5. Traffic Demand Forecast Model and Its Application to Alternative Development ScenariosMaster Plan

5. TRAFFIC DEMAND FORECAST MODEL AND ITS APPLICATION TO ALTERNATIVE DEVELOPMENT SCENARIOS

5.1 Model Development

5.1.1 Basic Approach

1) Outline

In general, traffic assignment technique is used to estimate road traffic volumes. This procedure requires two (2) sets of input data. One is road network expressed in the form of nodes and links. Each link must have a concept of traffic capacity and a speed-flow relationship. The other is a table of traffic demand approximated in the form of OD (Origin-Destination) matrices. The latter is assigned onto the former by computers under predetermined conditions.

This Section mainly deals with the methodology to estimate the OD matrices. The technique of traffic assignment is also explained in Section 5.1.6. The outline of the tasks included in this Section is presented in Figure 5.1.1.

2) Estimate of OD Matrices

Figure 5.1.2 shows the process applied in this Study for estimating OD matrices.

A. Trip Production Model

This model estimates the total number of trips produced in the Study Area. In relation to the Trip Generation/Attraction Model described below, the estimated value works as a control total.

B. Trip Generation/Attraction Model

This model analyzes the relation between number of trips generated/attracted and socio-economic indicators by zone. The model is constructed usually by trip purpose and the most suitable socio-economic parameter is selected for each trip purpose. Once future parameters are projected by zone, this model calculates the number of trips generated/attracted by zone.

C. Trip Distribution Model

This model produces OD matrices based on the estimated trip generation/attraction by zone. There are a number of model types such as Present Pattern, Gravity, etc.

D. Modal Split Model

This model determines modal share for each OD pair based on interzonal impedance. It needs to be constructed so that the levels of services of different modes should be reflected properly.

Figure 5.1.1
Outline of Future Traffic Forecasting

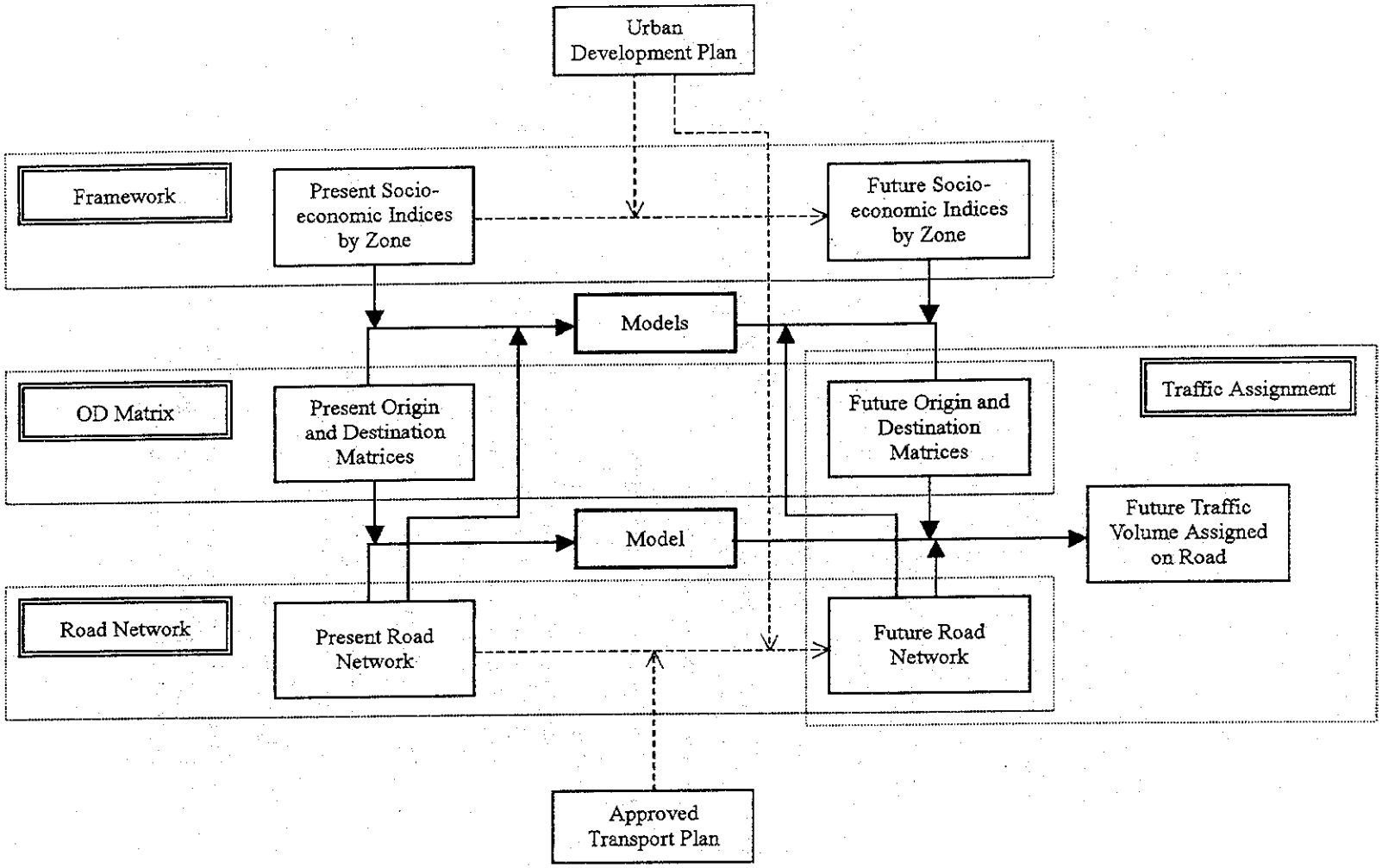
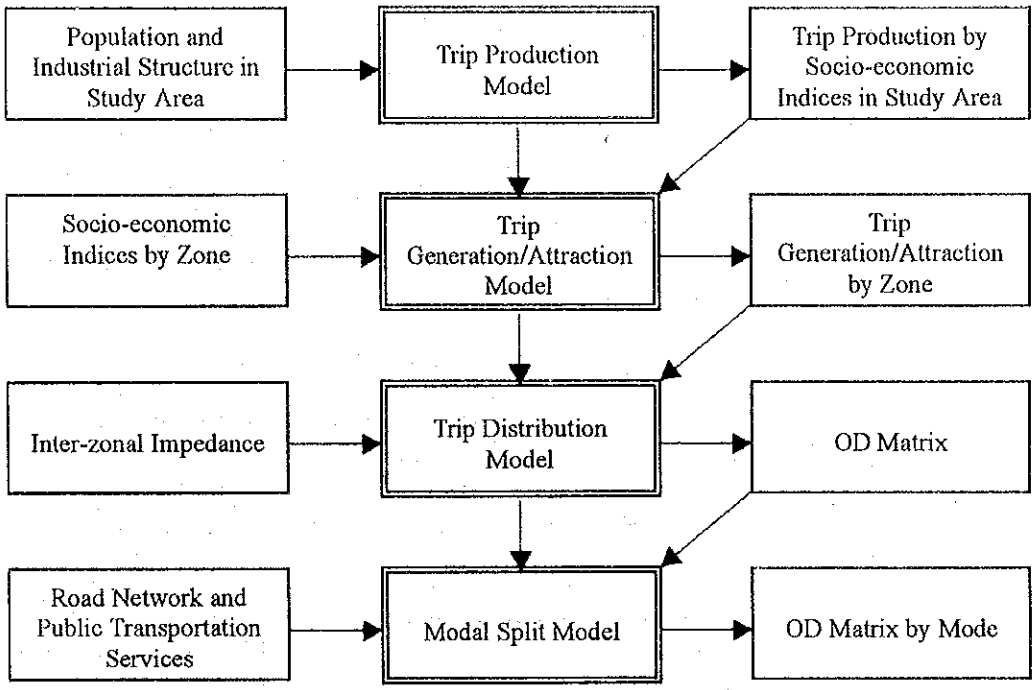


Figure 5.1.2
Models for Estimation of OD Matrices



5.1.2 Trip Production Model

This model aims to accurately estimate the total number of trips produced in the Study Area in the future. For this purpose, it is important to identify a parameter that:

1. Can be estimated reasonably in the future as an exogenous variable, and
2. Represents social groups of which trip behavior is clearly different with each other.

Based on the results of person-trip survey, trip production rate was calculated for various parameters as shown in Table 5.1.1 ~ 5.1.4. After comparing the results, car ownership was chosen as the parameter due to the large difference in trip production rate between the owning and the non-owning. The trip production rate presented in Table 5.1.3 will be used in this Study to estimate the total number of trips produced in the Study Area by its residents.

Table 5.1.1
Trip Production Rate by Sex, 1998

Item	Population	No. of Trip Makers	Rate (%)	No. of Trips	Production Rate	
					Gross	Net
Male	490,543	365,336	74.5	1,245,666	2.54	3.41
Female	552,304	350,775	63.5	1,107,597	2.01	3.16
Total	1,042,847	716,111	68.7	2,353,263	2.26	3.29

Table 5.1.2
Trip Production Rate by Age Group, 1998

Item	Population	No. of Trip Makers	Rate (%)	No. of Trips	Production Rate	
					Gross	Net
5-9	177,047	134,807	76.1	332,202	1.88	2.46
10-19	270,491	203,614	75.3	581,411	2.15	2.86
20-29	209,881	142,135	67.7	498,444	2.37	3.51
30-39	165,854	114,906	69.3	458,755	2.77	3.99
40-49	105,292	70,430	66.9	291,787	2.77	4.14
50-59	57,978	32,227	55.6	126,600	2.18	3.93
60-	56,304	17,992	32.0	64,064	1.14	3.56
Total	1,042,847	716,111	68.7	2,353,263	2.26	3.29

Table 5.1.3
Trip Production Rate by Car Ownership, 1998

Item	Population	No. of Trip Makers	Rate (%)	No. of Trips	Production Rate	
					Gross	Net
Non-car own	831,464	565,435	68.0	1,627,004	1.96	2.88
Car own	211,383	150,676	71.3	726,259	3.44	4.82
Total	1,042,847	716,111	68.7	2,353,263	2.26	3.29

Table 5.1.4
Trip Production Rate by Economic Activity, 1998

Item	Population	No. of Trip Makers	Rate (%)	No. of Trips	Production Rate	
					Gross	Net
Worker	316,341	274,993	86.9	1,052,097	3.33	3.83
Working House Wife	21,075	13,157	62.4	48,925	2.32	3.72
Working Student	21,107	20,061	95.0	95,270	4.51	4.75
Student	389,635	315,430	81.0	851,984	2.19	2.70
Housewife	153,426	49,030	32.0	162,283	1.06	3.31
Jobless	97,469	33,222	34.1	110,501	1.13	3.33
Other	43,794	10,218	23.3	32,203	0.74	3.15
Total	1,042,847	716,111	68.7	2,353,263	2.26	3.29

5.1.3 Trip Generation/Attraction Model

1) Generation/Attraction Model

This model intends to estimate the number of trips generated and attracted by zone, by car ownership and by trip purpose. The first step to construct this model is to find the most suitable parameter that best fits for each of the category defined by car ownership and by trip purpose. The parameter should be able to be reasonably estimated exogenously in the future situation.

After testing a number of parameters and equation types, a multiple regression model with no constant was adopted. The selected variables are shown in Table 5.1.5 together with coefficients and regression statistics. Figure 5.1.3 to 5.1.6 are the graphical presentation of correlation.

2) Intra-Zonal Trip Model

This model forms part of the Trip Generation/Attraction Model, aiming to extract the intra-zonal trips by zone separately from the rest which are inter-zonal trips to be distributed by the Trip Distribution Model.

The following equation was adopted:

$$T_{ii} = \alpha \cdot G_i^{\beta} A_i^{\gamma} \delta^K$$

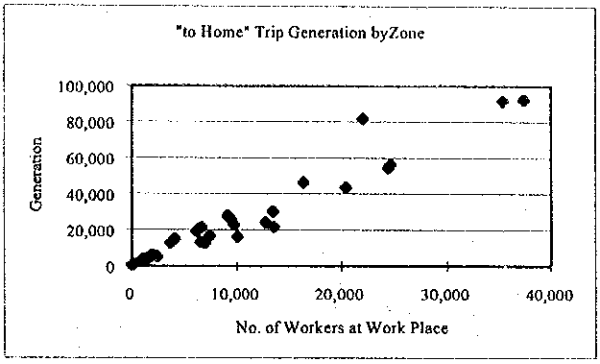
Where, T_{ii} = Intra-zonal trips of zone i
G_i = Generated trips from zone i
A_i = Attracted trips to zone i
K = Dummy (O or 1, 1 stands for abnormal data found in a few zones in 1998)
α, β, γ, δ = Coefficient

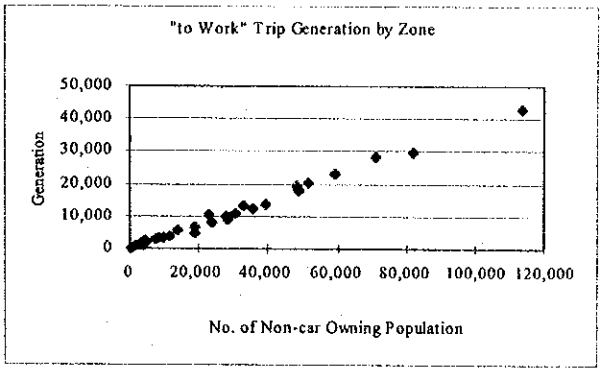
Table 5.1.6 presents the values of model coefficients, and Figure 5.1.7 and 5.1.8 graphically show the correlation of intra-zonal trips with total generation or attraction whichever is lower.

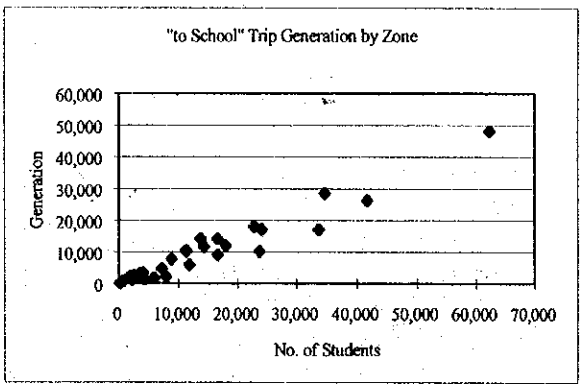
Table 5.1.5
Trip Generation/Attraction Model Parameters

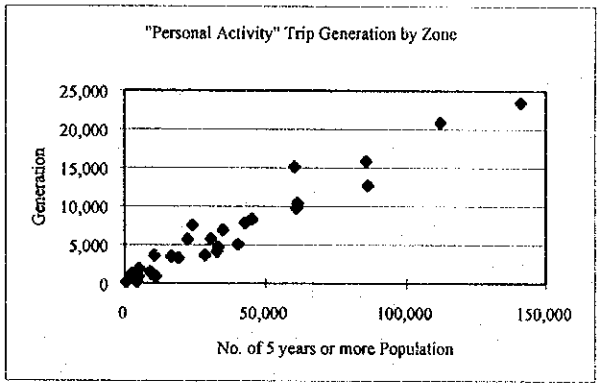
Car Ownership	Trip Purpose	Generation				Attraction			
		Variable	Coefficient	t Value	M C C	Variable	Coefficient	t Value	MCC
Non-car Owner	To Home	Population Workers at Work Place	0.193341 1.985816	5.0 16.6	0.982	Population Students at Residing Place	0.258237 1.281570	2.1 4.6	0.996
	To Work	Non-car Owning Population	0.375337	85.1	0.996	Worker at Work Place	1.010961	44.1	0.985
	To School	Students at Residing Place	0.703924	27.3	0.965	Students at School Place	0.724963	46.1	0.987
	Personal Activity	Population 5 yrs and more	0.174893	31.3	0.970	Tertiary at Work Place	0.839454	23.7	0.960
	Business Activity	Tertiary at Residing Place	0.158885	23.9	0.957	Tertiary at Work Place	0.183621	19.0	0.938
Car Owner	To Home	Tertiary at Work Place	1.312590	24.4	0.954	Car Owning Households	8.797144	60.1	0.993
	To Work	Car Owning Households	3.879856	52.5	0.991	Workers at Work Place	0.490231	19.6	0.935
	To School	Car Owning Households	2.838382	24.0	0.955	Students at School Place	0.249299	9.6	0.744
	Personal Activity	Car Owning Households	2.258926	17.7	0.922	Tertiary at Work Place	0.384650	26.7	0.967
	Business Activity	Car Own Population	0.150585	27.3	0.967	Tertiary at Work Place	0.129995	20.3	0.939

Figure 5.1.3
Generation of Non-car Owner by Zone, 1998









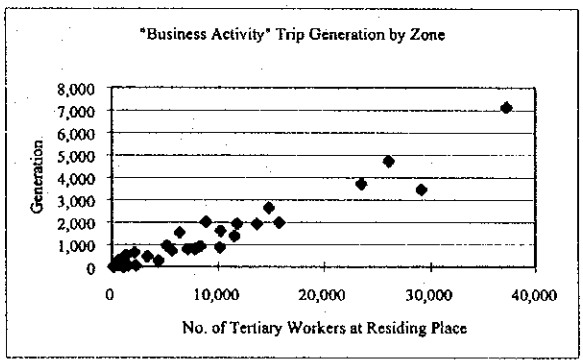
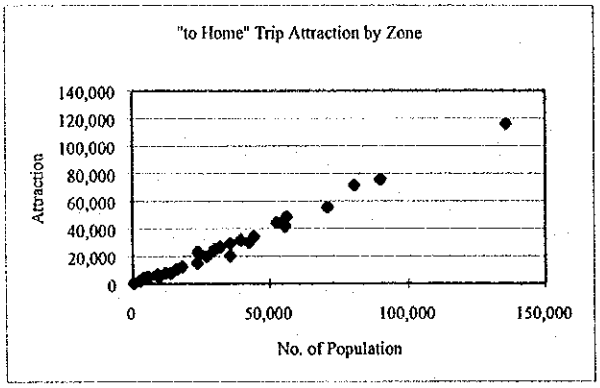
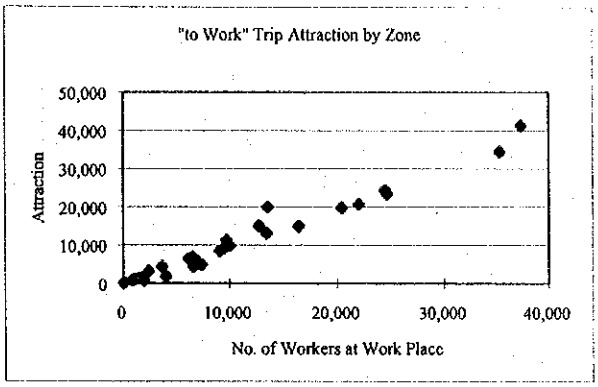
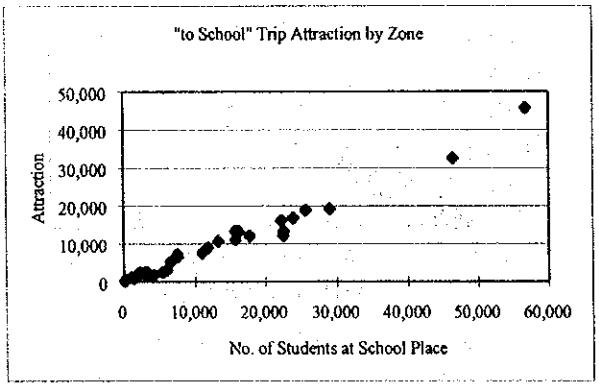
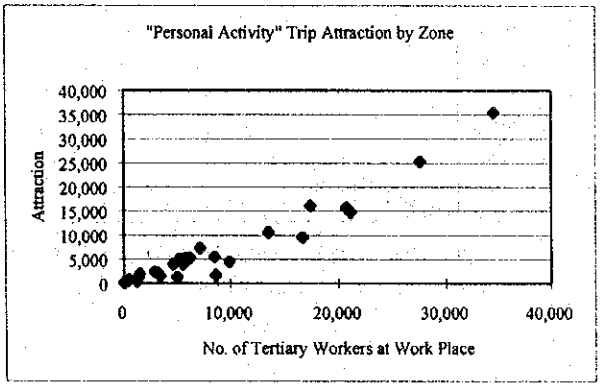


Figure 5.1.4
Attraction of Non-car Owner by Zone, 1998









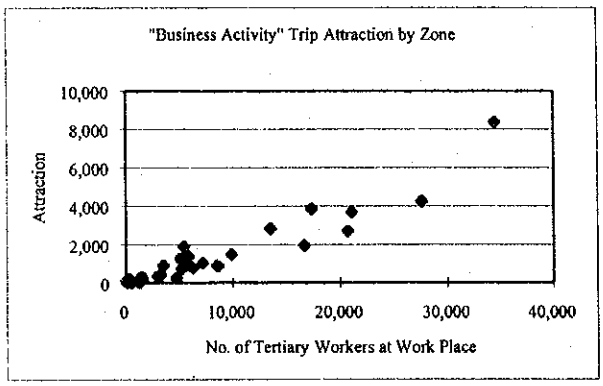
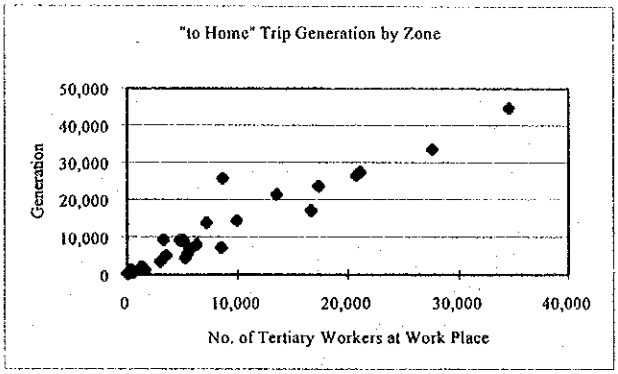
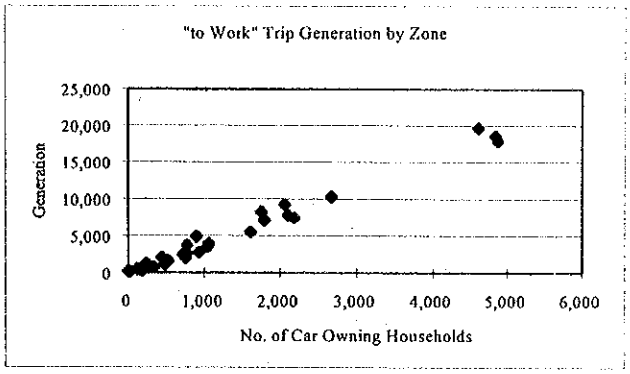
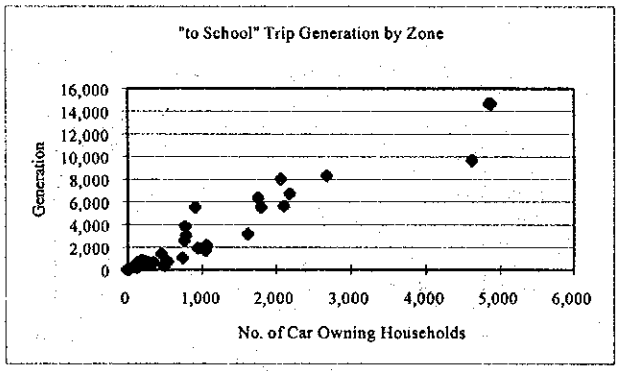
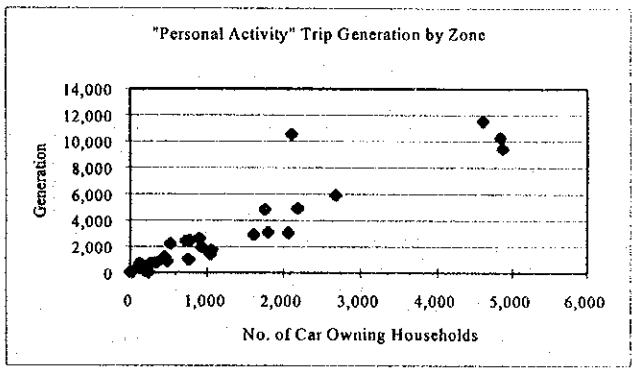


Figure 5.1.5
Generation of Car Owner by Zone, 1998









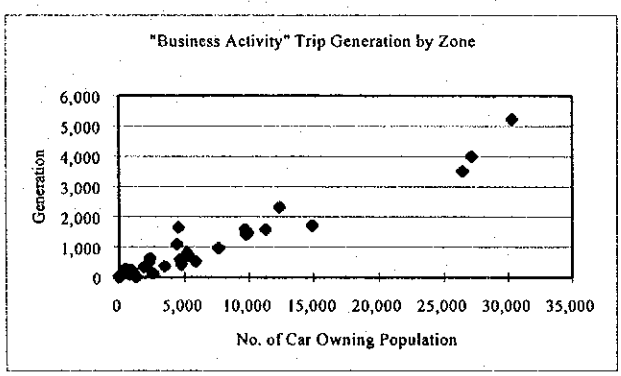
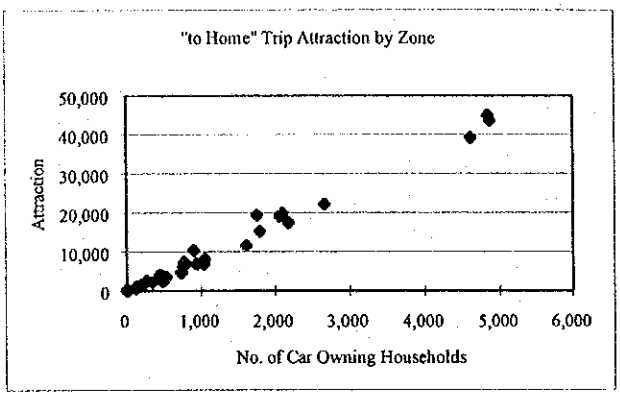
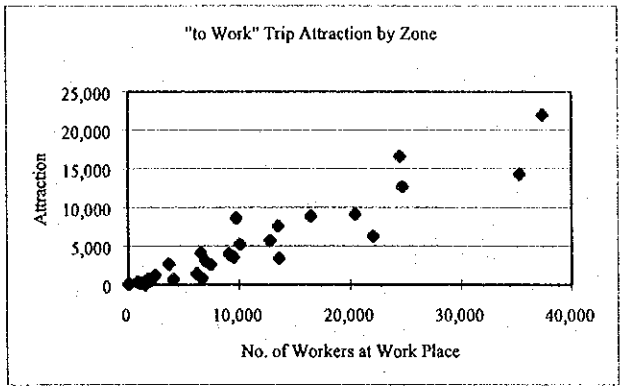
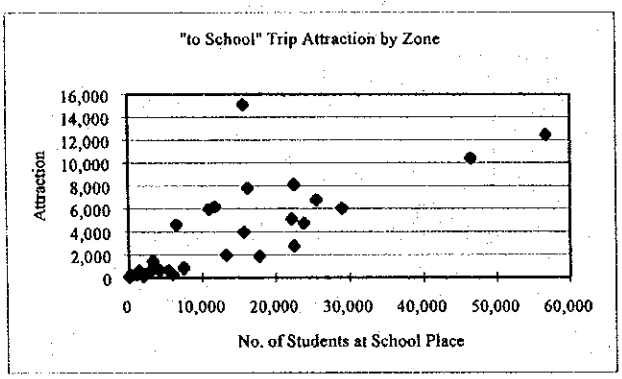
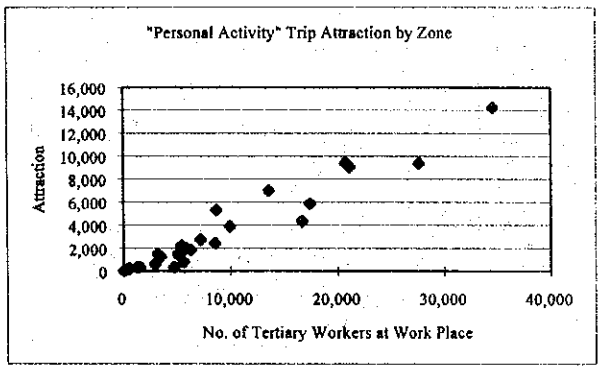


Figure 5.1.6
Attraction of Car Owner by Zone









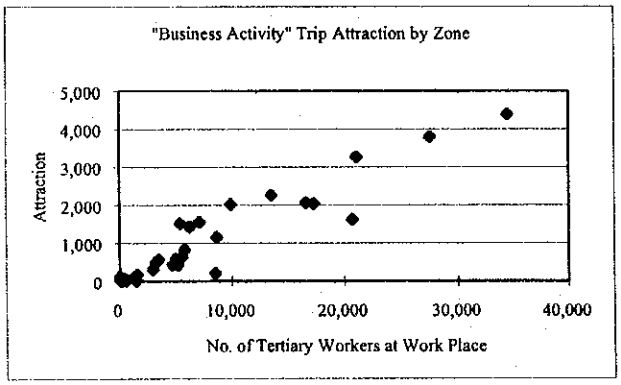
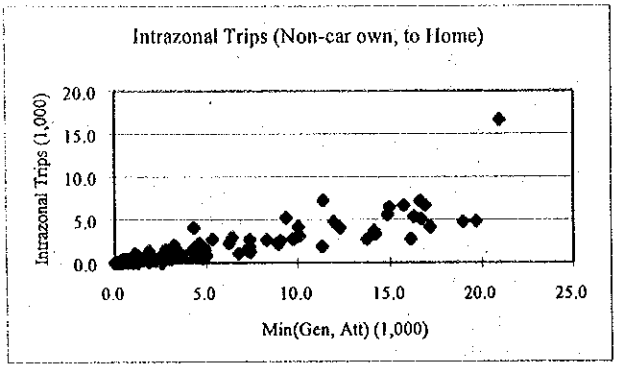
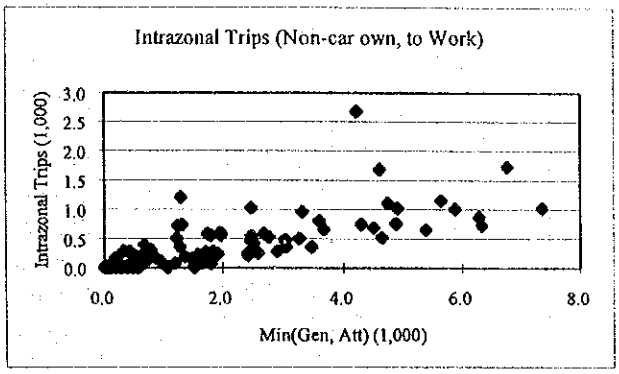


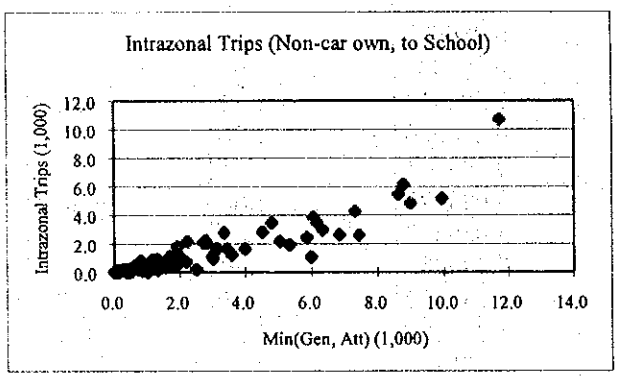
Table 5.1.6
Intra-zonal Trip Model Parameters

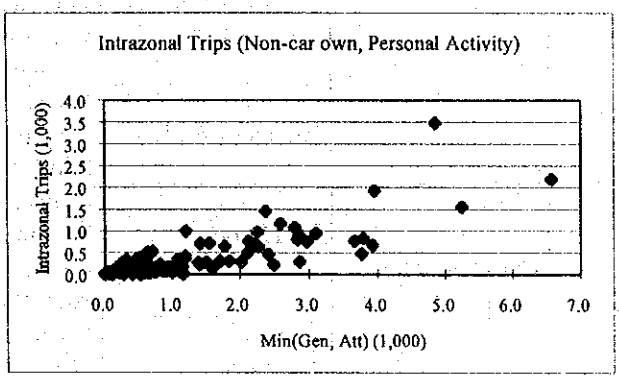
Car Ownership	Trip Purpose	Variable	Coefficient	t Value	MCC
Non-car Owner	To Home	Constant	0.014807	-6.45	0.887
		Dummy	1.940724	0.88	
		Generation	0.348490	4.53	
		Attraction	0.940626	11.23	
	To Work	Constant	0.402170	-1.46	0.796
		Dummy	2.631216	1.41	
		Generation	0.682305	7.98	
		Attraction	0.162121	2.16	
	To School	Constant	0.058447	-5.24	0.900
		Dummy	2.081454	1.10	
		Generation	0.908757	9.95	
		Attraction	0.305367	3.70	
	Personal Activity	Constant	0.114316	-3.56	0.836
		Dummy	2.677340	1.40	
		Generation	0.986023	9.29	
		Attraction	0.055087	0.61	
	Business Activity	Constant	2.204912	1.24	0.658
		Generation	0.250506	1.76	
		Attraction	0.309743	2.58	
Car Owners	To Home	Constant	0.085970	-3.68	0.857
		Dummy	3.679630	2.04	
		Generation	0.296885	3.69	
		Attraction	0.751830	9.83	
	To Work	Constant	1.735684	0.84	0.765
		Generation	0.571722	7.54	
		Attraction	0.068717	0.79	
	To School	Constant	1.266582	0.34	0.755
		Dummy	4.083434	2.78	
		Generation	0.417479	3.30	
		Attraction	0.329024	2.77	
	Personal Activity	Constant	0.751274	-036	0.695
		Dummy	4.874347	2.01	
		Generation	0.416821	3.26	
		Attraction	0.316449	2.71	
	Business Activity	Constant	16439237	1.91	0.625
		Dummy	2.368948	1.80	
		Generation	0.231383	1.04	
		Attraction	0.032798	0.17	

Figure 5.1.7
Intra-zonal Trips of Non-car Owner by Zone, 1998









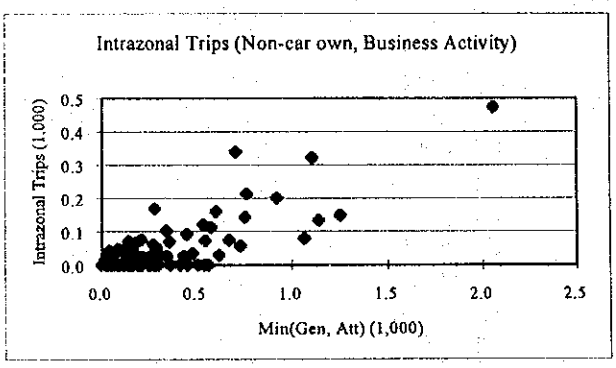
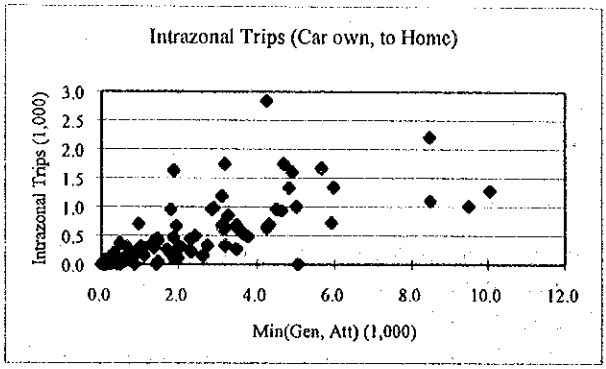
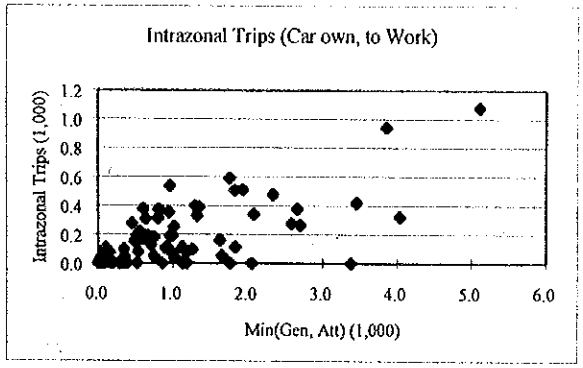
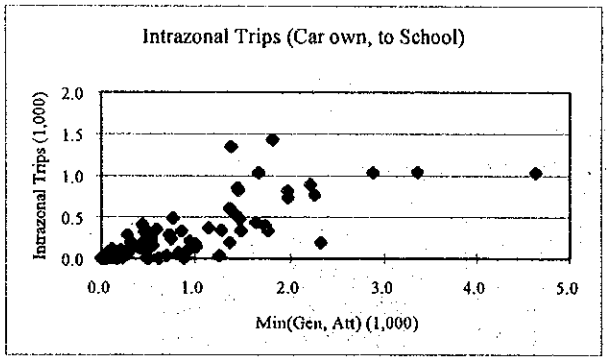
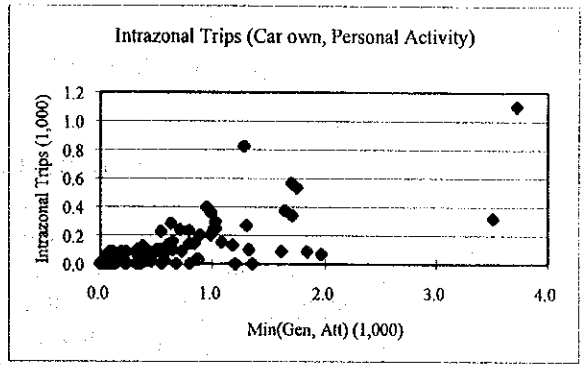


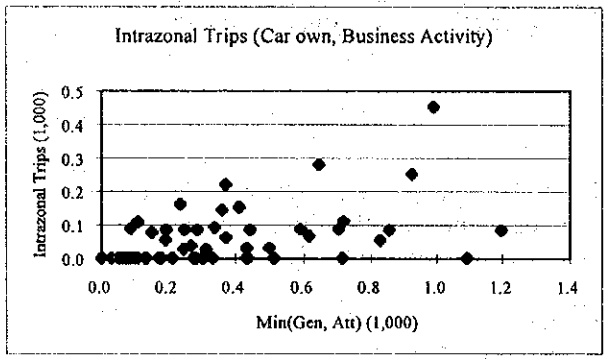
Figure 5.1.8
Intra-zonal Trips of Car Owner by Zone, 1998











5.1.4 Trip Distribution

A gravity model was adopted. The formulae is:

$$T_{ij} = G_i \cdot \frac{A_j D_{ij}^{\alpha}}{\sum A_j D_{ij}^{\alpha}}$$

Where,

T_{ij} = Number of trips between zone i and j
G_i = Trip generation of zone i
A_j = Trip attraction of zone i
D_{ij} = Minimum Distance between zone i and j on the road network
α = Coefficient

The result is shown in Table 5.1.7.

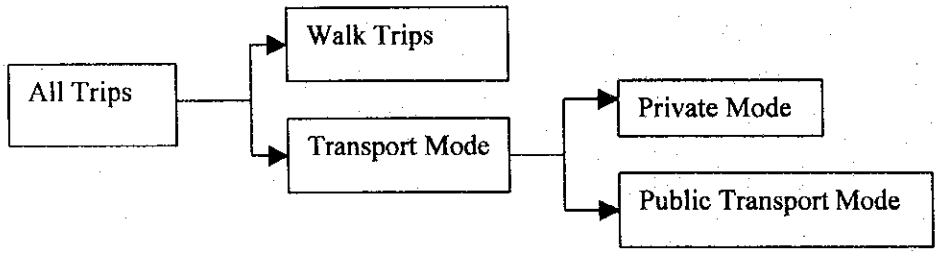
Table 5.1.7
Trip Distribution Model Parameters

Trip Purpose	Non-car Owning		Car Owning	
	Coefficient	C.C.	Coefficient	C.C.
To Home	0.580847	0.872	0.529578	0.830
To Work	0.507300	0.887	0.435999	0.763
To School	0.727246	0.768	0.643750	0.785
Personal Activity	0.575879	0.892	0.586841	0.793
Business Activity	0.493848	0.798	0.312598	0.647

5.1.5 Modal Choice Model

The purpose of this model is to estimate the modal shares for each OD pair. In order to reflect realistically the service level of each mode in modal split, trip interchange model was applied. The model is a two-step model as shown in Figure 5.1.9.

Figure 5.1.9
Structure of Modal Choice Model



1) Modal Choice Model to Segregate Walk Trips

The following equation was used:

$$P_{ij} = \frac{1}{1 + aD_{ij}^{b}}$$

Where,

P_{ij} = Share of walk trips between Zone i and j

D_{ij} = Distance between zone i and j

a, b = Coefficient

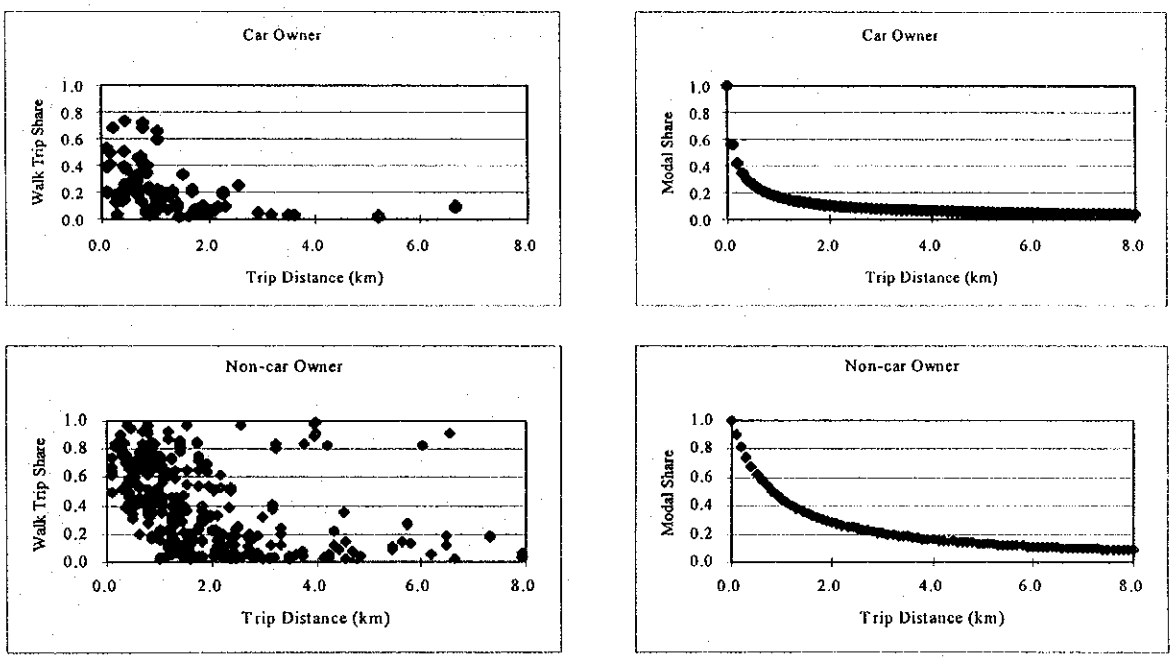
Table 5.1.8 presents the parameters obtained.

Table 5.1.8
Parameters of Modal Choice Model (I)

	Coefficient		Standard Error	t Value	M C C
No-car owning	a	1.242253	0.0893	2.43	0.721
	b	1.037875	0.0928	11.18	
Car owning	a	5.074970	0.0946	17.18	0.781
	b	0.807947	0.1048	7.71	

Figure 5.1.10 shows the current distribution of walk trip shares and estimated modal split curves for the car owning and non-car owning.

Figure 5.1.10
Actual Walk Trip Shares 1998 and Modal Split Curve



2) Modal Choice Model between Public and Private

The following logit equation was developed:

$$P_{ij} = \frac{1}{1 + e^{a(T_{ij}^C - T_{ij}^B) + b(C_{ij}^C - C_{ij}^B) + c}}$$

P_{ij} = Share of bus between zone i and j.
T_{ij}^C = Travel time by car between zone i and j (hour)
T_{ij}^B = Travel time by bus between zone i and j (hour)
C_{ij}^C = Cost of car between zone i and j (C$)
C_{ij}^B = Cost of bus between zone i and j (C$)

In addition, the cost of car was assumed to be the fuel cost (C$0.5/km) while that of bus the fare (C$1.4 flat per trip).

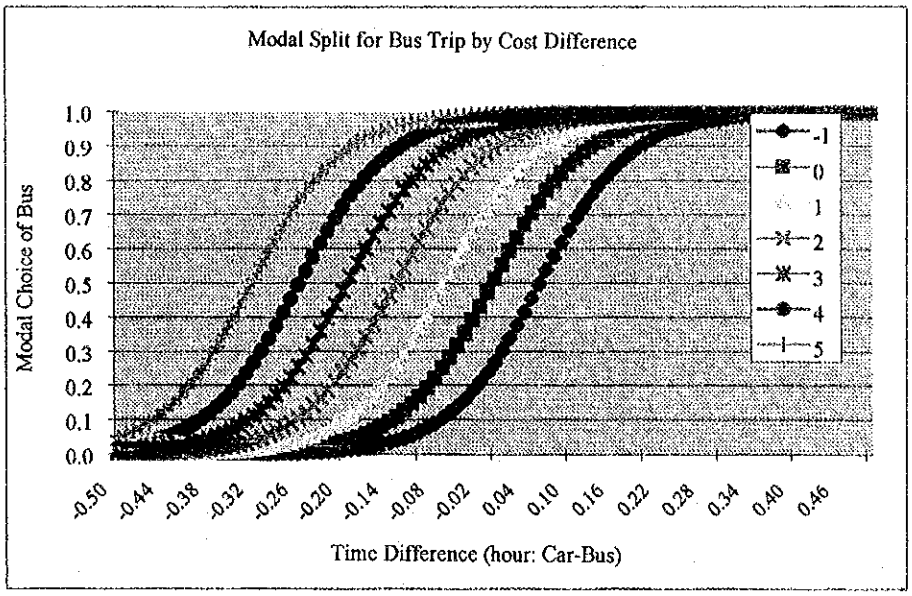
The resultant parameters and the modal split curve are shown in Table 5.1.9 and Figure 5.1.11, respectively.

Table 5.1.9
Parameters of Modal Choice Model (II)

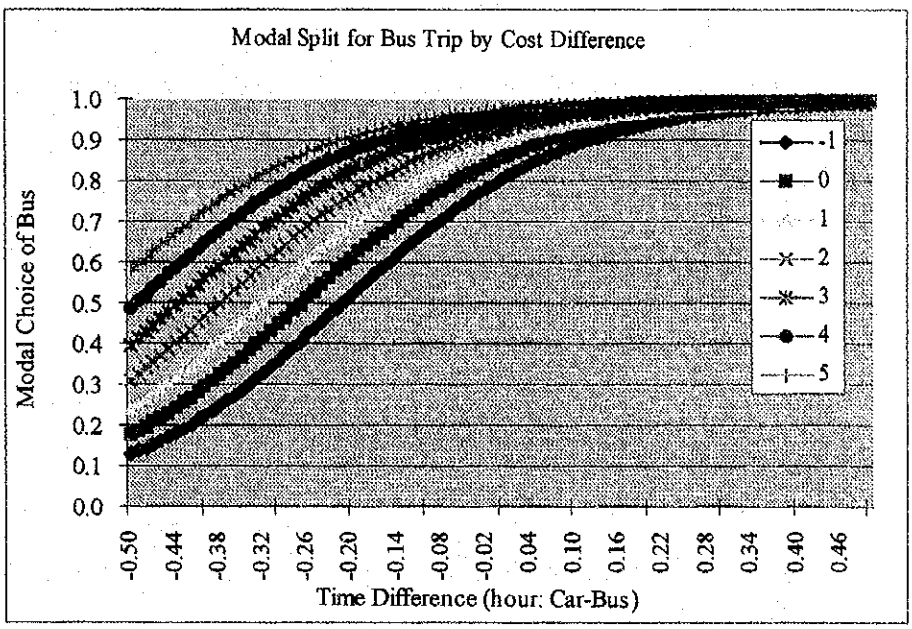
Car Ownership		Variable	Coefficient	Standard Error	t Value	M C C
Non-car owning	c	Constant	-1.774869	0.2407	-7.37	0.67
	a	Time Difference	-6.618006	2.7320	-2.42	
	b	Cost Difference	-0.370895	0.1898	-1.95	
Car Owning	c	Constant	-0.058705	0.2939	-0.20	0.73
	a	Time Difference	-16.430038	3.2919	-4.99	
	b	Cost Difference	-1.049055	0.2229	-4.71	

Figure 5.1.11
Modal Split Curve for Private/Public Selection

<Car Owner>



<Non-car Owner>



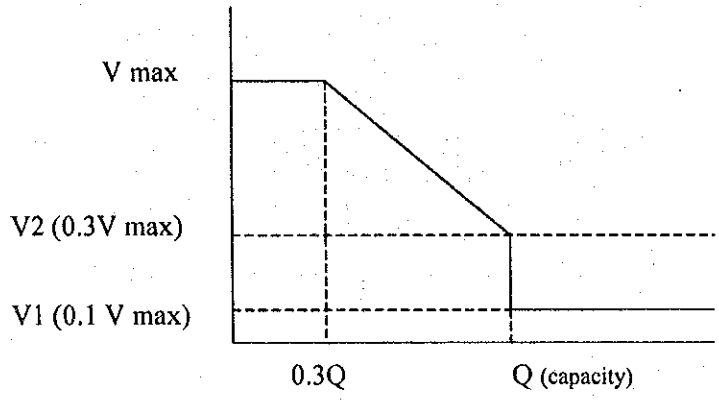
5.1.6 Traffic Assignment Model

This model assigns the traffic demand expressed in the form of OD matrices onto the road network approximated by a series of links and nodes. In this Study, the incremental assignment model included in JICA STRADA was used.

A. Speed-Flow Relationship (delay Function)

The function shown in Figure 5.1.12 was used.

Figure 5.1.12
Delay Function



B. Road Capacity

For two (2) – lane road, a capacity of 12,000 PCUs/day was assumed. For roads that have 3 or more lanes, 10,000 PCUs/lane/day was assumed.

C. Design Speed

The following was assumed:

Class 1 Travesía	80 km/h
Class 2 Primary Distributor	60 km/h
Class 3 Primary Collector	50 km/h
Class 4 Secondary Collector	40 km/h
Class 5 Local road (Calle)	30 km/h

D. Assignment Method

Firstly, the person-trip OD matrices were converted to PCU OD matrices using the following parameters:

Private Mode	1.963 persons/vehicle, 1 PCU/vehicle
Public Mode	29.525 persons/vehicle, 2 PCUs/vehicle

Secondly, the PCU OD matrices were assigned out road network by STRADA (usually 10 times x 10% incremental assignment).

5.2 Alternative Development Scenarios

5.2.1 Considerations for Formulating Alternative Scenarios

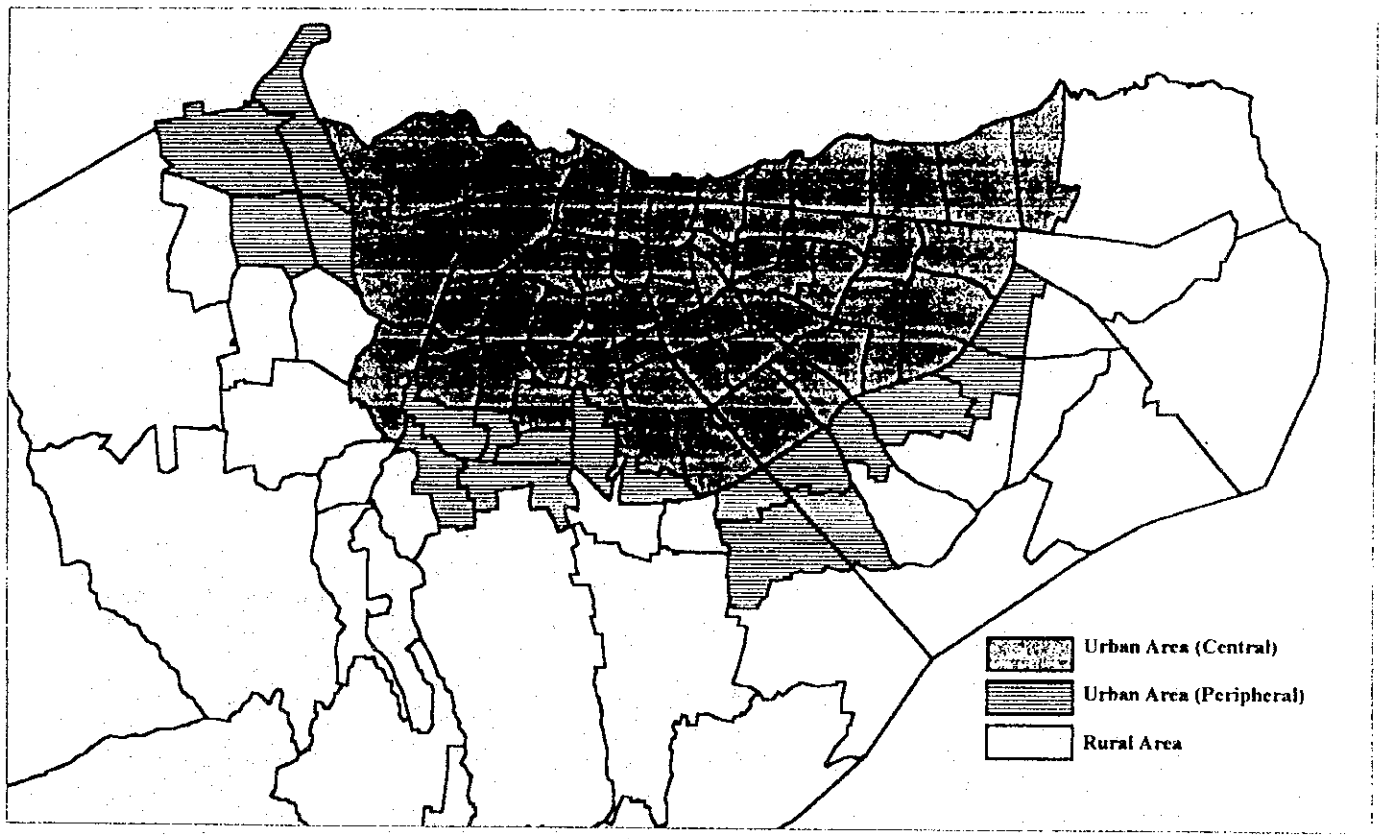
1) Definition of Existing Urban Area

Prior to the preparation of alternative urban development scenarios, existing urban area should be clearly defined. Table 5.2.1 and Figure 5.2.1 show the population distribution of the existing urban area defined based on the current population density and the extent of urbanization. This, however, does not mean that there is no urbanized area outside its boundary. The intention of defining this boundary is, after planning the future urbanization, to promote urbanization inside the boundary and to control outside.

Table 5.2.1
Distribution of Population, 1998

	Area (ha)	Population	Population Density (persons/ha)
1. Urban Area	12,358	1,116,575	90.4
- Central	8,581	913,568	106.5
- Peripheral	3,777	203,007	53.7
2. Rural Area	42,338	83,710	2.0
- Airport	614	1,800	2.9
- Others	41,724	81,910	2.0
Managua Total	54,596	1,200,285	22.0

Figure 5.2.1
Definition of Existing Urban Area



2) Land Requirements

As is explained in Chapter 4, Managua's population will increase from 1.2 million in 1998 to nearly 2.0 million in the next 20 years. The economy scale will grow by about three (3) times, and the employment will increase from 400 thousand in 1998 to 900 thousand in 2018. This growth produces a demand for land. However, the magnitude of this demand varies depending on a number of factors including:

- Redevelopment of built-up areas.
- Relocation of sub-grade residential areas.
- Direction of economic development.
- City planning in relation to disaster prevention, land use control, allocation of CBDs, etc.
- Road development.
- Miscellaneous.

A. Industrial

The increase in employment of the industry sector is predicted at 83,600 up to the year 2018. According to the Person-Trip Survey, about 65% of this employment are scattered in urbanized areas not classified as "industrial". This means that most of existing industries are small-scale. This tendency is supposed to remain during the study period.

Hence, the demand of land for industrial use is for an employment size of 29,300 (35% of 83,600). Assuming a 120 m^2 land space per head (refer to Table 5.2.2), the demand for industrial land area is estimated at about 350 ha. This, however, is an estimate excluding possible relocation of existing heavy industries.

B. Business/Commercial

The increase in employment of this sector is estimated at 314,200 by the year 2018. Similarly to the industrial sector, the Person-Trip Survey revealed that about 75% of the employment of this sector are scattered in residential and other areas of varied land use. This will be true also in the future considering the neighborhood commerce, service shops, small offices and public facilities located everywhere in the urbanized area.

Thus, the demand for land of this type is calculated at about 380 ha. For an employment size of 78,600 (25% of 314,200). Land area per head is assumed at 50 m^2 (refer to Table 5.2.2).

Table 5.2.2
Result of Sample Survey on Land and Floor Area for Selected Establishments, 1998

	Manufacturing Factory	Bank	Government Office	Supermarket	University
Number of Samples	11	2	3	2	3
Total Number of Persons Engaged	14,489	174	2,436	110	1,184
Total Land Area (m^2)	1,725,990.6	9,556.4	87,825.6	1,902.6	411,421.2
Total Floor Area (m^2)	207,833.3	2,833.8	31,484.1	1,151.5	40,611.9
Average Land Area Per Person (m^2)	116.2	54.9	36.1	17.3	347.5
Average Floor Land Area per Person (m^2)	14.0	16.3	12.9	10.5	34.3

C. Residential

The population increase in Managua for the next 20 years is estimated at 760 thousand. Considering the vacant land remaining in the existing urbanized area, about 1/3 of the increment would not need new urbanization being absorbed in the available space. Therefore, if the population density is assumed at 100 persons/ha (gross) for new urbanization, the demand for land of residential use will be about 5,000 ha.

However, this calculation is quite hypothetical, and needs to be modified depending on the development scenario.

5.2.2 Alternative Scenarios

1) Basic Features of Alternative Scenarios

Given the future socio-economic framework as a whole, the possible development scenarios should differ with each other in the following two (2) points:

1. Size and distribution of urbanized area.
2. Distribution of urban functions and population density.

As the city size becomes compact, the efficiency of urban activities becomes high, while the cost of urban redevelopment and vulnerability against earthquake will be remarkable. On the other hand, if urbanization expands without control, the cost of developing urban infrastructure will be enormous, while existing built-up area can be left untouched. Each alternative has its own pros and cons, and all the possible alternatives have to be compared in a comprehensive manner.

In this Study, the following alternative scenarios have been selected for comparison:

Alternative I Mono-polar High-Density Development

- Mono-polar development with the current CBD.
- Compact city with large-scale urban redevelopment in the existing built-up area.
- Suitable for mass transit system.

Alternative II Extended Low-Density Development

- Extension of the current tendency.
- Scattered functional distribution.
- Wide-spread low-rise conurbation towards rural areas.
- Suitable for car use.

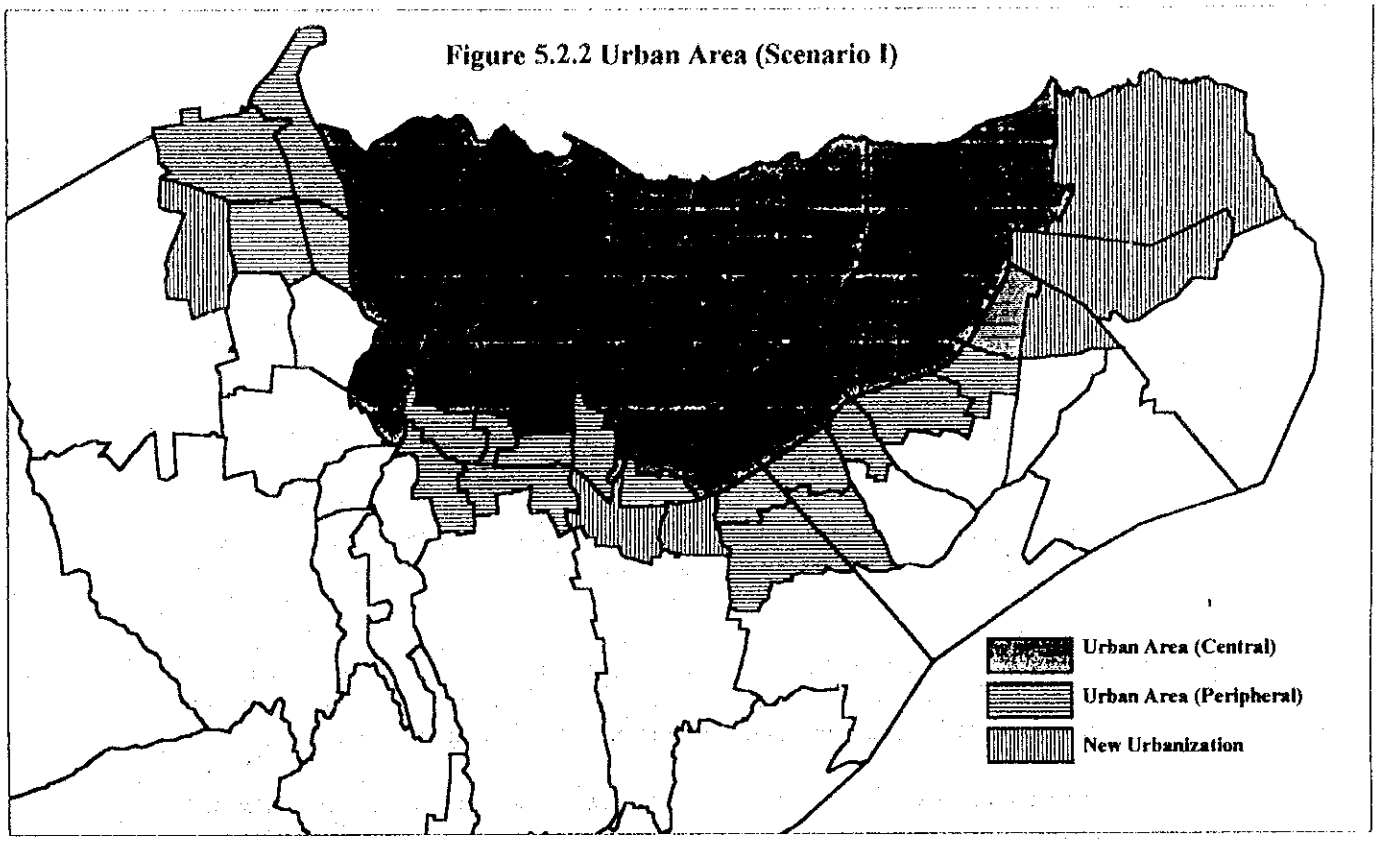
Alternative III Corridor Controlled Development

- Corridor development with functional sharing.
- Planned urbanization with urban redevelopment and relocation in existing critical areas.

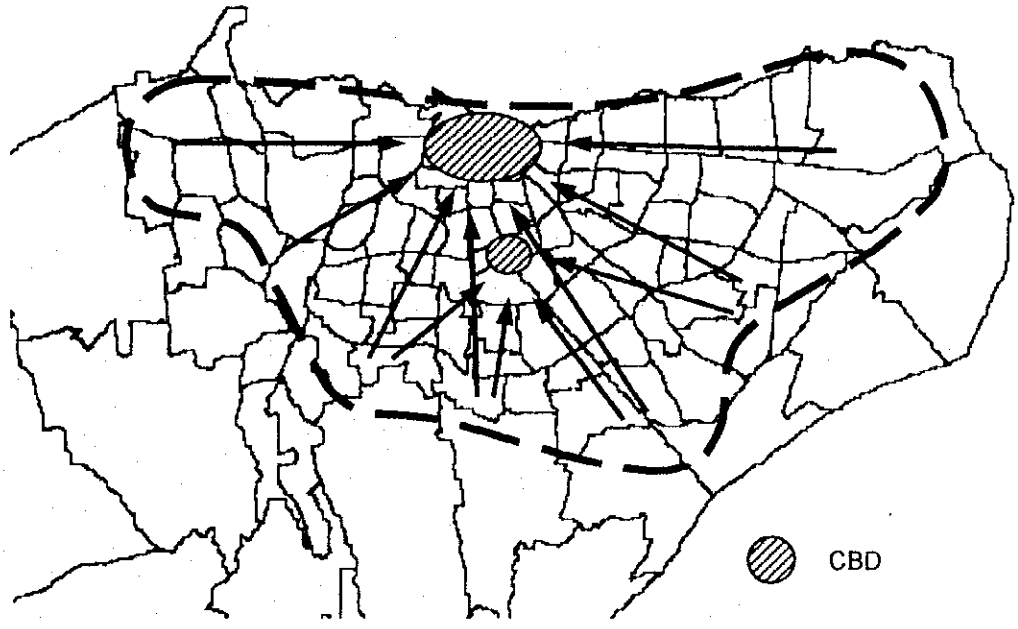
2) Description of Alternative Scenarios

A. Scenario I

- Urban area will be expanded slightly from 12,358 ha in 1998 to 15,341 ha in 2018 as shown in Figure 5.2.2.
- Urban redevelopment in the old CBD will be pursued to the maximum extent in order to concentrate urban activities such as commerce, business, administrative, cultural, social and recreational.
- Squatter area will be redeveloped to medium-rise residential area in order to accommodate the residents in the site and to produce public space.
- Most of the increased population shall be absorbed in medium-rise housing area to be constructed in the vacant lots existing in the built-up area.
- As a result of the measures mentioned above, 95% of population will be absorbed in the designated urban area with an average population density of 120 persons/ha.
- New industrial area will be secured in the West of Managua considering its importance as a basis of economic development of Nicaragua.
- For disaster prevention, some sort of building standard codes is assumed to be institutionalized.



<Distribution of CBD>



B. Scenario II

- Urban area will be expanded largely to 22,956 ha in 2018 as shown in Figure 5.2.3. This includes Sabana Grande in the East, Esquipulas in the south-east, Comarca Las Jinotepes in the South and Comarca Cedro Galán in the West.

- The existing old CBD shall be developed as a symbolic space of Nicaragua with administrative, cultural, historical and recreational facilities.

- Mercado Oriental shall be relocated excluding some neighborhood functions for District #4.

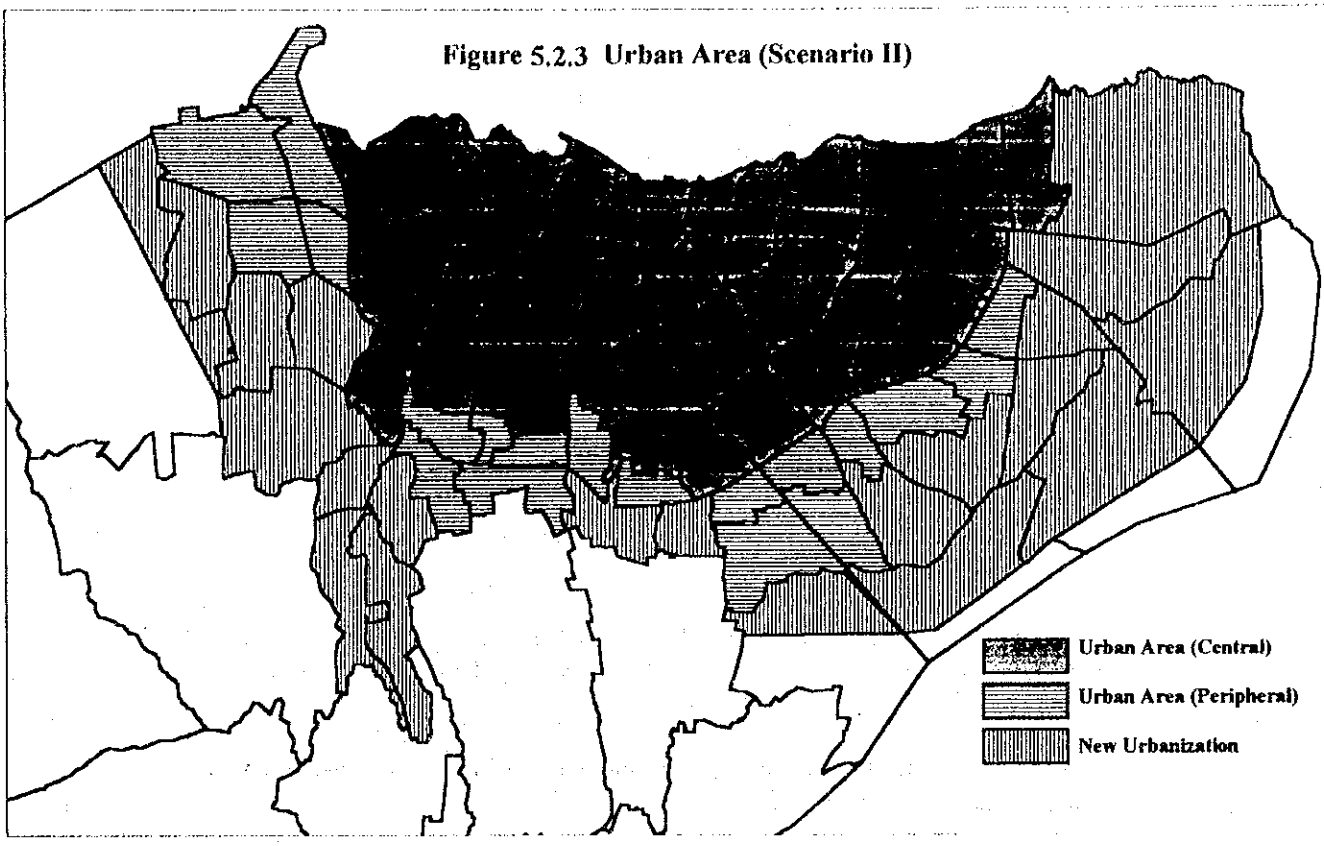
- Each District shall form its own CBD with development of access roads from various places of the district.

- Large universities such as UNI, UCA and UNAN will be relocated to the suburban area, and the remaining land lots will be utilized as residential and commercial area.

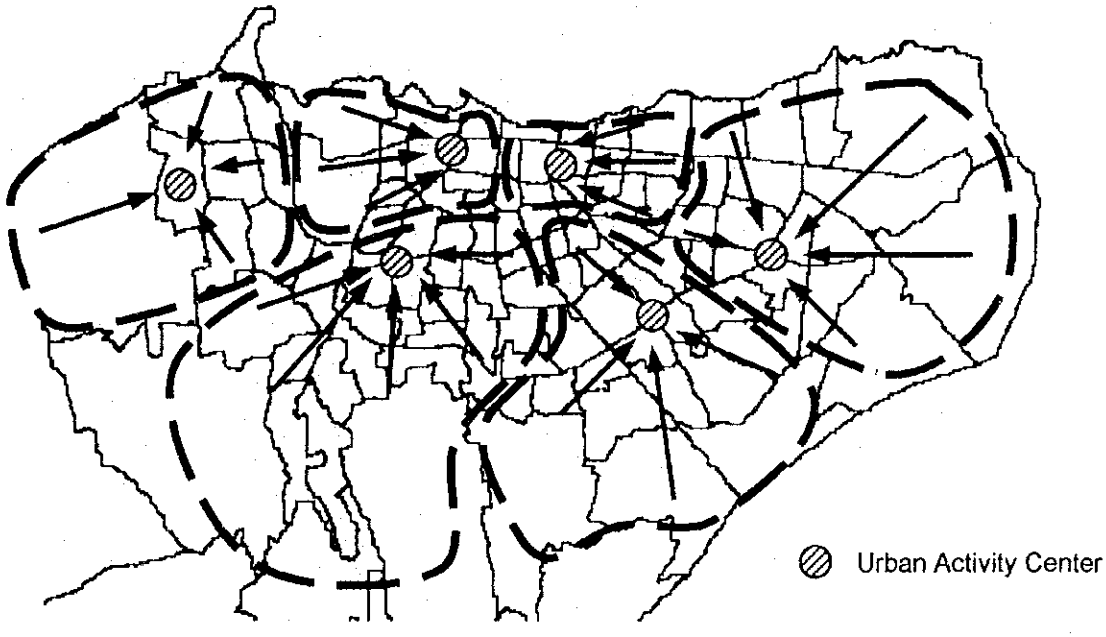
- Industrial zone shall be prepared in the western suburbs of Managua corresponding to the demand for new industrialization and relocation of environmentally hazardous factories existing in built-up areas (about 500 ha).

- The existing squatter area shall be redeveloped and the residents relocated to the suburbs.

Figure 5.2.3 Urban Area (Scenario II)



<Distribution of CBD>



C. Scenario III

- Urban area will be expanded to 19,447 ha in 2018 as shown in Figure 5.2.4.
- Urban axes will be formulated instead of mono-polar CBD (Scenario I) or scattered urban activity centers (Scenario II). These urban axes shall be accessible from all the directions.

  a. Main Urban Axis

     - Old CBD – Metrocentro – 7 km. Carretera Masaya
     - Metrocentro – Siete Sur

  b. Ancillary Urban Axis

     - Metrocentro – El Dorado – Sabana Grande
     - Siete Sur – New Urban Area in the West

- The old CBD shall be developed based on the current Plan Regulador de Managua. An employment of 100 thousand and a population of 60 thousand are assumed.
- The existing Centro Cívico shall be redeveloped as a focal business/commercial center of the Main Urban Axis.
- Industrial zone shall be secured for new industries in the West of Managua (about 350 ha).
- Existing squatter area shall be reorganized from the standpoint of social welfare and living environment.

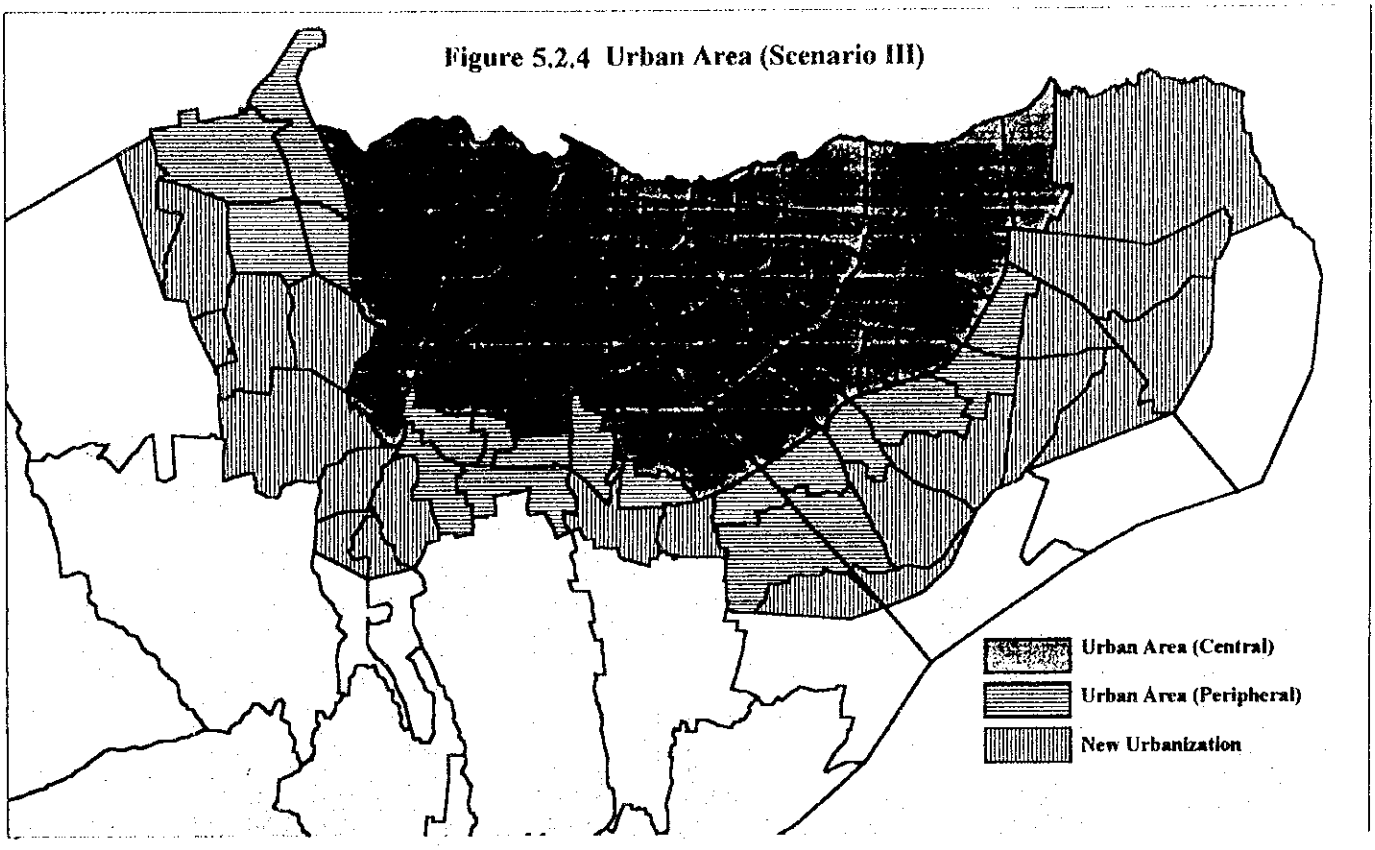
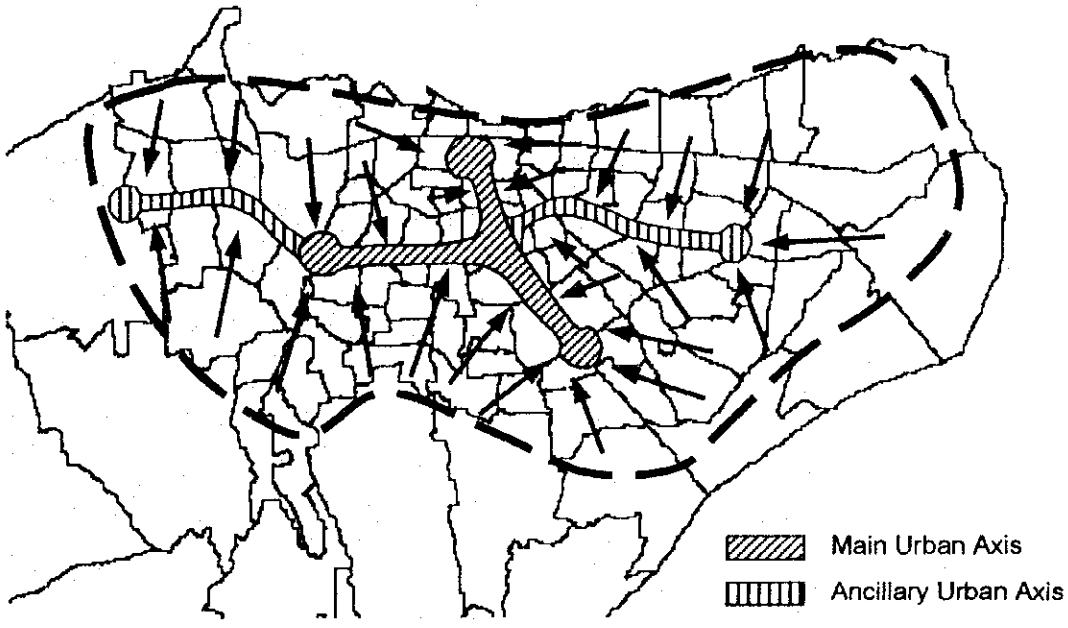


Figure 5.2.4 Urban Area (Scenario III)

<Distribution of CBD>



3) Quantitative Comparison of Alternative Scenarios

Table 5.2.3 compared quantitatively the alternative development scenarios in terms of planned land use for the year 2018. Scenario I will bring bout a compact, dense and transit-oriented city, while Scenario II will create a wide-spread and auto-based city. The current urbanization tendency is reflected in the latter. Scenario III which represents the intermediate direction seems to be more realistic. They will be compared in the light of transportation demand in the following sections.

Table 5.2.3
Land Use Comparison of Alternative Scenarios, 2018

	Scenario I			Scenario II			Scenario III		
	Area (ha)	Population	Population Density (pers/ha)	Area (ha)	Population	Population Density (pers/ha)	Area (ha)	Population	Population Density (pers/ha)
1. Urban Area	15,341	1,871,800	122.0	22,956	1,912,800	83.3	19,447	1,902,800	97.8
1.1 Existing Urban Area	12,358	1,814,400	146.8	12,358	1,204,600	97.5	12,358	1,402,700	113.5
- Central	8,581	1,423,400	165.9	8,581	813,600	94.8	8,581	1,011,700	117.9
- Peripheral	3,777	391,000	103.5	3,777	391,000	103.5	3,777	391,000	103.5
1.2 New Urbanization	2,983	57,400	19.2	10,598	708,200	66.8	7,089	500,100	70.5
- Residential	326	41,300	126.7	7,122	686,400	96.4	3,713	478,300	128.8
- Industrial	350	-	-	500	-	-	350	-	-
- Academic	-	-	-	150	-	-	-	-	-
- Airport	614	1,800	2.9	614	1,800	2.9	614	1,800	2.9
- Others	1,693	14,300	8.4	2,212	20,000	9.0	2,412	20,000	8.3
2. Rural Area	39,255	92,000	2.3	31,640	51,000	1.6	35,149	61,000	1.7
TOTAL	54,596	1,963,800	36.0	54,596	1,963,800	36.0	54,596	1,963,800	36.0

5.3 Future Socio-Economic Features by Development Scenario

This section aims to outline the features of the alternative development scenarios after zonal breakdown of the future socio-economic framework worked out in the previous chapter. Most of the explanations are given on the basis of "Integrated Planning Zones" in this section. Refer to Appendix 3 for the details of the zoning systems used in this Study.

5.3.1 Population Distribution

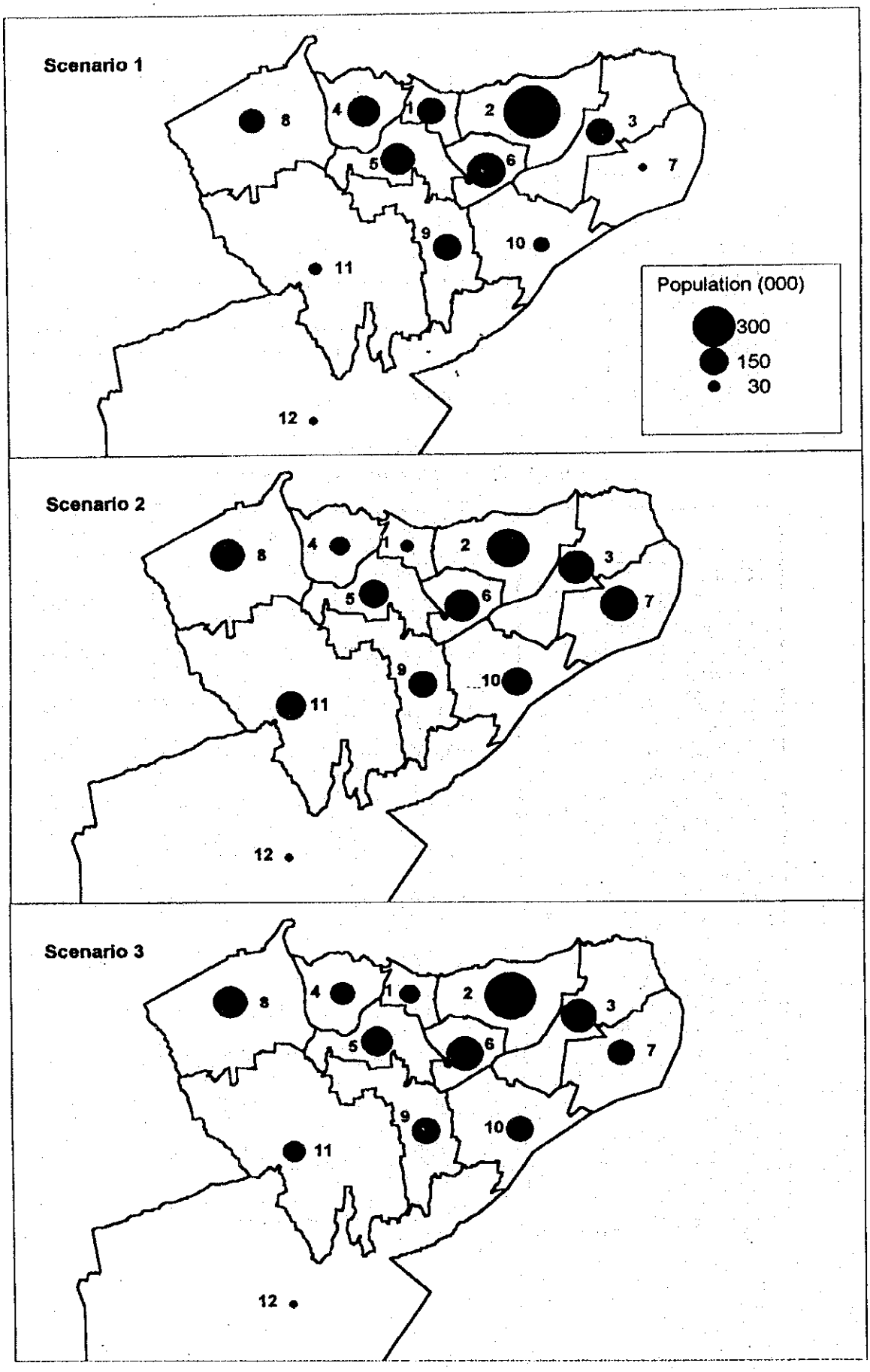
Table 5.3.1 and Figure 5.3.1 show the distribution of population in 2018 by alternative scenario. In Scenario I, nearly 1/3 of Managua's population concentrates in Urban East (Inner), and more than 1.4 million lives in the central urban area with a density of 165 persons/ha. On the contrary, population increase is extremely limited in suburban areas in this scenario. In Scenario II, population of the central urban area will be reduced to about 800 thousand by relocating the residents of spontaneous settlements to suburban zones, particularly to Suburban East and Suburban Southwest. Scenario III is a compromise of Scenario I and II, and shows an intermediate tendency.

Table 5.3.1
Distribution of Population by Scenario, 2018

	Scenario 1		Scenario 2		Scenario 3	
	Population	%	Population	%	Population	%
1. Centro (P. Z. 4 & 14)	148,000	7.5	38,300	2.0	83,400	4.2
2. Urban East (Inner) (P. Z. 15, 16, 23 & 24)	636,700	32.4	335,600	17.1	408,900	20.8
3. Urban East (Outer) (P. Z. 21, 22, 25, 26 &27)	147,100	7.5	212,700	10.8	212,700	10.8
4. Urban West (P. Z. 5 & 6)	198,000	10.1	78,000	4.0	117,300	6.0
5. Urban South (P. Z. 7, 8, 9, 10 & 11)	199,300	10.1	157,200	8.0	176,200	9.0
6. Urban Southeast (P. Z. 17 & 18)	241,400	12.3	204,500	10.4	225,900	11.5
7. Suburban East (P. Z. 28)	15,000	0.8	245,400	12.5	140,400	7.1
8. Suburban West (P. Z. 1, 2 & 3)	123,500	6.3	206,100	10.5	206,100	10.5
9. Suburban South (P. Z. 12 & 19)	145,900	7.4	146,400	7.5	146,400	7.5
10. Suburban Southeast (P. Z. 20)	58,900	3.0	162,300	8.3	132,300	6.7
11. Suburban Southwest (P. Z. 13)	35,000	1.8	162,300	8.3	99,200	5.1
12. Rural (P. Z. 29)	15,000	0.8	15,000	0.8	15,000	0.8
Managua (P. Z. Total)	1,963,800	100.0	1,963,800	100.0	1,963,800	100.0

Note: P. Z. = Planning Zone (refer to Appendix 3)

Figure 5.3.1
Distribution of Population by Scenario, 2018



5.3.2 Employment Distribution

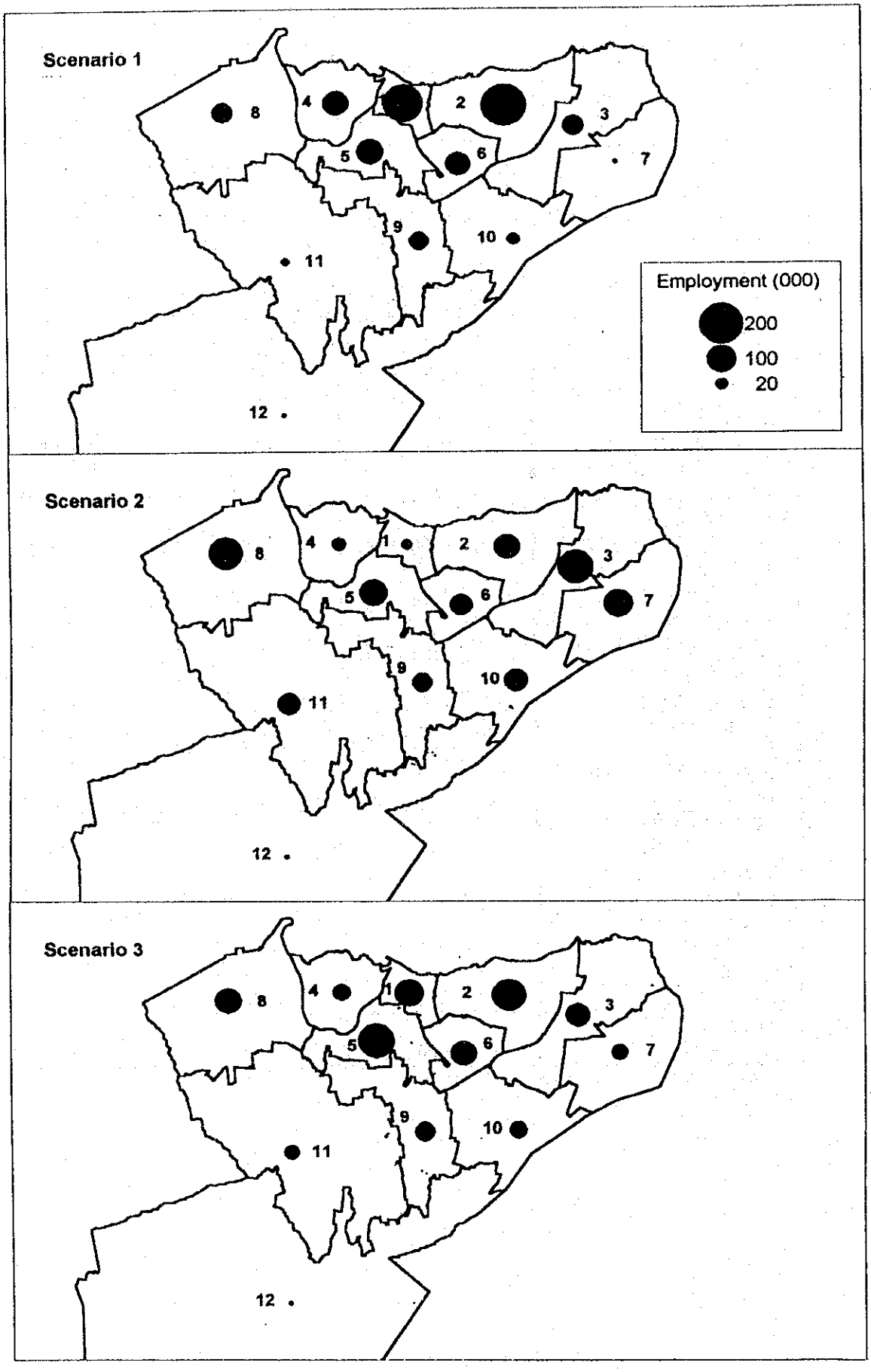
Table 5.3.2 and Figure 5.3.2 show the distribution of employment in 2018 for alternative development scenarios. Scenario I intends to concentrate the employment opportunities, as well as population, in the central urban area including the old CBD. In Urban East (Inner), existing industrial areas and commercial area in Bello Horizonte will be redeveloped. Scenario II will have major employment centers in the suburban areas and Urban East (Outer) along Pista del Mayoreo. In Suburban West, an industrial estate will be developed for new industries as well as relocated factories from built-up areas. Also in Suburban Southeast, an academic city will be formed mainly by relocated universities. Scenario III aims to create urban axes connecting old CBD and other business/commercial areas developed/redeveloped along Pista Juan Pablo, Rubén Darío, etc.

Table 5.3.2
Distribution of Employment by Scenario, 2018

	Scenario 1		Scenario 2		Scenario 3	
	Employment	%	Employment	%	Employment	%
1. Centro (P. Z. 4 & 14)	183,200	21.1	18,700	2.1	104,000	12.0
2. Urban East (Inner) (P. Z. 15, 16, 23 & 24)	218,600	25.1	85,200	9.8	134,700	15.5
3. Urban East (Outer) (P. Z. 21, 22, 25, 26 &27)	59,200	6.8	143,200	16.5	76,200	8.8
4. Urban West (P. Z. 5 & 6)	83,500	9.6	27,100	3.1	44,400	5.1
5. Urban South (P. Z. 7, 8, 9, 10 & 11)	90,600	10.4	98,700	11.3	156,000	17.9
6. Urban Southeast (P. Z. 17 & 18)	77,500	8.9	64,100	7.4	87,800	10.1
7. Suburban East (P. Z. 28)	3,700	0.4	105,500	12.1	40,600	4.7
8. Suburban West (P. Z. 1, 2 & 3)	56,600	6.5	134,000	15.4	92,600	10.6
9. Suburban South (P. Z. 12 & 19)	53,100	6.1	53,200	6.1	53,200	6.1
10. Suburban Southeast (P. Z. 20)	27,100	3.1	72,600	8.3	43,800	5.0
11. Suburban Southwest (P. Z. 13)	12,600	1.4	63,400	7.3	32,400	3.7
12. Rural (P. Z. 29)	4,300	0.5	4,300	0.5	4,300	0.5
Managua (P. Z. Total)	870,000	100.0	870,000	100.0	870,000	100.0

Note: P. Z. = Planning Zone (refer to Appendix 3)

Figure 5.3.2
Distribution of Employment by Scenario, 2018



5.3.3 Zones Attracting Students

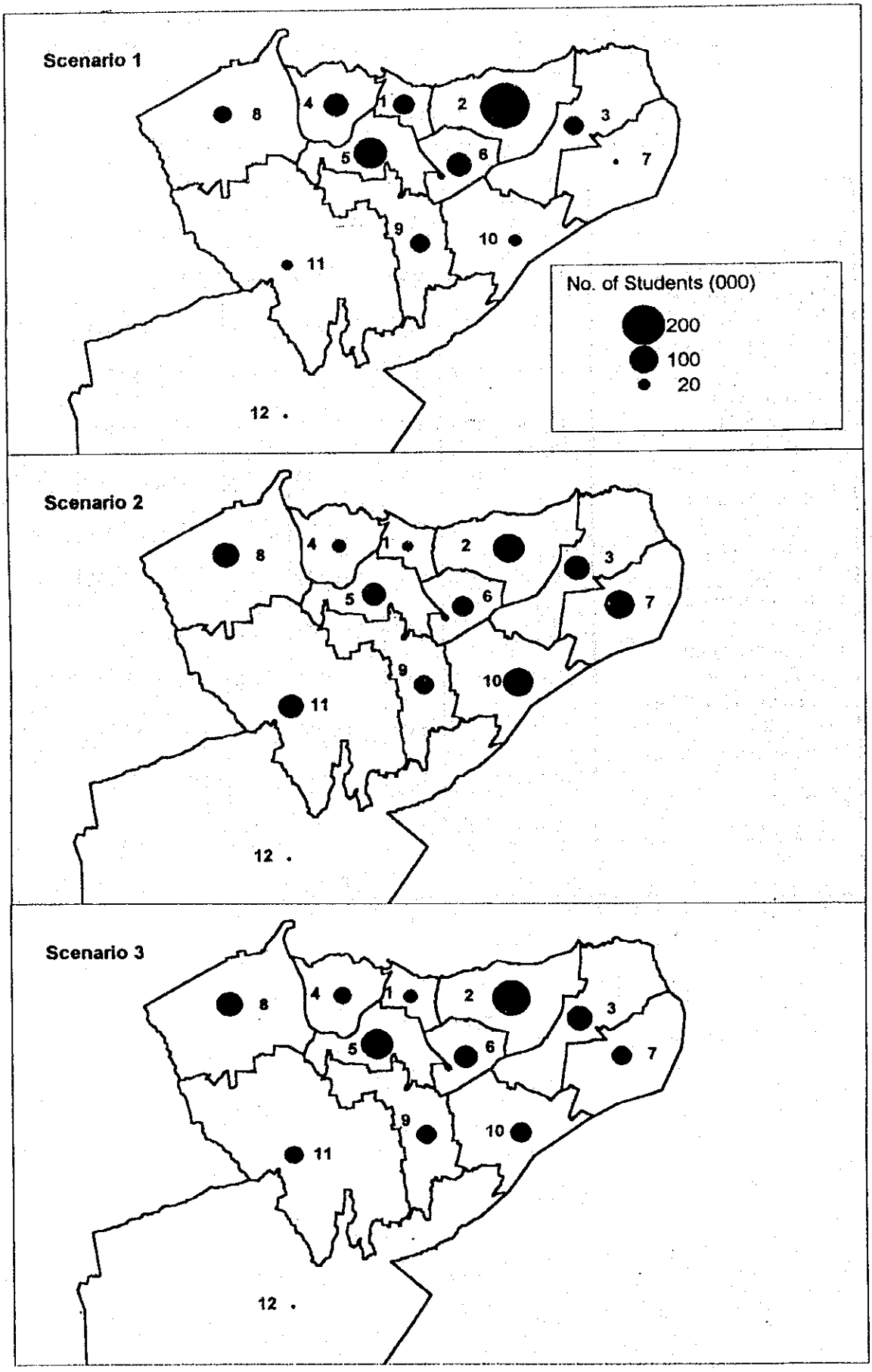
At present, large universities and private schools are concentrated in Urban South. While Scenario I and III do not consider their relocation, Scenario II assumes that they move out to Suburban Southeast.

Table 5.3.3
Distribution of Students at School Place by Scenario, 2018

	Scenario 1			Scenario 2			Scenario 3		
	Students	%	S/R	Students	%	S/R	Students	%	S/R
1. Centro (P. Z. 4 & 14)	59,600	7.4	0.99	17,300	2.2	1.12	30,100	3.8	0.96
2. Urban East (Inner) (P. Z. 15, 16, 23 & 24)	253,000	31.6	0.99	112,800	14.1	0.82	159,100	19.9	0.91
3. Urban East (Outer) (P. Z. 21, 22, 25, 26 &27)	53,000	6.6	0.83	82,700	10.3	0.96	82,700	10.3	0.96
4. Urban West (P. Z. 5 & 6)	80,700	10.1	1.01	31,200	3.9	0.99	43,900	5.5	0.91
5. Urban South (P. Z. 7, 8, 9, 10 & 11)	129,200	16.1	1.61	71,700	9.0	1.13	118,600	14.8	1.65
6. Urban Southeast (P. Z. 17 & 18)	77,500	9.7	0.77	57,900	7.2	0.89	70,400	8.8	0.82
7. Suburban East (P. Z. 28)	4,900	0.6	0.81	105,600	13.2	1.05	52,100	6.5	0.97
8. Suburban West (P. Z. 1, 2 & 3)	45,000	5.6	0.91	82,700	10.3	1.03	82,700	10.3	1.03
9. Suburban South (P. Z. 12 & 19)	52,600	6.6	0.96	53,000	6.6	0.96	53,000	6.6	0.96
10. Suburban Southeast (P. Z. 20)	23,500	2.9	1.00	105,200	13.1	1.58	57,100	7.1	1.09
11. Suburban Southwest (P. Z. 13)	18,100	2.3	1.31	77,000	9.6	1.12	47,400	5.9	1.25
12. Rural (P. Z. 29)	3,300	0.4	0.56	3,300	0.4	0.57	3,300	0.4	0.57
Managua (P. Z. Total)	800,400	100.0		800,400	100.0		800,400	100.0	

Note: S/R = Ratio of No. of Students at school place to that at residence.

Figure 5.3.3
Distribution of School Enrolment by Scenario, 2018



5.3.4 Income Level and Car Ownership

Table 5.3.4 and Figures 5.3.4 and 5.3.5 show the distribution of income level and car ownership by integrated planning zone. The distribution is controlled so that the total of Managua becomes equal to each other.

As a whole, there is no large difference between scenarios in the distribution of income and car ownership. The average income is higher in Suburban Southeast than in other zones due to the high-class residential areas such as Las Colinas and Los Altos de Santo Domingo.

Table 5.3.4
Income Level and Car Ownership by Scenario, 2018

	Scenario 1		Scenario 2		Scenario 3	
	Average Monthly Income (C$)	Car Owning Ratio (%)	Average Monthly Income (C$)	Car Owning Ratio (%)	Average Monthly Income (C$)	Car Owning Ratio (%)
1. Centro (P. Z. 4 & 14)	3,240	27.3	3,170	26.7	3,200	27.0
2. Urban East (Inner) (P. Z. 15, 16, 23 & 24)	4,090	35.5	3,930	33.9	4,050	35.1
3. Urban East (Outer) (P. Z. 21, 22, 25, 26 &27)	3,260	27.6	3,210	27.0	3,210	27.0
4. Urban West (P. Z. 5 & 6)	4,370	38.3	3,980	34.3	4,170	36.3
5. Urban South (P. Z. 7, 8, 9, 10 & 11)	4,550	40.3	4,540	40.2	4,490	39.7
6. Urban Southeast (P. Z. 17 & 18)	5,160	47.0	4,670	41.5	4,810	43.1
7. Suburban East (P. Z. 28)	3,000	25.8	2,770	23.4	2,790	23.5
8. Suburban West (P. Z. 1, 2 & 3)	3,510	29.8	3,770	32.2	3,790	32.5
9. Suburban South (P. Z. 12 & 19)	4,660	41.5	4,720	42.2	4,720	42.2
10. Suburban Southeast (P. Z. 20)	10,520	91.4	9,610	86.6	10,330	89.4
11. Suburban Southwest (P. Z. 13)	5,810	55.4	6,450	61.1	6,620	62.1
12. Rural (P. Z. 29)	2,810	23.5	2,810	23.5	2,810	23.5
Managua (P. Z. Total)	4,570	40.5	4,570	40.5	4,570	40.5

Figure 5.3.4
Distribution of Average Income by Scenario, 2018

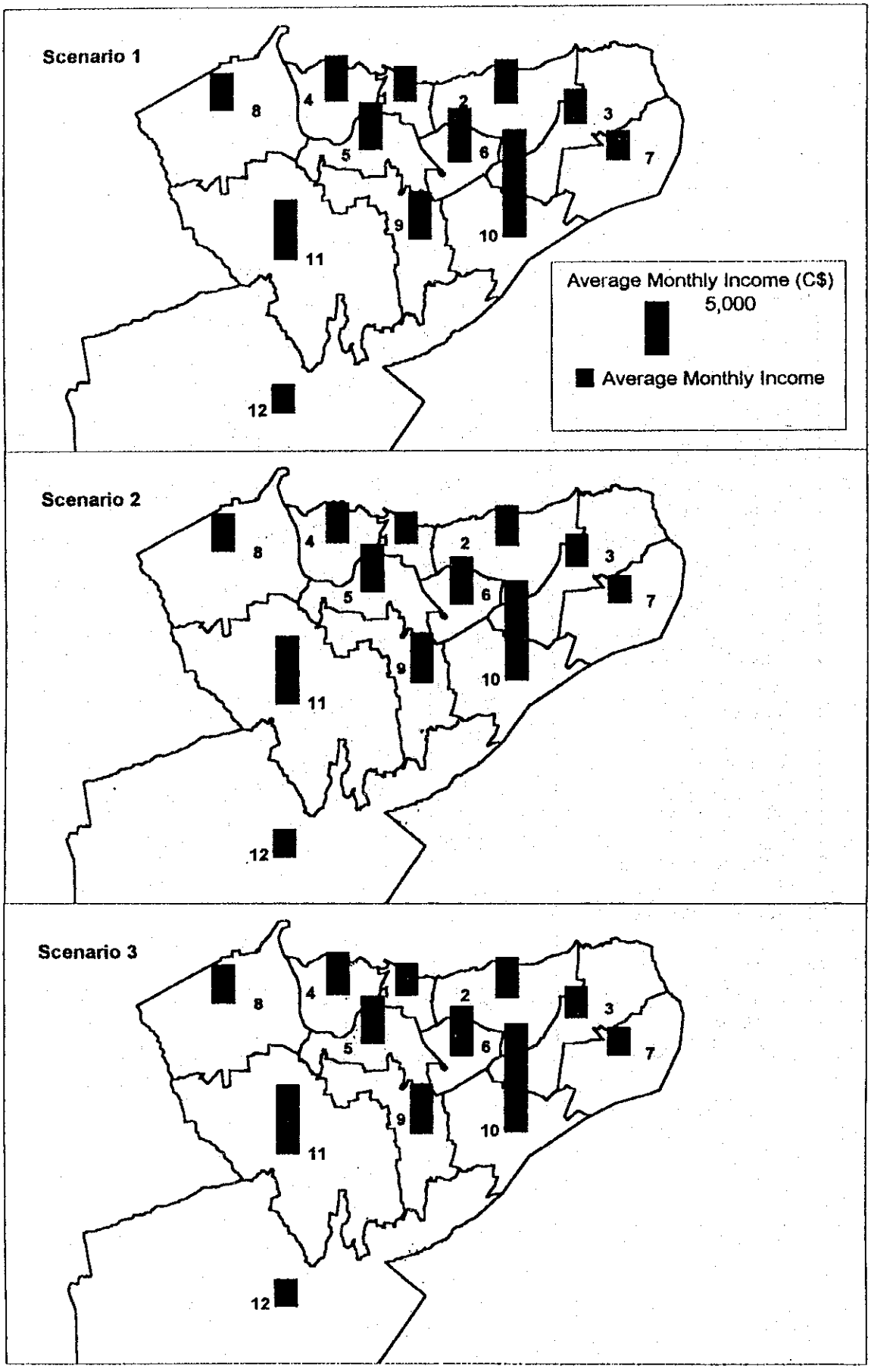
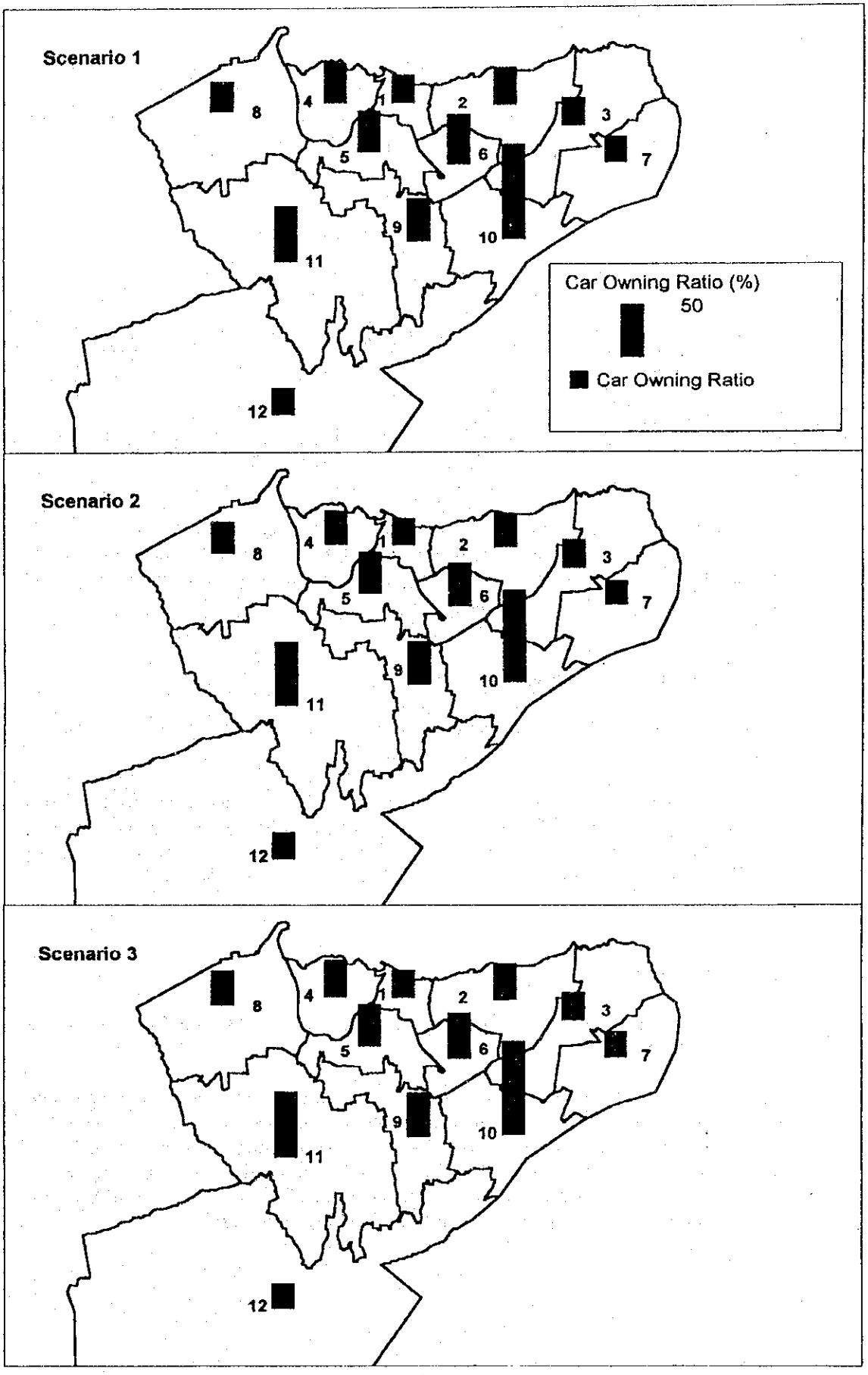


Figure 5.3.5
Car Owning Ratio by Scenario, 2018



5.4 Model Application to Alternative Development Scenarios

5.4.1 Trip Production

Since the socio-economic framework is the same for entire Managua as a whole for all the alternative scenarios, the trip production is also the same for all the scenarios. By multiplying the trip production rate by car ownership and by trip purpose, the trip production was estimated at 4.65 million a day in 2018, a shown in Table 5.4.1.

Table 5.4.1
Estimated Trip Production, 2018

Trip Purpose	Trip Production in 2018					Trips in 1998	Growth
	Non-car Owning		Car Owning		Total		
	Trip/psn.	Trips	Trip/psn.	Trips			
To Home	0.947	1,025,200	1,599	1,177,500	2,202,700	1,125,182	1.958
To Work	0.379	410,600	0.717	527,900	938,500	466,880	2.010
To School	0.347	376,100	0.524	385,400	761,500	399,436	1.906
Personal Activity	0.230	249,100	0.437	321,900	571,000	283,672	2.013
Business Activity	0.054	58,100	0.158	116,500	174,600	78,093	2.236
Total	1,957	2,119,100	3,436	2,529,200	4,648,300	2,353,263	1.975

The number of trips made by non-car owning vivienda members will increase by 30% from 1998 to 2018, while that of car owning vivienda members will grow by as much as 250%. This, however, does not mean that the intermodal relation between private and public mode would change as much.

5.4.2 Trip Generation and Attraction

Figure 5.4.1 and 5.4.2 show the distribution of estimated trip generation and attraction, respectively, in 2018 for alternative scenarios.

Scenario I shows a compact distribution of trip generation and a concentrated trip attraction around the old CBD, while in Scenario II, both trip generation and attraction shift to the peripheral areas of urbanization. Scenario III comes in between Scenario I and II, and its generation pattern is near to Scenario II while its attraction pattern to Scenario I.

5.4.3 Trip Distribution

Figure 5.4.3 and Table 5.4.2 show the estimated trip distribution by development scenario for the year 2018.

Scenario I shows the most compact trip distribution with a strong concentration around the old CBD. However, the total passenger-kms will increase by 2.9 times (2018/1998) even in this scenario. Scenario II which shows the most scattered distribution will have to carry traffic demand of about 4.1 times in 2018 as compared to 1998. In addition, the same indicator for Scenario III is 3.5. Although this is 23% larger than that of Scenario I, the traffic load in the central area seems to be less than Scenario I.

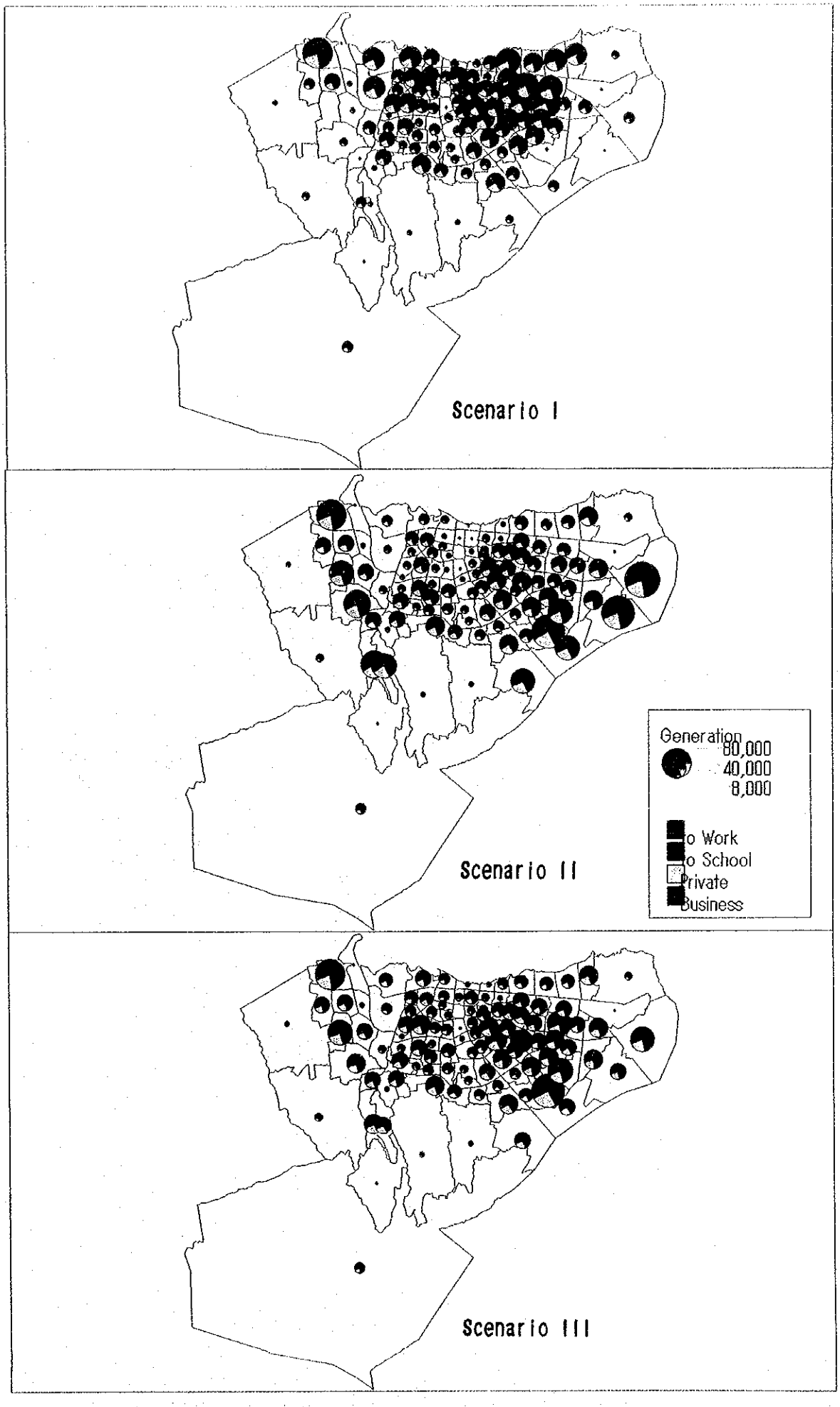


Figure 5.4.1 Trip Generation by Development Scenario, 2018

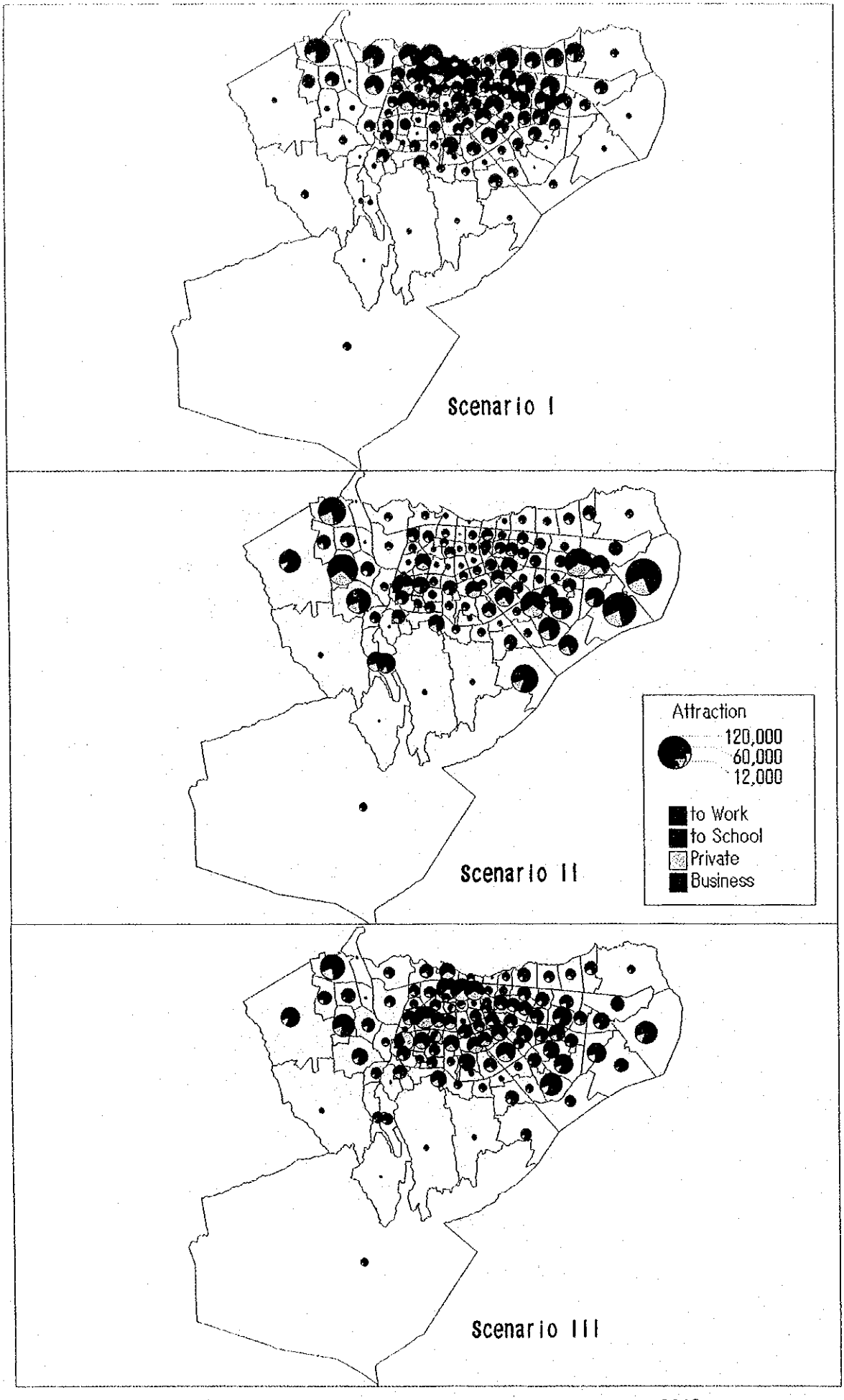


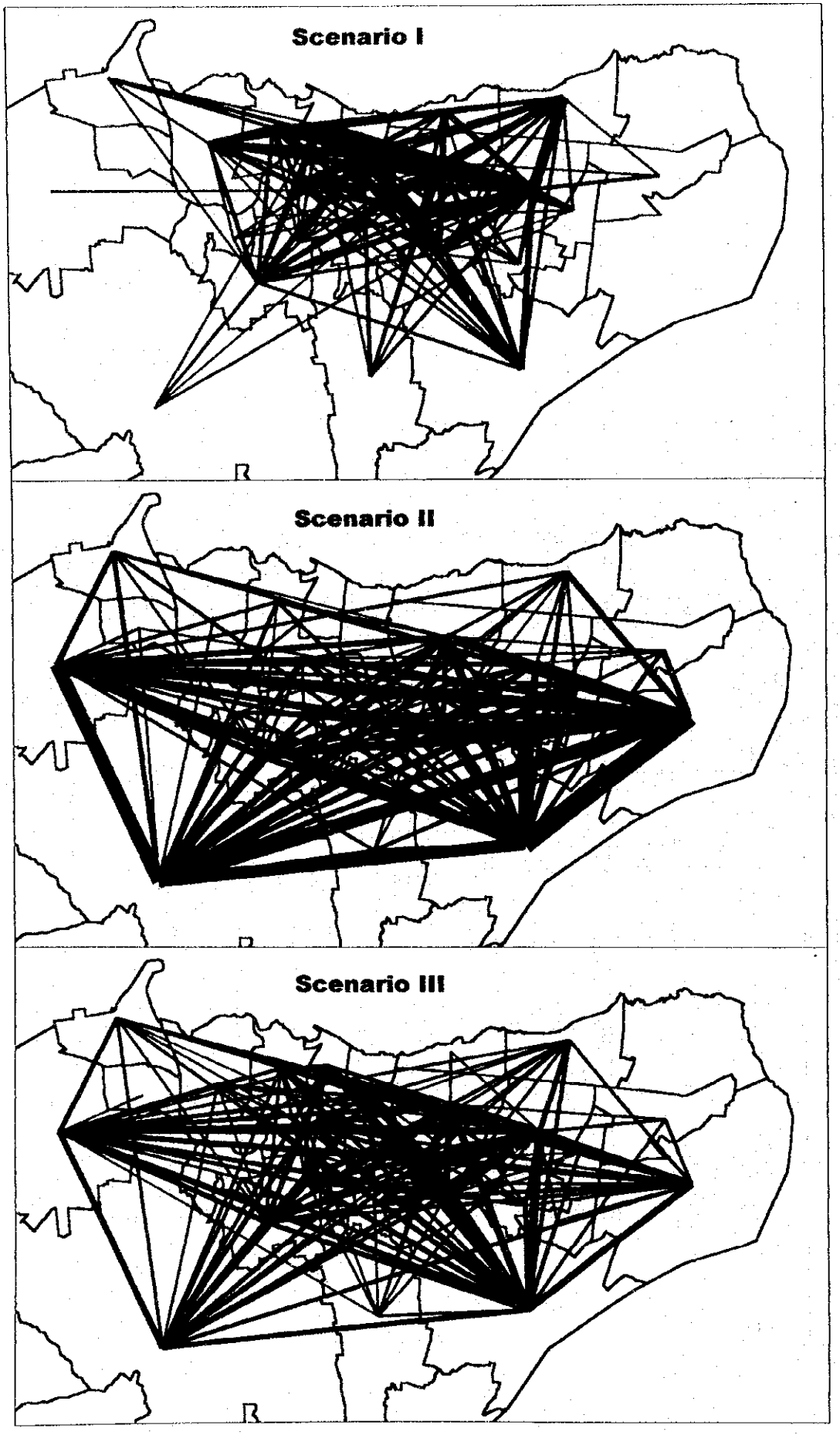
Figure 5.4.2 Trip Attraction by Development Scenario, 2018

Table 5.4.2
Average Trip Length and Trip Distance by Land Use Alternative, 2018

	Purpose	Trip Length Distribution (1,000 trips)										Trip/kms (1,000)	Average (km)
		=<1.0	=<2.0	=<3.0	=<5.0	=<7.5	=<10.0	=<15.0	=<20.0	20<	Total		
1998	to Home	146.7	184.6	156.9	220.8	123.1	33.0	12.1	0.4	0.0	877.6	2,774.5	3.16
	to Work	43.8	77.4	74.1	113.1	66.9	20.4	7.7	0.3	0.0	403.8	1,443.1	3.57
	to School	67.0	63.5	43.7	57.2	26.1	6.3	1.1	0.1	0.0	265.0	682.5	2.58
	Personal Activity	38.6	51.4	45.7	53.1	29.5	6.6	3.0	0.0	0.0	227.9	686.4	3.01
	Business Activity	8.6	12.0	14.1	15.7	10.5	3.9	1.2	0.0	0.0	66.0	231.1	3.50
	All Purpose	***304.8***	***388.8***	***334.5***	***460.0***	***256.0***	***70.3***	***25.0***	***0.8***	***0.1***	***1,840.3***	***5,817.6***	***3.16***
Scenario I	to Home	194.0	283.4	291.9	502.5	397.6	136.8	66.5	7.3	0.3	1,880.4	7,748.9	4.12
	to Work	76.8	121.0	126.9	228.8	189.8	74.3	38.5	4.4	0.2	860.6	3,772.3	4.38
	to School	76.5	89.4	91.1	156.3	115.4	47.1	22.6	2.6	0.1	601.1	2,430.6	4.04
	Personal Activity	55.4	78.5	80.1	136.6	106.5	33.4	15.5	1.5	0.1	507.6	2,029.8	4.00
	Business Activity	13.1	22.8	25.3	44.6	35.8	11.4	5.1	0.4	0.0	158.3	663.0	4.18
	All Purpose	***415.8***	***595.1***	***615.4***	***1,068.8***	***845.1***	***302.9***	***148.2***	***16.2***	***0.7***	***4,008.2***	***16,644.6***	***4.15***
Scenario II	to Home	112.9	158.0	158.6	432.2	447.8	286.7	241.9	28.1	1.8	1,868.0	11,034.5	5.91
	to Work	39.4	65.8	65.6	189.0	211.8	142.4	130.7	16.7	1.1	862.6	5,439.9	6.31
	to School	56.7	56.1	48.9	137.3	135.4	88.1	69.6	8.1	0.5	600.8	3,349.6	5.58
	Personal Activity	33.1	44.8	44.5	120.1	120.0	75.6	62.6	6.7	0.4	507.8	2,930.1	5.77
	Business Activity	6.6	11.3	12.6	37.1	39.4	26.4	22.7	2.3	0.1	158.3	980.4	6.19
	All Purpose	***248.7***	***336.0***	***330.1***	***915.7***	***954.4***	***619.3***	***527.4***	***61.9***	***4.0***	***3,997.5***	***23,734.5***	***5.94***
Scenario III	to Home	140.9	196.5	211.2	480.1	454.9	223.2	152.3	12.5	0.8	1,872.4	9,529.6	5.09
	to Work	52.5	81.1	89.1	213.4	213.6	114.9	86.6	7.7	0.6	859.5	4,688.0	5.45
	to School	59.1	67.1	67.5	153.6	129.7	71.5	47.9	3.9	0.3	600.6	2,948.9	4.91
	Personal Activity	40.9	54.8	58.1	131.2	122.1	57.3	37.1	2.7	0.1	504.4	2,492.8	4.94
	Business Activity	8.9	15.0	17.8	41.8	40.5	19.9	13.0	0.8	0.0	157.8	823.9	5.22
	All Purpose	***302.4***	***414.5***	***443.7***	***1,020.1***	***960.8***	***486.8***	***337.0***	***27.5***	***1.8***	***3,994.7***	***20,483.2***	***5.13***

Note: Trip length is measured by the crow-fly distance, not based on the actual road distance.

Figure 5.4.3 Trip Distribution by Development Scenario, 2018



5.4.4 Modal Choice

Table 5.4.3 presents the result of applying modal choice models in 2018 for three (3) alternative development scenarios.

The most outstanding fact is that the share of car will increase in any scenario compared to the current situation. In 1998, the share of car was 34.4% including walk trips and 49.5% excluding walk trips. However, these figures will be 43.8% and 58.5% respectively in Scenario I, 42.8% and 55.4% in Scenario II and 43.5% and 56.9% in Scenario III in the year 2018.

Table 5.4.3
Modal Choice by Development Alternative, 2018

Transportation Mode		Scenario I Trips		Scenario II Trips		Scenario III Trips	
		(1,000)	(%)	(1,000)	(%)	(1,000)	(%)
Non-car owning	Walk	832	37.4	753	33.7	779	35.0
	Car	338	15.2	349	15.6	344	15.4
	Bus	1,056	47.4	1,132	50.7	1,102	49.5
	Total	2,226	100.0	2,234	100.0	2,225	100.0
Car owning	Walk	377	14.7	342	13.3	352	13.6
	Car	1,763	68.5	1,711	66.4	1,746	67.7
	Bus	435	16.9	524	20.3	481	18.6
	Total	2,574	100.0	2,577	100.0	2,578	100.0
Total	Walk	1,210	25.2	1,095	22.8	1,131	23.5
	Car	2,100	43.8	2,060	42.8	2,089	43.5
	Bus	1,490	31.0	1,656	34.4	1,583	33.0
	Total	4,800	100.0	4,812	100.0	4,803	100.0

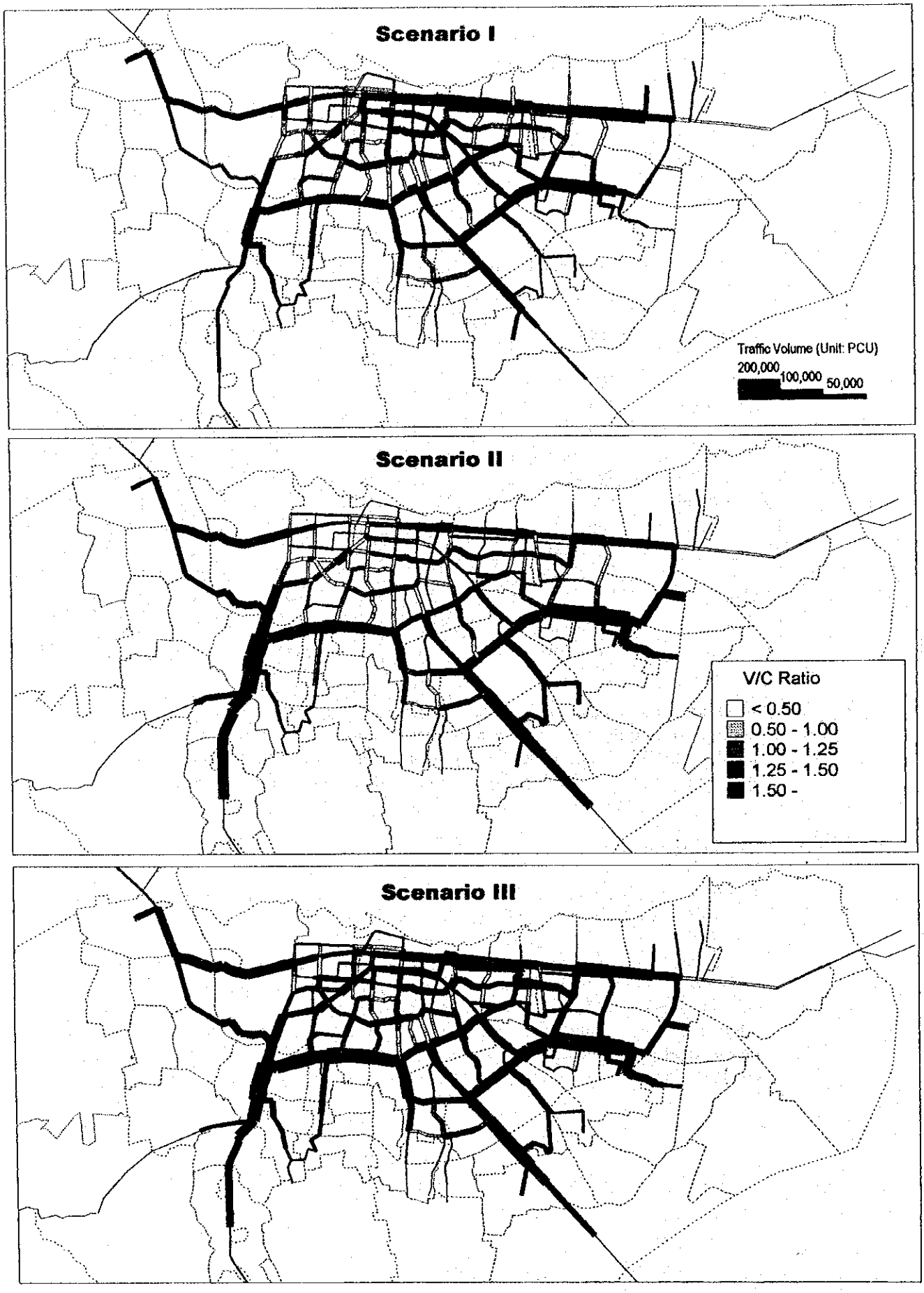
In addition, the share of bus is higher in Scenario II than in Scenario I. This seems to be contradicting to the land use scenario. It is due to the assumption that the bus fare is constant at C$1.40 flat for all the trips, longer or shorter. In the planning for master plan, this assumption shall be duly reviewed and modified for more realistic solution.

5.4.5 Traffic Assignment

Figure 5.4.4 presents the result of traffic assignment in 2018 by development scenario. The road network, however, is the existing one as of 1998.

The average volume/capacity ratio is 1.43 for Scenario I, 2.05 in Scenario II and 1.75 in Scenario III. This is an extreme traffic congestion which cannot occur in the actual situation due to the capacity constraints of road sections. This, however, tells an important fact that Managua's traffic situation will be incredibly serious in the future unless road infrastructure is developed properly in conjunction with other related countermeasures.

Figure 5.4.4 Assigned Traffic Volume by Development Scenario, 2018 (on 1998 Network)



5.5 Most Realistic Urban Development Scenario

5.5.1 Comparison of Traffic Situation

In the previous section, the alternative development scenarios were analyzed in the light of future traffic demand. Table 5.5.1 summarizes the results.

Table 5.5.1
Comparison of Traffic Situation of Development Scenarios

Indicator (on 1998 network)	1998	2018		
		Scenario I	Scenario II	Scenario III
Average Trip Length (km)	3.16	4.15	5.94	5.13
Ratio	100	131	188	162
Passenger-kms (000/day)	5,818	16,645	23,735	20,483
Ratio	100	286	408	352
Ave. Volume/Capacity Ratio	0.51	1.43	2.05	1.75
Ratio	100	280	402	343
Bus Modal Share (%)	50.5	41.5	44.6	43.1
Ratio	100	82	88	85

As is obvious in this table, Scenario I is the most effective and efficient in terms of traffic situation, although all the scenarios predict an incredibly serious traffic congestion in Managua in the future if no investment is done.. It is quite natural for Scenario I to have the best performance because it has the most compact and densest urban area. On the contrary, Scenario II shows a poor efficiency in terms of traffic due to its wide-spread urban area. If transportation infrastructure is to be developed in proportion to the network load (passenger-kms), Scenario II will require an investment 66% higher than that of Scenario I.

5.5.2 Selection of Most Realistic Development Scenario

Although Scenario I shows the best performance in relation to traffic, it is considered to be an extremity in the following aspects:

A. Scenario I assumes little urban expansion from the current situation. The predicted population increase of about 800 thousand by the year 2018 must be accommodated mostly in the existing built-up area. This needs, however, a very strong initiative and enforcement capacity of the Government.

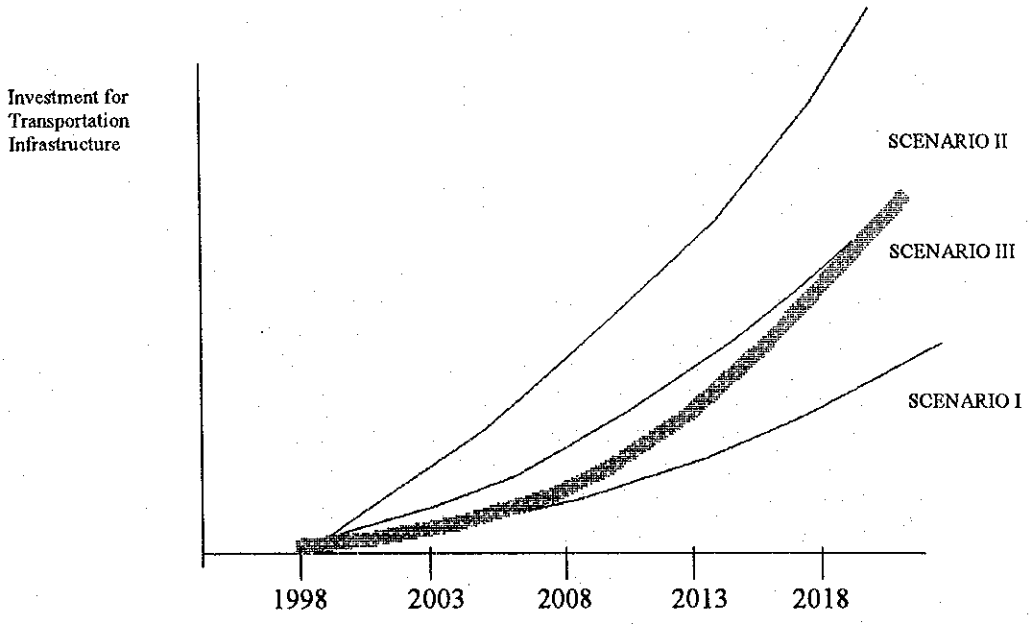
B. High density development and redevelopment assumed in Scenario I may be vulnerable to possible earthquakes.

C. Scenario I requires an urban redevelopment of about 4,000 ha while Scenario II and III assume that of about 900 ha and 1,200 ha respectively. Aside from the cost of redevelopment, an enormous difficulty is expected in legal, institutional and social aspects.

Scenario II is also an extremity in the sense that it is merely an extension of the current urbanization tendency without any strong control of the Government.

Thus, Scenario III is selected as the most realistic development scenario. The scenario assumes an ample space for the increasing population, poly-centric structure with urban axes and coordinated control on land use. Due, however, to the excellent performance of Scenario I, its concept should be taken into consideration in the short-term and medium-term when population increase is not so remarkable. This concept will be easily understood by Figure 5.5.1.

Figure 5.5.1
Concept of Combined Development
Scenarios of I and III



6. Fund Sources and Possible Investment Amount

6 FUND SOURCES AND POSSIBLE INVESTMENT AMOUNT

6.1 Possible Investment Amount by Existing Sources

6.1.1 Past Trends of Public Investment

Public investment in the Municipality of Managua is done by both Central Government and the Municipality of Managua.

1) Central Government

Table 6.1.1 shows the public investment amount from 1990 to 1997 realized by Nicaragua's central government in the Public Investment Program (PIP, Programa de Inversiones Públicas). Since 1990, it grew rapidly until 1995, then has decreased in 1996 and 1997 considerably in terms of US$. Economic infrastructure shares about 50% followed by social infrastructure at about 28%.

Table 6.1.1
Actual Investment Amount by Sector,
Public Investment Program of Nicaragua.

(C$ million)

SECTOR / INSTITUTION	PROGRAM 1990-1997									
	1990	1991	1992	1993	1994	1995	1996	1997	1990-1997 Total	1990-1997 %
Economic Infrastructure	26.3	180.1	556.3	746.6	975.7	1,101.4	1,143.0	1,052.8	5,782.2	50
Social Infrastructure	27.5	123.3	192.7	386.0	586.7	672.5	667.7	538.9	3,195.2	28
For Production	4.3	57.0	136.4	272.5	347.4	530.3	370.1	648.9	2,366.9	21
National Service		2.6	17.9	5.8	30.9	32.3	30.6	21.5	141.7	1
Total	58.1	363.0	903.3	1,410.9	1,940.7	2,336.5	2,211.4	2,262.0	11,485.9	100
Rate of Increase (%)		524.5	148.8	56.2	37.6	20.4	-5.4	2.3	-	-
Total (in US$ million)	58.1	72.6	180.7	230.5	288.8	310.3	262.3	239.4	1,642.7	-

Source: Ministry of Economy and Development
Note: Exchange Rate for US$:
1990 1.00, 1991 5.00, 1992 5.00 1993 6.12,
1994 6.72, 1995 7.53, 1996 8.43, 1997 9.45.

Nicaragua's public investment by the central government has been highly dependent on external sources as shown in Table 6.1.2. About 2/3 of external loans are from bilateral sources. Before 1995, ex-socialist nations including Russia and Cuba had been playing a major role.

Table 6.1.2
Composition of Fund Sources in Actual Investment Amount,
Public Investment Program of Nicaragua.

(%)

	PROGRAM 1990-1997								
	1990	1991	1992	1993	1994	1995	1996	1997	Total
Internal	67	47	53	29	23	16	21	20	25
External	33	53	47	71	77	84	79	80	75
- Donations	18	28	12	27	28	32	41	36	31
- Loan	15	25	35	44	49	52	38	44	44
Total	100	100	100	100	100	100	100	100	100

Source: Ministry of Economy and Development

2) MTI

With regard to the public investment on the transportation infrastructure, MTI is the agency in charge. Table 6.1.3 presents the historical data on the amount invested by MTI from 1990 to 1997.

The MTI investment has been increasing and they are invested mostly for the land transportation. Its dependency on external funds is large at about 60%.

Table 6.1.3
Investment Amount by MTI, Public Investment Program of Nicaragua.

	1990	1991	1992	1993	1994	1995	1996	1997
Total (C$000)	2,208.8	59,406.2	160,771.1	241,211.6	269,402.6	297,112.2	434,666.1	438,689.0
Total (US$000)	2,208.8	11,881.2	32,154.2	39,413.7	40,089.7	39,457.1	51,561.8	46,422.1
Internal Fund (%)	100	84	87	36	46	35	33	43
External Fund (%)	0	16	13	64	54	65	67	57
Land Transportation (%)	81	78	73	67	85	95	95	94
Others (%)	19	22	27	33	15	5	5	6

Source: Ministry of Economy and Development

In relation to Managua, however, the role of MTI is rather limited. Judging from the project records of MTI, the share of Managua in the MTI's investment was 7.4% in 1997. Moreover, most of this was invested on the maintenance of rural and interurban roads, not for urban transportation infrastructure. Table 6.1.4 shows the planned investment of MTI for the period 1998 to 2002. Note, however, that this plan is still tentative showing only the confirmed projects. It is observed that MTI's investment is on an increasing tendency. The dependency on external funds is likely to decrease. The share of Managua seems to be smaller than at present.

Table 6.1.4
Planned Investment Amount by MTI (Tentative), Public Investment Program of Nicaragua, June 1998.

	1998	1999	2000	2001	2002
MTI Total (C$000)	448,414	576,360	248,385	231,934	17,570
MTI Managua (C$000)	25,114	27,342	-	-	-
(%)	5.6	4.7	-	-	-
of which % Internal	78	N/A.	-	-	-
% Land Transport	100	N/A.	-	-	-

Source: Ministry of Economy and Development

3) Municipality of Managua

Table 6.1.5 shows the public investment amount realized by the Municipality of Managua from 1990 to 1997. The amount has been largely fluctuating and the share of transportation infrastructure jumped up suddenly in 1997. Those investments were done mostly by internal fund sources of Nicaragua.

Table 6.1.5
Public Investment by Municipality of Managua

	1990	1991	1992	1993	1994	1995	1996	1997
Total (C$000)	14,207	52,113	51,059	28,253	21.051	48,563	47,740	41,584
Total (US$000)	14,207	10,423	10,212	4,617	3,133	6,449	5,663	4,400
% Transportation *	53.3	7.6	7.0	1.0	5.2	3.2	1.0	56.1

Source: ALMA
Note: * Estimated as 100% of "Vialidad" and 90% of "Mantenimiento".

For the five-year period of 1998-2002, the Municipality of Managua assumes yearly investment of the same level as in 1997 in terms of US$.

4) Summary

For the transportation infrastructure in the Municipality of Managua, the Municipality invested about US$5 million in 1990. However, the Municipality's transportation investment has been minimal from 1991 to 1996. During this period, MTI seems to have invested more steadily, but this was mainly for the maintenance of rural and interurban roads. In 1997, the amount has suddenly increased both from MTI and ALMA, as shown in Table 6.1.6. The reason of this jump is not clear, but it may be related to the new government established in 1997.

Table 6.1.6
Estimated Public Investment on Transportation Infrastructure
In the Municipality of Managua.

(US$ million)

	1990	1991	1992	1993	1994	1995	1996	1997
MTI	0.7	1.8	0.3	0.5	0.4	1.1	1.1	3.4
Municipality (ALMA)	5.0	0.8	0.7	0.0	0.2	0.2	0.1	2.5
Total	5.7	2.6	1.0	0.5	0.6	1.3	1.2	5.9

Source: Estimated based on project records of MTI and ALMA.

6.1.2 Estimate of Possible Future Investment on Transportation Sector of Managua

1) Assumptions

This section aims to estimate the possible investment amount in the future on transportation infrastructure of Managua. However, this task is extremely difficult due to the following reasons:

1. The past trends of investment shows a large fluctuation reflecting the scarcity of funding resources and the lack of political continuity.

2. Although the dependency on external sources has been low in the investment on the transportation sector of Managua, its influence, if any, will be remarkable due to comparatively large scale of investment.

3. The guideline set by IMF is prohibitive for international funding organizations (World Bank, Inter-American Development Bank, etc.) and bilateral sources to arrange new loans for the Government of Nicaragua. This guideline will be lifted in the near future. The date, however, is not known yet.

Under these circumstances, the following assumptions have been introduced to estimate the possible amount of investment on the transportation sector of Managua:

A. Investment funded by internal sources will grow in proportion to future GRDP of Managua.

B. Investment funded by external sources on grant basis will be double of the committed amount from 1999 to 2002. From 2003, the amount will grow in proportion to future population of Managua.

C. Investment funded by external loans will start in 2003 at US$10 million, and will grow in proportion to future GRDP of Managua

2) Possible Future Investment in the Transportation Sector of Managua

Based on the assumptions above, the possible amount of investment on the transportation sector of Managua can be estimated as indicated in Table 6.1.7. It should be noted, however, that this is a hypothetical calculation based on a number of assumptions. If 30% allowance is admitted, the budget envelope can be estimated as shown in Table 6.1.8.

Table 6.1.7
Possible Investment Amount in Transportation Sector of Managua at 1998 Prices.

Year	Internal		External Grant		External Loan		Total
	% Growth	US$ million	% Growth	US$ Million	% Growth	US$ Million	(US$ million)
1997		5.9		1.5		-	7.4
1998	5.5	6.2		5.9		-	12.1
1999	5.5	6.6		5.9		-	12.5
2000		6.9		5.9		-	12.8
2001		7.3		5.9		-	13.2
2002		7.7		5.9		-	13.6
2003		8.1	2.9	6.1		10.0	24.2
2004	5.7	8.6	2.6	6.3	5.7	10.6	25.5
2005		9.1		6.4		11.2	26.7
2006		9.6		6.6		11.8	28.0
2007		10.2		6.8		12.5	29.5
2008		10.7		6.9		13.2	30.8
2009	5.7	11.3	2.4	7.1	5.7	13.9	32.3
2010		12.0		7.3		14.7	34.0
2011		12.7		7.4		15.6	35.7
2012		13.4		7.6		16.5	37.5
2013		14.2		7.8		17.4	39.4
2014	5.8	15.0	2.1	8.0	5.8	18.4	41.4
2015		15.9		8.1		19.5	43.5
2016		16.8		8.3		20.6	45.7
2017		17.7		8.5		21.8	48.0
2018		18.8		8.7		23.1	50.6

Table 6.1.8
Budget Envelope for the Transportation Sector of Managua at 1998 Prices

(US$ million)

Year / Period	Low	Medium	High
1997	-	7.4	-
1998	8.5	12.1	15.7
1999 - 2003	53.4	76.3	99.2
2004 – 2008	98.4	140.5	182.7
2009 – 2013	125.2	178.9	232.6
2014 – 2018	160.4	229.2	298.0

Note that a considerable percentage (presumably 30-40%) of this amount goes to the maintenance of existing transportation infrastructure.

6.2 Possible New Fund Sources

In the previous section of this report, possible future investment on transportation infrastructure has been estimated. The estimate methodology was basically an extrapolation of past trends, and, to be more important, it was an estimate for the existing public fund sources.

This section, however, intends to preliminarily analyze and evaluate the possibility and magnitude of "new" fund sources. The meaning of "new" is twofold:

A. Existing taxes and levies with increased rates.
B. New sources including tolls, TDM charges and private sector investment.

6.2.1 Existing Taxes and Duties with Increased Rates

1) Municipal Taxes and Duties

In relation to the development of transportation infrastructure, the municipal taxes and levies (see Table 6.2.1) of which rates can be reasonably increased are:

A. Sales Tax (Impuesto sobre ventas) on vehicles and fuel.
B. Real Property Tax (Impuesto bienes inmuebles).
C. Road user tax (Impuesto al rodamiento).

Sales Tax on Vehicles and Fuel

- At present, a 1.5% municipal tax is imposed on the sales amount materialized in Managua based on a decree (Decreto No.10-91, Plan de Arbitrios del Municipio de Managua). This is applied also to vehicles and fuel. Judging from the international comparison of prices of car and gasoline shown in Table 6.2.2 and 6.2.3, it seems realistic to raise the rate of taxation, particularly for car.

- However, this has been excluded due to the following reasons:

1. Raising the rate of this tax needs amendment of the decree. The decree has been amended just recently (January 1998) to lower the taxation rate from 2% to 1.5%.

2. If taxation rate is raised in Managua, people will buy vehicles and fuel outside Managua. This may cause serious objections in the existing business establishments of Managua, and may distort the economic activities in Nicaragua. If this is necessary, it is reasonable to tackle the issue from the national point of view.

Real Property Tax

- At present, 1% real property tax is imposed every year on the cadastral value of the property excluding those of under a certain threshold. When transportation infrastructure is constructed, it is natural to raise the cadastral value of the property of beneficiaries since its value will increase to a certain extent by the development.

- The possible revenue increase due to road development in the year 2018 can be roughly estimated as follows:

Table 6.2.1
Annual Income of Municipality of Managua, 1990-1997

(US$)

CONCEPT	1990	1991	1992	1993	1994	1995	1996	1997
Sales Tax	7,261,000.00	12,960,963.00	20,561,078.00	17,397,383.00	17,565,502.00	17,640,310.00	18,326,433.00	19,206,807.00
Registration & Licenses	397,140.00	1,453,432.00	2,233,304.00	1,472,596.00	1,710,068.00	1,871,297.00	1,836,918.00	1,520,810.00
Real State Tax	-	-	3,302,973.00	2,398,151.00	2,608,899.00	1,517,091.00	1,760,555.00	2,492,295.00
Road User Tax	-	-	2,568,147.00	1,684,314.00	1,281,193.00	1,196,287.00	487,287.00	645,076.00
Litter fare	-	-	-	808,556.00	1,335,138.00	1,421,540.00	867,885.00	991,688.00
Services Fare	398,890.00	1,846,903.00	3,218,127.00	493,312.00	412,386.00	348,755.00	300,870.00	317,382.00
Property Rentals	14,160.00	80,337.00	75,598.00	51,814.00	77,481.00	75,090.00	68,848.00	88,463.00
Various Tax	66,750.00	354,745.00	519,278.00	241,750.00	330,037.00	363,504.00	414,980.00	388,686.00
Fines	124,270.00	203,559.00	415,358.00	365,737.00	286,801.00	456,604.00	294,874.00	407,277.00
Cemetery Administration	22,150.00	109,171.00	136,663.00	107,978.00	107,966.00	146,351.00	199,319.00	207,252.00
Other Incomes	188,100.00	6,439,686.00	475,594.00	1,419,821.00	461,281.00	797,709.00	718,791.00	667,616.00
TOTAL	8,472,460.00	23,448,796.00	33,506,120.00	26,441,412.00	26,176,752.00	25,834,538.00	25,276,760.00	26,933,352.00

Source: ALMA

Table 6.2.2
Comparison of Car Price, June 1998 (Toyota Corolla, 98)

(US$)

CITY	*COUNTRY*	*PRICE*
Managua	Nicaragua	16,050
Mexico City	Mexico	19,418
San Jose	Costa Rica	29,500
Tegucigalpa	Honduras	27,894
Panama	Panama	17,000
Guatemala	Guatemala	25,000
Caracas	Venezuela	23,000
Quito	Ecuador	26,950
Bogota	Colombia	23,840
Rio de Janeiro	Brazil	35,480
Lima	Peru	23,480
Asuncion	Paraguay	26,730
Santiago	Chile	15,132
Montevideo	Uruguay	48,000
La Paz	Bolivia	36,000
Buenos Aires	Argentina	25,800
Miami	USA	19,200

Source: Tiempos del Mundo, June 11, 1998

Table 6.2.3
Comparison of Gasoline Price, June 1998

(US$/gallon)

CITY	*COUNTRY*	*PRICE*
Managua	Nicaragua	1.90
Mexico City	Mexico	1.78
San Jose	Costa Rica	1.44
Tegucigalpa	Honduras	1.98
Panama	Panama	1.75
Guatemala	Guatemala	2.00
Caracas	Venezuela	0.65
Quito	Ecuador	1.12
Bogota	Colombia	1.71
Rio de Janeiro	Brazil	0.68
Lima	Peru	2.90
Asuncion	Paraguay	1.94
Santiago	Chile	2.22
Montevideo	Uruguay	4.40
La Paz	Bolivia	2.04
Buenos Aires	Argentina	3.70
Miami	USA	1.49

Source: Tiempos del Mundo, June 11, 1998

<ASSUMPTIONS>

- Length of road to be constructed or improved: 50 km. by 2003, 144 km. by 2008 and 327 km. by 2018 (see Section 7.2).
- Definition of area of beneficiaries: 100 m from the road on both sides.
- Property price: US$20/m^2 on average.
- Rate of increase in cadastral value: 30%
- Rate of capture: 50%

<ESTIMATE>

- Annual revenue:

2003	US$ 0.3 million/year
2008	US$ 0.9 million/year
2018	US$ 2.0 million/year

- Revenue by period:

Short-Term	US$ 0.9 million
Medium-Term	US$ 3.3 million
Long-Term	US$12.9 million
Total	US$17.1 million

- This revenue that seems hopeful, however, needs further investigation on the following aspects:

  - How to define the area of beneficiaries.
  - How to evaluate the magnitude of benefit.
  - How to maintain and update the cadastral records in a timely manner.

- In many of latino-american countries, there is a system called "valorización" (evaluation) which intends to capture the indirect benefit of transportation

infrastructure development enjoyed by property owners in order to cover the construction cost. Also in Managua, there is a "special contribution" system to cover the pavement cost up to 80%. This, however, is only for local road (calle), sidewalk and side ditch, and, moreover, it is not applied actually in the current administrative set up. This system needs to be improved and utilized positively to cover infrastructure development cost even partially.

Road User Tax

- This tax is currently collected yearly from all the vehicles plying on roads in Managua according to the rates determined by the Municipality of Managua (see Table 6.2.4). The rates are considered still low and could be raised gradually to cover partially the cost of transportation infrastructure development and maintenance. If private car use is to be discouraged, the rates for private vehicles should be raised considerably.
- At present the revenue of this taxation is raised from private vehicles by about 2/3. If the tax rate is doubled for private vehicles, the revenue increase in 2018 can be roughly calculated as follows:

<ASSUMPTIONS>

- Revenue from road user tax in 1998: US$0.7 million
- Share of private vehicles: 2/3
- Increase of private vehicles: 1.6 times in 2003, 2.5 times in 2008 and 4.0 times in 2018.

<ESTIMATE>

- Annual revenue:

2003	US$ 0.7 million/year
2008	US$ 1.2 million/year
2018	US$ 1.9 million/year

- Revenue by period:

Short-Term	US$ 2.1 million
Medium-Term	US$ 4.5 million
Long-Term	US$15.6 million
Total	US$22.2 million

2) National Taxes and Duties

The following three (3) tax items are related to transportation (see Table 6.2.5):

A. General Value-Added Tax (IGV) on vehicles.
B. Petroleum Consumption Tax (Impuesto Específico al Consumo, IEC).
C. Import Duty (Tributario Sobre Importaciones) on vehicles.

Table 6.2.4
Road User Tax, 1997

TYPE OF VEHICLE	TAX
Private Use Vehicle	
Car and Vehicle Rent/Car	250.00
Pick-up Family Use	250.00
Jeep	150.00
Microbus family use	300.00
Motorcycle	125.00
Commercial Use Vehicle	
Taxi	123.00
Microbus Commercial Use	367.00
Buses	489.00
Pick-ups 2-1/2 Tons	178.00
Trucks 2 to 5 Tons	245.00
Trucks 5-1/2 to 7 Tons	300.00
Trucks 7-1/2 to 10 Tons	489.00
Trucks 10-1/2 to 15 Tons	611.00
Trucks 15-1/2 to 22 Tons	923.00
Trailer	167.00
Construction Equip.	56.00
Fork-lift	278.00
Towing	278.00
Agricultural tractors	167.00

Source: ALMA

Table 6.2.5
Annual Income of Nicaragua's Central Government, 1990-1997

(US$ million)

CONCEPT	1990	1991	1992	1993	1994	1995	1996	1997
Income Tax	45.8	41.0	61.3	43.6	39.1	53.2	60.6	71.5
IGV	26.9	31.8	42.3	52.4	52.7	54.4	61.5	74.4
Consumption Tax on Petroleum	29.5	41.8	59.5	66.9	76.4	76.3	79.1	90.9
Consumption Tax on Others	50.8	71.8	100.9	75.5	83.0	85.8	83.8	95.0
Import Tax	32.4	53.3	72.8	72.5	76.8	90.2	92.3	112.0
Other Taxes	20.3	23.7	19.0	26.2	26.5	29.7	31.7	21.1
No Tax Income	23.5	23.0	20.2	16.4	17.2	18.0	18.9	25.7
Capital Gains Tax	-	2.9	2.5	9.6	4.7	9.0	5.0	2.6
TOTAL	229.2	289.3	378.5	363.1	376.4	416.6	432.9	493.2

Source: MIFIN

General Value-Added Tax

- This tax is imposed on almost all goods and services at a rate of 15%. However, for petroleum, the tax is substituted by petroleum consumption tax (IEC).
- Judging from the international comparison of car prices (see Table 6.2.2), there seems to exist a large room for imposing more tax on the sales of vehicles.
- However, it is not recommended to change the rate or structure of this tax in relation to vehicles. Aside from the institutional amendment needed to do so (creation of another IEC, etc.), the same effect could be obtained by increasing the import duty.

Petroleum Consumption Tax

- At present, different rates are applied by type of petroleum product (see Table 6.2.6). Basically, the rate is high for transportation use, and its share in consumer price is about 40% (diesel) to 45% (gasoline).

Table 6.2.6
Petroleum Consumption Tax, 1998

PRODUCT	IEC (US$/GAL)
Liquid Gas (GLP)	0.0000
Aviation Gasoline (AVGAS)	0.9027
Super Gasoline	0.8019
Regular Gasoline	0.7989
Kerosene	0.4224
Turbo	0.5489
Turbo Jet	0.0087
Diesel	0.5578
Fuel Oil (Power)	0.0000
Fuel Oil (Other Uses)	0.1888
Asphalt	0.4658
Varsol (Thinner)	0.1726
H. H. A. Other Dissolvent	1.2267

Source: MIFIN

- In comparison with other countries, the fuel price in Nicaragua is not so low. This may suggest that there is no ample room for further raising the price. However, if the use of private vehicles should be restricted, the fuel price (particularly gasoline) would have to be raised to a reasonable extent.

- Recently, a Road Maintenance Fund (Fondo de Mantenimiento Vial) was proposed by MTI backed by World Bank, Interamerican Development Bank and other international organizations. This proposal intends to collect funds by raising the rate of this tax by 10-15% reportedly.

- If the rate increase is 10%, the revenue will increase by about US$10 million in 1998 and the order of US$40 million in 2018. The total revenue is likely to reach US$63 million in the short-term, US$100 million in the medium-term and US$312 million in the long-term.

- In general, the economic efficiency of road maintenance projects is very high compared to road construction. Therefore, the creation of the Road Maintenance Fund earmarked for road maintenance is an agreeable proposal for Managua, if the fund is allocated to Managua reasonably (say, in proportion to fuel consumption).

Import Duty

- At present, import duty is not imposed on fuel (again covered by IEC mentioned above) and the taxation rate for imported vehicles is 9 to 20% by vehicle type. As pointed out earlier, the price of vehicles in Managua is low.

- If vehicle price could be raised by 20% to an internationally comparable level (the same as Mexico City, still lower than most of other latino-american countries), the potential of revenue increase will be very large at around US$30 million in 1998 and presumably around US$120 million in 2018. The total revenue is likely to reach US$190 million in the short-term, US$300 million in the medium-term and US$940 million in the long-term.

- In order to realize the above, existing laws and regulations must be amended (such as Ley 257, Ley de Justicia Tributaria y Comercial and Decreto No.37-97, Reglamento a la Ley de Justicia Tributaria y Comercial).

6.2.2 New Fund Sources

This section discusses qualitatively on the possible new sources of funding.

1) Tolls

The candidate toll road in Managua is the planned Travesía. Assuming the opening of the toll road in 2014, the total toll revenue in the long-term period (2009-2018) will be around US$66 million (see Section 7.2).

2) TDM Charges

A variety of TDM measures can be conceived in Managua. The following is the representative ones.

A. Road Pricing
B. Parking Pricing

Road Pricing

- The candidate roads to be priced need to be identified after careful investigation in relation to social consensus and possible impact on urban road network. Based on the concept of Public Transportation–Based City, the determined Public Transportation Corridors will be suitable for application.

- If this TDM measure is applied, its revenue potential is generally very large. However, its implementation must be done on clearly determined target roads not to bring about negative economic impacts.

Parking Pricing

- This measure aims to discourage car use in a specified area by charging additionally on the provision of parking spaces beyond a certain threshold (possibly the Mandatory Parking Provision determined by the Plan Regulador de Managua).

- In general, the impact on traffic and revenue potential by this TDM measure are small as compared to road pricing. When problem area is identified, this can be one of the possible countermeasures.

3) Private Sector Investments

- This is a concept of using financial resources of the private sector for the development of transportation facilities. In the world, this is seen typically in construction/operation of:

  A. Toll Roads.
  B. Railways.
  C. Terminals and Stations.
  D. Others (Airports, Ports, etc.).

- In Managua, this concept may be adopted in developing toll roads, busways (or railways in the future) and bus terminals. Presumably, however, 100% privately operated projects may be difficult financially, socially and institutionally. After assessing the proposed projects economically and financially, suitable strategies and policies are later recommended in this Study regarding the private sector participation.