3.2.3. EXPANSION

The Person Trip survey is a sample survey. Therefore, the expansion is needed as the expanded information will represent the whole population in the Study area. The expansion is in general related closely to the methodology of sampling. The way of sampling applied in the Study is called "Area Sampling" and the sample size is examined based on the population by traffic zone. Therefore, the population-based expansion is employed after the consideration of several means of expansion.

3.2.4. CALIBRATION

The Study Team applies two different ways of calibration; (1) screen line calibration and (2) calibration at the sections on the trunk road. For the screen line calibration, two imaginary lines: Rímac river screen line and Av. Pan Americana Sur screen line, separating the Study area into two areas, are adopted. After the screen line calibration is done, the origin and destination matrices were assigned on an existing network by using a highway assignment technique. Then, the assigned traffic volume calculates by the technique is compared with the result of the traffic count survey. This is the calibration at the sections on the trunk road.

(1) Screen Line Calibration

The Person Trip survey is conducted with the sampled household, and it is expanded to represent the whole of the trips traveled in the Study area. Therefore, the expanded data may sometimes have bias. The screen line calibration aims to check the accuracy of the Person Trip data and adjust it by comparing it with the screen line traffic volume to reflect the actual situation.

Table 3.2-2 shows the result of the screen line adjustment done according to the comparison explained above.

Table 3.2-2 Calibration on Screen Line at Rimac River

Transport Mode	Person Trip Survey			Traffic Count Survey	Adjustment Factor
	N → S	S → N	Total	(000)	
Motorcycle	1.6	1.6	3.2	6.3	1.98
Moto-taxi	2.3	1.8	4.1	1.6	0.39
Car	78.6	77.5	156.1	345.6	2.21
Taxi	50.0	52.7	102.8	245.7	2.39
Combi	326.7	316.8	643.5	896.4	1.39
Microbus	490.5	488.0	978.5	1,005.3	1.03
Bus	144.3	141.6	285.9	751.4	2.63

(2) Calibration by Traffic Volume Counted

Figure 3.2-2 shows the sections where the traffic volume assigned is compared with the observed traffic volume. The result of the comparison is shown in Figure 3.2-3. Statistical fitness is indicated at 0.86, which means the calibration is effectively done.
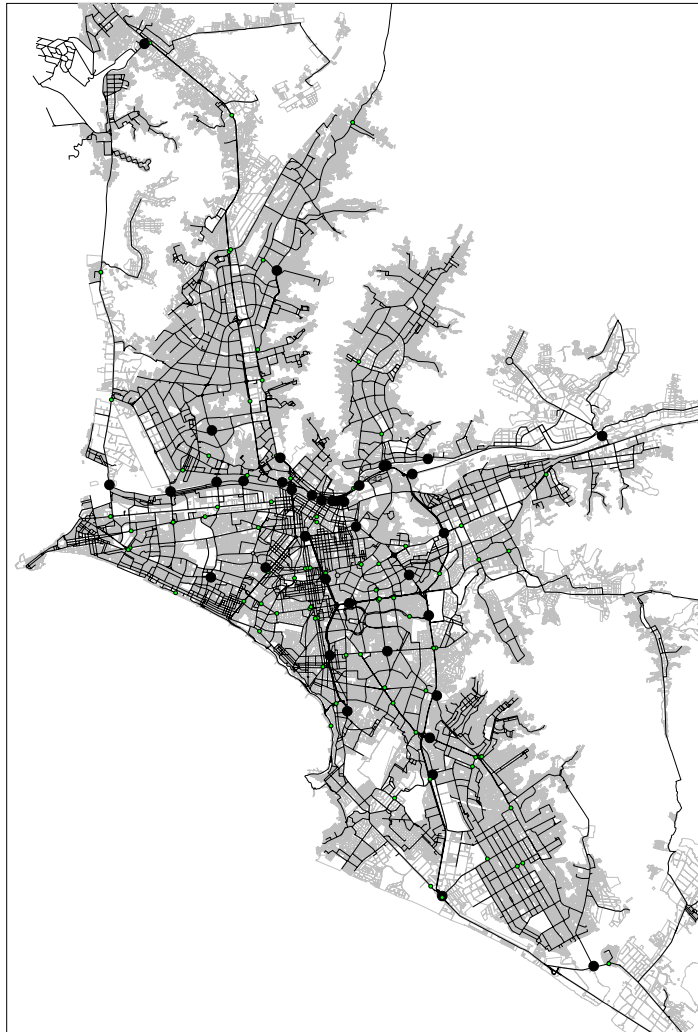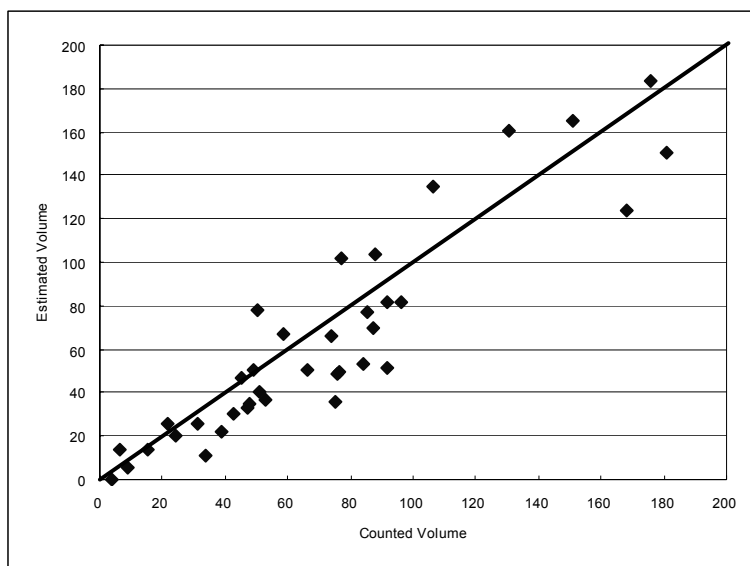
Figure 3.2-2 Calibration Points

Figure 3.2-3 Fitness

3.2.5. ANALYSIS OF ESTRATO

The socio-economic level of the household is one of the important factors, not only for the analysis of existing situations but also for building models of future traffic demand forecast. The concept of ESTRATO prevails in this country. However, there is hardly a defined and established methodology for the analysis. Therefore, the Study Team applied the proposal of the survey company conducting the Person Trip survey.

(1) Methodology

The methodology to group all households surveyed into five according to the economic level is as follows:

1) All households were divided into 20 groups by using "Cluster" analysis with the following variables.

   a) Household income
   b) Level of education of household leader
   c) Housing conditions
   d) No. of rooms
   e) Vehicle ownership
   f) Ownership of electrical appliances

2) The twenty groups are lined up in order, of higher income level and are grouped into five, by gathering the nearest groups considering the distance calculated by "Cluster" analysis.

(2) Distribution

The result of the "Cluster" analysis is shown in Table 3.2-3. The ratio of A-class household, the highest level, indicates 3.6% while Estrato E, the lowest, indicates 16.8%.

Table 3.2-3 Distribution of Households by Estrato

ESTRATO	Households		Population	
	No.	Rate (%)	No.	Rate (%)
A	63.7	3.6	305.5	3.8
B	283.3	15.8	1,330.3	16.5
C	439.2	24.5	1,871.6	23.3
D	706.4	39.4	3,306.9	41.1
E	301.6	16.8	1,228.8	15.3
Total	1,794.3	100.0	8,043.1	100.0

3.3. URBAN TRANSPORT DEMAND CHARACTERISTICS

3.3.1. SOCIO-ECONOMIC PROFILE OF RESIDENTS

(1) Demographic Features

The total population in the Study area is estimated at 8,043 thousand habitants, while there are 7,160 thousand habitants in the province of Lima and 883 thousand habitants in the province of Callao respectively. The total number of households can also estimated at 1,794 thousand based on the average number of members in the households obtained by the Person Trip survey.

The population structure is illustrated in Figure 3.3-1. The highest age group is from 20 to 24 years old, representing 10% to whole population. The ratio of working age group ranging from 15 years old to 60 indicates 66% and the ratio of old people ranging more than 60 years is 10%.

Figure 3.3-2 shows the change of population distribution by age group between 1993, in which National Census was conducted, and 2004.

Table 3.3-1 Population and Households

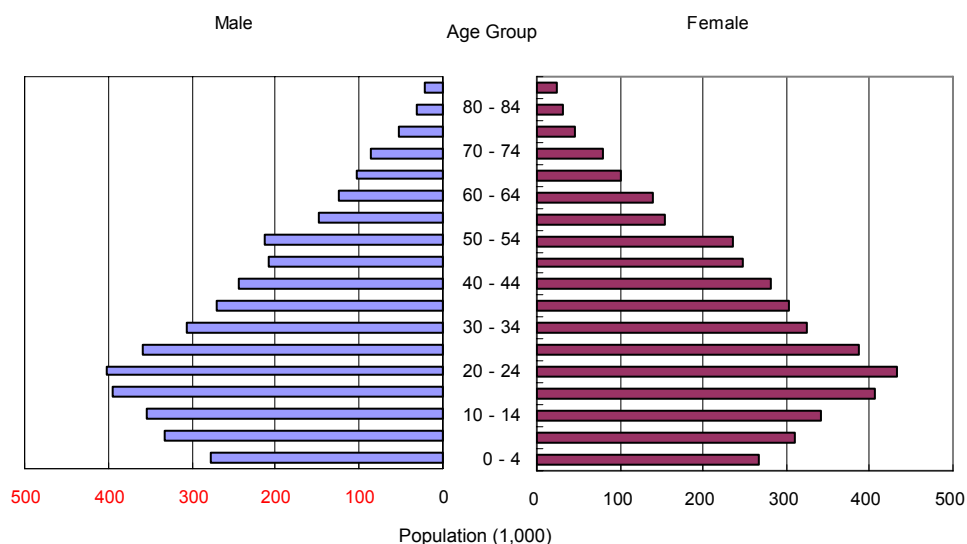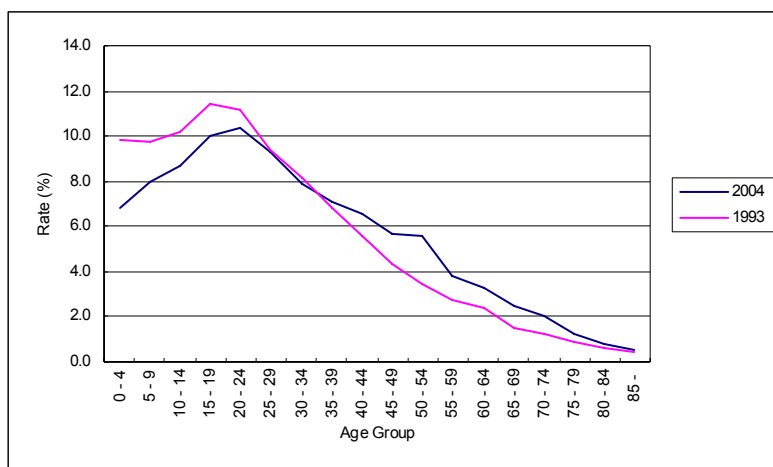| Area	Population (000)	Population 6 yrs old and above		No. of Households (000)	Average Household Member
		Male (000)	Female (000)		
Lima	7,160	3,200	3,376	1,608	4.5
Callao	883	386	411	186	4.7
Study Area Total	8,043	3,586	3,788	1,794	4.5
Ratio (%)		48.6	51.4		

Figure 3.3-1 Population Structure

Figure 3.3-2 Changes from CENSUS in 1993

The gainful worker ratio, which can be calculated with the number of workers divided by the population more than 15 years old, is about 50%. The student ratio indicates 16.5% for male and 15.7% for female as shown in Table 3.3-2, and the economic activity by sex is shown in Table 3.3-3.

Figure 3.3-3 illustrates the distribution of population both by traffic zone and by integrated zone. This shows that there is a concentration of population in the north area of Rímac River such as San Juan de Lurigancho, Comas and San Martin de Porres.

Table 3.3-2 Population by Sex

Item	Male		Female		Total	
	Population	Rate	Population	Rate	Population	Rate
	(000)	(%)	(000)	(%)	(000)	(%)
Labor Force	2,963	100.0	3,195	100.0	6,158	100.0
Gainful Worker	1,935	65.3	1,110	34.7	3,045	49.5
Student	490	16.5	480	15.0	969	15.7
Housewife	2	0.1	1,223	38.3	1,225	19.9
Jobless	536	18.1	383	12.0	918	14.9

Table 3.3-3 Economic Activity by Sex

| Occupation	Male		Female		Total	
	Population	Rate	Population	Rate	Population	Rate
	(000)	(%)	(000)	(%)	(000)	(%)
Manager	53	2.8	18	1.8	71	2.5
Professional	130	6.9	72	7.3	202	7.0
Office Employee	454	24.0	382	38.9	836	29.1
Technician	107	5.7	29	3.0	136	4.7
Labor	225	11.9	49	5.0	274	9.5
Vendor	69	3.6	73	7.5	142	4.9
Worker	551	29.1	350	35.6	902	31.3
Police	57	3.0	5	0.6	62	2.2
Driver	196	10.3	2	0.2	198	6.9
Security Guard	51	2.7	2	0.2	53	1.8
Sub-total	*1,894*	*100.0*	*983*	*100.0*	*2,877*	*100.0*
Pupil	824	48.7	785	28.0	1,609	35.8
Student	285	16.9	282	10.1	567	12.6
Working student	39	2.3	34	1.2	73	1.6
Housewife	2	0.1	1,224	43.6	1,225	27.2
House servant	4	0.3	94	3.3	98	2.2
Jobless	244	14.4	225	8.0	469	10.4
Others	295	17.4	162	5.8	456	10.1
Sub-total	*1,693*	*100.0*	*2,805*	*100.0*	*4,498*	*100.0*
Total	*3,586*		*3,788*		*7,374*	
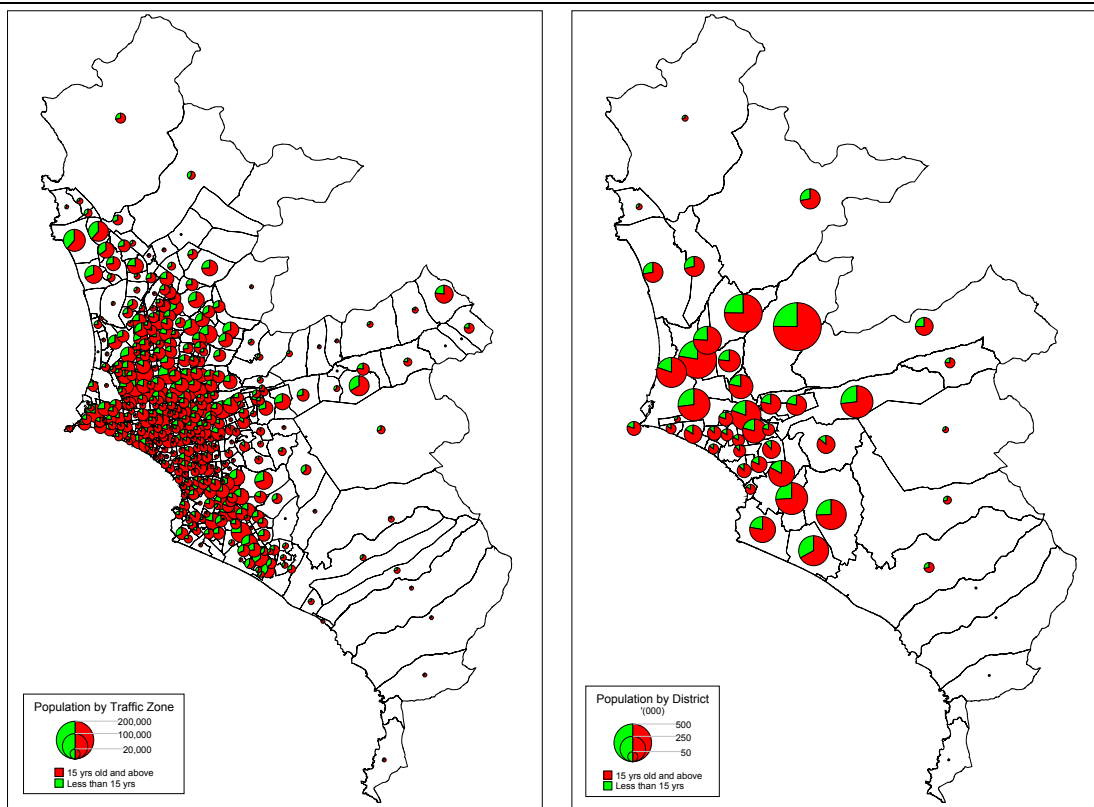
Figure 3.3-3 Population Distribution

(2) Day/Night Ratio

Table 3.3-4 shows the number of residents, employment (working population) and enrollment (student population) by district. In the table the day/night ratio defined by the following formula is also indicated.

$$\text{Day/night ratio} = \frac{\text{Number of population at working/studying place}}{\text{Number of population at resident place}}$$

High ratio on the day/night ratio for working can be calculated in districts such as Lima, Jesus Maria, Miraflores, and San Isidro, in the Central area. On the other hand, in the case of studying place, Lima and Jesus Maria are extremely high points as shown in .

Table 3.3-4 Distribution of Population by District

| Area	District Name	Population (000)	6 yrs and above (000)	Working Population			Sudent Population		
				(000)	(000)	Day/ Night Ratio	(000)	Day/Night Ratio Primary/ Secondary	Superior
	Study Area Total	*8,043*	*7,374*	*3,047*	*3,047*	*1.00*	*2,249*	*1.00*	*1.00*
	Lima Total	*7,160*	*6,577*	*2,723*	*2,770*	*1.02*	*1,999*	*1.00*	*1.05*
Central Area	Lima	345	322	127	378	2.99	88	1.43	6.58
	Barranco	47	44	15	27	1.77	11	2.93	0.68
	Breña	97	90	36	48	1.31	26	1.58	1.27
	Jesús María	68	64	27	65	2.44	16	2.03	5.32
	La Victoria	234	215	88	178	2.02	59	0.91	0.36
	Lince	73	69	30	38	1.26	16	1.06	2.73
	Magdalena del Mar	55	52	21	20	0.92	12	1.26	0.83
	Pueblo Libre	82	78	35	31	0.89	18	1.50	2.00
	Miraflores	97	92	41	118	2.88	20	1.89	2.54
	Puente Piedra	175	158	65	48	0.73	57	0.91	0.21
	Rímac	213	200	84	61	0.73	59	0.93	1.12
	San Borja	127	121	54	61	1.13	29	0.84	0.41
	San Isidro	72	69	34	123	3.58	13	1.61	3.82
	San Luís	61	56	25	32	1.25	16	1.16	0.45
	San Miguel	133	125	53	61	1.14	33	1.19	2.34
	Santiago de Surco	258	243	111	116	1.05	66	0.98	1.44
	Surquillo	101	95	38	46	1.23	26	0.70	0.48
North Area	Ancon	22	20	7	8	1.15	7	1.47	0.04
	Carabayllo	165	149	60	39	0.65	49	0.80	0.10
	Comas	495	451	183	114	0.63	139	1.01	0.29
	Independencia	207	190	76	54	0.70	52	0.92	1.41
	Los Olivos	305	280	115	94	0.81	98	1.17	0.54
	San Martín de Porras	511	470	179	107	0.60	146	0.76	0.31
	Santa Rosa	24	21	7	2	0.26	8	0.34	0.00
	Chorrillos	261	238	95	82	0.86	68	0.91	0.37
South Area	Cieneguilla	14	13	6	4	0.75	5	0.96	0.13
	Lurín	51	45	17	18	1.09	15	1.08	0.10
	Pachacamac	32	29	11	8	0.69	9	0.80	0.00
	Pucusana	5	4	2	2	0.95	1	1.02	0.00
	Punta Hermoza	5	5	2	2	0.95	1	0.45	0.18
	Punta Negra	4	4	2	1	0.64	1	0.61	0.14
	San Bartolo	4	3	1	1	0.99	1	1.20	1.66
	San Juan de Miraflores	378	338	137	93	0.68	99	0.98	0.49
	Santa María del Mar	0	0	0	0	0.00	0	0.00	0.00
	Villa el Salvador	337	296	118	71	0.60	103	0.90	0.36
	Villa María del Triunfo	337	304	128	67	0.52	93	0.93	0.22
East Area	Ate	359	329	135	169	1.25	116	0.94	0.20
	Chaclacayo	42	38	17	11	0.63	12	1.26	0.22
	El Agustino	166	156	68	35	0.52	49	0.87	0.24
	La molina	140	135	62	52	0.84	41	1.23	1.44
	Lurigancho	128	118	49	39	0.81	42	0.88	1.08
	San Juan de Lurigancho	770	704	296	180	0.61	233	0.95	0.20
	Santa Anita	158	144	64	67	1.04	45	0.92	0.87
	Callao Total	*883*	*797*	*325*	*277*	*0.85*	*250*	*0.99*	*0.52*
West Area	Callao	382	349	140	163	1.17	108	0.89	0.26
	Bellavista	86	79	35	30	0.85	20	1.79	3.05
	Carmen de la Legua	46	43	17	12	0.69	12	0.88	0.03
	La Perla	68	64	27	13	0.50	15	0.96	0.21
	La Punta	7	7	3	4	1.11	1	1.66	2.07
	Ventanilla	293	255	103	55	0.54	94	0.96	0.18

(Source: JICA Study Team)
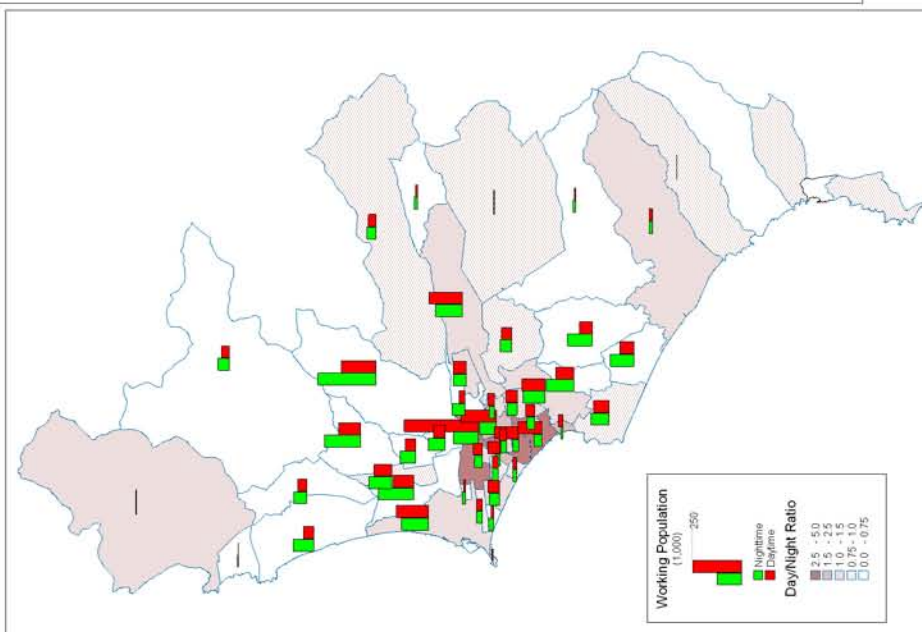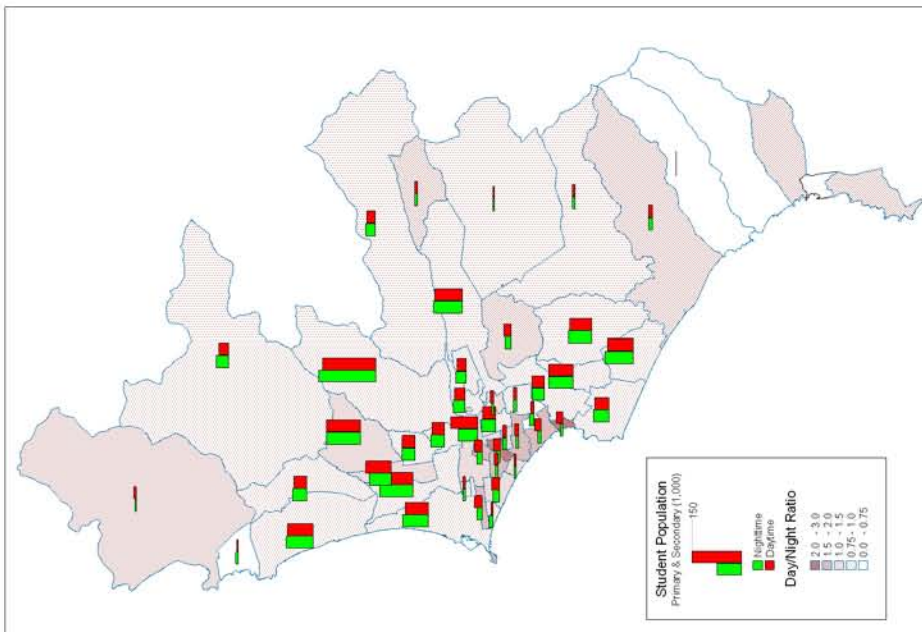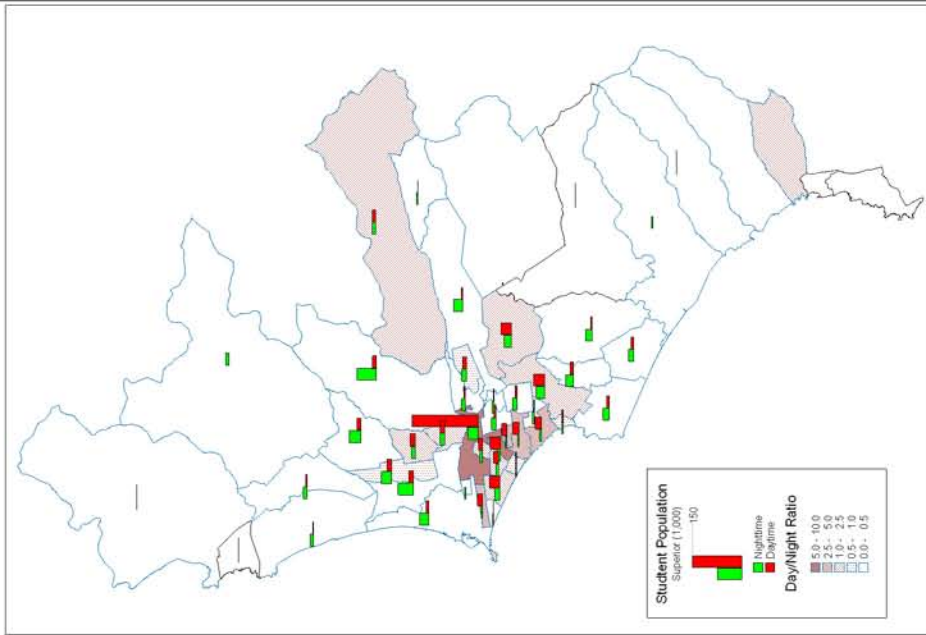
Figure 3.3-4 Day/Night Population

(3) Social Aspects

Almost all people in the Study area live in their own houses except in the case of the Central area. More than 20% of people in the Central area live in rented houses. For the physical condition of houses, the share of condominiums and tenement houses is higher in the Central area while all houses in the rest of areas are independent as shown in Table 3.3-5.

Almost all families have a television set and gas range for cooking. On the other hand, households having a computer, a washing machine and a microwave are very few, based on Table 3.3-6.

Table 3.3-5 Housing Condition by Area

Item	Central	North	South	East	West	Legend
Ownership						Others / Own / Rent
House Condition						Others / House / Tenement House / Cond / Close / Apartment
Average Number of Rooms	4.2	3.7	3.5	4.1	3.7	

Table 3.3-6 Property of Electrical Appliances

Item	Central	North	South	East	West
TV					
Telephone					
Refregerator					
Washing Machine					
Computer					
Electric Clearner					
Gas Range					
Electric Range					
Microwave					

YES   NO

3.3.2. OVERALL TRAVEL DEMAND

(1) Overall Travels Demand

According to the result of the Person Trip survey conducted by the Study Team, the total transport demand in the Study area is estimated at 16.5 million trips per day, of which 12.2 million trips are produced by vehicles. Trip rate can be also calculated at 2.1 (including walk trips) and 1.5 (excluding walk trips) as shown in Table 3.3-7.

Table 3.3-7 Overall Travel Demand

Items	Central	Other Area	Study Area Total
Population (1,000)	2,064	5,979	8,043
No. of Trips (1,000)	4,700	11,838	16,538
Trip Rate	2.3	2.0	2.1
No. of Trips Excluding Walk Trips	3,688	8,558	12,246
Trip Rate	1.8	1.4	1.5

(2) Trip Purpose and Modal Share

Table 3.3-8 shows the composition of travel purposes and Table 3.3-9 shows that of the representative travel mode. "To work" trips and "To school" trips, being estimated that they produce the congestion in the morning peak, account for 31% and 26%, respectively.

Modal share of public transport is 52% when "walk" trips are included, it is about 70% when "walk" trips are excluded. The share of both private mode and paratransit mode is about 10% of total trips. Combi is the most often-used mode in the public transport mode; its share is estimated to be 45% as shown in Figure 3.3-5

Table 3.3-8 Number of Trips by Trip Purpose

Trip Purpose	All Mode Trips			Excluding Walk Trips		
	(1,000)	Ratio (%)	Ratio excl. "To home" (%)	(1,000)	Ratio (%)	Ratio excl. "To Home" (%)
To work	2,677	16.2	30.5	2,413	19.6	36.7
To school	2,300	13.9	26.2	1,519	12.3	23.1
Business	511	3.1	5.8	433	3.5	6.6
Business	383	2.3	4.4	348	2.8	5.3
Back to office	128	0.8	1.5	86	0.7	1.3
Private	3,294	19.9	37.5	2,206	17.9	33.6
Shopping	1,248	7.5	14.2	677	5.5	10.3
Restaurant	151	0.9	1.7	93	0.8	1.4
Entertainment	164	1.0	1.9	109	0.9	1.7
Pick-up/send off	311	1.9	3.5	185	1.5	2.8
Others	1,420	8.6	16.2	1,142	9.3	17.4
To home	7,756	46.9	-	5,758	46.7	-
Total	*16,538*	*100.0*	*100.0*	*12,330*	*100.0*	*100.0*

Table 3.3-9 Number of Trips by Trip Mode

Mode	No. of Trips (1,000)	% to Total	% of Public/ Private
Walk	4,208	25.4	-
Private Mode	2,122	12.8	100.0
Bicycle	84	0.5	4.0
Motorcycle	30	0.2	1.4
Car	1,856	11.2	87.5
Others	152	0.9	7.2
Paratransit	1,683	10.2	100.0
Mototaxi	600	3.6	35.7
Taxi	902	5.5	53.6
Colectivo	181	1.1	10.7
Public Mode	8,525	51.5	100.0
Combi	3,791	22.9	44.5
Microbus	3,072	18.6	36.0
Bus	1,661	10.0	19.5
Total	*16,538*	*100.0*	-
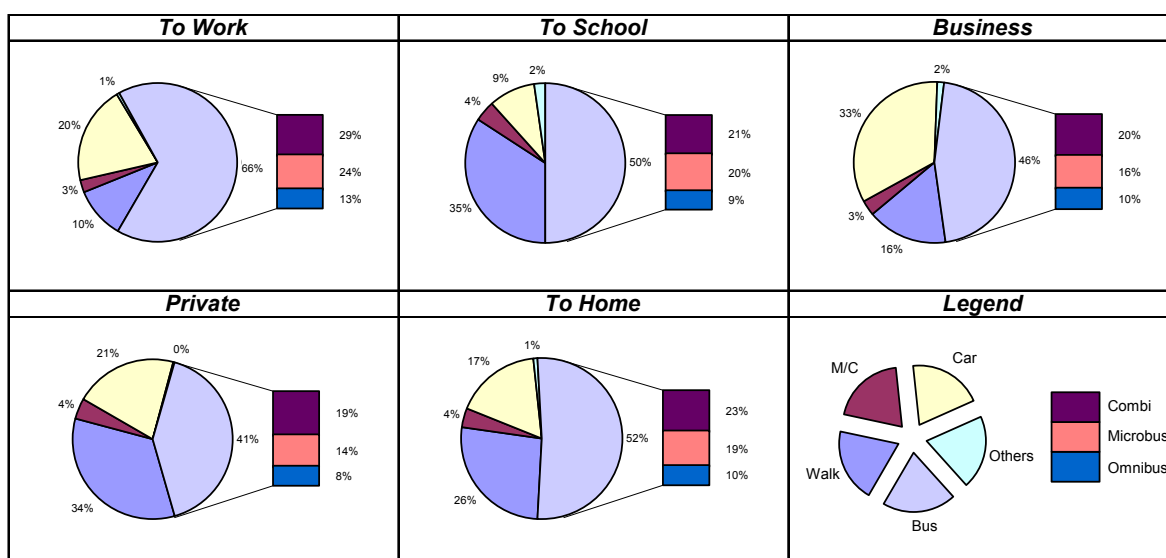
Figure 3.3-5 Modal Share by Trip Purpose

(3) Demand by Integrated Zone

Figure 3.3-6 describes trip generation and attraction by integrated zone. In the figure, the size of the pie chart expresses the volume of trips generated and attracted while the composition of trip purpose is expressed by color in the circle.

The volume of trip generation is distributed in proportion to the population in the Study area while the large number of trip attraction is concentrated in the city center. The strong concentration to the city center consists of "to work" and private trips.
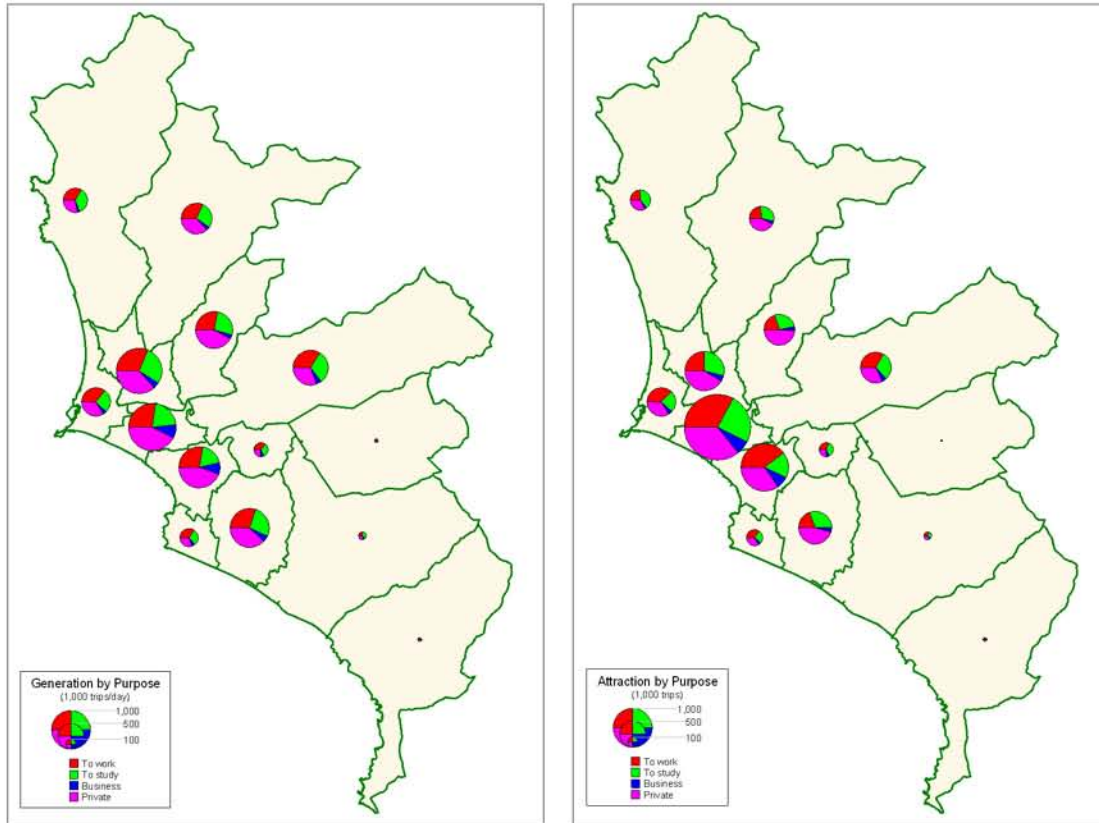
Figure 3.3-6 Demand by Integrated Zone

(4) Hourly Distribution

Figure 3.3-7 and Figure 3.3-8 show the hourly distribution of travel demand varies by hour. Like cities of other countries, there are three travel demand peaks: in the morning, midday and late afternoon. The morning peak (06:00 – 07:00 hours) shows the sharp and highest concentration of 15%, which is contributed by "to work" and "to school" trips. The second peak is somewhere between 11:00 to 14:00 hours with 8% concentration. The third peak can be seen at periods between 17:00 to 18:00 hours, which is estimated being contributed by "to home" trips.
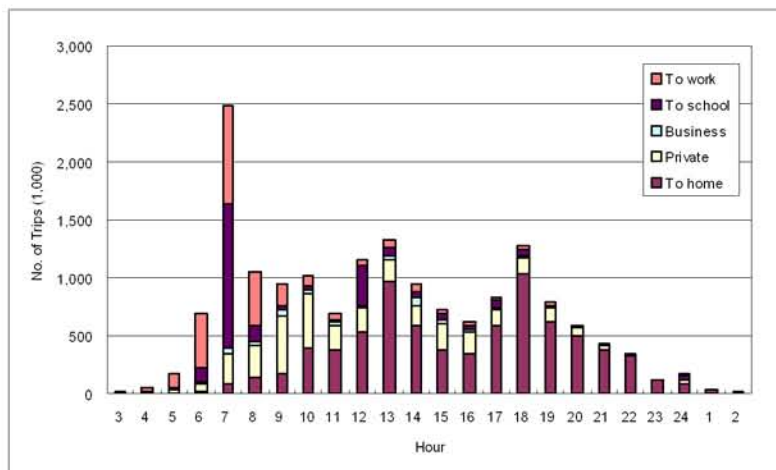
Figure 3.3-7 Hourly Distribution
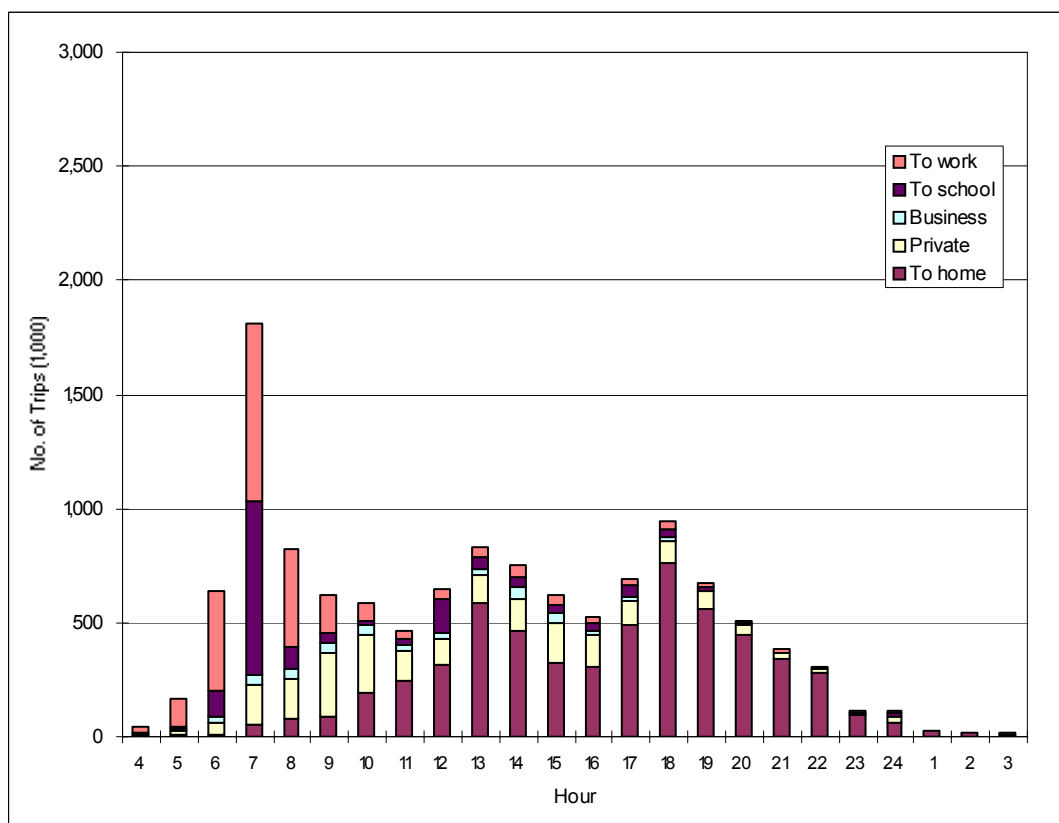
Figure 3.3-8 Hourly Distribution (excluding walk trips)

Table 3.3-10 shows the peak ratio and peak hour by travel purpose. A peak ratio of both "to work" and "to school" trips is extremely high, while the rest of trips are not so high.

Table 3.3-10 Peak Ratio

Items	To work	To school	Business	Private	To home
Peak Hour	7:00 - 8:00	7:00 - 8:00	14:00 - 15:00	9:00 - 10:00	18:00 - 19:00
Peak Ratio	32.0	54.1	12.9	14.8	13.4

(5) Travel Time

Table 3.3-11 and Table 3.3-12 indicate average travel time by travel purpose and travel mode.

Average travel time of one trip in the Study area is 31 minutes, which is relatively short compared with Tokyo metropolitan area. Travel time for "to work" trips is relatively long and that of "to school" trips are short, which is attributed to a short trip produced by primary school students.

In general, average travel time by public transport mode is longer than by private car. The former takes 1.8 times of the later.

Table 3.3-11 Average Travel Time

Purpose	(min.)
To work	40.4
To school	26.8
Business	31.9
Private	24.9
To home	32.3
All Purpose	31.4

Table 3.3-12 Average Travel Time

Mode	(min.)
Walk	12.4
M/C	10.8
Car	24.9
Bus	44.7
Others	29.8
All Mode	31.4

Figure 3.3-9 illustrates average travel time generated from each traffic zone. When a traffic zone is located in the outer edge of the Study area, the average travel time of trips generating from the traffic zones become longer, especially in District of Ventanilla, Carabayllo, and Lurin. This means that people living in these areas need to make trips even if the distance is long.
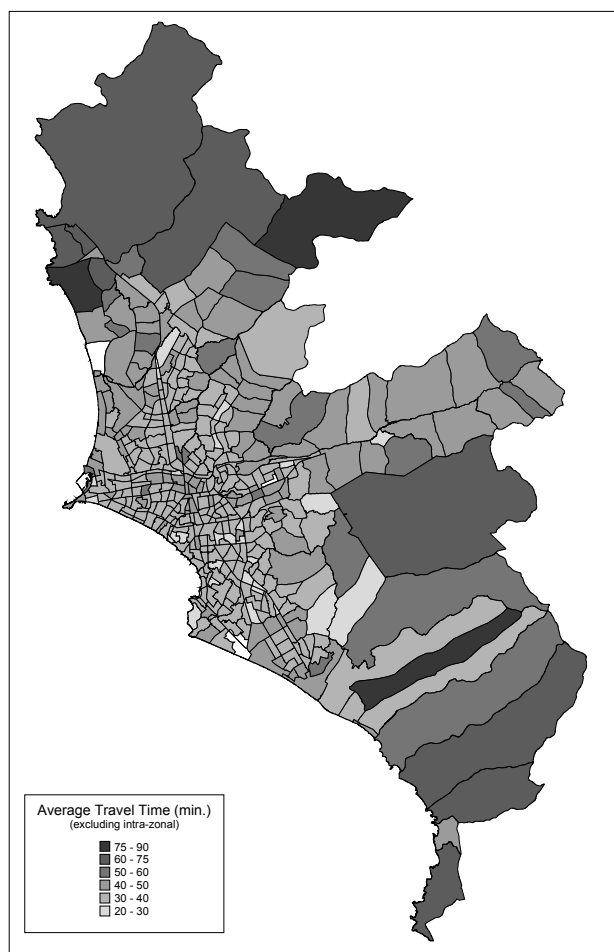
Figure 3.3-9 Average Travel Time by Traffic Zone

3.3.3. ORIGIN AND DESTINATION

(1) OD Matrix

One of the objectives for the Person Trip survey is to obtain the travel volume of demand. The OD (origin and destination) matrix is a simple way to express travel demand in the Study area. Through the Person Trip survey conducted by the Study Team, the OD matrix with 427 traffic zones, 10 travel purposes and 16 transport modes, is obtained. The following tables show OD matrices summarized into 5 areas and outside.

The highest demand is estimated at 4.2 million trips traveling within the Central Area, followed by 2.3 million trips traveling within the East Area. The highest demand among inter-area trips is 1.5 million trips between the Central Area and the East Area, followed by 1.2 million trips between the Central Area and the North Area.

The number of trips traveling by area and motorized mode are shown in Table 3.3-13 and Table 3.3-14.

Table 3.3-13 Number of Trips Traveling between Areas

Unit: 1,000 trips

Origin \ Destination	Central	North	South	East	West	Total
Central	4,201	616	490	737	285	*6,330*
North	621	2,250	41	98	149	*3,160*
South	497	39	1,709	68	21	*2,335*
East	740	97	68	2,296	43	*3,247*
West	287	149	22	44	958	*1,460*
Total	*6,347*	*3,152*	*2,332*	*3,245*	*1,456*	*16,532*

Table 3.3-14 Number of Trips Traveling by Motorized Mode between Areas

Unit: 1,000 trips

Origin \ Destination	Central	North	South	East	West	Total
Central	3,175	611	487	730	283	*5,286*
North	616	1,289	41	97	141	*2,186*
South	493	39	966	67	21	*1,588*
East	733	97	67	1,281	43	*2,224*
West	285	141	22	44	548	*1,040*
Total	*5,303*	*2,178*	*1,585*	*2,223*	*1,036*	*12,324*

(2) Travel Demand by Integrated Zone

The travel demand by integrated zone is summarized in , and travel demand by each integrated zone is shown in Figure 3.3-11.

Figure 3.3-11 show the travel demand excluding "to home" trips by colored lines, which are generated from each integrated zone, and trip generation by pie chart. The characteristics of travel demand generated by integrated zone can be summarized as follows:

a) Integrated zone N°1 (Lima, San Miguel, La Victoria, etc.)
Total trip generation: 3,601 thousand (including "to home" trips)
Total trip generation: 1,437 thousand (excluding "to home" trips)
Intra-zonal trips: 1,000 thousand (70%)
Strong relation to   N°3 (364 thousand)
                     N°4 (367 thousand)

b) Integrated zone N°2 (Callao)
Total trip generation: 1,076 thousand (including "to home" trips)
Total trip generation: 566 thousand (excluding "to home" trips)
Intra-zonal trips: 333 thousand (59%)
Strong relation to   N°1 (179 thousand)

c) Integrated zone N°3 (Los Olivos, Independencia, etc.)
Total trip generation: 2,213 thousand (including "to home" trips)
Total trip generation: 1,296 thousand (excluding "to home" trips)
Intra-zonal trips: 703 thousand (70%)
Strong relation to   N°1 (365 thousand)

d) Integrated zone N°4 (San Isidro, Miraflores, San Borja, etc.)
Total trip generation: 2,253 thousand (including "to home" trips)
Total trip generation: 1,053 thousand (excluding "to home" trips)
Intra-zonal trips: 674 thousand (64%)
Strong relation to   N°1 (370 thousand)

e) Integrated zone N°5 (La Molina)
Total trip generation: 323 thousand (including "to home" trips)
Total trip generation: 166 thousand (excluding "to home" trips)
Intra-zonal trips: 58 thousand (35%)
Strong relation to   N°4 (85 thousand)

f) Integrated zone N°6 (Chorrillos)
Total trip generation: 460 thousand (including "to home" trips)
Total trip generation: 265 thousand (excluding "to home" trips)
Intra-zonal trips: 130 thousand (49%)
Strong relation to   N°1 (52 thousand)
                     N°4 (81 thousand)

g) Integrated zone N°7 (San Juan de Miraflores, Villa El Salvador, etc.)
Total trip generation: 1,716 thousand (including "to home" trips)
Total trip generation: 1,046 thousand (excluding "to home" trips)
Intra-zonal trips: 660 thousand (63%)
Strong relation to   N°1 (142 thousand)
                     N°4 (178 thousand)

h) Integrated zone N°8 (Puente Piedra, Ventanilla, etc.)
Total trip generation: 751 thousand (including "to home" trips)
Total trip generation: 446 thousand (excluding "to home" trips)
Intra-zonal trips: 274 thousand (61%)
Strong relation to   N°1 (65 thousand)
                     N°3 (52 thousand)

i) Integrated zone N°9 (Comas, Carabayllo)

Total trip generation: 1,056 thousand (including "to home" trips)
Total trip generation: 653 thousand (excluding "to home" trips)
Intra-zonal trips: 374 thousand (57%)
Strong relation to   Nº1 (125 thousand)
                     Nº3 (104 thousand)

j)   Integrated zone Nº10 (San Juan de Lurigancho)
      Total trip generation: 1,519 thousand (including "to home" trips)
      Total trip generation: 938 thousand (excluding "to home" trips)
      Intra-zonal trips: 584 thousand (62%)
      Strong relation to   Nº1 (233 thousand)

k)   Integrated zone Nº11 (Ate, Santa Anita, Lurigancho, etc.)
      Total trip generation: 1,441 thousand (including "to home" trips)
      Total trip generation: 836 thousand (excluding "to home" trips)
      Intra-zonal trips: 508 thousand (61%)e
      Strong relation to   Nº1 (221 thousand)

l)   Integrated zone No. 12, No.13, and No. 14.
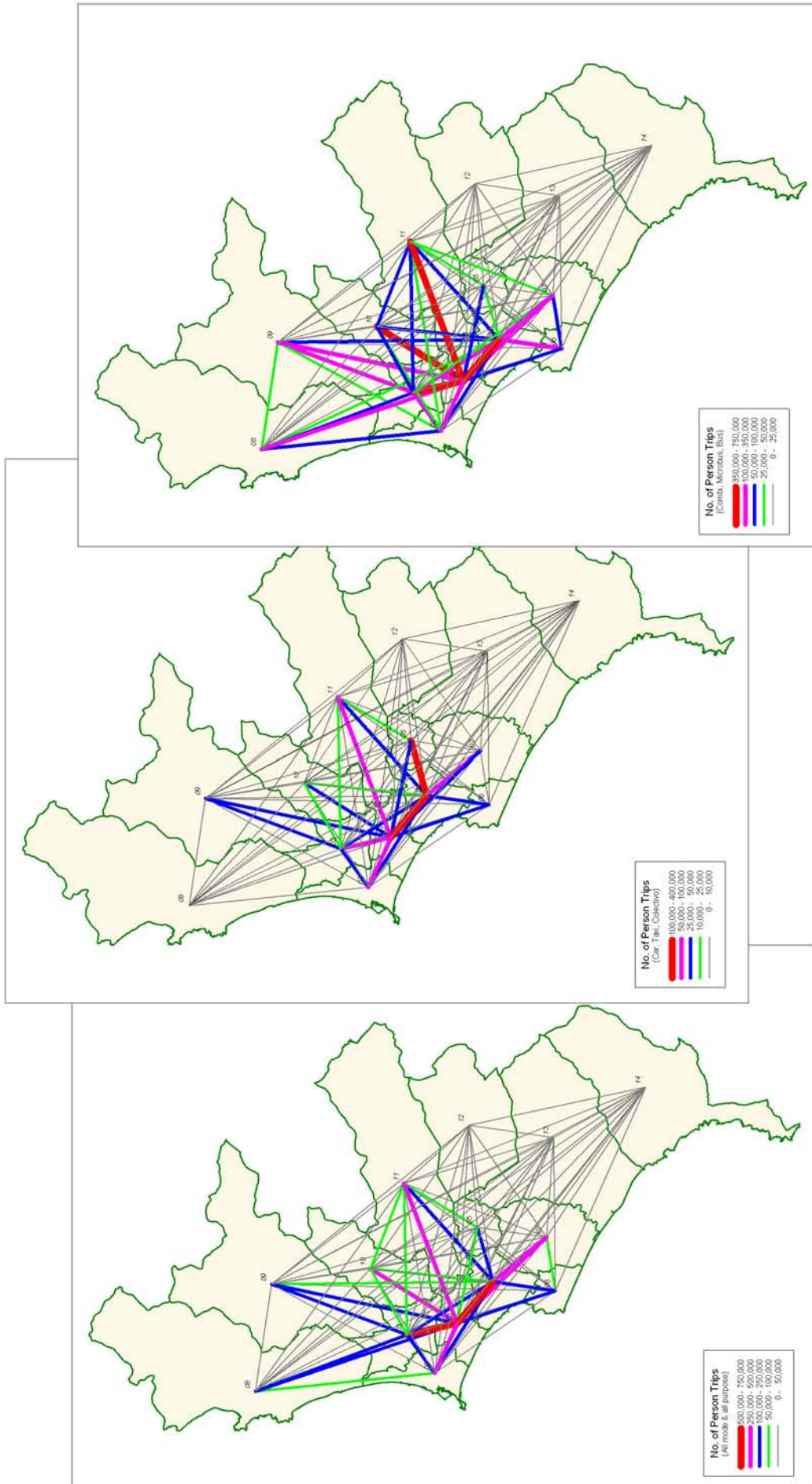   Total trip generation is very few, and there is not remarkable trip characteristics.

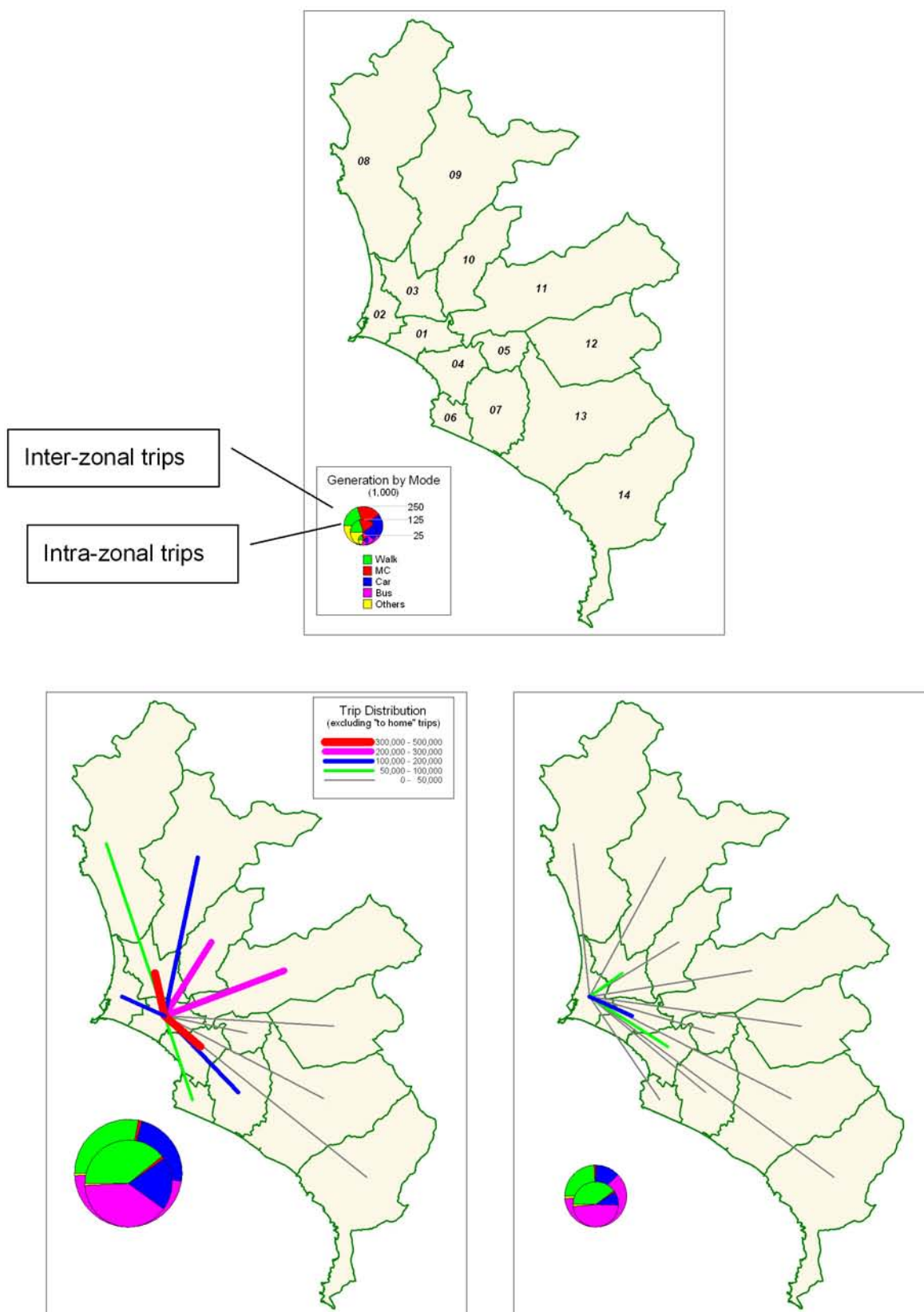Figure 3.3-10 Origin and Destination by Travel Mode

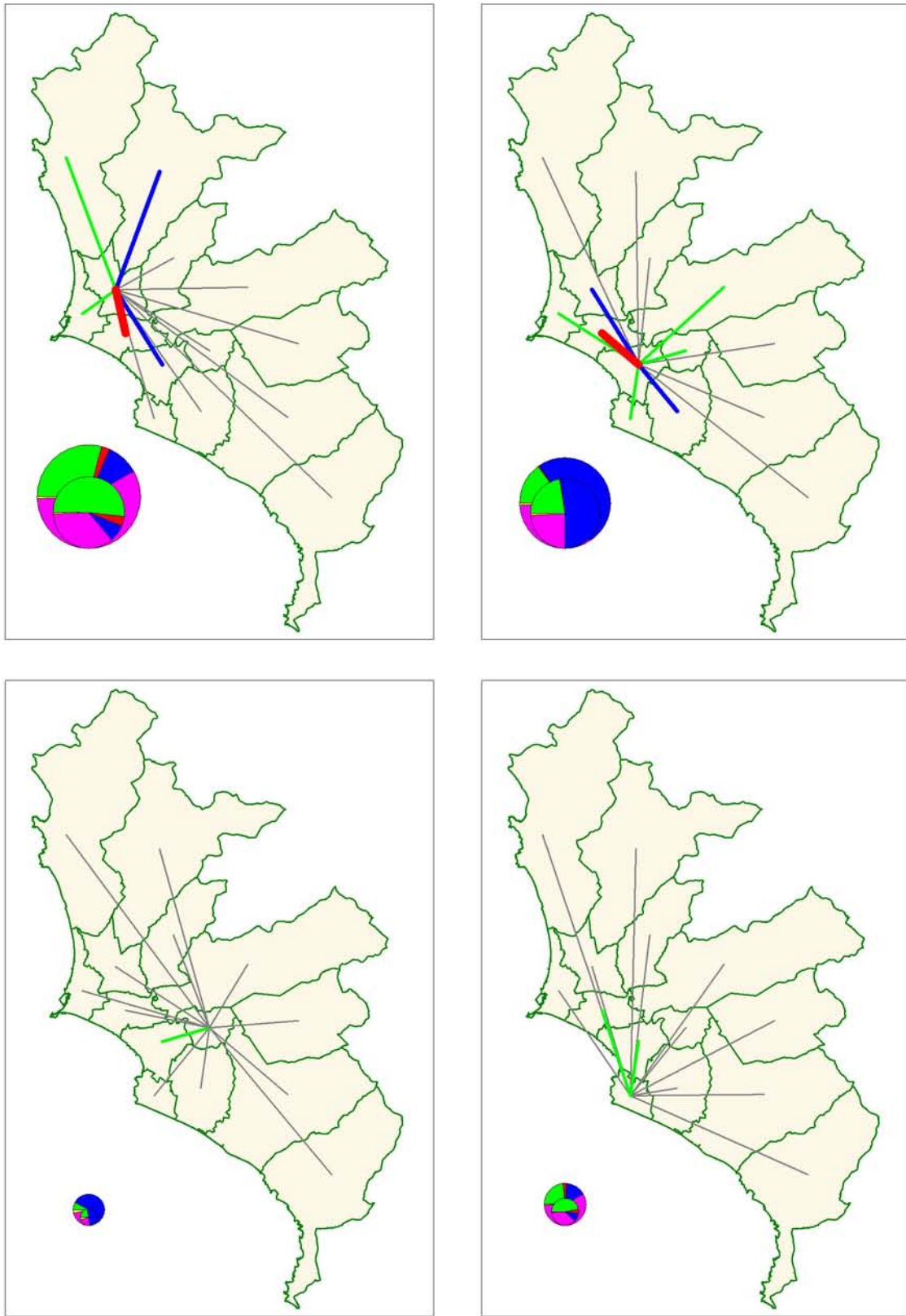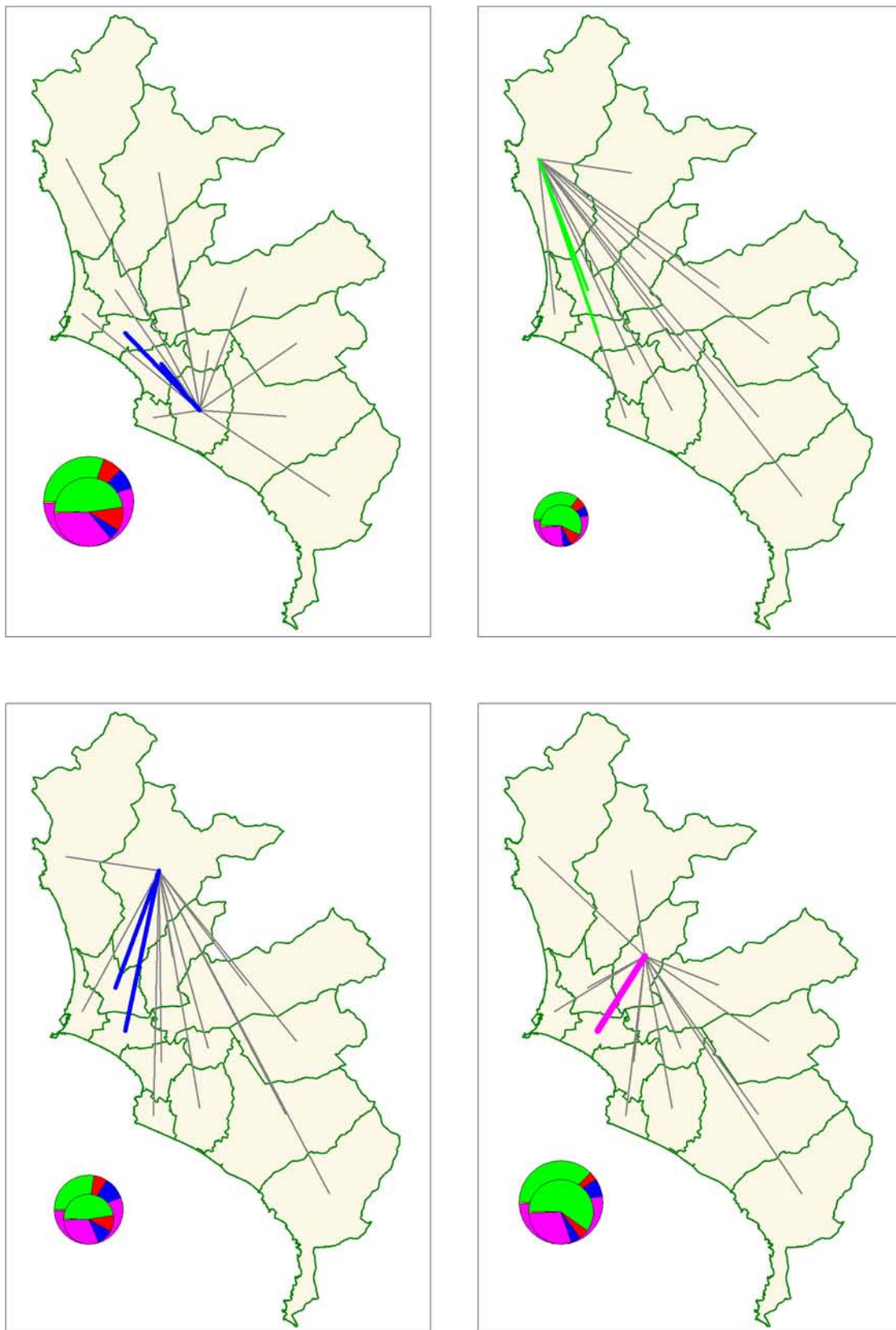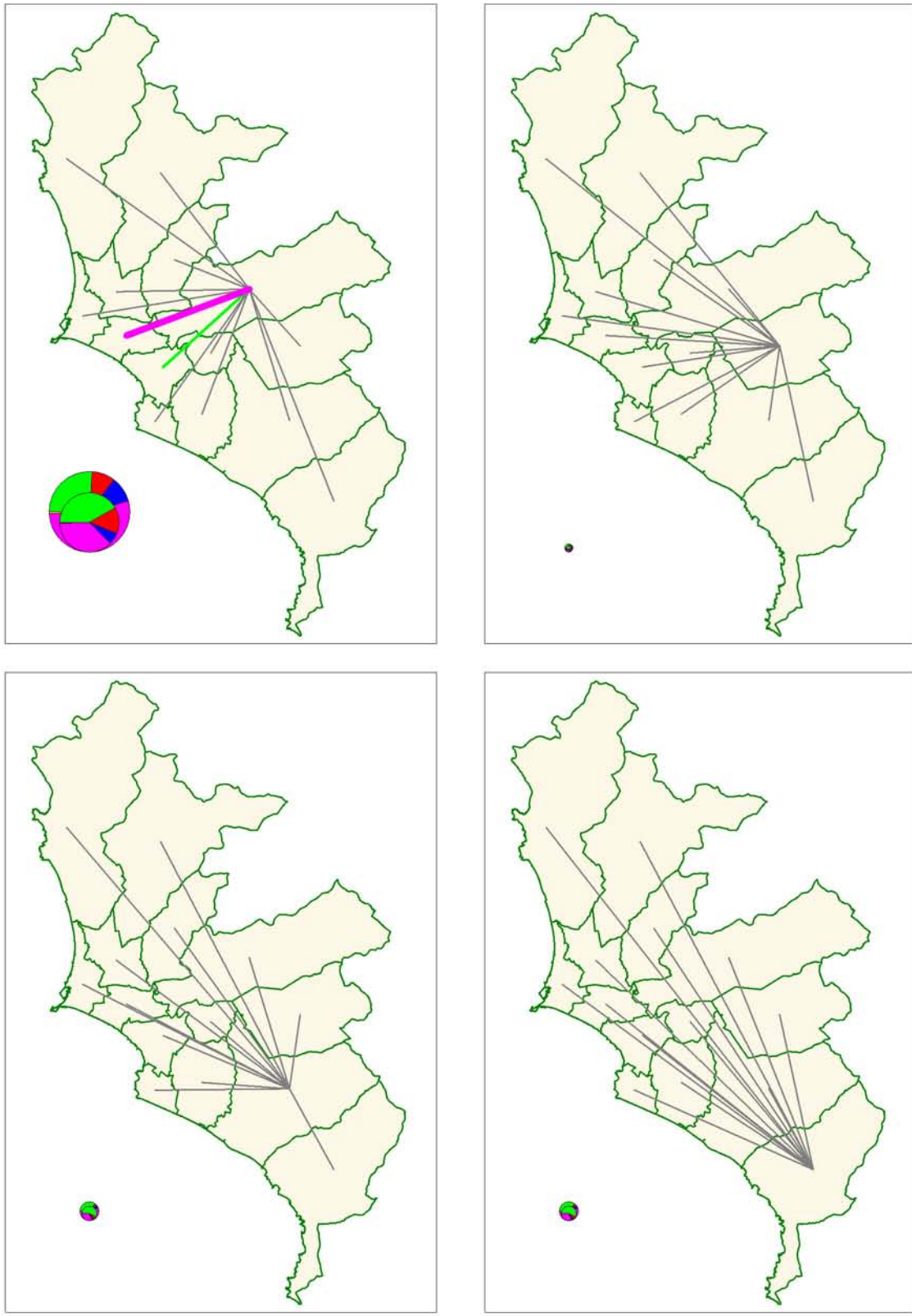Figure 3.3-11 Trip Distribution by Integrated Zone

Figure 3.3.11 Trip Distribution by Integrated Zone (continued)

Figure 3.3.11 Trip Distribution by Integrated Zone (continued)

Figure 3.3.11 Trip Distribution by Integrated Zone (continued)