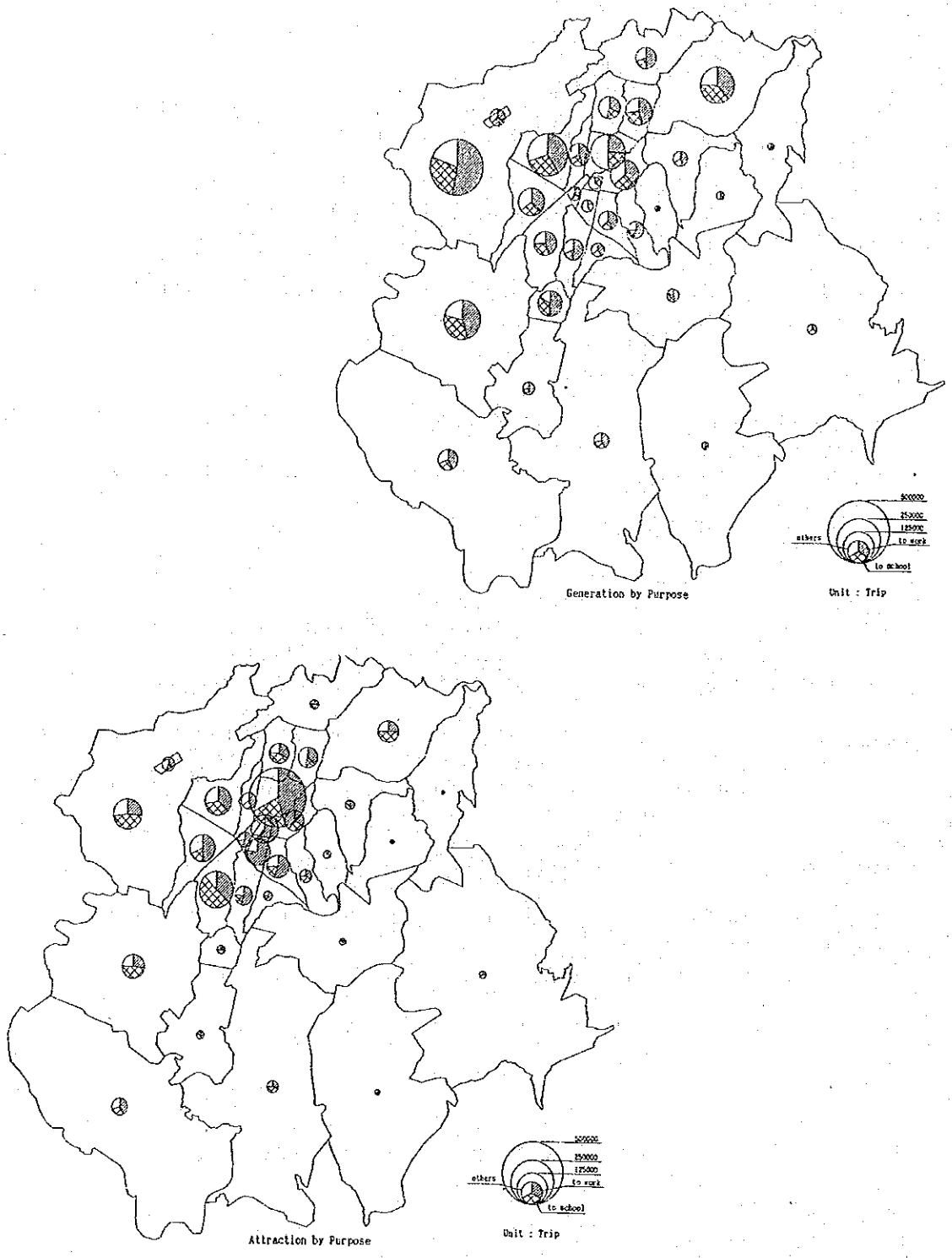


Figure 3.4.1 Trip Generation and Attraction by Trip Purpose

Table 3.4.1 Trip Generation and Attraction by Traffic Zone

Postal Zone/ Municipality	Traffic Zone	Generation by Trip Purpose							Attraction by Trip Purpose						
		to work	to school	shopping	business	others	to home	Total	to work	to school	shopping	business	others	to home	Total
1	1	10,546	9,722	8,087	7,750	9,714	234,451	280,250	97,880	89,189	23,554	17,951	46,633	17,959	273,166
	2	11,256	11,847	4,443	5,383	7,883	131,068	171,878	80,019	14,565	12,144	14,712	22,833	22,229	166,502
	3	5,761	3,025	476	1,470	3,808	16,711	31,251	9,317	4,910	772	1,302	2,076	13,027	31,404
	4	5,579	4,361	2,600	2,163	2,486	23,685	41,174	17,295	2,353	1,995	2,450	1,795	14,561	40,449
2	5	16,208	10,614	4,667	2,888	5,398	36,270	76,545	16,939	15,952	1,666	3,181	4,197	35,512	77,447
3	6	6,376	3,414	1,269	2,016	2,912	10,736	26,723	5,984	1,259	1,601	912	2,714	14,372	26,842
	7	17,059	8,853	2,569	2,441	3,469	18,062	52,453	8,908	4,518	2,137	1,292	3,145	33,664	53,664
4	8	2,361	3,023	2,202	2,277	2,158	93,660	105,681	59,895	1,739	18,266	11,018	9,221	1,515	101,654
5	9	10,317	5,823	2,330	1,385	5,135	17,998	42,988	7,210	5,517	2,453	792	4,063	23,865	43,900
	10	23,730	16,476	7,717	3,816	12,618	30,880	95,237	10,578	9,100	3,046	3,428	7,370	60,933	94,453
6	11	8,850	6,869	983	1,955	4,141	22,929	45,727	8,232	2,671	7,272	1,565	4,943	20,750	45,433
	12	14,551	8,780	2,059	3,056	5,698	22,342	56,486	10,138	4,566	2,518	2,346	5,533	32,766	57,867
	13	11,081	5,523	394	891	1,801	3,683	23,173	1,655	1,608	140	361	375	18,651	22,790
7	14	27,907	21,492	6,531	2,523	9,130	22,261	89,844	4,479	15,125	1,351	970	2,728	65,516	90,169
	15	10,869	5,852	1,401	2,758	3,204	30,601	54,685	17,793	8,134	1,059	2,182	3,708	21,580	54,456
	16	35,284	25,299	7,093	7,208	14,325	39,535	128,744	15,769	11,643	4,309	3,876	8,850	84,441	128,908
8	17	6,642	4,536	1,881	3,260	3,120	24,792	44,231	16,311	4,384	1,721	3,133	3,577	15,972	45,098
9	18	936	1,614	1,047	2,115	665	28,795	35,222	24,502	2,447	1,196	4,013	2,298	1,028	35,484
	19	1,221	2,590	1,403	2,469	1,343	46,959	55,985	39,089	2,339	3,311	4,455	6,027	756	55,977
10	20	5,236	3,111	2,455	1,884	1,696	42,002	56,394	27,994	9,537	1,507	3,061	6,494	7,982	56,575
	21	10,033	3,721	1,737	4,143	2,201	13,459	35,294	7,912	2,844	717	2,590	2,283	19,257	35,403
11	22	22,123	17,814	3,935	7,070	11,605	59,457	122,004	31,405	13,676	7,794	6,072	10,515	53,607	123,069
	23	6,027	3,051	1,455	1,686	1,772	23,033	37,024	15,205	3,954	1,568	2,128	2,013	10,883	35,771
12	24	20,882	12,656	2,125	2,523	3,648	22,625	64,459	12,452	6,654	868	1,760	1,353	44,378	67,465
	25	5,327	4,412	1,469	2,237	3,162	137,356	153,963	49,113	78,177	3,288	6,077	6,800	7,243	150,478
13	26	22,561	7,309	3,024	6,761	4,156	39,760	83,571	24,779	9,439	1,698	3,200	5,926	38,747	83,789
14	27	7,727	4,353	1,686	2,201	2,764	8,806	27,539	5,872	2,004	454	553	1,501	17,156	27,540
15	28	6,876	1,963	1,045	572	1,005	7,304	18,765	2,645	3,382	405	811	905	10,457	18,605
	29	9,275	2,780	1,494	1,633	2,013	12,568	29,763	4,699	5,416	1,203	739	1,736	16,158	29,911
16	30	1,084	623	315	254	579	7,763	10,618	888	6,521	117	281	354	2,452	10,613
17	31	9,905	5,123	1,852	1,104	4,568	9,831	32,381	5,004	3,687	118	775	1,167	22,418	33,369
18	32	9,390	7,881	1,298	1,130	3,690	12,913	36,302	7,593	4,293	621	1,327	2,502	21,623	37,959
	33	41,642	40,880	9,391	5,572	12,484	37,516	147,485	7,015	24,749	5,226	1,109	4,024	107,767	149,890
19	34	10,213	7,938	3,374	2,834	4,583	22,066	51,008	7,604	6,139	3,493	3,080	3,838	26,566	50,720
22	35	33,695	21,806	3,736	1,154	6,148	9,200	75,739	2,809	4,816	189	736	1,712	66,078	76,340
24	36	2,357	1,215	2,048	259	999	1,879	8,757	508	1,204	75	259	37	6,302	8,385
25	37	1,682	988	1,268	308	360	1,293	5,899	466	401	84	361	189	4,570	6,071
Guatemala City Total		452,619	307,337	102,839	101,449	168,739	1,324,249	2,455,232	666,936	368,912	119,936	114,856	195,235	982,741	2,447,616
Mixco	38	46,143	24,986	4,986	3,882	15,216	38,223	133,436	9,466	17,679	5,027	2,366	5,898	93,525	133,961
	39	67,838	26,420	5,162	3,220	4,424	23,195	130,257	5,395	14,675	2,880	233	1,829	112,204	137,216
	40	28,417	20,417	4,336	2,761	6,815	29,983	94,729	10,200	12,839	2,940	1,754	4,535	63,285	95,553
	41	14,789	11,812	1,348	969	2,112	9,190	40,220	4,111	4,097	283	857	1,155	29,854	40,157
	42	8,330	5,370	488	2,661	776	7,233	24,863	1,563	4,803	1,830	215	627	15,180	24,218
	43	1,669	967	38	45	96	1,132	3,947	479	300	38	102	0	3,065	3,984
V.Nueva	44	8,225	17,200	444	482	3,685	15,952	45,988	2,515	12,005	256	119	268	30,917	46,080
	45	7,186	4,786	423	87	257	8,198	20,937	4,219	3,324	392	72	226	12,721	20,954
	46	31,932	12,638	4,159	4,079	3,064	11,261	67,133	2,446	4,954	652	587	1,156	58,963	68,738
	47	20,225	15,538	7,678	4,958	3,250	34,119	85,768	9,669	14,293	7,550	4,188	2,065	47,956	85,921
	48	2,965	2,091	914	84	134	1,638	7,826	387	1,128	80	159	0	6,062	7,816
Petapa	49	8,447	4,564	3,579	135	889	7,430	25,044	3,233	3,189	774	57	533	17,225	25,011
Amatitlan	50	14,616	9,090	3,826	3,271	4,033	28,420	63,256	13,044	7,860	3,348	2,948	3,728	32,112	63,040
	51	3,769	2,941	949	546	707	7,015	15,927	3,053	2,485	815	537	421	8,628	15,937
V.Canales	52	7,389	4,490	2,474	1,988	691	11,151	28,181	3,343	5,167	1,796	95	906	16,624	27,931
	53	3,026	2,395	696	184	988	5,570	12,857	1,864	2,362	754	116	553	7,046	12,695
Sta.C.Pinula	54	3,203	1,323	268	546	200	2,569	8,189	1,062	851	123	343	29	5,732	8,140
	55	4,668	4,413	1,040	288	1,070	3,113	14,902	413	2,355	210	62	121	11,058	14,219
San Jose Pinula	56	2,817	3,528	1,668	274	1,883	7,025	17,015	1,963	2,901	1,033	651	843	9,500	16,891
Fraijanes	57	1,728	1,400	195	670	1,706	3,566	9,263	929	1,110	109	47	1,362	5,805	9,362
Chinautla	58	22,326	9,613	4,102	3,201	8,310	10,843	56,395	2,510	5,900	910	461	1,105	43,832	54,718
Out of Guatemala Total		309,704	185,982	48,793	34,319	60,164	266,851	905,813	62,064	124,277	31,800	15,749	27,360	631,292	912,542
Study Area Total		762,323	493,319	151,632	135,768	228,903	1,591,100	3,361,045	748,000	493,189	151,736	130,605	222,595	1,614,033	3,360,158

(2) Trip Generation and Attraction by Mode

There are not so much difference of modal split between the trip generation and attraction volume in each zone. This clearly indicates that there is no modal change between "going" and "return" trips. For instance, a mode utilized for "to work" purpose is also utilized for "to home" purpose.

Figure 3.4.2 describes the distribution of trip generation and attraction volumes by mode in each zone.

The trip generation volumes by passenger cars are heavy in zone 10, 13, 14, 15, etc., where the car ownership rates and the average household income level are high. On the other hand, modal split of buses are high in zone 1, 4 and 5 as the central business area, and zone 6 and Mixco as the residential area.

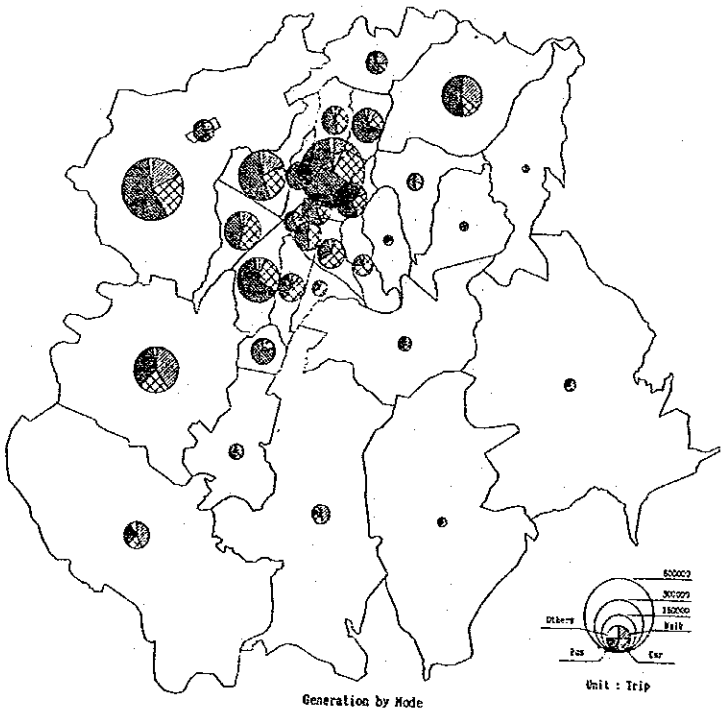


Figure 3.4.2 Trip Generation by Mode

(3) Hourly Fluctuation of Trip Generation and Attraction

Figure 3.4.3 shows the number of trips by departure time and purpose, and the number of trips by arrival time and purpose.

According to this figure, the trip generation peak is between 7 a.m. and 8 a.m., and almost all of the purposes are "to work" or "to school". As a contrary, there is no particular generation peak in the evening. However, there is the trip generation peak at 1 p.m. and the share of trips by "to

home" purpose continuously is high until around 7 p.m..

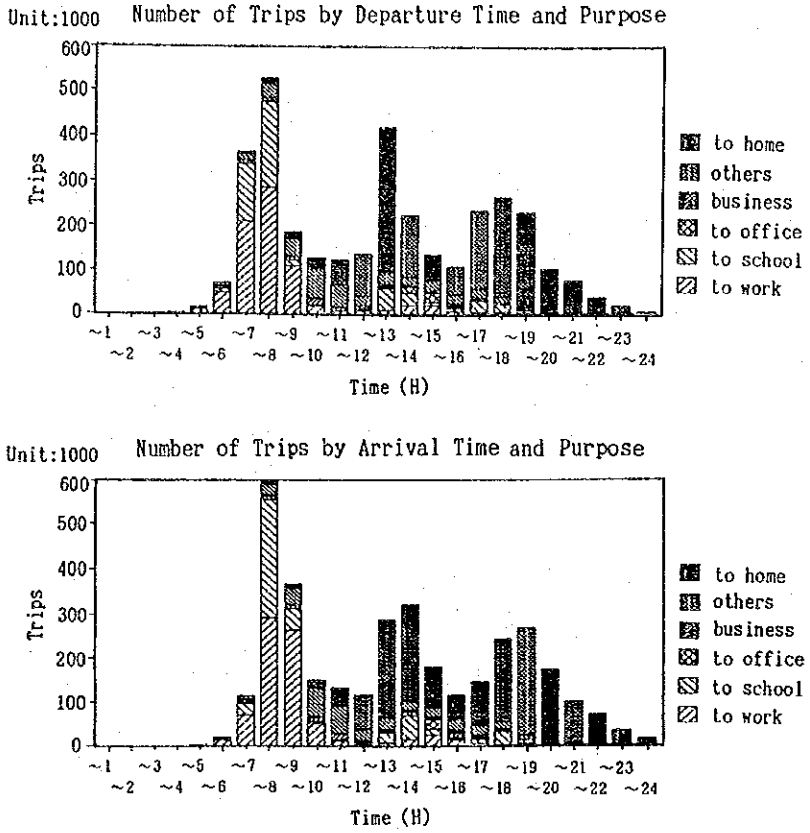


Figure 3.4.3 Number of Trips by Departure or Arrival Time

Also, there are "to school" purpose trips around 2 p.m. and 5 p.m.. It is supposed that these trips are made by business students who go to school after finishing job.

About arrival time, there is the same tendency as the distribution of departure time. However, the generation peak in the morning is very high, due to concentration of arrival trips.

3.5 Trip Distribution

(1) Trip Distribution of All Purposes

Figure 3.5.1 illustrates the desired lines of trip distribution of all purposes between zones.

As a peculiar points, very heavy OD trips can be seen between the western area, especially Mixco and Villa Nueva, and the central area of Guatemala City (zones 1 and 4). For the eastern area, particularly heavy trips generate in zone 18 and the relation to zone 1 is strong.

In Guatemala City, trips between zone 1 and its adjacent zones (zones 2 though 6), and between zone 4 and the western areas (zones 7, 9, 11, 12, and 13) are heavy.

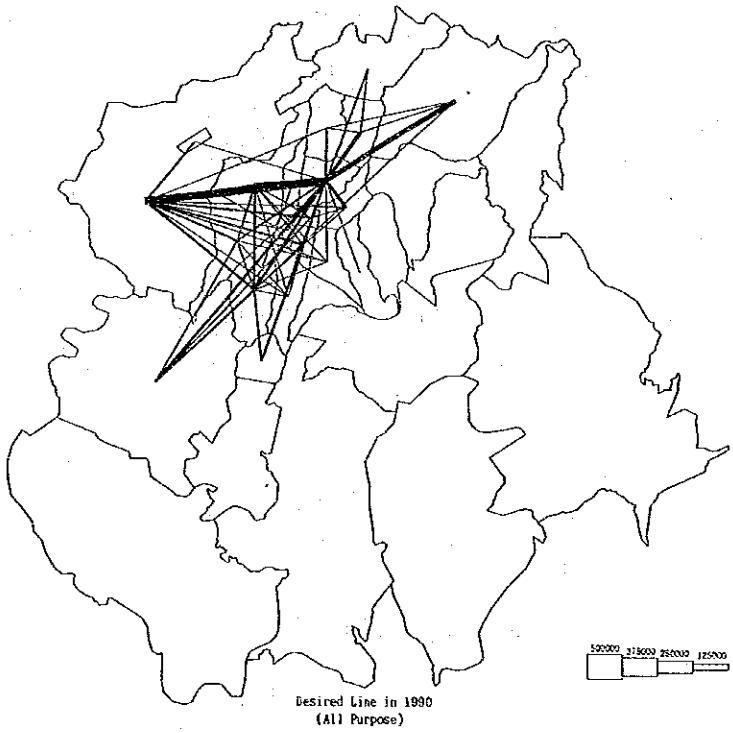


Figure 3.5.1 Desired Line of All Purposes

(2) Trip Distribution by Purpose

Figures 3.5.2 through 3.5.5 exhibit the desired lines of trip distribution by trip purpose. As seeing these figures, the following points can be pointed out.

1) to work

Since the desired lines of "to work" purpose trips connect residential areas and working places, heavy trips are found between large population areas (Mixco, Villa Nueva and zone 18) and the center of business area (zone 1). As a contrary, no heavy trip is found

between adjacent zones. Therefore, it can be said that length of many trips for "to work" purpose is relatively long.

2) to school

Comparing with "to work" purpose, the "to school" purpose trips are relatively heavy between adjacent zones. On the other hand, concentration of trips in certain zones (zones 1 and 12) are also found, and in this case, many students make rather long trips. It is supposed that "to school" trips between adjacent zones are mainly made by pupils and younger students, while longer trips are made by elder students, such as university students.

3) Other Purposes

About the "business" and "shopping" purpose trips, many of them are related to the central business district, such as zone 1 and 9. In addition, there are also relatively short trips between adjacent zones.

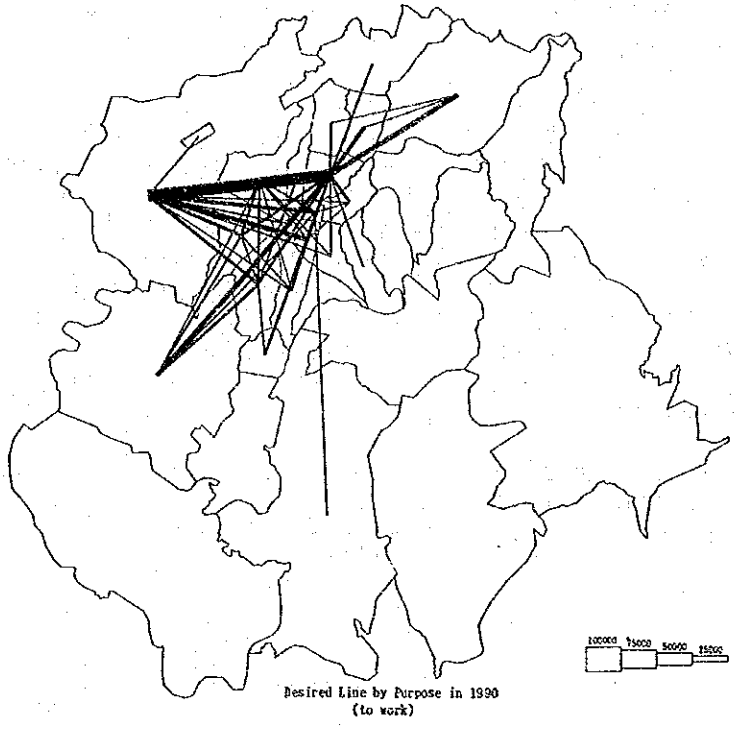


Figure 3.5.2 Desired Line of "to work" Purpose Trip

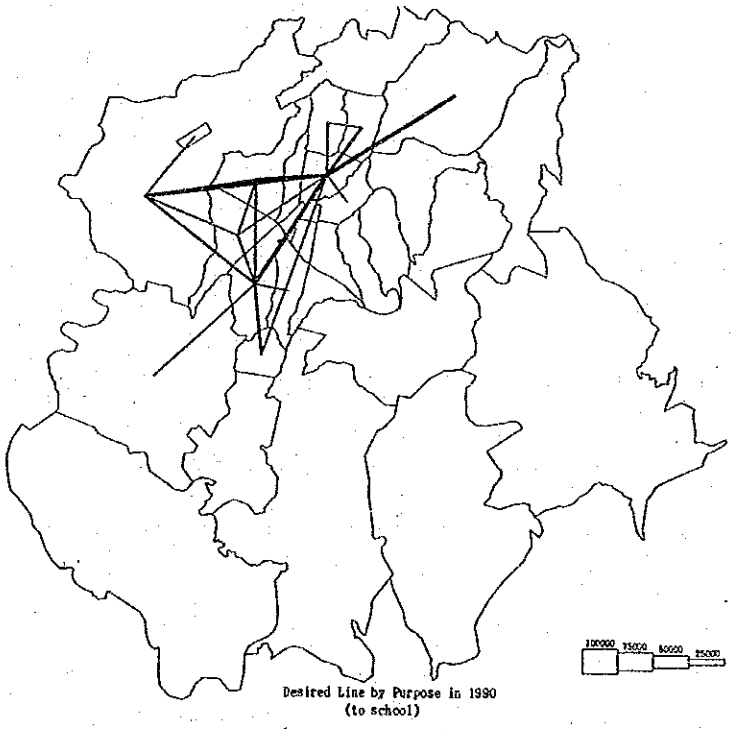


Figure 3.5.3 Desired Line of "to school" Purpose Trip

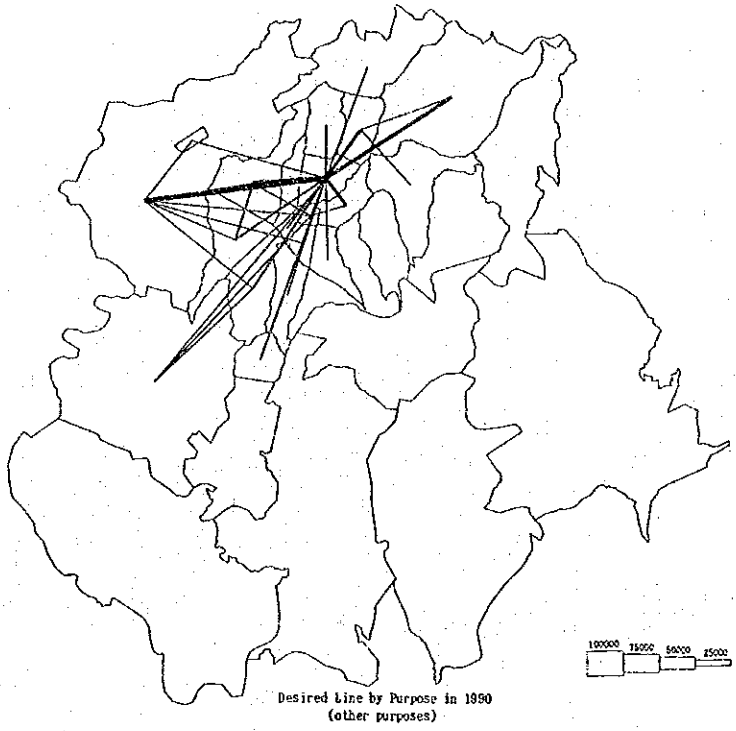


Figure 3.5.4 Desired Line of Other Purposes' Trip

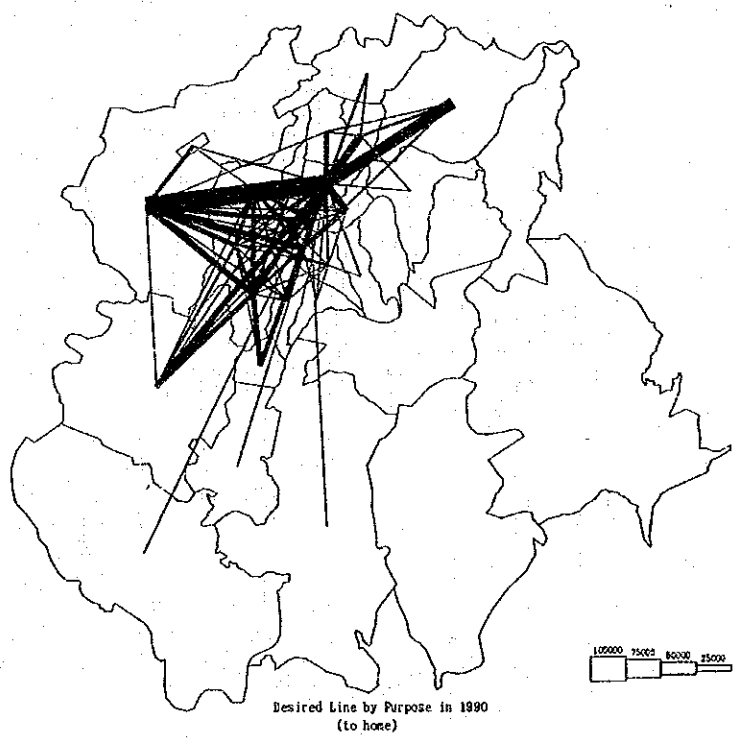


Figure 3.5.5 Desired Line of "to home" Purpose Trip

(3) Present OD Table of All Purpose

The distribution of trips (made by only residents in the Study Area) in terms of all purpose and all mode of transport for postal zone and municipality is compiled in an OD table shown in Table 3.5.1.

Table 3.5.1 Present OD Table of All Purpose and All Mode by Postal Zone

Postal Zone/ Municipality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	78,094	20,267	19,915	5,295	29,318	32,720	44,247	5,946	6,250	9,406	17,099	30,027	10,727	3,243	6,234	1,524	5,333
2	20,668	8,280	1,576	1,272	2,670	6,569	2,916	683	1,617	4,255	1,549	2,888	1,079	574	1,735	207	203
3	19,856	1,467	15,358	1,470	1,456	1,150	3,664	2,475	3,120	1,408	3,053	6,590	1,433	350	576	414	90
4	4,917	1,511	1,403	2,151	7,349	4,628	10,938	1,589	525	2,191	3,667	4,264	4,182	1,395	2,159	260	1,817
5	27,545	2,687	1,689	7,853	47,111	3,258	3,815	563	4,571	4,769	4,101	5,355	3,050	1,010	1,500	850	1,601
6	32,706	7,273	1,208	3,905	3,212	27,884	2,500	654	2,829	2,763	1,852	4,677	2,838	626	930	437	4,731
7	45,859	2,850	3,854	10,756	3,319	2,302	100,542	4,317	8,675	5,693	16,241	16,975	5,647	1,058	1,864	696	1,192
8	6,273	845	2,338	1,683	841	841	4,174	4,565	1,388	1,103	2,095	2,828	723	363	459	128	24
9	6,755	1,764	2,705	701	4,034	2,831	8,627	980	3,849	3,484	4,710	6,068	2,477	3,506	2,844	543	143
10	8,638	4,230	1,389	1,975	4,662	2,926	5,732	902	4,070	13,607	5,034	5,892	4,060	3,400	4,278	443	595
11	17,250	1,818	3,165	3,216	3,545	1,966	16,557	2,479	4,536	5,269	34,824	12,728	5,409	1,086	1,664	691	593
12	21,668	2,728	7,355	2,590	6,682	5,159	18,542	2,904	3,957	5,153	12,575	34,665	5,516	1,401	2,063	371	992
13	10,413	1,022	1,362	4,242	2,790	2,798	5,439	794	2,614	4,120	5,663	6,510	15,622	1,651	1,932	274	61
14	3,438	574	397	1,336	973	595	888	389	3,498	3,230	1,340	1,362	1,716	3,634	1,018	381	86
15	6,278	1,844	590	2,036	1,582	881	2,060	501	2,421	4,309	1,440	2,159	1,926	942	10,438	322	472
16	1,244	207	475	266	836	335	864	154	221	466	756	509	248	336	356	1,386	54
17	4,537	472	144	1,678	1,302	4,914	831	0	206	380	875	744	701	86	268	94	13,237
18	44,093	6,213	1,308	2,838	2,595	9,472	2,445	930	2,980	2,175	2,448	5,401	1,645	111	573	203	1,008
19	6,307	541	849	1,487	875	540	3,831	282	1,070	586	2,079	1,639	337	94	107	36	124
22	20,260	994	727	2,921	569	478	2,099	1,473	3,312	1,473	3,451	17,526	2,390	134	299	164	0
24	1,788	98	0	269	0	2,623	38	104	106	0	0	0	0	0	0	37	49
25	823	103	67	397	76	1,456	83	0	219	0	76	62	67	0	0	0	0
Mixco	73,710	4,783	7,684	17,140	5,571	2,670	25,102	7,567	21,114	8,478	20,873	22,395	5,555	1,584	3,549	1,087	148
Villa Nueva	21,824	2,575	3,745	8,557	1,624	1,052	3,634	2,913	3,143	1,832	7,995	17,604	2,039	158	878	0	172
Petapa	3,540	35	35	1,046	230	76	135	428	768	439	516	2,655	175	0	126	0	329
Amatitlan	3,696	191	452	600	290	77	169	234	279	458	990	1,596	465	0	684	0	61
Villa Canales	1,953	0	204	4,932	1,907	59	93	159	829	610	253	505	1,048	23	44	0	0
Sta.C.Pinula	2,778	280	31	1,853	205	184	141	120	981	2,170	583	872	745	444	292	47	0
San Jose Pinula	1,469	42	48	1,274	262	38	51	108	226	78	214	190	101	0	47	0	0
Fraijanes	533	43	0	799	71	142	95	0	43	85	178	426	85	0	341	0	0
Chinautla	11,745	1,099	208	4,880	1,199	5,401	845	379	1,687	1,181	825	1,268	824	131	258	0	0
Outside Study Area	863	863	245	34	827	245	2,385	408	77	769	1,377	1,585	1,456	202	1,000	18	214
Total	511,521	77,447	80,506	101,654	138,353	126,050	273,533	45,098	91,461	91,978	158,840	217,943	83,789	27,540	48,518	10,613	33,369

18	19	22	24	25	Mixco	Villa Nueva	Petapa	Amatitlan	Villa Canales	Sta.C. Pinula	San Jose Pinula	Fraijanes	Chinautla	Outside	Total
46,964	6,524	18,678	1,769	1,833	75,711	23,063	3,564	3,512	1,929	2,350	1,303	490	10,926	892	524,553
5,682	541	1,470	96	31	5,250	2,175	35	191	0	256	42	43	1,052	920	76,545
1,453	876	649	0	0	7,727	3,401	35	236	204	36	0	0	208	411	79,176
2,644	1,293	2,130	212	316	20,110	8,787	905	600	4,713	1,834	1,369	799	4,792	61	105,681
2,791	851	992	0	35	5,745	1,674	140	220	1,934	223	206	71	1,245	770	138,225
9,617	490	591	2,623	1,448	2,527	1,087	76	126	59	178	38	142	5,076	283	125,386
2,210	3,793	2,063	38	83	24,995	3,862	135	427	120	141	51	95	751	2,671	223,273
948	282	1,473	48	0	6,761	2,701	428	234	158	129	153	0	379	579	44,231
2,766	837	2,926	49	219	20,618	2,785	768	356	829	1,017	226	90	1,659	41	91,207
2,057	608	1,200	0	0	8,632	1,654	453	468	634	2,091	78	85	1,121	754	91,678
2,060	2,226	3,376	0	76	20,501	8,879	516	990	202	652	160	129	949	1,516	159,028
6,504	2,035	21,193	0	62	26,428	18,125	2,689	1,244	502	1,197	159	468	1,730	1,564	218,422
1,524	375	2,122	0	67	5,600	2,143	175	465	972	536	101	85	596	1,583	83,571
118	99	170	0	0	1,440	158	0	0	30	444	0	0	84	136	27,538
576	154	299	0	0	3,421	678	126	684	44	370	47	440	258	1,000	48,528
224	36	206	37	0	1,230	47	0	0	0	47	0	0	0	18	10,618
1,068	133	0	49	0	148	172	329	61	0	0	0	0	0	214	32,381
91,457	443	280	75	545	1,607	328	63	188	88	29	89	0	474	1,683	183,787
367	11,792	873	0	0	15,650	110	0	23	94	145	150	0	815	405	51,608
200	766	13,613	0	0	669	952	76	67	36	55	67	0	0	558	75,739
114	0	0	3,048	192	293	0	0	0	0	0	0	0	0	0	8,157
545	0	0	48	1,758	26	0	0	0	0	0	0	0	0	93	5,899
2,149	14,830	764	293	113	168,933	4,333	210	649	341	387	90	128	1,492	3,750	427,452
281	151	476	0	0	4,380	132,577	2,723	1,681	1,148	64	128	125	395	3,377	227,652
63	0	76	0	0	210	2,629	10,480	120	767	0	0	70	61	35	25,044
208	57	57	0	0	547	1,677	120	64,745	478	42	0	43	31	896	79,183
110	94	36	0	0	341	1,148	778	478	23,445	641	475	0	139	713	41,018
29	145	55	0	0	367	64	0	42	641	9,178	334	43	31	36	22,791
69	150	0	0	0	90	157	0	0	475	363	11,295	180	97	53	17,015
0	0	0	0	0	128	125	70	43	0	43	180	5,635	0	0	9,263
927	815	40	0	0	1,476	363	72	31	88	0	97	0	19,383	973	56,395
1,904	324	522	0	93	3,528	3,445	35	896	697	0	53	0	973	190	25,208
187,849	50,720	76,340	8,365	6,071	435,069	229,509	25,011	78,977	40,626	22,359	16,891	9,362	54,718	26,035	3,386,253

3.6 Modal Split

(1) Modal Split by Purpose

Bus is the highest share for "to work" purpose trips, followed by passenger cars. As a contrary, shares of buses and walking are high for "to school" and "shopping" purpose trips. On the other hand, for "business" and "to office" purpose trips, the share of passenger cars is the highest, while share of buses is lower compared with other trip purposes. In addition, trucks are also used for "business" purpose trips.

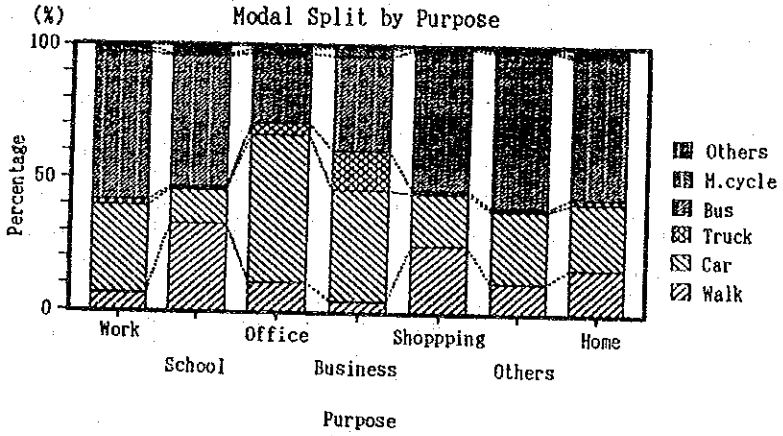


Figure 3.6.1 Modal Split by Purpose

(2) Trip Distribution by Mode

Figures 3.6.2 and 3.6.3 illustrate the desired lines of trip distribution by major transport mode.

In case of passenger cars, an OD pair with heaviest trips is between zone 1 and Mixco, besides many trips between zones are also found inside the central area of Guatemala City. On the other hand, majority of bus trips are between surrounding areas and the central area of Guatemala City, while movements inside the central area are limited. Particularly, trips between the central business district of Guatemala City and Mixco, zones 18 and 22, and Villa Nueva along major arterial roads, as a radial pattern, are very heavy.

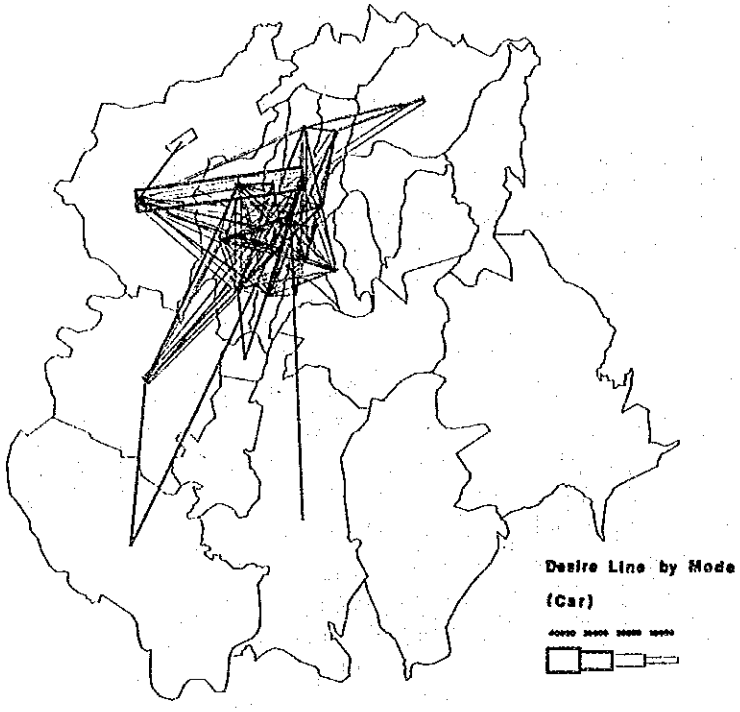


Figure 3.6.2 Desired Line of Trips by Passenger Car

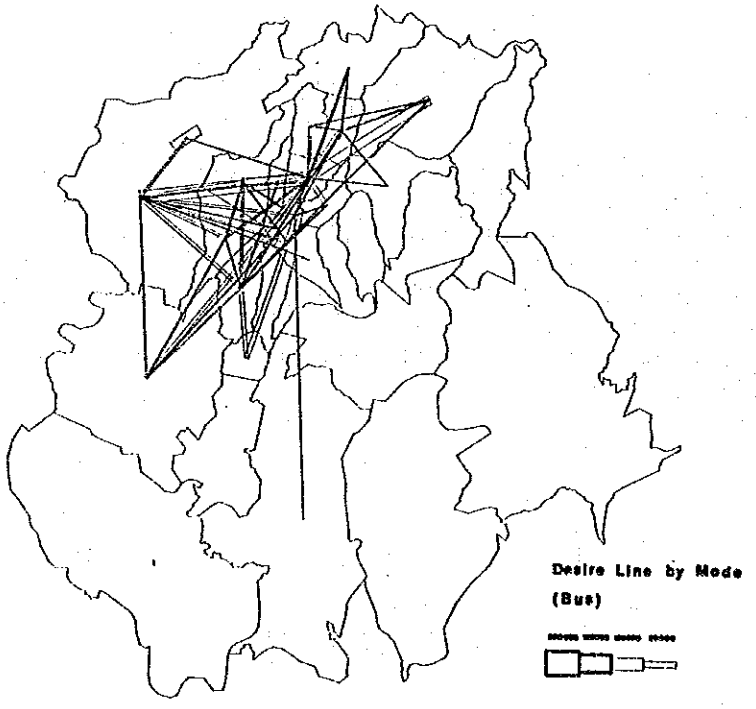


Figure 3.6.3 Desired Line of Trips by Bus

(3) Modal Split by Travel Time

Figure 3.6.4 shows the modal split characteristics by travel time.

The highest share of travel time is 15 - 30 min., followed by less than 15 min. and 45 - 60 min. In fact, it should be noticed that it is easy to response during the survey for units like 30 min. or 1 hour. However, the majority of travel time for trips can be said less than 1 hour.

About modal split characteristics by travel time, many trips with less than 30 min. travel time are traveled by walking, while shares of buses increase for trips with longer travel time. As a contrary, there is no particular difference of characteristics of trips traveled by passenger cars. This means that people who own a passenger car use their car, nevertheless the difference of travel time.

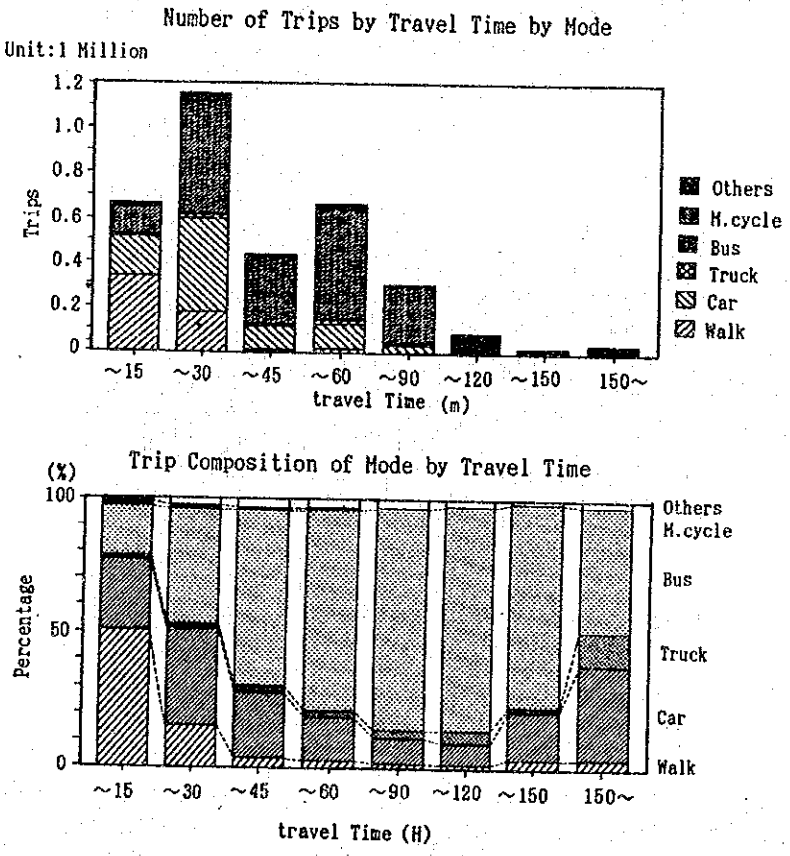


Figure 3.6.4 Modal Split by Travel Time

(4) Modal Split by Travel Distance

Figure 3.6.5 shows the modal split characteristics by trip distance.

According to this figure, both buses and cars are used for any trip distance. While, many walking trips are made up to the distance of 4 km.

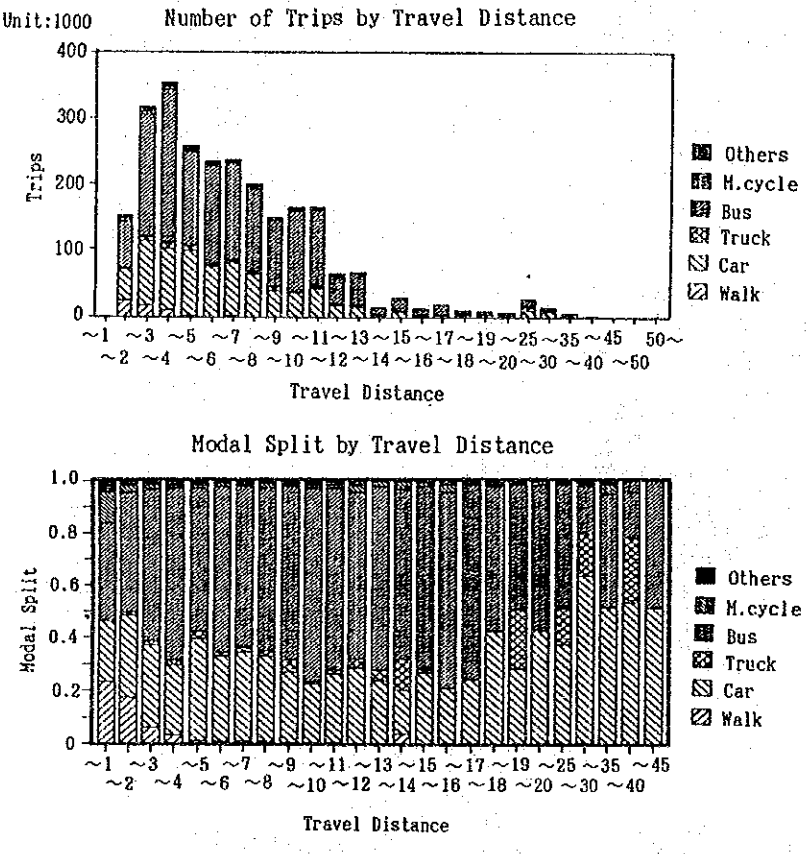


Figure 3.6.5 Modal Split by Travel Distance

(5) Modal Split by Car Owning

There is big difference in the tendency of modal choice between car owning households and non-car owning households. For non-car owning households, the share of trips made by buses and walking are very high. On the other hand, in car owning households, the share of trips by passenger cars are higher than that of buses, and share of trips by walking is extremely low.

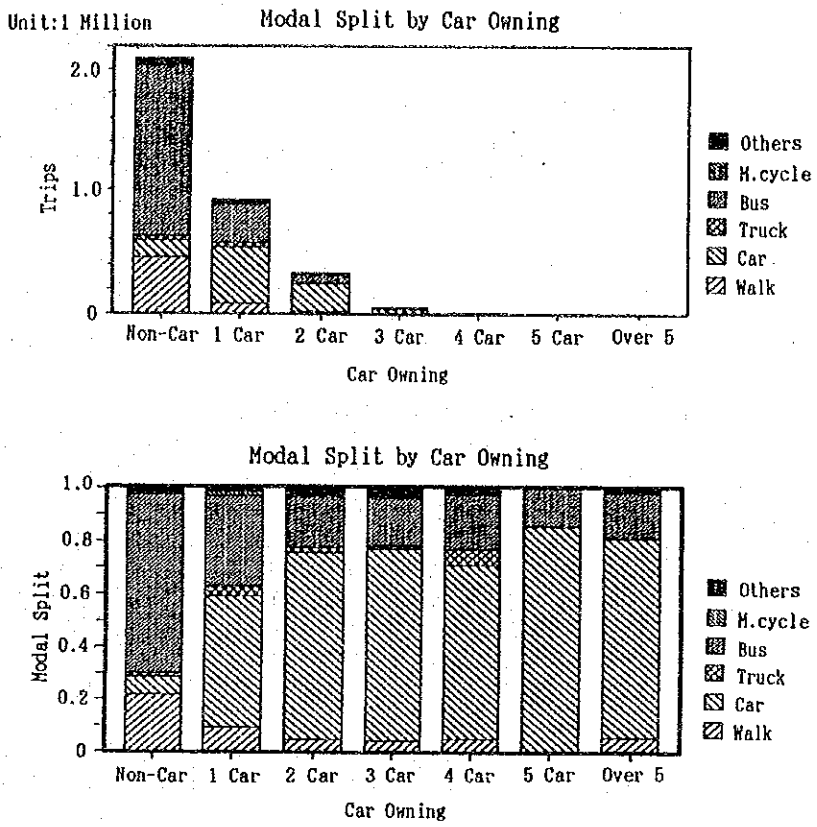


Figure 3.6.6 Modal Split by Car Owning

4. ROAD FACILITIES AND ROAD TRAFFIC

4.1 Existing Road Facilities Conditions

The road inventory survey and field reconnaissance survey were conducted during July and August 1990 by the Study Team. The results of the road inventory survey and survey data were presented in the Technical Report namely "Road Inventory Survey".

Based on the results of this survey, the existing road facilities conditions and their problems are examined.

4.1.1 Geographical Features

The outline of geographical features in the Study Area has been described in Progress Report(II). Guatemala City is located on the ridge of a mountainous area, and is divided into two (2) catchment areas of rain-fall by C.A-1 (Central American Highway No. 1).

When available land for housing development is assumed to be limited to land with a ground slope of less than 30 percent slope. The available land for development is about 47% of the total Study Area.

4.1.2 Road Space Ratio

Road space ratio is calculated to evaluate the existing road conditions. The road ratio is represented by the following formula.

$$\text{Road space ratio} = \frac{\text{Road Space Area}}{\text{Land Area}} \times 100 \quad (\%)$$

The road space ratio of each zona in Guatemala City is calculated as shown in Table 4.1.1. From this table, the following facts can be described.

a) The road space ratio of Central District (Zona 1 to 4) and Central Urban Area (Zona 1 to Zona 10, excluding northern parts of Zona 2) are 21.3% and 22.2% respectively. These values show that the existing road space is comparatively good for inhabitants.

b) The road space ratio of the central area of Zonas 1, 8 and 9 exceeds 28.0 percent. The road space in this area and Zona 3 is quite good for the inhabitants.

c) However, the road space ratios of Zonas 2, 16, 18 and 22 are less than 10 percent. New road construction may be required in these areas.

d) The road space ratios of surrounding areas of Guatemala City such as Mixco, Villa Nueva, Petapa, and Amatitlán, have not been calculated, however, they may be very low based on the results of the field reconnaissance survey.

Table 4.1.1 Road Space Ratio

Name of Zona	Available Land (A) Area (ha)	Road Space Area (B) (ha)	Road Space Ratio (B/A) (%)
Zona 1	617.6	111.5	18.1 (28.8%)*
Zona 2	490.7	31.3	6.4
Zona 3	246.2	84.3	34.2
Zona 4	105.8	26.0	24.6
Zona 5	423.1	87.2	20.3
Zona 6	527.8	109.2	20.7
Zona 7	1,003.9	137.8	13.7
Zona 8	127.8	36.7	28.7
Zona 9	235.1	66.7	28.4
Zona 10	491.8	94.7	19.3
Zona 11	605.8	120.6	19.9
Zona 12	958.7	178.5	18.6
Zona 13	642.6	65.4	10.2
Zona 14	581.0	77.3	13.3
Zona 15	524.8	128.7	24.5
Zona 16	1,699.1	79.1	4.7
Zona 18	2,166.5	150.5	6.9
Zona 19	104.0	30.4	29.2
Zona 22	381.0	34.1	9.0
Total	11,939.4	1,650.0	13.8
Zona 1.4.9	958.5	204.2	21.3
Zona 1-10 (Expect Zona 2.7)	2,781.2	616.3	22.2

4.1.3 Road Facilities Conditions

(1) Existing Road Network

a) As already described in Progress Report (I) and (II) which were submitted to Guatemala Municipality, the existing road network configuration in the Study Area has basically a ring road and radial road network pattern, while the Central Urban Area (Zonas 1 to 10) has a completely grid road network pattern, as shown in Figure 4.1.1.

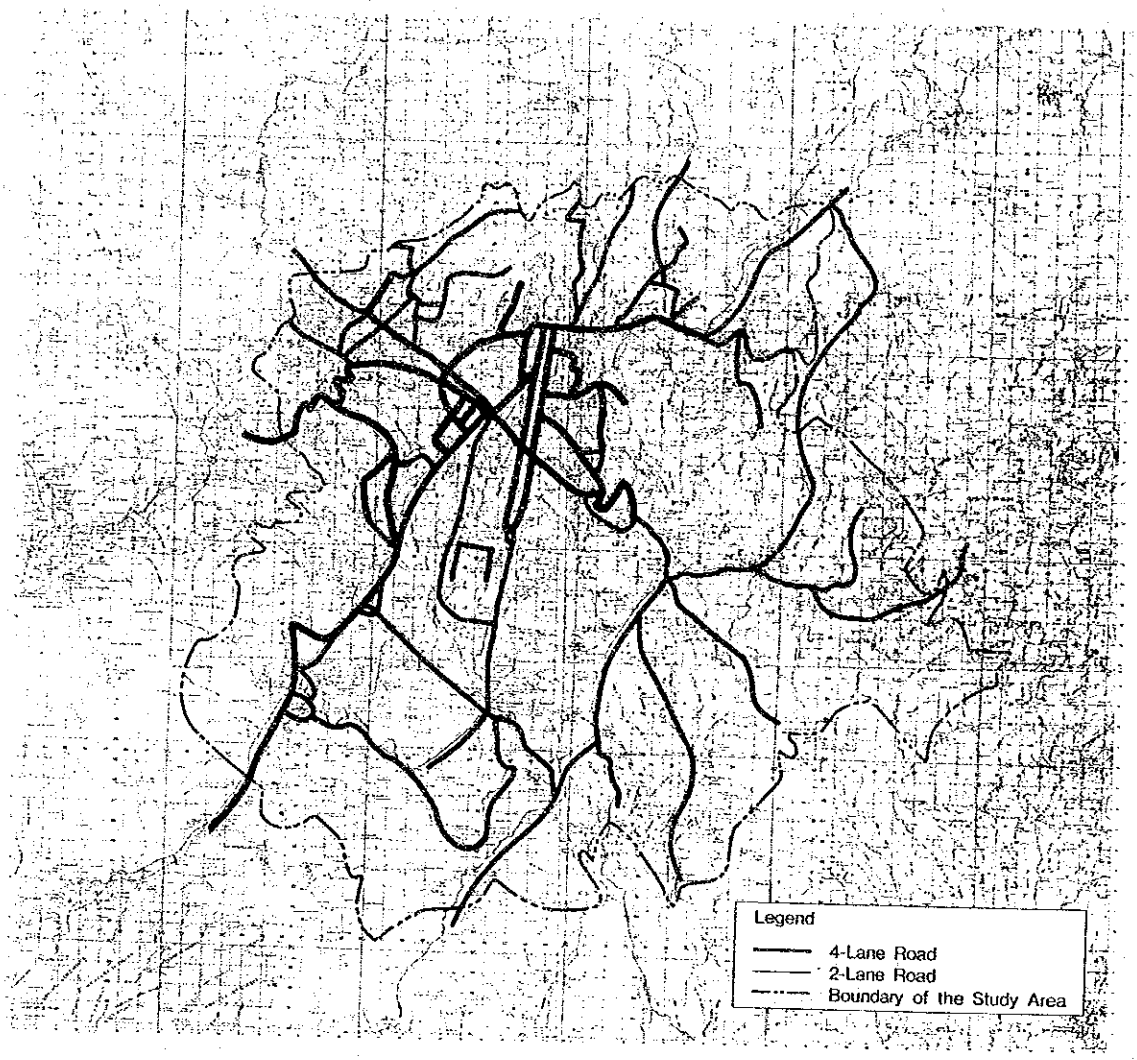


Figure 4.1.1 Existing Road Network

b) The road network in newly developed housing areas has a ladder road network pattern without linked road. This unlinked road network can be seen in Mixco, Chinautla, and Villa Nueva, as well as in Zonas 15, 18 and 22 of Guatemala City.

(2) Typical Cross-Sections and Numbers of Lanes

The number of lanes on the major roads are illustrated in Figure 4.1.1, and the typical cross sections of the major roads are illustrated in Figure 4.1.2 and Figure 4.1.3 respectively.

a) The trunk road network in Guatemala City comprising the eastern part of C.A-1, southern part of C.A-9 and Periférico are 6-lane roads with a central reservation.

b) The major road network in housing estates such as Colonia El Maestro, Colonia Campo, Ciudad San Cristóbal and Colonia San Francisco are 4-lane roads with a central reservation.

c) Most other roads in Guatemala City are 2-lane roads without a central reservation.

d) The multilane roads with a 9.0 meter wide carriageway for each direction are maintained as 3-lane roads without parking space or as 2-lane roads with parking space.

e) However, since there are no road lane markings, the actual lane widths on the existing roads cannot be determined.

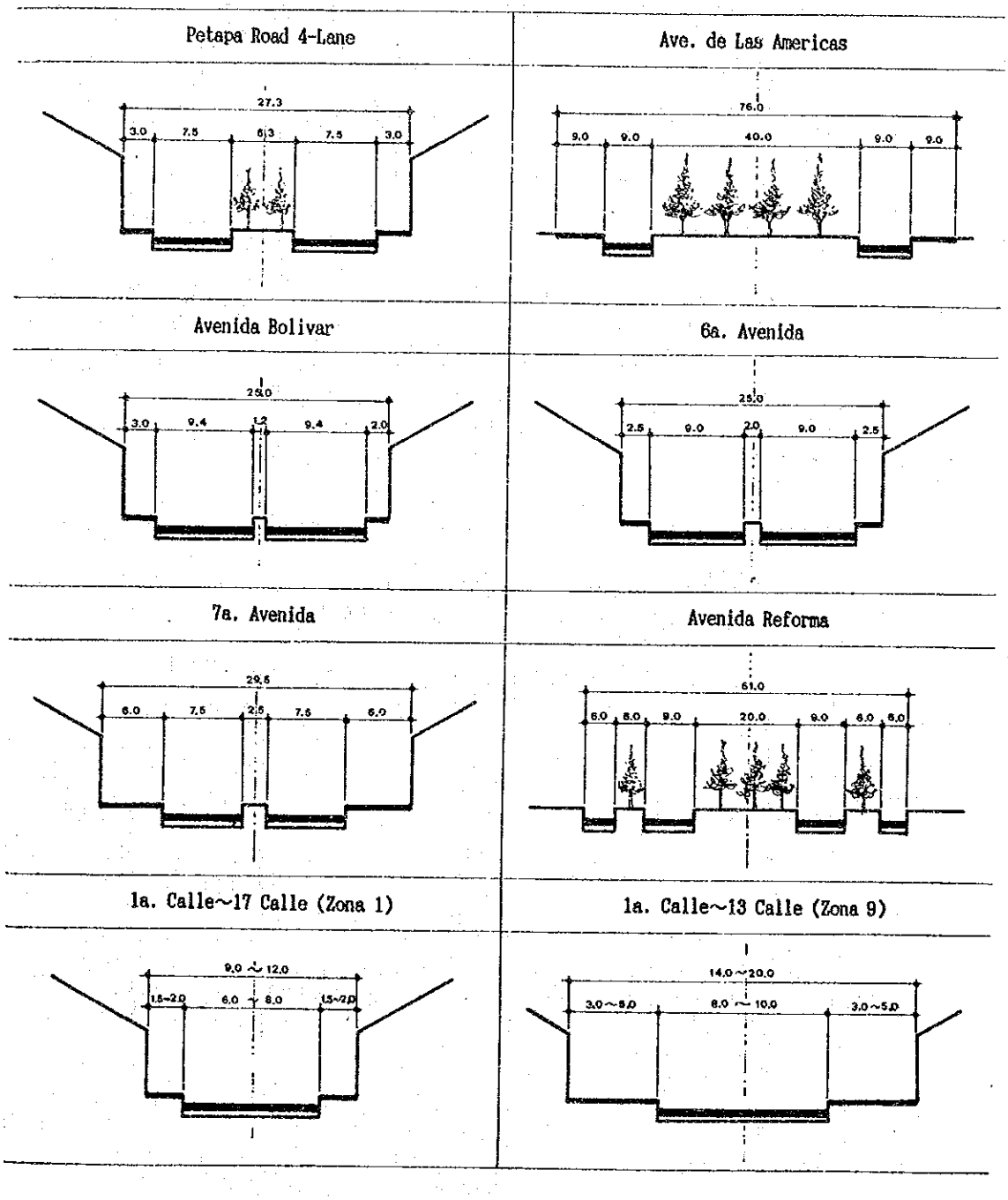


Figure 4.1.2 Typical Cross-Section (1)

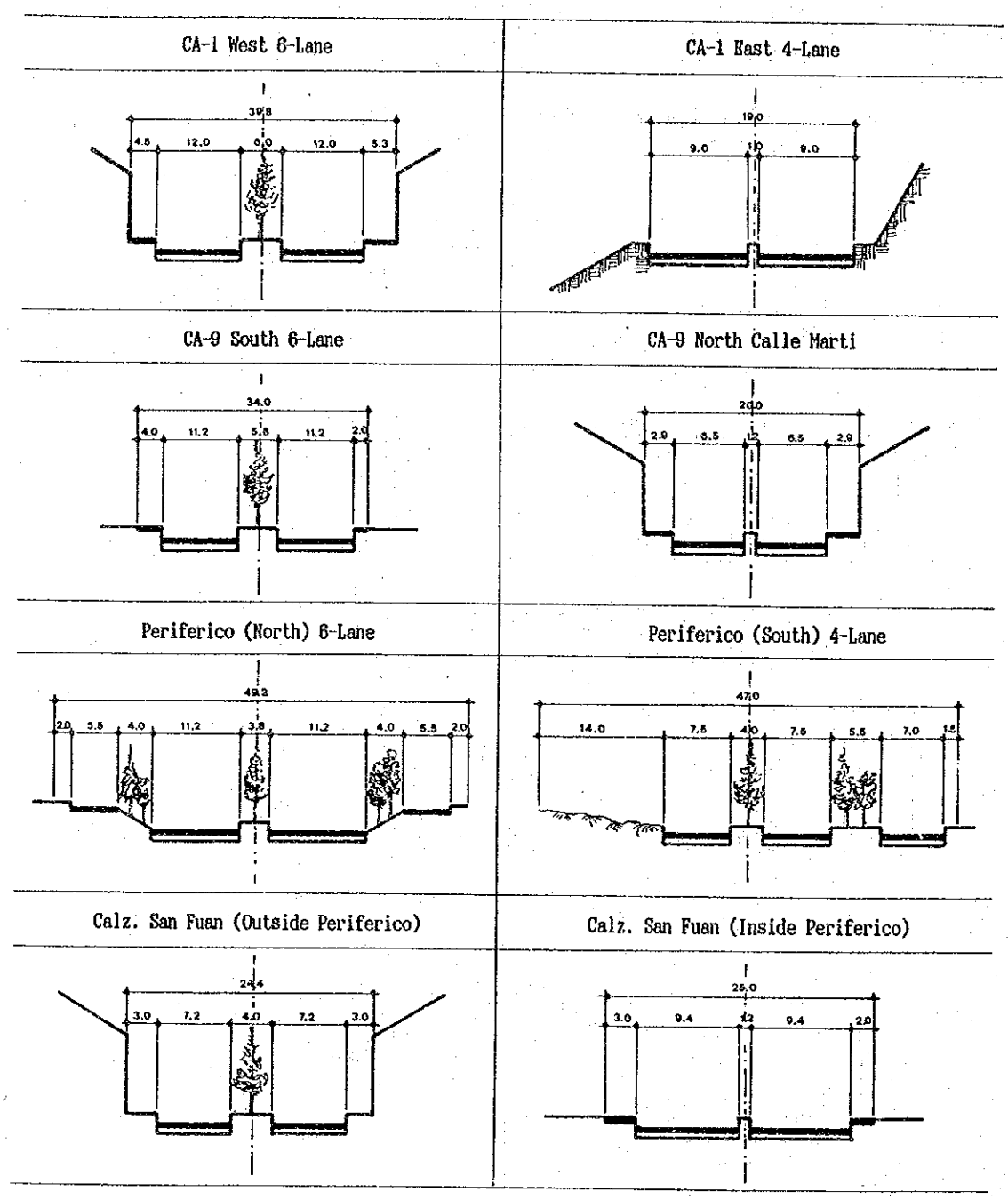


Figure 4.1.3 Typical Cross-Section (2)

(3) Bridge Structure Conditions

The following bridges are located on the major roads.

1) Cross point between C.A-9 and Río Las Vacas

This 6-lane road bridge was constructed in 1960. A 14 Ton design load was adopted.

2) Cross point between Periférico and Río La Barranca.

This 4-lane road bridge was constructed in 1973. At present, the center of bridge has been bent and traffic running speed is controlled by a concrete speed bump.

3) Cross point between Av. San Cristóbal and Río Molino.

This bridge has 2-lanes only, but the approaching roads on each side of the bridge are 4-lane roads.

4) Cross point between C.A-9 and Río Molino

There are two bridges at this point. These bridges are 4-lane road bridge and the structure is maintained as comparatively good conditions.

5) Cross point between Av. Hincapié and Río Pinula.

This bridge is very old one-lane road bridge. The approaching roads on each side of the bridge are 2-lane roads.

6) Cross point between Av. Cipresales and Río La Barranquilla.

(4) Maintenance Conditions

a) The maintenance of existing roads within Guatemala City is carried out by Guatemala Municipality.

The existing road length of individual pavement in Guatemala City is as follows:

* Asphalt Concrete Pavement road length	= 618 km	(54%)
* Cement Concrete Pavement road length	= 182 km	(16%)
* Concrete Block Pavement road length	= 28 km	(3%)
* Earth road length	= 307 km	
Total	1,135 km	

b) The initial construction costs of asphalt concrete and Cement concrete pavement are about Q80/m^2 and Q45/m^2 respectively. At present, when a new road is constructed, asphalt concrete pavement is adopted.

c) As shown by the results of the road inventory survey and field reconnaissance survey, the condition of most road pavement cannot be

described as good. Road rehabilitation such as over-lays or patching on pot holes with asphalt concrete are required.

d) The main roads in suburban areas are also paved by asphalt concrete, however, the surface condition cannot be described as good.

e) Generally speaking, the road surface in Guatemala City and its suburban area is not maintained in good condition.

4.1.4 Road Related Facilities Condition

The detailed road related facilities conditions such as signals, traffic information, and lane-marks are described in Chapter 6, "Traffic Management".

In this section, the general conditions of road related facilities are described as follows.

a) The pedestrian crossing bridges are located on Calle Martí, Periférico, Western parts of C.A-1, Southern part of C.A-9 and San Juan Sacatepéquez. A total of 21 pedestrian crossing bridges in Guatemala City were existed. Most of pedestrian crossing bridges are located on the major roads, however, pedestrians are still crossing the major roads without using the pedestrian crossing bridges.

b) The bus composition ratio on major roads such as C.A-1, C.A-9, Petapa Road, Av. Reforma, 6a. Avenida, etc., is about 20 percent with total traffic volume. However, the bus bays are located only on the San Juan Sacatepéquez and C.A-9. Many buses stop on the roadside without using bus bays.

c) Lane line markings and stopping lines at intersections, cannot be observed on most of the existing roads. Lane line markings are sometimes established on a few major roads, however, two or three months later, the lane line markings are often indistinguishable since regular maintenance is not carried out.

4.1.5 Existing Environmental Conditions

(1) General

The existing environmental conditions were examined based on the collected data and the results of field reconnaissance survey.

In the last few years, environmental problems are observed in Guatemala City, based observations of the inhabitants. However, the greenery in Guatemala City are well maintained, even in the Urban Central Area.

(2) Greenery and Open Spaces

Guatemala City has several green areas. According to the information provided by the Municipality, these are:

a) 78 parks, some of which are no larger than one hectare in area. A concentration of parks is noticeable in residential zones.

b) 30 public squares with an average area of approximately half an hectare. All these public squares are located in only 10 of the 21 Zonas into which Guatemala City is divided.

c) 54 monuments. Almost all these monuments are located in public squares and parks.

d) Almost all the important drives in Guatemala City have road-side trees. When drawing the streets and avenues with road-side trees on a map, a concentration of them is noticeable in zones 9, 10, 13, and 14 at the South of the City. In other zones, a spaced network of drives having road-side trees can be recognized.

In addition, there are some remarkable historical monuments in Guatemala City as described below:

* Cementerio General (Zona 3)
* Kaminal Juyú
* Montículo del Culebrón (Snakes' Hill) (Zona 10, 14)

(3) Noise and Vibration

The major source of (increasing) noise in Guatemala City is motor vehicles. The limited capacity of the streets and avenues causes very low traffic speed and/or bottlenecks with the consequent abuse of horns. Also, many of the motor vehicles, especially those used for public transportation, are in poor condition because their useful life has already been exceeded, and their muffler systems are not working properly. This problem is particularly important because it presents economical connotations.

Noise from aircraft has also registered increases, and is causing some annoyance. Due to the fact that the airport is located in the city, a greater number of people are subjected to harsh noises during takeoffs and landings.

(4) Air Pollution

At present, there are no guidelines or standards for air pollution measures; in addition, there are very few studies on air pollution control measurement.

From visual observations, the following facts can be described:

a) During peak hours, a large number of vehicles are stationary in the vicinity of the bus stops on Ave. Bolívar and Calzada San Juan Sacatepéquez and pollution from the exhaust fumes is noticeable.

b) Many vehicles, especially buses and including minibuses, generate a large volume of visible exhaust fumes due to the fact that the buses are very old.

4.1.6 Projects Planned by Guatemala Municipality

The intersection between Periférico and 13 calle zona 11 was constructed as a grade separated intersection in November, 1990, and the intersection between Periférico and Calle Bethania Zona 7 is also under construction as a grade separated intersection by Guatemala City.

At present, as mentioned above, the condition of road facilities in Guatemala City are gradually being improved by Guatemala Municipality to reduce traffic congestion of Guatemala City.

In addition, Guatemala City has many future plans for solutions of traffic congestion. The list and location map of the future plans are illustrated in Figure 4.1.4 respectively.

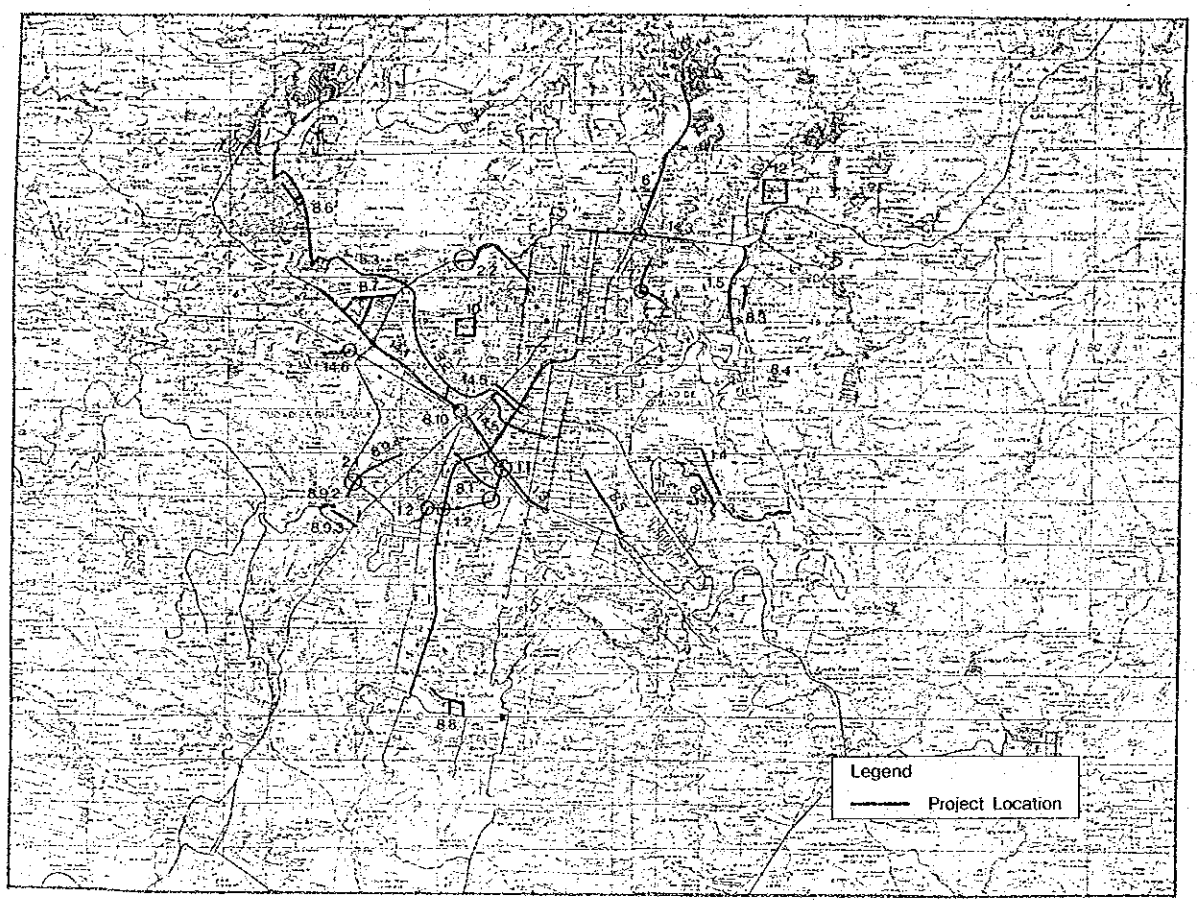


Figure 4.1.4 Planned Project Location Map

4.2 Present Traffic Condition

4.2.1 Number of Registered Vehicle

(1) Number of Registered Vehicles

Table 4.2.1 summarizes the number of registered vehicles in Guatemala City and the whole country.

Table 4.2.1 Number of Registered Vehicle in 1990

Vehicle Type / Area	Private Vehicle	Commercial Vehicle	Taxi	Urban Bus	Diplomatic Consular Mission	Official Vehicle	Agricultural Vehicle	Trailer	Motorcycle	Total
Study Area	158,957 (68.5%)	21,616 (49.1%)	1,371 (42.1%)	2,377 (90.7%)	1,241 (97.6%)	6,042 (95.1%)	137 (39.5%)	4,873 (74.6%)	34,600 (51.2%)	231,213 (63.5%)
Guatemala Department	164,942 (71.1%)	22,598 (51.3%)	1,396 (42.9%)	2,394 (91.3%)	1,244 (97.9%)	6,050 (95.2%)	138 (39.8%)	4,913 (75.3%)	36,266 (53.7%)	239,941 (65.9%)
Other Department	66,972 (28.9%)	21,438 (48.7%)	1,860 (57.1%)	228 (8.7%)	27 (2.1%)	305 (4.8%)	209 (60.2%)	1,615 (24.7%)	31,247 (46.3%)	123,901 (34.1%)
Whole Country	231,914 (100%)	44,036 (100%)	3,256 (100%)	2,622 (100%)	1,271 (100%)	6,355 (100%)	347 (100%)	6,528 (100%)	67,513 (100%)	363,842 (100%)

Source: Commercial Activity Department, Ministry of Finance

From this table, it can be understood that about 64% of vehicles are registered in the Study Area, even though its population is only about 20% of the whole country. Particularly, about 69% of private vehicles are concentrated into the Study Area. On the other hand, only a half of commercial vehicles and motorcycles are registered in the Study Area.

(2) Past Trend of Vehicle Registration

Table 4.2.2 shows the past trend of vehicle registration in the Metropolitan Area of Guatemala and the whole country.

Table 4.2.2 Past Trend of Vehicle Registration in Guatemala

Year / Area	Vehicle Type	1980	1982	1984	1986	1988	1989	Average Annual Growth Rate*
Guatemala Metropolitan Area **	Cars	99,694	112,248	123,771	116,257	159,113	196,657	7.8%
	M/C	n.a.	n.a.	22,538	n.a.	27,876	36,920	10.4%
	Total	n.a.	n.a.	146,309	n.a.	186,989	233,577	9.8%
Other Area	Cars	57,529	57,868	63,909	45,325	73,394	92,693	5.4%
	M/C	n.a.	n.a.	11,513	n.a.	23,142	30,646	21.6%
	Total	n.a.	n.a.	75,422	n.a.	96,536	123,339	10.3%
Whole Country	Cars	157,223	170,116	187,680	161,582	232,507	289,350	7.0%
	M/C	n.a.	n.a.	34,051	n.a.	51,018	67,566	14.7%
	Total	n.a.	n.a.	221,731	n.a.	283,525	356,916	10.0%

Source : Ministry of Energy, compilation was made according to vehicle registration data of the Ministry of Finance.
Note * : Annual growth rates were calculated for between 1980 and 1989 for cars and between 1985 and 1989 for Motorcycles and all vehicles, respectively.
** : Guatemala Metropolitan Area defined by the Ministry of Energy consist of 3 municipalities (Guatemala, Mixco and Villa Nueva)
*** : Number of registered vehicles in this table excluding official vehicles.

In the Guatemala Metropolitan Area, the average annual growth rate of registered cars for the last 9 years is calculated as 7.8%, while it is 5.4% for the rest of the country. In the whole country, the growth rate is calculated as 7.0%.

On the other hand, the growth rates of number of registered motorcycles are 10.4%, 21.6% and 14.7% for the Guatemala Metropolitan Area, the rest of the country and the whole country, respectively. The growth rate of 21.6% in the rest of the country means rapid pace of motorization by motorcycles.

4.2.2 Traffic Condition in Guatemala City

(1) Results of Traffic Volume Counting Survey

Based on the traffic volume counting data at road sections, the present traffic conditions in the Study Area, particularly in Guatemala city, have been analyzed. In addition, the results of the traffic volume counting surveys are compiled in the Technical Report - 4 "Traffic Volume Counting Survey and Its Results".

Tables 4.2.3 and 4.2.4 summarize the results of traffic volume counting survey at road sections for 24 hours and 12 hours, respectively. For 12 hours traffic volume data, 24 hours traffic volume are estimated based on day/ night ratio at an approximate 24 hours traffic volume counting station.

Major findings from these tables are as follows.

a) The day/night ratio of traffic volume (12 hours traffic volume divided by 24 hours traffic volume) varies from 73.7% to 80.1%. The average day/night ratio is 75.4%.

b) The peak ratio (peak hour traffic volume divided by 24 hours traffic volume) varies from 7.1% to 12.7%. The average peak ratio for 24 hours traffic volume counting stations is 8.0%.

c) Extremely heavy traffic volume of 110,000 vehicles is observed at Calzada Roosevelt in front of INCAP., where two major roads from Mixco and Florida are merged and number of lane is eight (8). At this section, a peak hour traffic volume is counted as nearly 9,000 vehicles, with a peak hour ratio of 8.0%.

d) Anillo Periférico, which is a part of ring road in Guatemala City carries nearly 44,000 vehicles, while the peak hour traffic volume is about 3,500 vehicles.

Table 4.2.3 Results of Traffic Volume Counting Survey at Road Sections for 24 Hours

No.	Road Name	24 Hours Traffic Volume (1)	12 Hours Traffic Volume (2)	Day/ Night Ratio (2)/(1)	Peak Hour Traffic Volume (3)	Peak Ratio (3)/(1)
R-7	6a Ave., Zona 1	23,026	17,328	75.1%	1,689	7.3%
R-8	5a Ave., Zona 1	10,218	8,122	79.5%	1,017	10.0%
R-9	4a Ave., Zona 1	11,067	8,861	80.1%	925	8.4%
R-20	6a Calle, Zona 1	35,004	24,719	70.6%	2,497	7.1%
R-21	Cal. Roosevelt	111,484	84,074	75.4%	8,954	8.0%
R-22	A. Periférico	45,661	34,635	75.9%	3,481	7.6%
R-27	Ave. Reforma	54,639	41,934	76.7%	4,442	8.1%
R-32	18 Calle, Zona 10	18,360	13,531	73.7%	1,398	7.6%
R-33	Blvd. A. Batres	49,245	37,377	75.9%	4,140	8.4%
Average				75.4%		8.0%

Source : JICA Study Team

Table 4.2.4 Results of Traffic Volume Counting Survey at Road Sections for 12 Hours

No.	Road Name	12 Hours Traffic Volume (1)	Day/ Night Ratio (2)	Estimated 24 Hours Traffic Volume (3) = (2)/(1)	Peak Hour Traffic Volume (4)	Peak Ratio (4)/(3)
R-1	11 Ave., Zona 1	9,654	75.1%	12,854	1,030	8.0%
R-2	10a Ave., Zona 1	8,156	79.8%	10,220	971	9.5%
R-3	9a Ave., Zona 1	7,595	75.1%	10,113	846	8.4%
R-4	8a Ave., Zona 1	6,817	79.8%	8,542	683	8.0%
R-5	7a Ave. Zona 1	13,971	75.1%	18,603	1,528	8.2%
R-6	6a Ave. A, Zona 1	4,613	79.8%	5,780	501	8.7%
R-10	3a Ave., Zona 1	5,832	75.1%	7,765	653	8.4%
R-11	2a Ave., Zona 1	9,323	79.8%	11,682	931	8.0%
R-12	12 Ave., Zona 1	11,855	79.8%	14,855	1,243	8.4%
R-13	1a Ave., Zona 1	5,155	75.1%	6,864	608	8.9%
R-14	Ave. Centroamérica	1,691	77.6%	2,179	208	9.5%
R-15	Ave. Elena	10,886	77.6%	14,028	1,374	9.8%
R-16	8a Calle, Zona 1	6,322	75.1%	8,418	693	8.2%
R-17	5a Calle, Zona 1	4,705	79.8%	5,895	591	10.0%
R-18	9a Calle, Zona 1	9,203	75.1%	12,254	1,255	10.2%
R-19	8a Calle, Zona 1	9,220	79.8%	11,553	1,202	10.4%
R-23	Calzada Roosevelt	44,557	75.4%	59,094	5,817	9.8%
R-24	35 Calle, Zona 11	11,624	75.9%	15,314	1,939	12.7%
R-25	Calzada San Juan	26,621	75.4%	35,306	2,685	7.6%
R-26	Ave. Bolívar	38,260	75.4%	50,742	3,882	7.7%
R-28	7a Ave., Zona 9	19,632	75.1%	26,141	2,012	7.7%
R-29	6a Ave., Zona 9	24,297	79.8%	30,447	2,676	8.8%
R-30	12 Calle, Zona 9	26,697	76.7%	34,807	2,843	8.2%
R-31	2a Calle, Zona 15	18,000	73.7%	24,423	1,941	7.9%
R-34	Periférico, Z.11	19,702	75.9%	25,957	2,501	9.6%
R-35	Ave. Petapa	27,472	75.9%	36,194	3,103	8.6%
R-36	Ave. Hincapíe	6,940	75.9%	9,143	973	10.6%

Source : JICA Study Team

(2) Daily traffic Volume on Major Roads

Based on results of the traffic volume counting survey, the screen line survey and the turning movement counting survey at intersections, the daily traffic volume on major roads are illustrated in Figure 4.2.1.

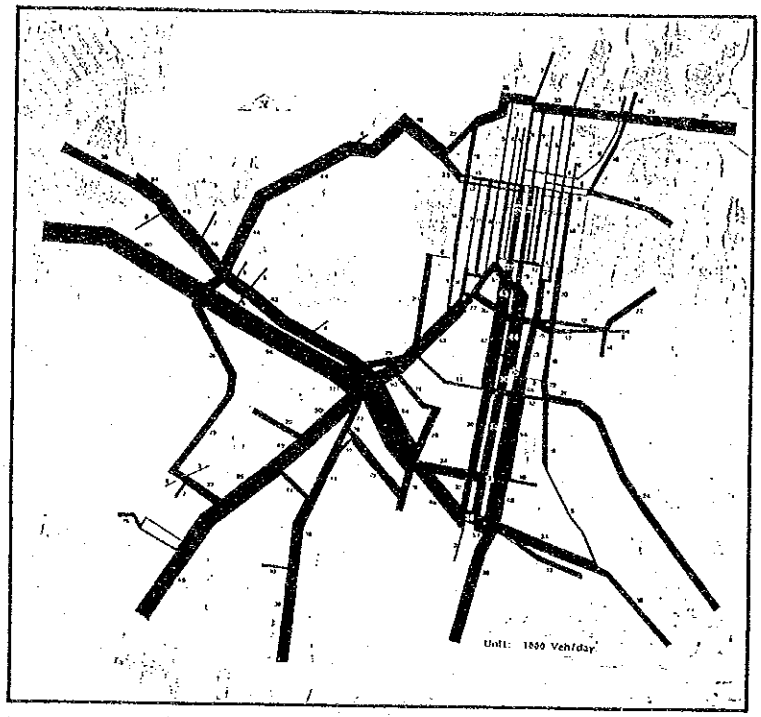


Figure 4.2.1 Daily Traffic Volume on Major Roads

(3) Hourly Fluctuation of Traffic Volume

Based on the traffic counting survey the hourly fluctuations of traffic volume are pointed out as follows.

a) There is no particular peak period on roads (5a Ave. and 6a Ave., in Zona 1) in the Centro Area, where many commercial activities concentrate. It seems that traffic flows in this area mainly related to the commercial activities, hence a particular peak period generated by commuting traffic could not be observed.

b) On the contrary, peculiar peak periods can be found on Calzada Roosevelt, which is a main gateway to Mixco, and Anillo Periférico. At those two stations, a morning peak hour is between 7-8 a.m. for the traffic toward the center of the city, while an evening peak hour is between 5-6 p.m. for the traffic coming from the center of the city. This means that peak hour traffic on those roads are considered to be mainly commuting traffic.

c) There are peculiar peak periods between 8-9 a.m. and 5-6 p.m. on Ave. Reforma. However, on this road, traffic volume of both directions are heavy for these peak periods, even though this road is one of major gateway to the Centro Area from south. It is considered

that this is mainly because of the land use around this survey station, since many offices are also located in Zonas 9 and 10.

d) On Blvd. Aguilar Batres, there is only one peculiar peak period in the morning between 7-8 a.m., while there are not so much difference between hourly traffic volumes from 8 a.m. to 6 p.m.

(4) Vehicle Composition

Based on the traffic counting survey the vehicle composition at certain road sections are as follows.

a) Composition of passenger cars varies from 36.3% on the Belice Bridge to 69.7% on Blvd. Vista Hermosa in Zona 15. These variations of passenger car composition mainly depend on composition of autobuses/microbuses.

b) Composition of pick-ups are almost similar at every station between 14.9% and 21.5%.

c) On principle arterial roads (Calzada Roosevelt and 18 Calle in Zona 10) and an urban expressway (Anillo Periférico), composition of light trucks and heavy trucks are comparatively higher as 4% to 6% than other roads as 1% to 3%.

d) Composition of autobuses/microbuses fully depending on the bus routing. Some roads, such as 6a Ave. and 11 Ave. in Zona 1 and Calzada Roosevelt, where many bus routes concentrate, composition of autobuses/microbuses count as more than 15%. On the other hand, composition of autobuses/microbuses are less than 10% on Ave. Reforma and Anillo Periférico.

e) Composition of other vehicles (mainly motorcycles) are less than 9% at all stations.

(5) Daily Fluctuation of Traffic Volume

Based on the results of traffic volume counting survey carried out by the Municipality in 1987, the daily fluctuation of traffic volume on major roads are analyzed.

Generally, traffic volume are almost same level between Monday and Thursday, while it is about 10% higher on Friday at every road section. On Saturday, traffic volumes are almost 10 to 20% less than weekdays, while it is the same level as Friday on Calle Martí. On Sunday, traffic volumes are almost 30 to 50% less than the weekday traffic at all stations.

4.2.3 Traffic Condition at Intersections

Generally speaking, many problems regarding to the urban road traffic often concentrate at major intersections. Especially, if there are many wide roads, such as in the Study Area, most bottlenecks are considered to be at intersections. In addition, many severe traffic accidents also occur at major intersections, where traffic flows cross each other.

For identification of present condition at intersections in the Study Area, the Study Team analyzed the level of service at intersections, travel speed decline and number of traffic accident/casualties.

The detail results of turning movements counting survey at those intersections are compiled in a supplemental "Technical Report - 5 Turning Movement Counting Survey Results".

(1) Traffic Capacity at Signalized Intersections

As same as road sections between intersections, the comparison between the traffic capacity and the actual traffic volume at signalized intersections are made according to the methodology described in the "Highway Capacity Manual, 1985 edition" (hereinafter referred as HCM).

By applying this procedure, the Study Team analyzed the volume/capacity ratio and the service level at 29 signalized intersections. Results of analysis are summarized in Table 4.2.5.

Table 4.2.5 Results of Signalized Intersection Analysis

No.	Intersection Location	Critical v/c Ratio	Intersection Delay (sec/veh)	Level of Service	Degree of Problem
I-1	7 Ave./18 Calle, Zona 1	0.81	43.83	E	H
I-2	6 Ave./18 Calle, Zona 1	0.80	69.27	F	H
I-3	6 Ave./Diag. 2, Zona 1	0.97	96.23	F	H
I-5	Ave. Bolívar/24 Calle, Zona 1	1.22	175.19	F	H
I-6	15 Ave./7 Calle, Zona 1	1.03	186.17	F	H
I-8	Calle Martí/10 Ave., Zona 2	1.16	89.61	F	VH
I-9	Calle Martí/11 Ave., Zona 2	1.06	113.66	F	H
I-10	6 Ave./Ruta 2/Vía 1, Zona 4	1.62	426.05	F	VH
I-11	7 Ave./Ruta 2/Vía 7, Zona 4	2.81	190.38	F	VH
I-13	12 Ave./27 Calle, Zona 5	1.73	73.23	F	VH
I-14	27 Calle/Diag. 14/29 Ave., Zona 5	0.65	141.48	F	H
I-15	Calle Martí/15 Ave., Zona 6	0.92	70.68	F	H
I-17	C. San Juan Sacatepéquez/9 Ave./ 12A Ave., Z.7	0.62	21.83	C	VL
I-19	C. San Juan Sacatepéquez/23 Ave., Zona 7	1.20	66.23	F	H
I-21	C. San Juan Sacatepéquez/33 Ave., Zona 7	1.79	385.08	F	H
I-22	C. San Juan Sacatepéquez/37 Ave., Zona 7	1.53	394.34	F	VH
I-24	Ave. Bolívar/32 Calle, Zona 8	0.72	345.71	F	H
I-25	Ave. Bolívar/33 Calle, Zona 8	1.16	59.39	E	H
I-26	Ave, Reforma/2 Calle, Zona 9	1.09	169.64	F	VH
I-27	Ave. Reforma/12 Calle, Zona 9	1.07	385.45	F	VH
I-28	Obelisco, Zona 9	1.35	301.89	F	VH
I-29	Boul. Liberación/6 Ave., Zona 9	0.92	75.31	F	H
I-30	Boul. Liberación/12 Calle/7 Ave., Zona 9	1.51	412.57	F	VH
I-31	Boul. Liberación/Ave. Castellana, Zona 9	1.42	87.33	F	H
I-32	6 Ave./2 Calle, Zona 10	1.60	69.02	F	H
I-34	Boul. Aguilar Batres/13 Calle, Zona 11	1.07	597.19	F	VH
I-35	Boul. Aguilar Batres/19 Calle, Zona 11	1.03	295.70	F	H
I-38	Ave. Petapa/19 Calle, Zona 12	0.99	48.00	E	L
I-39	Ave. Petapa/USAC, Zona 12	0.66	72.23	F	H

(2) Traffic Capacity at Unsignalized Intersection

Even though there are 168 signalized intersections in the Study Area, many intersections are still unsignalized, including intersections on major arterial roads. Hence, analysis of traffic capacity at unsignalized intersections are also required.

The analysis of a gap between vehicle platoons on a major road and its utilization by turning vehicles on major road as well as minor roads are the basic factors for analysis.

Then, the service level of an intersection is determined according to the reserve capacity for turning vehicles from minor roads. Hence, the meaning of the service level between the signalized and the unsignalized intersection analysis are different.

According to the method mentioned above, the Study Team conducted the traffic capacity analysis at 10 major unsignalized intersections in the Study Area. Table 4.2.6 summarizes the results of the analysis.

Table 4.2.6 Results of Unsignalized Intersection Analysis

No.	Intersection Location	Degree of Problem
I-4	7 Ave./21 Calle/Diag. 2, Zona 1	H
I-7	Calle Martí/6 Ave./6 Calle, Zona 2	H
I-12	Ave. Reforma/Calle Mariscal Cruz, Zona 4	VH
I-16	C. Roosevelt/12 Ave., Zona 7	L
I-18	C. Roosevelt/23 Ave., Zona 7	VH
I-20	C. San Juan Sacatepéquez/30 Ave., Zona 7	VH
I-23	A. Periférico/13 Ave., Zona 7	H
I-33	18 Calle/18 Ave./Diag. 6, Zona 10	L
I-36	A. Periférico/9 Ave., Zona 11	H
I-37	Ave. Petapa/14 Ave., Zona 12	H

(3) Identification of Bottlenecks from Travel Speed Decline

Based on the travel speed survey results, bottlenecks are identified from the travel speed decline points of view. In the analysis, the time-distance diagrams are drawn from each survey route. In these diagrams, locations with longer waiting time or drastic decline of travel speed are considered as bottlenecks. This analysis, however, is done based on a limited number of samples. Hence, the identification results might be rather subjective.

(4) Identification of Hazardous Intersection

In parallel with the traffic volume/travel speed points of view, it is also very important to identify problem intersections from the traffic accident point of view.

4.2.4 Traffic Congestion Degree at Peak Hour on Major Roads

The traffic congestion degree at peak hour has been calculated to locate the traffic bottlenecks, to clarify the traffic conditions and also to identify the traffic problems on the major roads.

(1) Traffic Volume in 1990

A traffic volume counting survey on major road sections and a turning movement counting survey at major intersections were conducted in August 1990 by the Study Team. The results of this survey are illustrated in Figure 4.2.1. Based on this traffic volume, the traffic congestion degree on the major roads are calculated.

(2) Traffic Capacity Calculation

The traffic capacity taking into account various road conditions such as prohibited parking, one-way traffic and number of lanes are calculated according to HCM.

The conditions assumed for the capacity calculation are as follows:

a) Basic capacity per one lane of multi-lane road is 2,000 PCU/lane/hour.

b) Basic total capacity per both directions of 2-lane road is 2,800 PCU/2-lane/hour.

c) Heavy vehicle composition ratio is 10% based on the results of the traffic volume counting survey.

d) Peak hour ratio of major and minor roads is 8.0% and 8.8% respectively based on the results of the traffic volume counting survey.

e) Adjustment factors are adopted in accordance with HCM.

f) The formula is as follows:

$$C(p) = C(b) \times Fw \times Fn \times Fr \times Fs$$

where;
- C (p) : Possible capacity (veh./hour/lane)
- C (b) : Basic capacity (PCU/hour/lane)
- Fw : Adjustment factor for lane width
- Fn : Adjustment factor for heavy vehicle composition ratio
- Fr : Adjustment factor for road type and land use along a road.
- Fs : Adjustment factor for traffic signal phasing

(3) Congestion Degree on Major Roads

The congestion degree in year 1990 can be estimated using the following formula.

$$\text{Congestion degree} = \frac{\text{Traffic Volume in 1990}}{\text{Possible Capacity}}$$

The congestion degree in 1990 on major roads were calculated, and the results are illustrated in Figure 4.2.2.

The congestion degree of 1.0 means that the actual traffic volume has already reached the possible capacity and traffic conditions are maintained as Level of Service "E" according to the HCM. Some improvements on these road sections are required as soon as possible.

A congestion degree of 0.8 means that actual traffic volume has reached 80% of the possible capacity and traffic conditions are operating at Level of Service "D" according to the HCM. Some improvement on these road sections are required at an early stage.

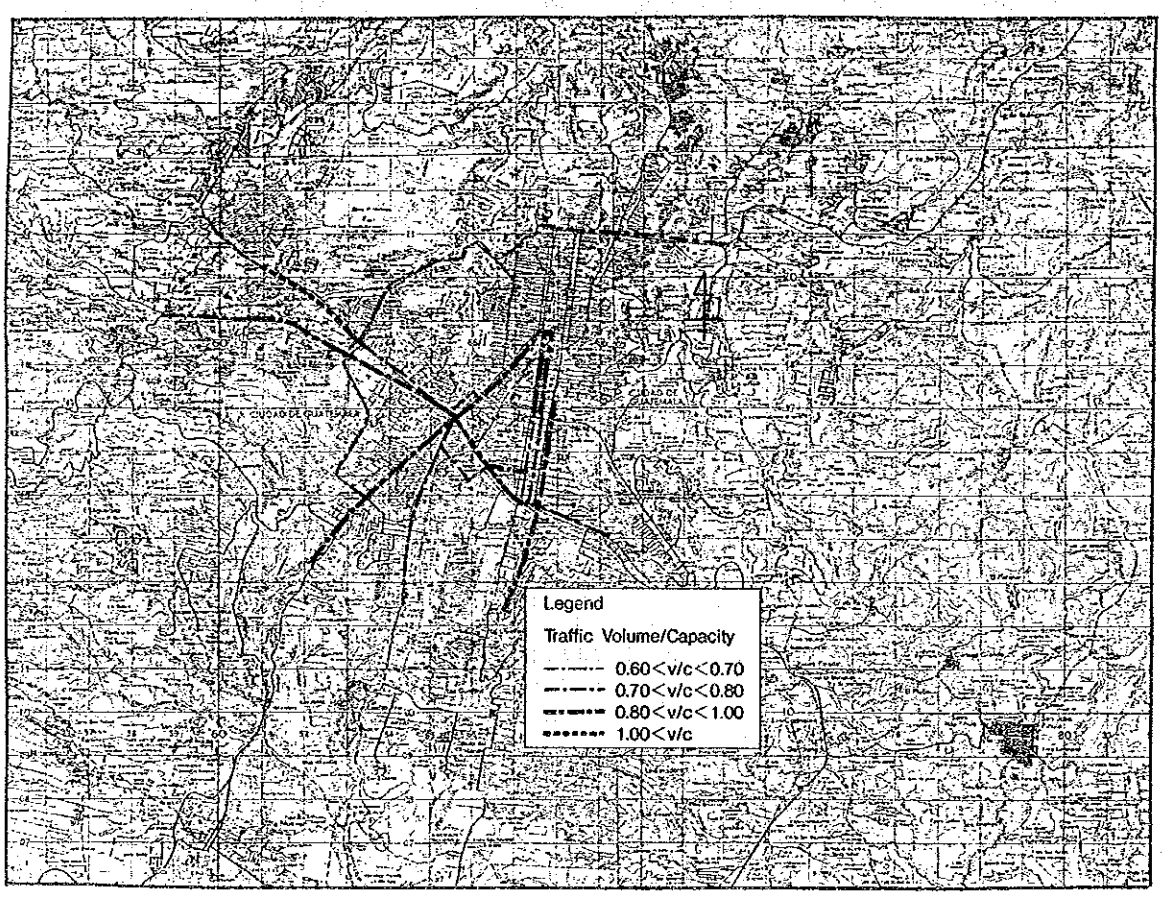


Figure 4.2.2 Congestion Degree of Major Roads