2.3.4 Land Use Plan

2.3.4.1 Demand for Space

Corresponding to the economic development of the State, more space will be utilized for this activity.

This section describes the estimate of the demand for space in line with the future economic frame of the Study Area as given in the previous chapter.

A. Residential Area

Regarding populations, the residential population in the State of Penang is expected to increase from 950,000 in 1979 to 1,550,000 in the year 2000. Thus, the need for residential area relevant to future increase in population will be as follows:

Increase in Population during 1979 to 2000	600,000 persons
Average Gross Residential Population* Density	100 persons/ha.
Required Residential Area	6,000 ha.

* Existing average gross population density is 110 persons/ha.

Additional residential area required in the State of Penang by the year 2000 is about 6,000 hectares. Taking into account this expected increase in demand, the supply of residential area is examined by using the residential area proposed in the Interim Zoning Plan.

In the Study Area, about 4,800 hectares or 80 percent of this area will be supplied by the year 2000. Both Penang Island, and Province Wellesley, will get an equal share of this area i.e. 50 percent of the total area each.

B. Commercial Area

According to the employment projection mentioned in Fig. 2.2 of this section, employment in tertiary industry is expected to increase from 148,000 in 1979 to 175,000 in the year 2000. The actual increase in employment in the tertiary industry will be 127,000 for the next 20 years. At present, the share of the existing commercial and business sectors in the Study Area are

as follows:

Penang Island	210 hectares
Province Wellesley	160 hectares
Total	370 hectares

It is assumed that the existing employment density in the commercial and business areas is about 400 per hectare. In this study, it is assumed that this density will decrease from 400 in 1979 to 300 by the year 2000. On the basis of this assumption, the need for commercial and business areas by the year 2000 will be 920 hectares in the Study Area.

C. Industrial Area

At present, the following industrial development plans exist.

1. In Province Wellesley
   1) Prai Industrial Estate
   2) Mak Mandin Industrial Estate
   3) Bagan Serai Industrial Estate
2. In Penang Island
   1) Bayan Lepas Industrial Estate
   2) Bayan Lepas Free Trade Zone
   3) Pulau Jerejak Free Trade Zone

The size and present situation of these industrial areas are as follows:

	Present Situation	Ultimate Plan
1. In Province Wellesley	(ha.)	(ha.)
1) Prai Industrial Estate	64 has.	847 has.
2) Mak Mandin Industrial Estate	54	114
3) Bagan Serai Industrial Estate	19	80
2. In Penang Island		
1) Bayan Lepas Industrial Estate	1	50
2) Bayan Lepas Free Trade Zone	46	140
3) Pulau Jerejak Free Trade Zone	18	160

Note: Present situation of industrial development is defined to be those areas that are occupied by factories.

This situation is summed up as follows:

Total ultimate area	1,390 has.
Total land occupied at present	200 has.
Balance	1,190 has.

Available industrial land presently occupies more than 1,190 hectares.

According to the employment projection in the manufacturing industry, the figure is expected to increase from 83,000 in 1979 to 230,000 by the year 2000.
Thus the actual increase in the number employed in the manufacturing industry will be about 147,000 by the year 2000.

Assuming that the employment density of the manufacturing industry is 80 workers per hectare, the shortage of industrial area will be as follows:

Employment on Planned Estates 1,190 has. x 80 workers/ha. = 95,200 workers

147,000 workers - 95,200 workers = 51,800 workers

51,800 workers ÷ 80 workers/ha. = 650 has.

In the land use plan, it was proposed that the following industrial area be expanded and constructed.

1. Prai Industrial Estate (Phase 2)	520 hectares
2. Kg. Pisang Industrial Estate	50 hectares
3. Permatang Keling Industrial Estate	80 hectares
Total	650 hectares

D. Total Demand

According to these assumptions, the increase in area for urban activities total about 6,000 hectares.

Residentital Area	4,800 ha.
Commercial Area	550 ha.
Industrial Area	650 ha.
Total	6,000 ha.

This required area will be supplied by converting waste land, cultivated land and unused land, also, in this Study Area, reclamation will also be expected to meet demand for more space.

2.3.4.2 Allocation of Demand

Taking on-going and committed development projects into account, the future land use pattern was studied in detail. Although the plan alternative C provides the guide - lines for planning at the conceptural level, it does not take into account details. Therefore, the following policies for each category of land use were prepared.

A. Residential Area

In Penang Island recent trends show that residential developments have concentrated in and around Bayan Lepas. This trend is expected to continue in the future. Within the city of George Town, an adequate urban renewel programme is being undertaken. However, no increase of residential area is expected except through land reclamation.

In Province Wellesley, there are many areas for residential development which will expand towards Bukit Mertajm along the existing Federal Route No. 1.

B. Commercial and Business Area

1. The Central Business District (C.B.D.) in George Town is defined as the Regional Center of the State of Penang. The importance of this Regional Center will increase in propotion to the development of the State of Penang. The C.B.D. will expand towards the north of the reclamation site where the Dispersal Road will be constructed and this area will then become a commercial and business area.

2. Allocation will be made for a commercial area in the Bayan Baru Development Project which will serve the Bayan Baru area as well as the Bayan Lepas corridor. This area will comprise the second urban core of George Town.

3. The tourist industry will grow at a rapid rate along the seaside area in the north. This trend will continue in the future.

4. Butterworth is defined as the sub-regional center as well as the center of the district. The commercial area will increase in propotion to the growth in population and other activities. An extension to the northern part of the existing marine port is being planned whereby, the residential area in this vicinity will be converted into a business area.

5. In the Seberang Jaya Development Project, a commercial and institutional area has been planned which is defined as the center of the district. This center will serve the eastern areas of Sungai Perai.

6. The commercial area of Bukit Mertajam, another district center, will also increase in proportion to its population growth.

C. Industrial Area

Most of the factories in Penang are located in the industrial estates in an attempt to reduce environmental problems. Therefore, future demand for industrial activities will be supplied in new industrial estates as far as possible.

In the Central Business District (C.B.D.) of George Town, there exists small-scale industrial factories which produce consumer goods. In the future, the team recommends that these factories be re-located at new industrial estates specified for small-scale industries.

The reasons for this recommendation are as follows:

1. There is no room for expansion of these facilities. If this situation is not remined, productivity will be affected and will not be expected to increase.

2. These factories tend to affect the surrounding environment adversely, therefore, it is neccessary to have safeguards so that a better environment in the future is not an impossible goal to achieve.

Regarding the distribution of cargo and commodities, Province Wellesley will have more advantages than Penang Island because

of the development of the industrial estates, the benefits of a new port, the Federal Route 1 and the East-West Highway.

In Penang Island, the reclaimed area along the Dispersal Road which is developed mainly for residence and commerce will provide space for commodity services and distributions.

D. Open Space and Others

It is desirable to prepare sports fields and public parks of about 30 hectares in the reclamation area where the Dispersal Road will be constructed.

To maintain the urban environment, it is proposed that effective usage of land must be made along rivers, ponds and seashores. Also, the development of Penang Hill should be restrained in order to maintain its pleasant landscape.

To preserve the rich agricultural land in Seberang Prai future development in this area should not be allowed, thus, helping to preserve the urban environment of the surrounding residential areas.

Based on these considerations, the land use plan in the year 2000 is illustrated in Figs. 2.12 and 2.13.

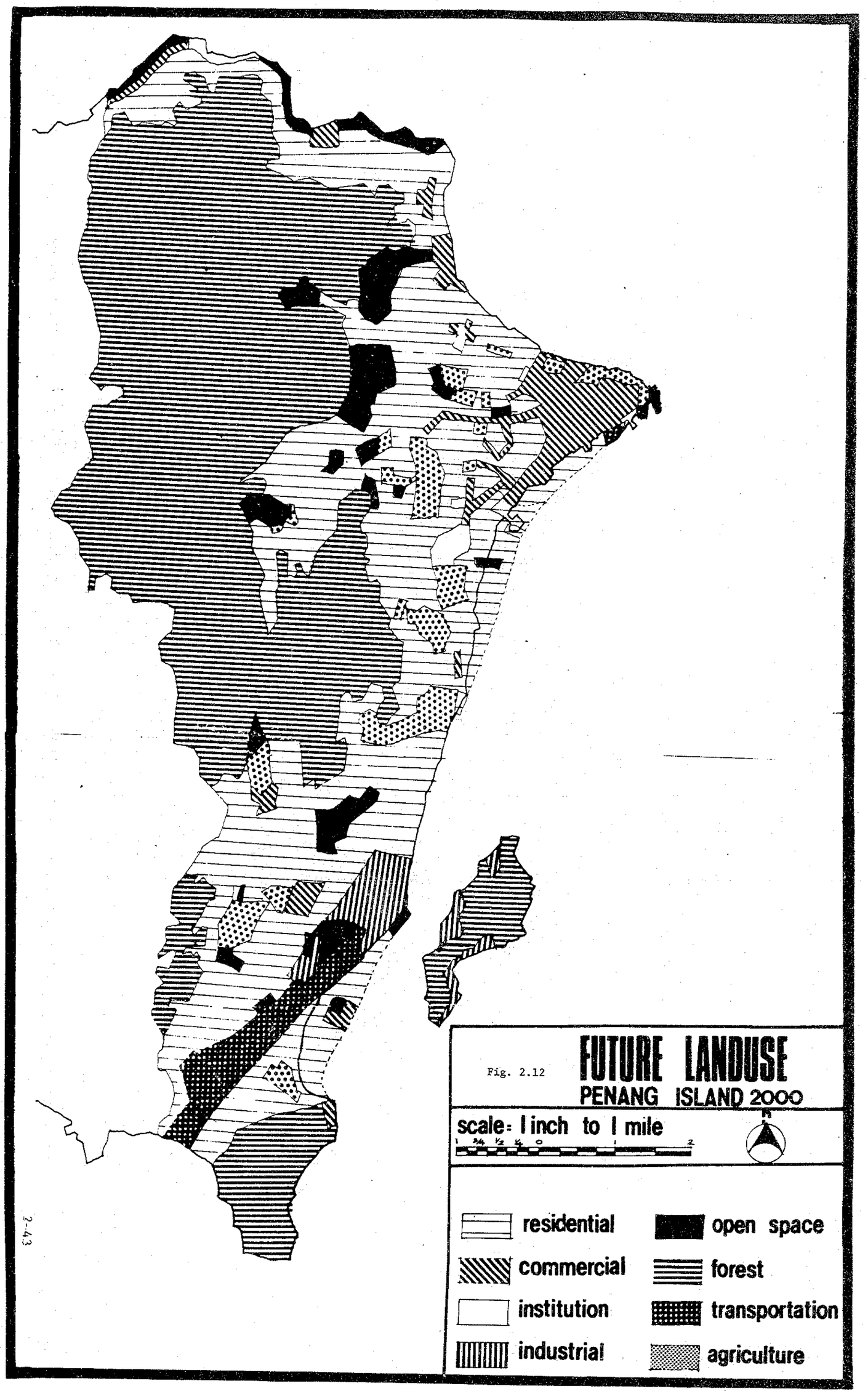
Fig. 2.12
FUTURE LANDUSE
PENANG ISLAND 2000
scale: 1 inch to 1 mile
N
residential
commercial
institution
industrial
open space
forest
transportation
agriculture

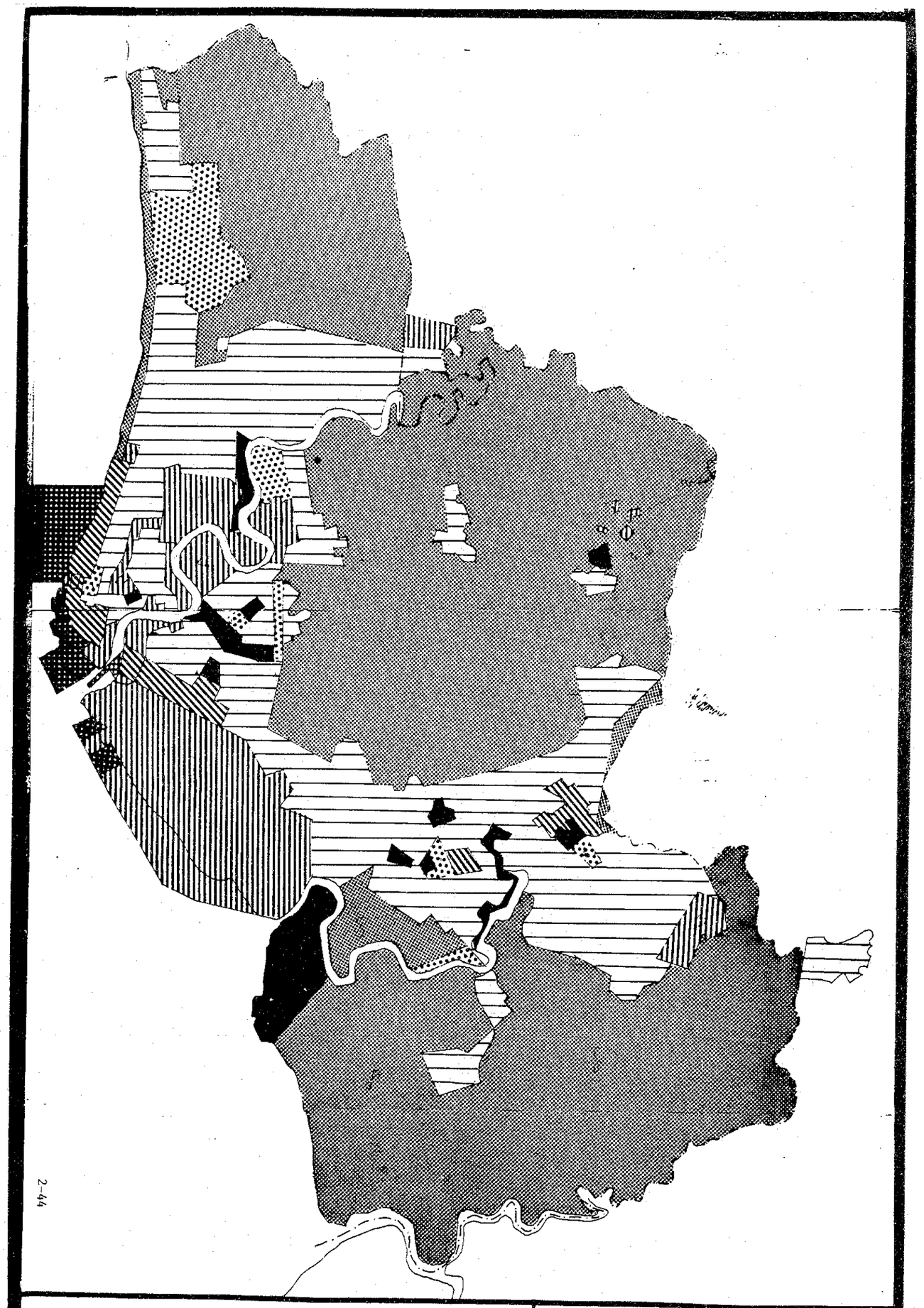

Fig. 2.13 **FUTURE LANDUSE**
SEBERANG PRAI 2000

scale: 1 inch to 1 mile

N

Legend

residential
industrial
open space
transportation
commercial
institution
forest
agriculture

2.3.4.3 Future Land Use.

Based on the policies mentioned earlier, future land use was planned as illustrated in Figs. 2.12 and 2.13 while the following table shows the change of area size by land use.

Table 2.26 AREA SIZE BY LAND USE

(ha)

Area	Penang Island		Province Wellesley		Total		Change of '79-90'
	1979	2000	1979	2000	1979	2000	
Residential	2,700	5,100	3,100	5,100	5,800	10,200	+4,400
Commercial	210	600	160	420	370	1,020	+ 650
Industrial	360	320	1,020	1,930	1,380	2,250	+ 870
Institutional	730	1,140	-	700	730	1,840	+1,110
Open Space	390	740	1,620	1,280	2,010	2,020	+ 10
Others	10,300	7,300	16,200	13,100	26,500	20,400	-6,100
Total	14,690	15,200	22,100	22,530	36,990	37,730	+ 940*

* Supplied through reclamation of land.

Provided that the populace live in residential and commercial areas, the population density will undergo change. In Penang Island, gross density will lessen due to the decrease in density of built-up areas

Penang Island		Province Wellesley	
1979	2000	1979	2000
162 per/ha	119 per/ha	80 per/ha	96 per/ha

where population density is often more than 300 persons per hectare. On the other hand, in Province Wellesley the built-up areas will be more than the present whereby there will be an increase in the population density.

2.4 Populations Distribution Plan

2.4.1 The Present Population Spread.

2.4.1.1 Population Spread in 1970

The Population Census of 1970 describes the population of each

mukim, town and village. The traffic zones used in this study were based mainly on the mukims except in several instances where the mukims were divided into several traffic zones. These instances were in the urbanized areas like George Town, Bayan Baru, Butterworth and Bukit Mretajam.

The method of breaking down the mukims into the traffic zones was done by using the population of the enumeration blocks which show the population of smaller units of zones.

2.4.1.2 Population Spread in 1979.

The population growth from 1957 to 1970 was used as a base to show population trend from 1970 to 1979. Thus the population of each traffic zone was expanded by the rate which was obtained from the population change between 1957 and 1970.

1. Penang Island

   The comparison of the 1957 and 1970 population census gives us the population growth of each mukim. In the case of the mukims which were divided into traffic zones, the growth rate of the mukim was adopted for all the traffic zones.

2. Province Wellesley

   Population growth rate used here is based on the growth rate of Butterworth, Bukit Mertajam and the rest of the districts from 1957 to 1970.

   After the above calculations, total population was adjusted to the population of the State of Penang as projected by the department of statistics.

   (1) The population growth rate of Penang Island from 1970 to 1979 is 1.9 percent, therefore, the control total is about 533,000 persons.

   (2) As the population of the State in 1979 is 946,580, the population of Province Wellesley is obtained through the following calculations.

$$\text{Population of Province Wellesley} = 946{,}580 - 533{,}000 = 413{,}580$$

(3) The population of the traffic zones in Province Wellesley was adjusted to make its total equal that of the population obtained through (2).

2.4.2 Population Distribution Plan

2.4.2.1 Population Distribution Plan in the year 2000.

Projected future population in the State of Penang is distributed to each zone by the method of multiplying future residential areas by population density. Sizes of residential areas by zones were obtained from the land use plan. Therefore only population density has to be determined.

According to the guidelines of the interim zoning plan, five (5) types of net population density were planned:

- Low density
- Low medium density
- Medium density
- High medium density, and
- High density.

However, gross population density instead of net population density is used in this study, because the aim of this study is to prepare the population data for traffic projection.

In the population plan, it is assumed that the gross density is equal to 60 percent of the net density. On the basis of this assumption, the following typical population density can be made.

Typical Population Density

	Net Density	Gross Density
Low Density	15 - 89 persons/ha	10 - 50 persons/ha
Low Medium	90 - 220 persons/ha	51 - 130 persons/ha
Medium Density	221 - 440 persons/ha	131 - 260 persons/ha
High Medium Density	441 - 880 persons/ha	261 - 530 persons/ha
High Density	881 and more persons/ha	531 and more persons/ha

On the basis of the above-mentioned density, the following population density is adopted for each zone.

*	Low		40	persons/ha
*	Low - Medium	-1	60	persons/ha
		-2	80	persons/ha
		-3	100	persons/ha
		-4	120	persons/ha
*	Medium		150	persons/ha
	High - Medium		200	persons/ha
*	High		300	persons/ha

Note: Planning Guide line of Population Density in Residential Areas, based on the Interim Zoning Plan.

a. Low Density: Net Density range of 1-6 residential units/36 persons per acre (88.8 p/ha)

b. Low Medium Density: 7-16 units/90 persons per acre (222.2 p/ha)

c. Medium Density: 16-30 units/180 persons per acre (444.4 p/ha)

d. High Medium Density: 31-60 units/360 persons per acre (888.8 p/ha)

e. High Density: Exceeding a net density of 60 units/360 person persons per acre. Regarding each of the above, any other suitabale uses are subject to the approval of the Council.

2.4.2.2 Population Distribution Plan in 1985.

Population of the zones for 1985 was estimated on the assumption that the population of each zone would change constantly from 1979 to the year 2000. The population of each zone was adjusted to the eatimated population in the framework plan.

Population Density in the Year 2000

George Town

Zone	Residential Area (has.)	Population Density (Persons/ha.)	Pop lation
111	106*	300	31,800
121	93*	300	27,900
122	223	150	33,450
123	146	150	21,900
124	141	150	21,180
125	146	120	13,920
131	282*	300	84,500
132	166	200	33,200
133	165	200	33,000
141	103	150	15,400
142	128	200	25,500
143	180	200	36,000

* including commercial area

Tg. Bungah Corridor

211	207	90	18,640
212	140	90	12,570
221	206	40	8,230

Ayer Itam and its periphery

143	180	200	36,000
311	738*	-	3,780
321	134	200	36,720
322	492*	-	2,080
323	539*	-	750

* including open space

Paya Terubong and its periphery

331	418	100	41,840
332	78	100	7,800
333	368	100	36,820
334	259	60	15,550
335	382*	-	2,740

* including open space

Bayan Lepas Corridor

411	306	100	30,620
412	668	100	66,850
413	219	60	13,120

Butterworth and its periphery

Zone	Residential Area (has.)	Population Density (Persons/ha.)	Population
511	182	200	36,480
512	152*	120	18,240
513	200	100	20,000
514	142	120	17,040
521	127	80	10,160
522	260	80	20,800
523	548	80	43,880
524	122**	40	4,880
525	187	80	14,960

* including commercial area
** including kampung area

Seberang Jaya and its periphery

611	424	200	84,880
612	165	120	19,800
621	82	80	6,560
622	137*	40	5,480
623	434	80	34,720

* including kampung areas

Bukit Mertajam and its periphery

711	70	40	2,790
712	56	40	2,250
713	219	40	8,740
721	125	40	5,000
722	70	40	2,800
723	62	80	4,960
731	140	60	8,400
732	165	120	20,040
733	66	100	6,600
734	100	80	8,000
741	158	80	12,660
742	602	80	48,150

Simpang Ampat and its periphery

811	190	80	15,200
812	469	80	37,560
821	109	40	4,350
822	116	40	4,620

Table 2.27 SUMMARY TABLE OF POPULATION DISTRIBUTION

State of Penang 1979, 1985 and 2000.

	1979		1985		2000		Average Annual Growth Rate (%)		
	Number	Per Cent	Number	Per Cent	Number	Per Cent	1979 - 85	1985-2000	1979-2000
100	341,220	66.5	349,900	60.6	378,900	50.5	0.4	0.5	0.5
200	26,980	5.3	29,940	5.3	39,440	5.3	1.8	1.9	1.8
300	73,630	14.3	91,590	16.4	148,080	19.7	3.7	3.0	3.4
400	27,870	5.4	47,890	8.9	110,590	14.8	9.4	5.4	6.8
Inter Total	469,700	91.5	519,320	91.2	677,000	90.3	1.7	1.8	1.8
External	43,550	8.5	49,780	8.8	73,000	9.7	2.3	2.4	2.4
Penang Is. Total	513,250	100.0	569,100	100.0	750,000	100.0	1.7	1.8	1.8
500	111,310	25.7	126,630	24.1	186,440	23.3	2.2	2.5	2.5
600	49,330	11.4	81,770	16.4	151,440	18.9	8.8	3.9	5.5
700	67,210	15.5	79,710	15.3	130,390	16.3	2.8	3.2	3.2
800	26,310	6.1	29,510	5.6	61,730	7.7	1.9	4.7	4.1
Internal Total	254,160	58.7	317,620	61.9	530,000	66.3	3.8	3.3	3.6
External	178,500	41.3	293,820	38.1	270,000	33.7	2.2	1.8	2.0
Pro. Wellesley Total	433,330	100.0	520,900	100.0	800,000	100.0	3.1	2.9	3.0

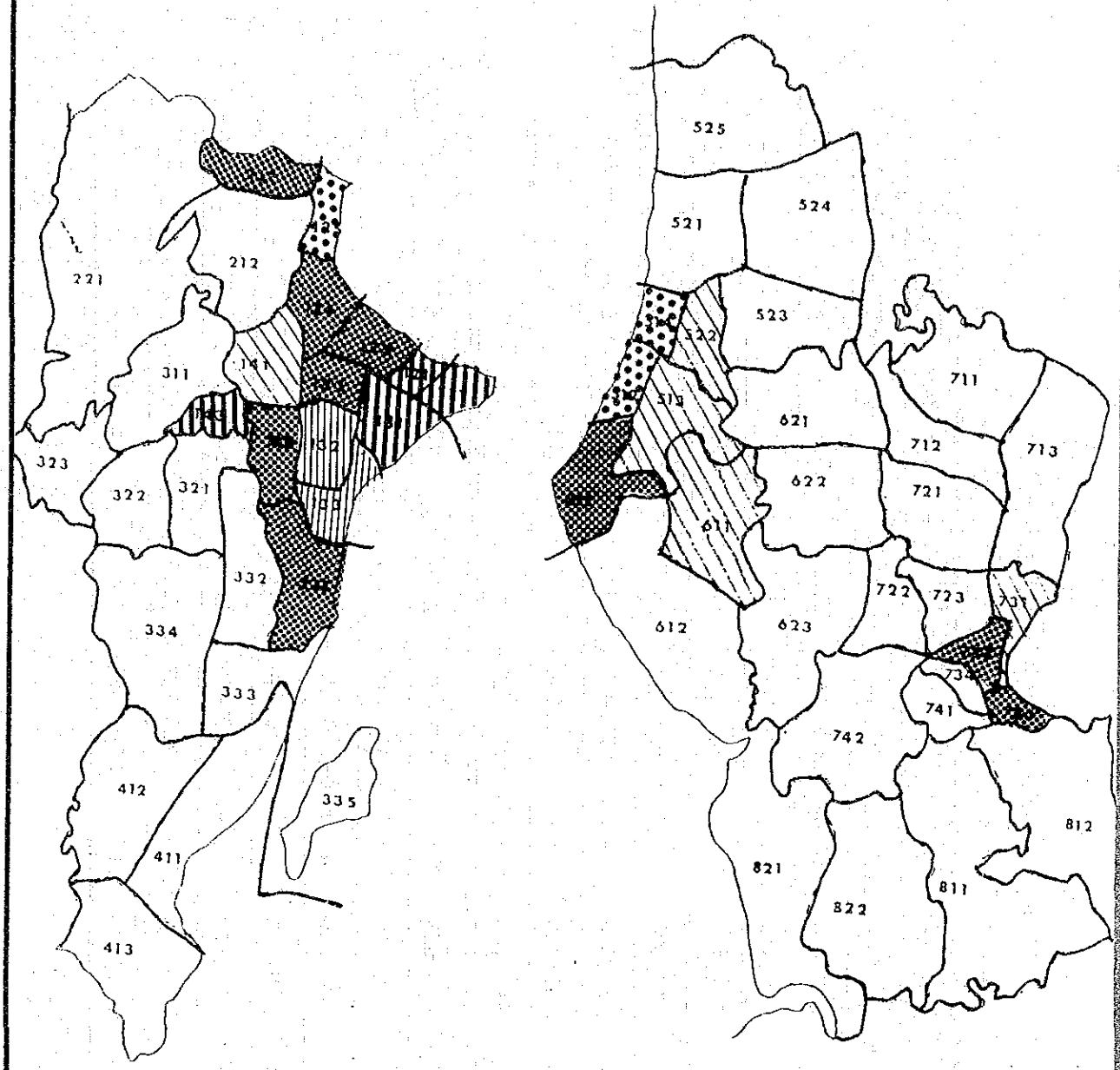

FIG. 2.14: POPULATION DENSITY (1979)

- 0 - 20 Persons/ha
- 20 - 40
- 40 - 80
- 80 - 120
- 120 - 180
- above 180

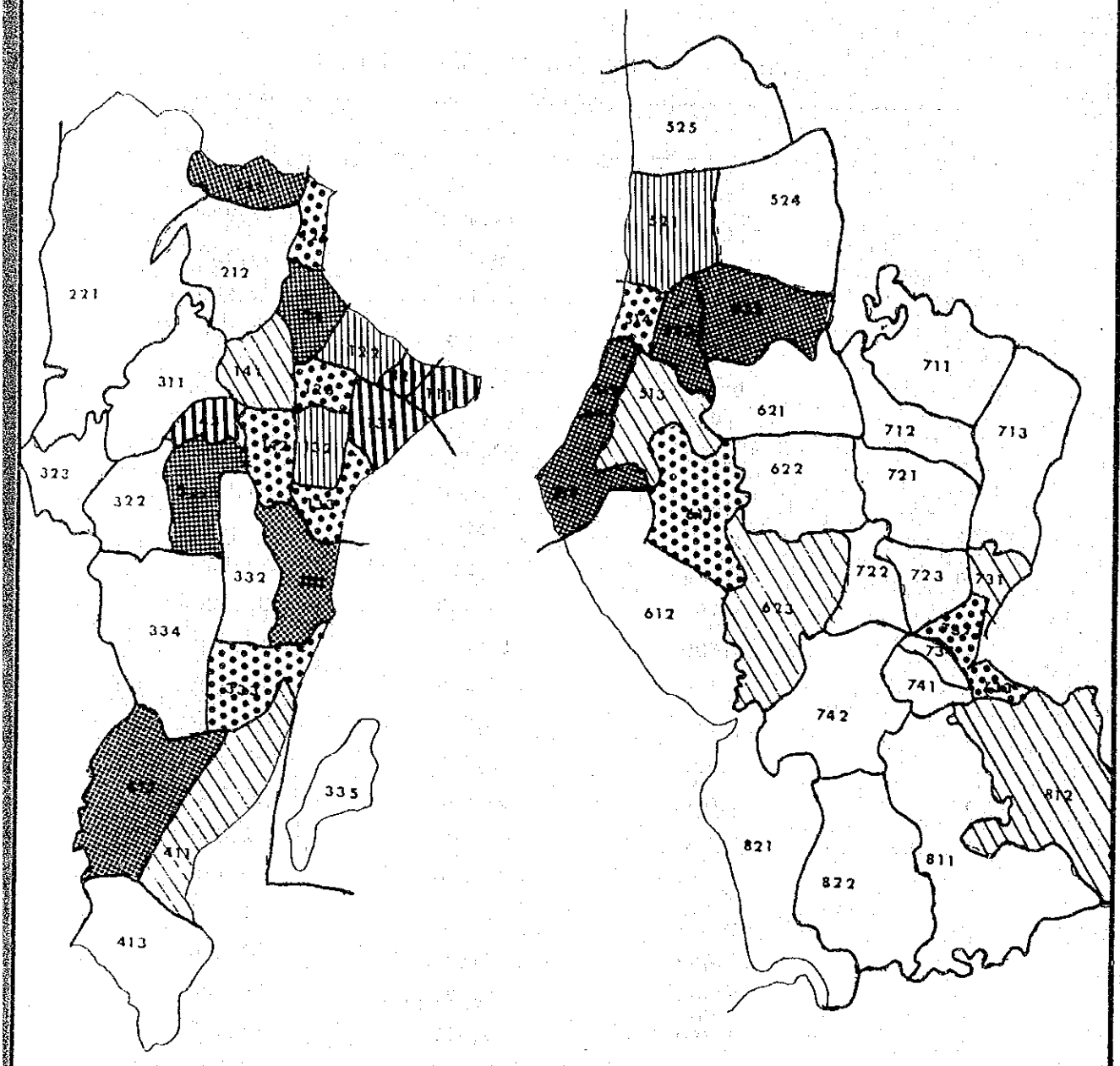

FIG. 2.15: POPULATION DENSITY (2000)

	0 - 20 Persons/ha
	20 - 40
	40 - 80
	80 - 120
	120 - 180
	above 180

Table 2.28 (1) POPULATION DISTRIBUTION PLAN

	1979	1985	2000
111	55,540	49,790	31,800
121	27,980	27,960	27,900
122	17,060	20,980	33,450
123	13,080	15,190	21,900
124	13,350	15,430	11,180
125	13,630	13,700	13,920
131	75,080	77,100	84,500
132	32,300	32,540	33,300
133	32,630	32,670	33,000
141	11,550	12,450	15,450
142	13,820	16,610	25,500
143	35,290	35,460	36,000
211	14,890	15,790	18,640
212	8,380	9,340	12,570
221	3,710	4,810	8,230
311	1,620	2,150	3,780
321	33,050	33,940	36,720
322	1,150	1,400	2,080
323	320	420	750
331	22,950	27,510	41,840
332	2,460	3,750	7,800
333	8,300	15,180	36,820
334	2,360	5,560	15,550
335	1,420	1,740	2,740
411	8,050	13,520	30,620
412	13,760	26,600	66,850
413	6,060	7,770	13,120
Total	469,700	569,100	677,000

Table 2.28 (2) POPULATION DISTRIBUTION PLAN

	1979	1985	2000
511	29,740	32,560	36,480
512	15,570	16,680	18,240
513	15,020	16,680	20,000
514	14,100	15,330	17,040
521	8,510	8,690	10,160
522	10,780	14,130	20,800
523	4,260	8,520	43,880
524	3,300	3,470	4,880
525	10,030	10,560	14,960
611	21,700	48,130	84,880
612	11,770	14,460	19,800
621	4,150	4,410	6,560
622	5,760	5,800	5,480
623	5,950	8,980	34,720
711	2,500	2,530	2,790
712	2,070	2,090	2,250
713	7,970	8,050	8,740
721	4,100	4,180	5,000
722	2,420	2,460	2,800
723	4,020	4,120	4,960
731	6,170	6,410	8,400
732	14,060	18,310	20,040
733	4,200	5,200	6,600
734	5,850	5,010	8,000
741	6,430	7,110	12,660
811	9,650	10,240	15,200
812	10,710	12,960	37,560
821	2,870	3,050	4,350
822	3,080	3,260	4,620
Total	254,160	317,620	530,000

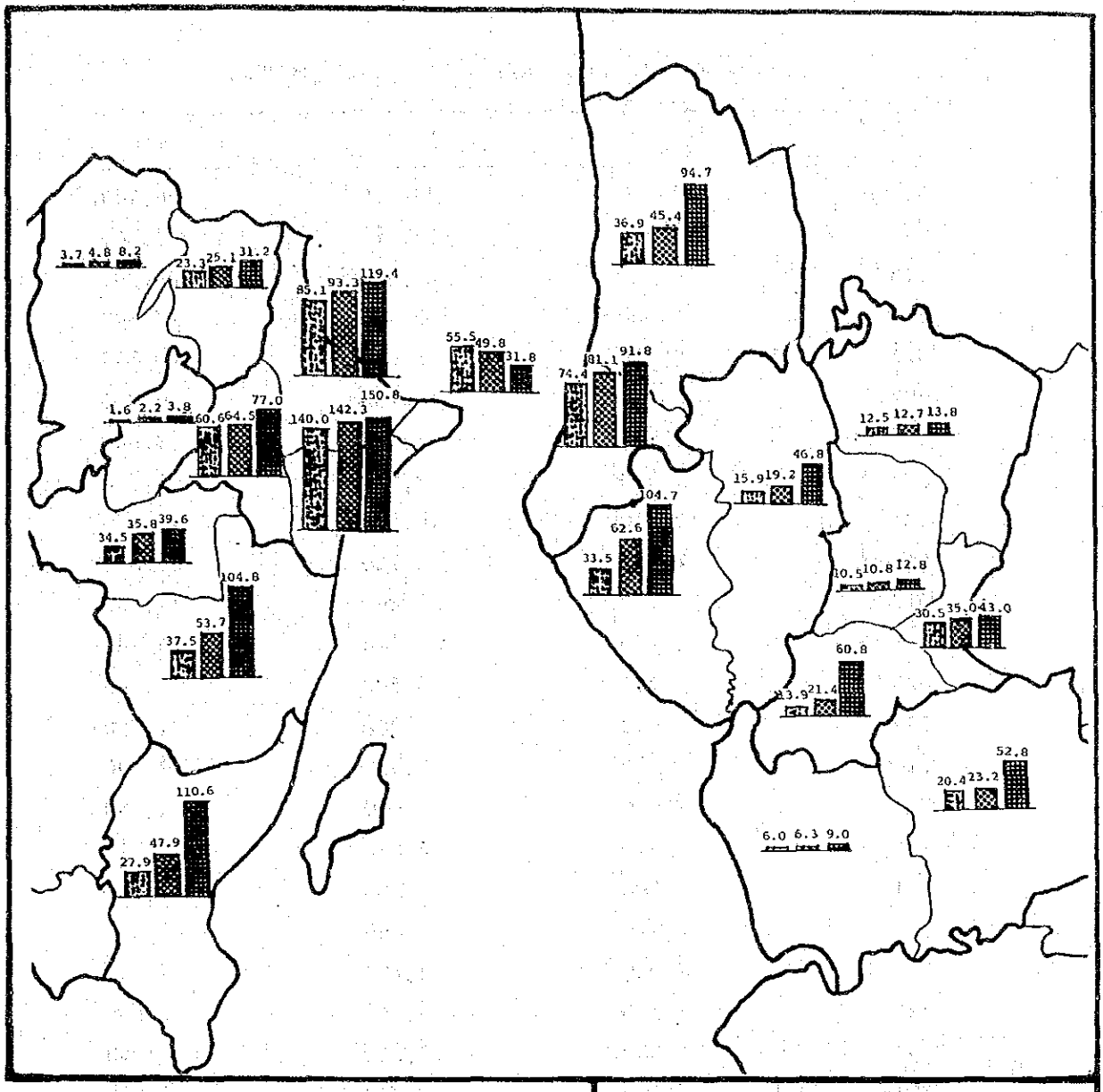

Fig. 2.16 POPULATION DISTRIBUTION PLAN
(In thousand)

2.4.3 Employed Population by Work Place

The distribution plan of employed population by work place is made on the basis of employment projected in the State of Penang.

Classification of employment is as follows:

Primary Industry		Agriculture, Fishing and Forestry
Non-Primary Industry	Secondary Industry	Manufacturing, Construction and Mining.
	Tertiary Industry	Commerce, Financing Transport and Communication and Services.

There is no available data for employment by industry and zone and so the two (2) classifications of industry are used for our study.

1. Primary Industry

Size of employment in the primary industry will decrease steadily in the future. This is because lower productivity is expected in this industry than in the other industries, while moreover, urbanization will be promoted in the future. Employment in this sector will decrease form 54,000 in 1979 to 22,000 by the year 2000. Primary employment for each zone is projected by using an average reduced rate of agricultural lands between the years 1979, 1985 and the year 2000.

2. Non-Primary Industry

The projection for this industry is made by adding the increase in secondary and tertiary employment between the design years 1985 the year 2000 and the base year 1979 to the employment of non-primary industry in the base year 1979. Increase in the employment in the non-primary industries was already estimated in the previous section.

The pattern of increase in employment in the secondary and tertiary industries is quite different. Employment in the secondary industry is mostly located in the industrial development sites.

On the other hand, some of the employment in the tertiary industry is distrubuted to each zone in proportion to the population increase while the others are distributed only to major urban cores.

The former pattern of employment belongs to the neighbourhood commerce and services while the latter belongs to regional and district commerce, services and financing. Considering these concepts, the increase of employment in the non-primary industry is distributed to each zone and the results are shown in Table 2.30. The results show that major growth areas within Metropolitan Penang Area are Bayan Lepas and Seberang Jaya, which will record a growth rate of over 12 percent per annum between 1979 and 1985. The other growth district is Batu Ferringhi where there is a growing tourist industry.

Table 2.29 EMPLOYED POPULATION DISTRIBUTION PLAN
Penang State, 1979, 1985 and 2000

	1979			1985			2000			Average Annual Growth Rate %	
	Primary	Non-Primary	Total	Primary	Non-Primary	Total	Primary	Non-Primary	Total	1979-85	1985-2000
100	1,310	87,260	88,570	1,120	95,830	96,950	0	125,400	125,400	1.6	1.7
200	690	2,990	3,680	590	4,060	4,650	400	6,930	7,330	4.0	3.1
300	1,710	30,430	32,140	1,490	32,240	33,730	480	44,020	44,500	0.1	1.8
400	2,220	9,350	11,570	1,910	25,290	23,380	380	63,330	63,710	12.4	6.9
500	2,110	45,110	47,220	1,830	51,720	53,550	850	72,050	72,900	2.1	2.0
600	1,260	21,900	23,160	1,090	45,210	46,300	510	126,570	127,080	12.2	6.9
700	3,510	21,640	25,150	3,030	25,140	28,170	1,510	35,250	36,760	1.9	1.8
800	3,590	2,210	5,800	3,100	2,870	5,970	1,570	8,750	10,320	0.5	3.7
Internal Total	16,400	222,600	239,000	14,150	282,360	296,510	5,700	482,300	488,000	3.7	3.4
External Total	37,250	17,750	55,000	32,150	22,040	54,190	16,000	37,700	53,700	0.0	0.0
Grand Total	53,650	240,350	294,000	46,300	304,400	350,700	21,700	520,000	541,700	3.0	2.9

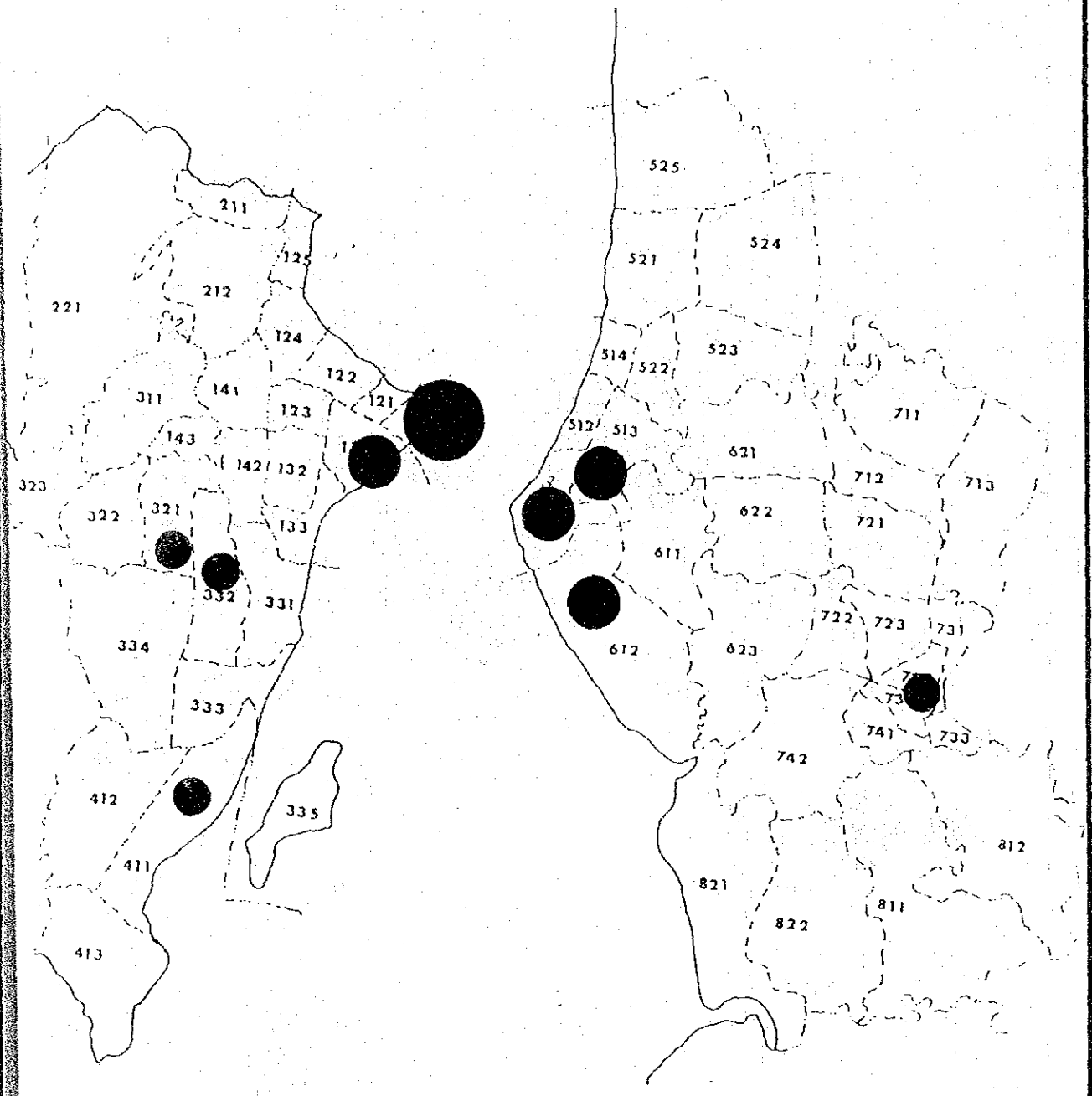

Fig. 2.17 Distribution of Employed Population (1979)

above 50,000 Persons

20,000 - 49,999

10,000 - 19,999

6,000 - 9,999

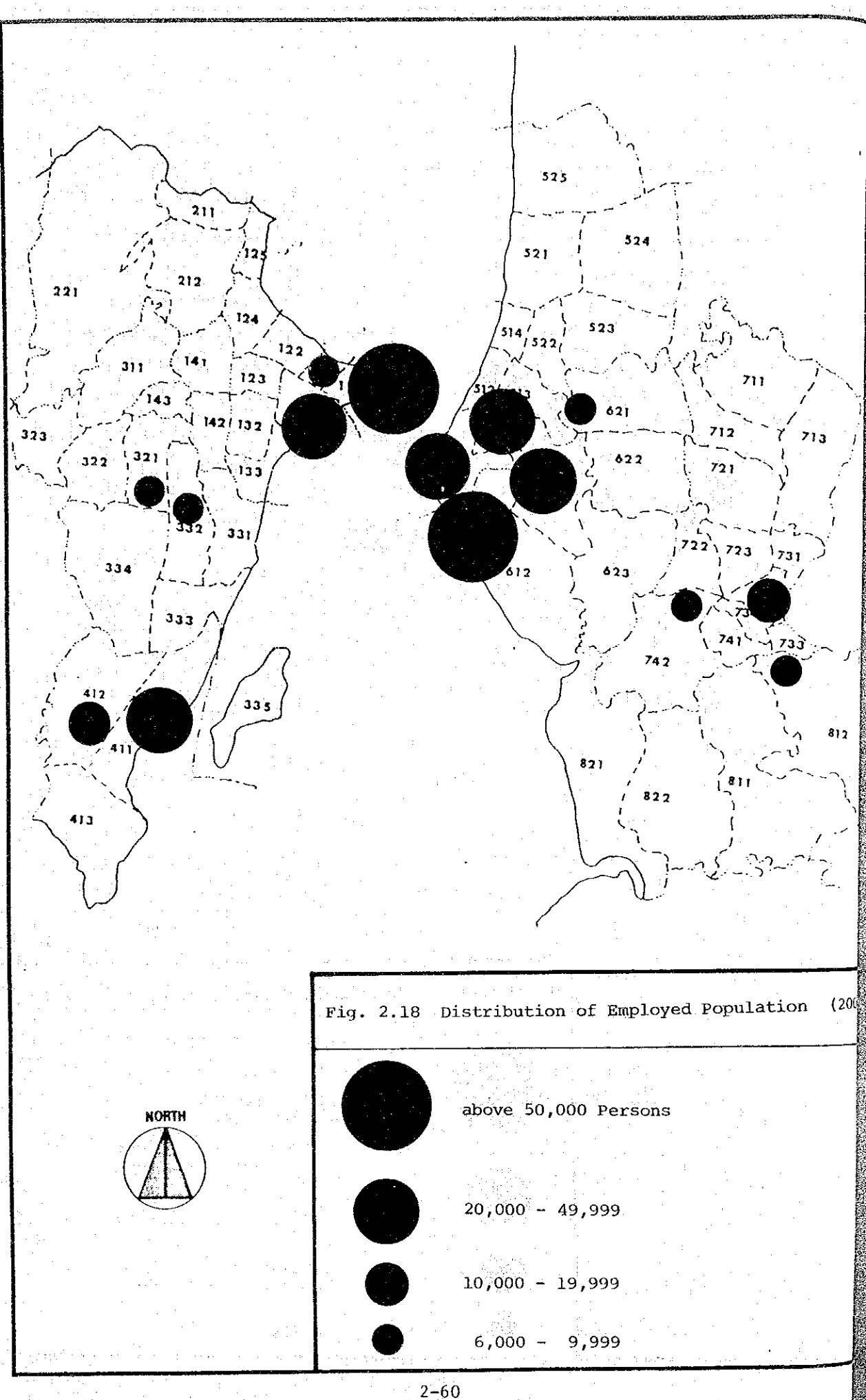

Fig. 2.18 Distribution of Employed Population (200

Table 2.30 (1) EMPLOYED POPULATION BY ZONE
Penang Island, 1979, 1985 and 2000

	1979			1985			2000		
	Primary	Non-Primary	Total	Primary	Non-Primary	Total	Primary	Non-Primary	Total
111	980	41,750	42,730	840	47,210	48,050	0	65,720	65,720
121	0	4,680	4,680		5,140	5,140	0	6,710	6,710
122	0	1,430	1,430		1,730	1,730	0	2,740	2,740
123	0	4,160	4,160		4,320	4,320	0	4,870	4,870
124	0	5,070	5,070		5,230	5,230	0	5,770	5,770
125	0	900	900		950	950	0	1,100	1,100
131	330	13,910	14,240	280	15,670	15,950	0	22,260	22,260
132	0	4,160	4,160		4,180	4,180	0	4,240	4,240
133	0	4,420	4,420		4,400	4,400	0	4,290	4,290
141	0	780	780		850	850	0	1,080	1,080
142	0	3,050	3,050		3,270	3,270	0	4,000	4,000
143	0	2,950	2,950		2,880	2,880	0	2,620	2,620
211	370	1,340	1,710	320	1,430	1,750	210	1,740	1,950
212	50	350	400	40	450	490	30	800	830
221	270	1,300	1,570	230	2,180	2,410	160	4,390	4,550
311	100	500	600	90	550	640	50	730	780
321	110	8,200	8,310	100	8,290	8,390	60	8,590	8,650
322	110	4,260	4,370	100	4,280	4,380	60	4,360	4,420
323	100	4,290	4,390	90	4,300	4,390	60	4,340	4,400
331	0	3,510	3,510	0	3,970	3,970	0	5,540	5,540
332	450	7,540	7,990	390	7,670	8,060	0	8,110	8,110
333	400	1,430	1,830	340	2,130	2,470	0	4,490	4,490
334	440	530	970	380	850	1,230	250	1,950	2,200
335	0	170	170	0	200	200	0	5,910	5,910
411	790	6,630	7,420	680	18,770	19,450	0	44,600	44,600
412	780	1,940	2,720	670	5,570	6,240	0	17,190	17,190
413	650	780	1,430	560	950	1,510	380	1,540	1,920
Internal Total	5,930	130,030	135,960	5,110	157,420	162,530	1,260	239,680	240,940
External	7,260	4,380	11,640	6,270	4,960	11,230	3,120	8,490	11,610
Total	13,190	134,410	147,600	11,380	162,380	173,760	4,380	248,170	243,790

Table 2.30 (2) EMPLOYED POPULATION BY ZONE
Province Wellesley, 1979, 1985 and 2000

	1979			1985			2000		
	Primary	Non-Primary	Total	Primary	Non-Primary	Total	Primary	Non-Primary	Total
511	140	18,080	18,220	120	20,290	20,410	0	27,790	27,790
512	0	3,270	3,270	0	3,700	3,700	0	5,140	5,140
513	0	12,050	12,050	0	15,680	15,680	0	25,130	25,130
514	330	3,370	3,700	280	3,420	3,700	140	3,610	3,750
521	180	6,160	6,340	160	6,190	6,350	80	6,290	6,370
522	0	630	630	0	810	810	0	1,430	1,430
523	460	640	1,100	400	1,370	1,770	200	3,820	4,020
524	460	450	910	400	480	880	200	580	4,800
525	540	460	1,000	470	550	1,020	230	860	1,090
611	100	3,150	3,250	90	8,210	8,300	0	21,960	21,960
612	0	14,740	14,740	0	31,840	31,840	0	87,190	87,190
621	440	90	530	380	130	510	190	8,480	8,670
622	450	3,370	3,820	390	3,380	3,770	200	3,400	3,600
623	270	550	820	230	1,650	1,880	120	5,540	5,660
711	660	250	910	570	250	820	290	270	560
712	330	460	790	280	460	740	140	470	610
713	910	1,180	2,090	790	1,190	1,980	390	1,240	1,630
721	330	820	1,150	280	840	1,120	140	890	1,030
722	230	90	320	200	100	300	100	120	220
723	230	550	780	200	570	770	100	630	730
731	230	2,000	2,230	200	2,040	2,240	100	2,180	2,280
732	0	9,540	9,540	0	10,200	10,200	0	12,630	12,630
733	0	2,550	2,550	0	2,590	2,590	0	2,740	2,740
734	0	2,720	2,720	0	3,120	3,120	0	4,550	4,550
741	50	490	540	40	600	640	20	990	1,010
742	540	990	1,530	470	3,180	3,650	230	8,540	8,770
811	790	990	1,780	680	1,090	1,770	340	1,440	1,780
812	1,180	490	1,670	1,020	990	2,010	520	6,290	6,810
821	750	330	1,050	650	360	1,010	330	450	780
822	870	400	1,270	750	430	1,180	380	520	900
Internal Total	10,470	90,860	101,330	9,040	124,940	133,980	4,440	242,620	247,060
External	29,990	15,080	45,070	25,880	17,080	42,960	12,880	29,210	42,090
Total	40,460	105,940	146,400	34,920	142,020	176,940	17,320	271,830	289,150
Grand Total	53,650	240,350	294,000	46,300	304,400	350,700	21,700	520,000	541,700

3. Traffic Projection of Base Situation

TRAFFIC PROJECTION OF BASE SITUATION

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3. TRAFFIC PROJECTION OF BASE SITUATION

3.1 Introduction

Fig. 3.1 shows the main steps in the long-term transport planning of this urban transport study. The procedure starts with the collection of data which will constitute the basis for the analysis of statistical relationships. Then a traffic demand forecast model is formulated on the basis of the present analysis and the future land use.

Future traffic demand of base situation is estimated according to the land use pattern and the methodology of traffic estimation. This estimation is conducted in order to obtain guidelines in the preparation of the proposals for the future transport plan.

After this work is done, the transport plans are selected. The traffic estimation and cost estimation are conducted by alternative transport plans. When the distribution of traffic in the network is obtained, the total trip length and travel time are also computed. These figures, together with construction costs, constitute the basis for the economic evaluation of the alternative transport plans.

In this chapter, the formulation of a traffic demand forecast model and the estimation of the future traffic demand of base situation are only dealt with. The detailed contents of other items will be shown in the following chapter.

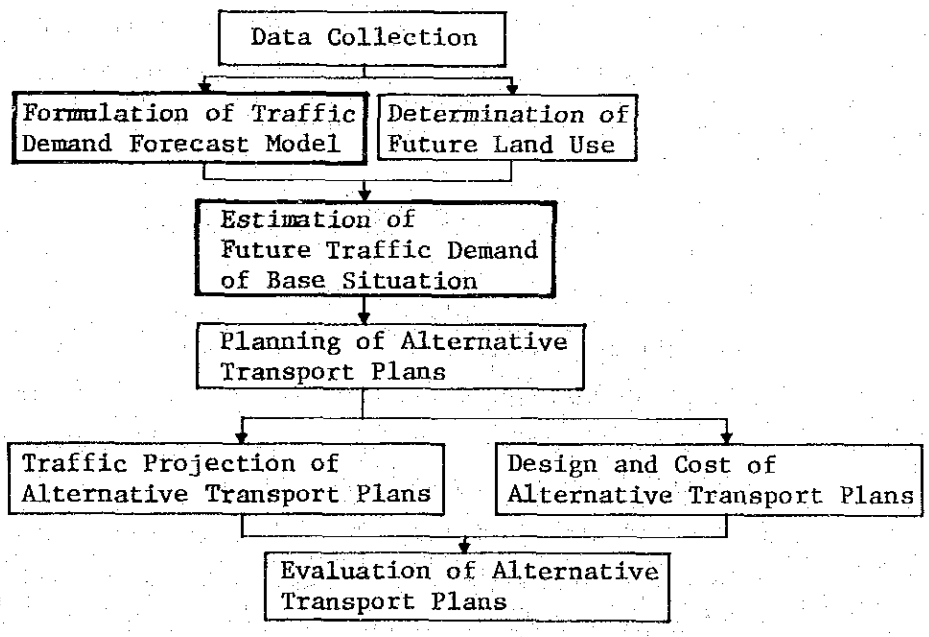


Fig. 3.1 FLOW CHART OF TRAFFIC PROJECTION

3.2 Procedure of Traffic Estimation

The traffic estimation of base situation regarding the traffic demand of vehicles and the bus passengers demand are conducted separately.

The flow chart is as follows:

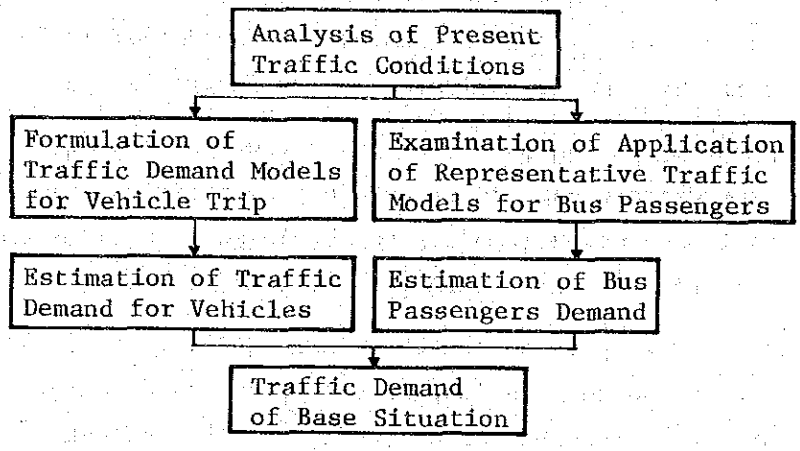


Fig. 3.2 FLOW CHART OF ESTIMATION OF BASE SITUATION

3.2.1 Procedure of Traffic Estimation for Vehicles

Car Owner Interview Surveys were executed in order to obtain the present vehicle movements on ordinary days in June 1979. By using these results, the traffic models are developed and verified with the present figures.

Based on the land use pattern and the socio-economic framework, the future traffic demand of vehicles is estimated through three (3) steps, viz. trip production, trip generation and attraction, and trip distribution.

Here follow some brief explanations about these steps.

1. Trip Production

This is the first step in the estimating of O-D tables. The purpose of this is to estimate the total number of trips related to the Study Area. As is usually done, trip product is estimated by multiplying the total number of vehicles by the unit trip production of each vehicle. The unit trip production used is obtained from the actual survey, i.e., the car O-D survey. Another method which is used occasionally is the correlation

formula which is calculated from the population figure, the number of vehicles, etc.

2. Trip Generation and Attraction

This is the estimation of the number of trips that start from and arrive at each traffic zone. It is easy to understand this concept if we consider the purpose of each trip. For example, when the purpose of the trip is to get to the working place, a single commuter usually produces one (1) trip. Therefore, the trip generation for this purpose is related to the number of residents, number of employees, landuse area by utilization etc.

3. Trip Distribution

This is the most complicated step in the estimation of future traffic demand because, if there are 66 traffic zones, we must estimate for 4,356 (66 x 66) pairs of trip distribution. Many empirical formulae were formulated by many of our predecessors for the purpose of estimating the trip distributions. Among them, the gravity model is the most general method.

Although these estimations are conducted by type of car, the final figures are expressed by using the following car passengers unit.

Table 3.1 CAR PASSENGERS UNIT

(Unit: p.c.u.)

	Car	Lorry	Bus	Taxi	M/C
P.C.U	1.0	2.0	3.0	1.0	0.5

Source: "Roads in Urban Areas" Scottish Development

3.2.2 Procedure of Traffic Estimation for Bus Passengers

The projection is made according to the following keynotes.

1. Up to the present moment, the demand for bus trips which is measured by per capita riding is inclined to follow past trends.
2. Even if ownership ratio increases to a great extent, the demand for bus trips still remains as the bus should provide its services to the 'transport poor' such as elders and children.

3. The projection of bus passenger demand is conducted by using the tendency of the per capita riding factor.

3.3 Estimation of Vehicle Traffic Demands

3.3.1 Formulation of Traffic Demand Forecast Model

The traffic models are drawn up while paying attention to the following matters:

1. The data which is used for the models has been obtained from the various traffic surveys conducted in Penang.
2. The traffic models make use of the methodology which has been developed, e.g., the basic unit method, the growth rate method, the regression method and the stimulation method.
3. The compatibility of the model is verified by using the present data.
4. Some of the existing data is from the last few years or from the previous year only. Therefore, various appropriate hypotheses are made for formulating the traffic models.

This analysis is conducted according to the trip purpose and type of vehicle used because in this way it is easier to decide on the variables used for the estimation, viz., the trip generation with the trip purpose of 'going to work' is proportional to the resident population, and the trip attraction is proportional to the number of workers at the work place.

Therefore, in this analysis, vehicles are divided into the following types;

Table 3.2 CLASSIFICATION OF TYPE OF VEHICLES

1 Car: trip to work	5 Lorry
2 Car: business trip	6 Taxi
3 Car: private trip	7 Bus
4 Car: trip home	8 Motor-cycle

Note: 'Bus' in Table 3.2 means only company bus and school bus, not scheduled bus.

1. Analysis of Trip Production

From the owner-interview survey, the average number of trips per day can be obtained. Using the technical term in traffic studies, these figures are called "unit trip production". There are two (2) types of unit trip production. One is the gross unit trip production while the other is the net unit trip production.

Some vehicles did not make any trips on the day of the interview. Therefore the former (the gross unit trip production) is the average trip per day of one (1) vehicle which also includes zero (0) and the latter is the actual average number of trips per day of one vehicle.

Table 3.3 THE UNIT TRIP PRODUCTION

(Unit: trip per vehicle per day)

	The unit trip production (gross)	The unit trip production (net)	The % of zero number of trips
Car	3.98	4.25	6.3%
Lorry	3.01	3.60	16.4%
Taxi	8.07	8.07	0%
Bus	20.6	20.8	0.9%
(Vehicles)	4.09	4.43	7.7%
Motor-cycle	3.78	4.01	5.7%
All vehicles	3.90	4.17	6.5%

The relationship between the traffic volume and vehicle ownership shows that the size of the traffic volume is close to vehicle ownership.

It can be said that the traffic volume up to this time increases in proportion to the size of vehicle ownership. Therefore it is estimated that the unit trip production is constant every year.

On the basis of these considerations, the unit trip production will be used in principle for the future. However, in developed urban areas a situation where the unit trip production of private cars and motor-cycles is decreasing in proportion to the rapid growth of ownerships must be reckoned with.

2. Analysis of Trip Generation and Attraction

The analysis was conducted using two (2) methods, viz, the basic unit method and the regression method. The results of both methods were examined and the regression method was selected to be used in the traffic model of trip generation and attraction.

In the regression method, the least square method is used to obtain the regression equation. The regression equation consists of the explained variable and the explanatory variables. In this case, it is natural that the explained variable is the trip generation by zone while the explanatory variables make use of the following factors, viz, the area by land-use, the floor size by purpose of building, the population and the employed population by industry, etc.

For the purpose of drawing up the traffic model of trip generation only some factors need be chosen. However, the following criteria must be observed:-

1) The explanatory variables for the present and also for the estimated target year must be obtained.

2) The explanatory variables must not be chosen only from the degree of the co-efficient of correlation, in order to avoid a causal relationship.

Taking into consideration the above matter, some indices of population are chosen as the explanatory variables in this study as shown in the following figures:-

Table 3.4 TRIP MODEL OF TRIP GENERATION AND TRIP ATTRACTION

		Trip generation	Trip attraction
Car	Trip to work	$y = 0.0916xp + 0.844$ (R=0.774)	$y = 0.405x_E - 404$ (R=0.884)
	Business trip	$y = 0.172x_E - 80.7$ (R=0.894)	$y = 0.172x_E - 80.7$ (R=0.894)
	Private trip	$y = 0.0560xp + 0.0829x_E - 101$ (R=0.828)	$y = 0.250x_E - 38.2$ (R=0.811)
	Trip home	$y = 0.440x_E - 247$ (R=0.864)	$y = 0.101xp + 177$ (R=0.711)
Lorry		$y = 0.116x_E + 92.4$ (R=0.851)	
Taxi		$y = 0.000941xp + 0.0186x_E - 12.2$ (R = 0.770)	
Bus		$y = 0.0242xp + 0.00728x_E - 44.5$ (R = 0.736)	
Motor-cycle		$y = 0.340xp + 1.01x_E - 1,514.5$ (R = 0.945)	

y = trip generation or trip attraction by zone

xp = population by zone

x_E = employed population by zone

R = co-efficient of correlation

This model is to be used for the calculation of increasing trip generation and attraction from the year 1979 to 1985 or the year 2000.

3. Analysis of Trip Distribution

For the purposes of estimating the trip distribution, the following two (2) methods are representative. One is the present pattern method and the other is the model method. Usually, the former is used for short term estimation or when it is anticipated that the land-use pattern will not be subject to too much change.

On the other hand, the model method which is designed for adjusting to the change in land-use pattern is suitable for long term estimation.

In our land-use plan, it is perceived that the future land-use pattern would be different from the present pattern. In addition to this, the main flow of traffic would be diverted because the Penang Bridge plan and the East-West Highway plan would have reached fruition and consequently there would be a change in the major road network. As a result of the above, the most popular method was chosen for our estimation and this is the gravity model method.

The gravity model is as follows:-

$Tij = \alpha gi \cdot aj \cdot tij - r$

Tij : number of trips between zone i and j

gi : total number of trip generation in zone i.

ai : total number of trip attraction in zone i

α : constant of proportion

γ : exponent of gravity model

tij : time distance between zone i and j

The exponent of the gravity model is estimated by the trip purpose or vehicle type through the least square method applied to the relationship between the present O-D tables and the present travel time of each zone pairs.

The results from using the model for all the zone pairs in the Study Area are as follows:-

Table 3.5 FORMULA OF TRIP DISTRIBUTION

		The formula for Trip Distribution
Car	trip to work	$Tij = 1.147 \frac{Ai^{0.340} gj^{0.424}}{tij^{0.624}}$
	business trip	$Tij = 0.461 \frac{Ai^{0.402} gj^{0.398}}{tij^{0.396}}$
	private trip	$Tij = 0.749 \frac{Ai^{0.398} gj^{0.404}}{tij^{0.576}}$
	trip home	$Tij = 1.269 \frac{Ai^{0.415} gj^{0.367}}{tij^{0.709}}$

Continued

(Cont'd)

	The formula for Trip Distribution
Lorry	$Tij = 1.737 \frac{Ai^{0.355} gj^{0.381}}{tij^{0.635}}$
Taxi	$Tij = 0.0998 \frac{Ai^{0.425} gj^{0.413}}{tij^{0.115}}$
Bus	$Tij = 0.523 \frac{Ai^{0.417} gj^{0.407}}{tij^{0.419}}$
Motor-cycle	$Tij = 0.237 \frac{Ai^{0.514} gj^{0.510}}{tij^{1.100}}$

However, the use of one formula alone is not enough to explain the present traffic distribution because the traffic patterns in Penang Island, Province Wellesley and across the straits each have their unique characteristics. Therefore these formula are amended according to each area pair. The Study Area is divided into four (4) areas that is, two (2) areas in Penang Island and two (2) areas in Province Wellesley. Therefore one trip distribution formula is made up of 16 formula (4x4) from each pair.

3.3.2 Estimation for Traffic Demand of Base Situation

The estimations for the future traffic demand are carried out on the basis of the traffic model and the above mentioned premises.

1. Estimation of Trip Production

The future traffic volume related to the Study Area is divided into the following types, viz, internal trip, external trip, through trip and trip production from specific facilities. 'Particular facilities' in this section means the new port, other port facilities and the airport.

These facilities will produce more traffic than that produced as a result of population increase. This is because there will be a rapid increase in the volume of cargo handled by the port and also in the volume of air passengers. Therefore, trip production from these facilities must be considered separately from the usual trip production.

(a) Internal trip

The internal trip production is estimated by multiplying the number of vehicles with the unit trip production already determined in this analysis. With regards to Penang Island, the growth rate of external trips is estimated by using the growth rate of population and vehicle ownerships in the external area of Penang Island.

With regard to Province Wellesley on the other hand, the feasibility study of Federal Route 1 and the East-West Highway are used in addition to the growth rate of population and vehicle ownership in the external area.

Some explanation is needed regarding the trip production of private cars and motor-cycles. As the ratio of ownership increases, the unit trip production made by private cars and motor-cycles will decrease. Therefore, in the estimation of the volume of trip production of those vehicles, the unit trip production is to decrease with the increase of the ownership ratio of these vehicles.

(b) External trip and through trip

The growth rate of external trips and through trips in the future depends on the economic and social growth rate of external area.

(c) Trip production from specific facilities

Trip production from wharfs is estimated on the basis of their carrying volume by each commodity type, and trip production from the airport is based on the number of passengers arriving and departing.

Regarding the specific facilities, only increased volume is added to the future trip production because the present volume of these facilities is obtained through traffic surveys and is already included in the internal trips, external trips and through trips of the present trip production data.

Table 3.6 TRIP PRODUCTION FROM SPECIFIC FACILITIES

(unit: 1,000 trips per day)

year	1979	1985	2000
New development area	-	4.0	15.9
Other area	15.5	17.6	25.1
Port	15.5	21.6	41.0
Penang Airport	2.2	3.5	13.0

(d) Total number of trips related to the Study Area

The estimation for the number of trips is conducted separately according to the type of trips. The summary of this estimation is as follows:

Table 3.7 TOTAL NUMBER OF TRIPS

(unit: 1,000 trips per day)

year	1979	1985	2000
Internal Trip	286.1	381.5	864.2
External and Through Trip	35.3	51.5	144.4
Increased Trip from Port	-	6.1	25.5
Increased Trip from Airport	-	1.3	10.8
Vehicles ex. m/c	321.5	440.0	1,044.9
Internal Trip	397.3	437.7	499.3
External and Through Trip	25.1	27.7	28.6
Motor-cycle	422.4	465.3	477.9
P.C.U (1,000 p.c.u.)	609.8	776.6	1,538.1

2. Estimation of Trip Generation and Attraction

The future volume of trip generation and attraction is calculated by the population data and the trip generation and attraction models which are derived from the present traffic situation.

Fig. 3.3 shows that the growth rate of trip generation is almost proportional to the growth rate of the resident population. Therefore the growth rate of trip generation in Province Wellesley is more rapid than that in Penang Island.

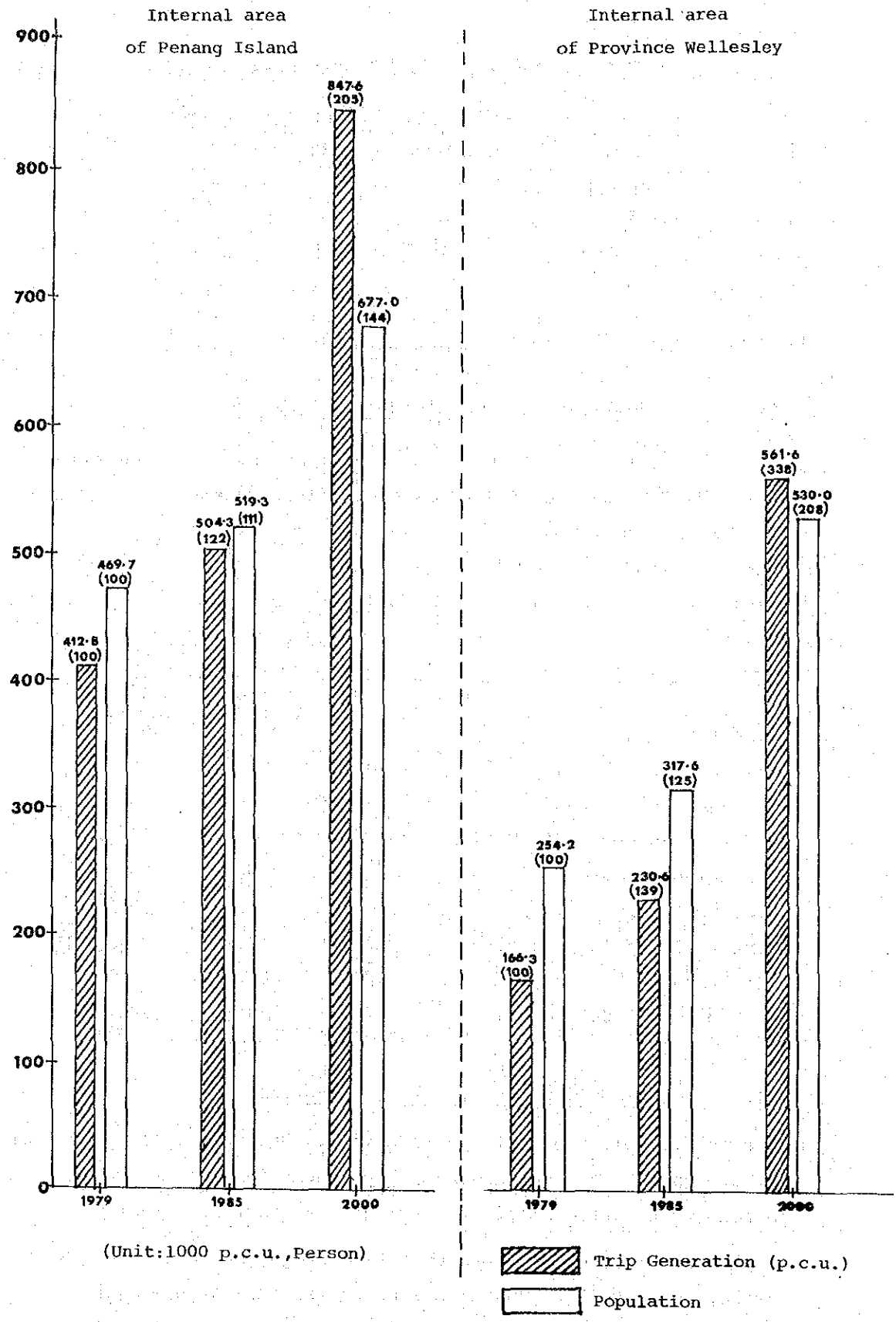


Fig. 3.3 The Relationship with Trip Generation and Population

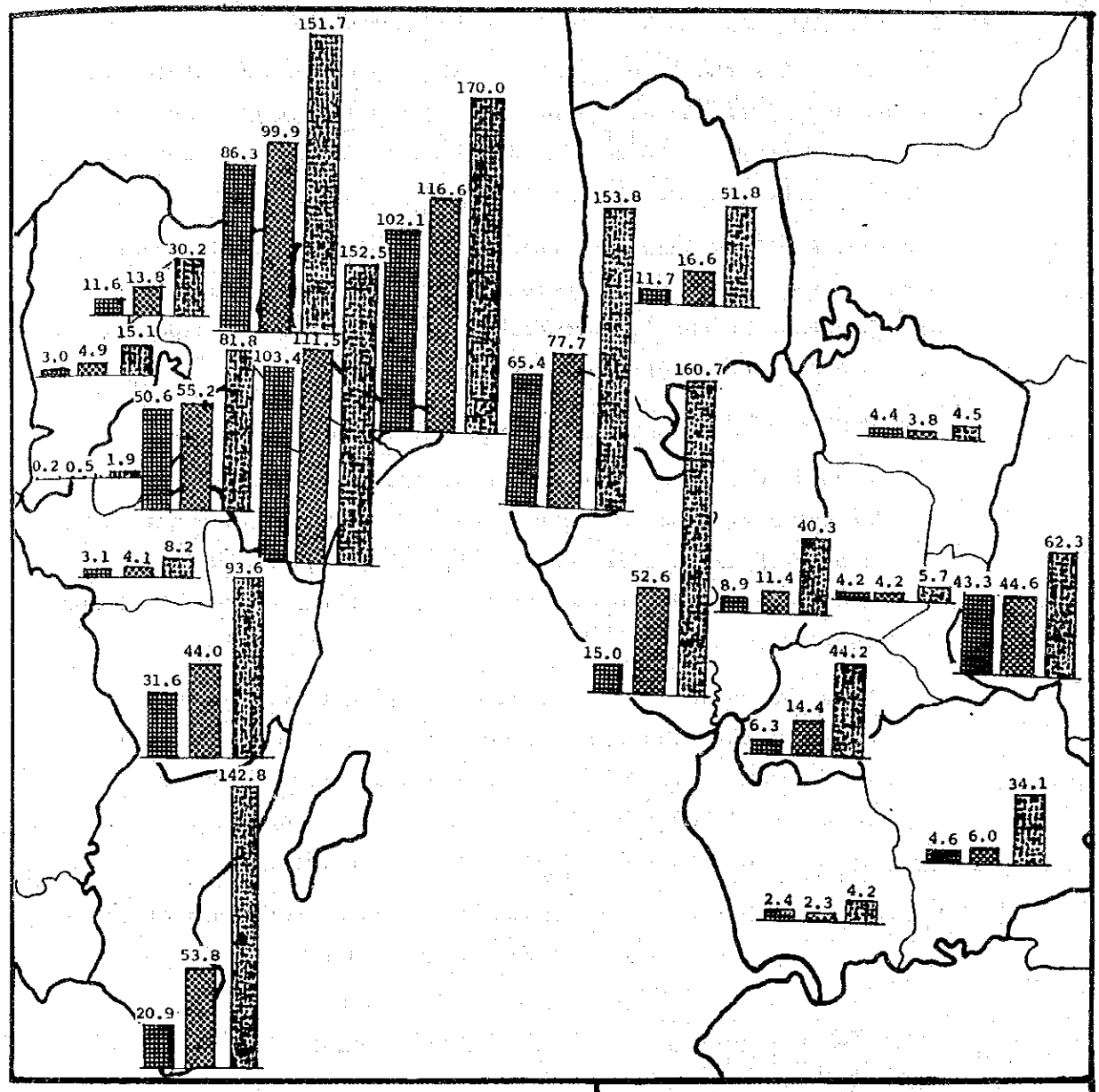


Fig. 3.4 Projected Trip Generation by Zones

3. Estimation of Future O-D Table of Base Situation

O-D tables for the future are estimated by using the future trip generation, trip attraction and time distance between each zone pair together with the gravity model which is derived from the present traffic data.

The desired lines show that the movement of vehicles is becoming more active due to the reduction in time distance. This is brought about by the improvement of the road network, especially by the construction of the Penang Bridge.

(a) Number of trips in each type of traffic flow

According to the rapid growth of car ownership, the number of trips are increasing year by year and in future the total number of trips will become 776,600 and 1,538,100 in 1985 and the year 2000 respectively from a total of 609,800 trips in 1979.

From the volume of each type of traffic flow, it can be observed that the annual growth rate of internal trips is 5.2 percent from 1979 to 1985 and 5.6 percent from 1985 to the year 2000; on the other hand, those of external trip are 7.0 percent and 7.9 percent respectively.

The growth rate of external trip is more rapid than of internal trip due to the reduction in time distance.

Table 3.8 NUMBER OF TRIP IN EACH TRAFFIC TYPE

(Unit: 1,000 trips)

		Vehicle									
		Car									
	Year	Going to Work	On Business	Private	Going Home	Sub-Total	Lorry	Taxi	Bus	Sub-Total	M/C
internal trip	1979	66.4	33.4	53.1	83.2	236.0	28.4	2.7	19.0	286.1	397.3
	1985	88.1	44.0	70.8	110.1	312.9	43.2	6.1	24.7	386.9	437.7
	2000	200.1	100.0	160.7	249.9	710.7	92.2	24.5	51.5	878.9	449.3
external and through trip	1979	4.3	4.8	6.4	7.5	23.2	9.8	2.1	0.4	35.3	25.1
	1985	6.0	7.2	9.8	10.3	33.3	15.8	3.4	0.6	53.1	27.7
	2000	14.4	21.6	27.3	25.5	89.0	66.4	9.2	1.4	166.0	28.6
Total	1979	70.7	38.2	59.5	90.7	259.2	38.2	4.8	19.4	321.5	422.4
	1985	94.1	51.2	80.6	120.4	346.2	59.0	9.5	25.3	440.0	465.3
	2000	214.5	121.6	188.0	275.4	799.7	158.6	33.6	52.9	1,044.9	477.9

Table 3.9 NUMBER OF TRIP PRODUCTION IN EACH TRAFFIC TYPE (P.C.U.)

(Unit: 1,000 P.C.U.)

year	1979	1985	2000
internal trip	551.2 (100)	692.2 (126)	1,287.5 (234)
external and through trip	58.6 (100)	84.4 (144)	250.6 (428)
total	609.8 (100)	776.6 (127)	1,538.1 (252)

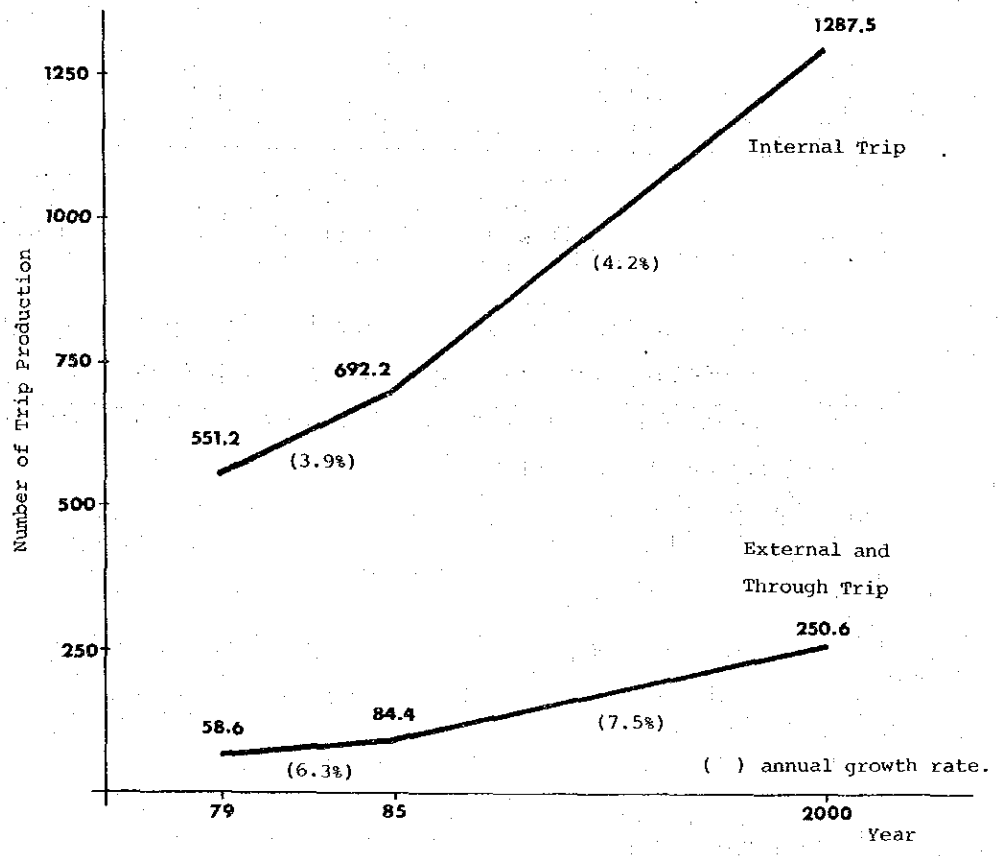


Fig. 3.5 TREND OF EACH TRAFFIC TYPE

(b) O-D Pattern

The estimated O-D table is as follows:

Table 3.10 VEHICLE O-D TABLE

(Unit: 1,000 p.c.u. per day)

	Internal Area		External Area		
	Penang Island	Province Wellesley	Penang Island	Province Wellesley	Total
	399.9	6.2	3.8	3.1	413.0
P.I	480.6	10.5	8.1	4.5	503.7
	786.2	23.7	26.3	11.5	847.7
	6.1	138.9	0.2	20.9	166.1
P.W	10.2	190.9	0.4	28.0	229.5
	23.3	454.3	1.9	82.0	561.5
	3.8	0.2	0.0	0.1	5.9
P.I	8.1	0.5	0.0	0.3	8.9
	26.3	2.0	0.1	1.3	29.7
	3.2	20.8	0.1	1.8	25.9
P.W	4.8	27.7	0.1	1.9	34.4
	11.7	81.5	1.3	4.7	99.2
			upper	in year 1979	609.8
			middle	in year 1985	776.6
			lower	in year 2000	1,538.1

From this table, internal trip in Province Wellesley shows a more rapid growth rate than in Penang Island, due to the more rapid increase of resident population and employment in Province Wellesley.

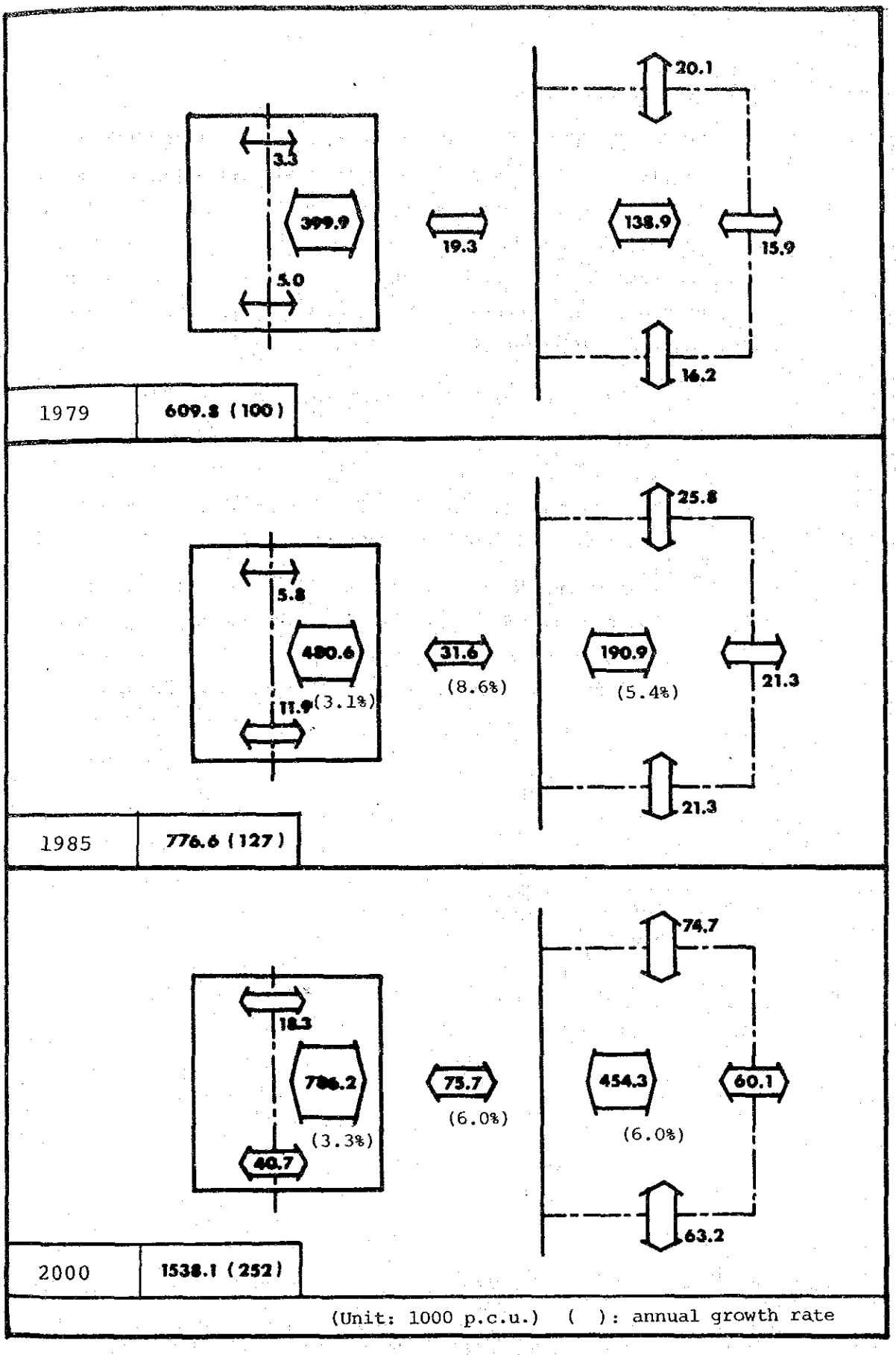


Fig.3.6 Outline of Traffic Movement

(c) Desired Assignment

For the purpose of grasping the traffic movement approximately, the desired assignment is conducted using the method of simple assignment. Here, the traffic demand of each O-D pair (in this case middle zone pair) is assigned to the shortest desired route according to the distance. The growth rate of traffic demand on major section estimated by the desired assignment are as follows:

From these figures, the following can be observed:

1. In Penang Island, the traffic movement between George Town and Bayan Lepas will become greater. (Section C). The traffic movement in 1979, 1985 and the year 2000 are 63,000, 106,000 and 239,000 respectively.

2. In Province Wellesley, the traffic movement between Butterworth, Seberang Prai and Bukit Mertajam (Section F) will be increased remarkably from 41,000 to 73,000 in 1985, and further to 20,400 in the year 2000.

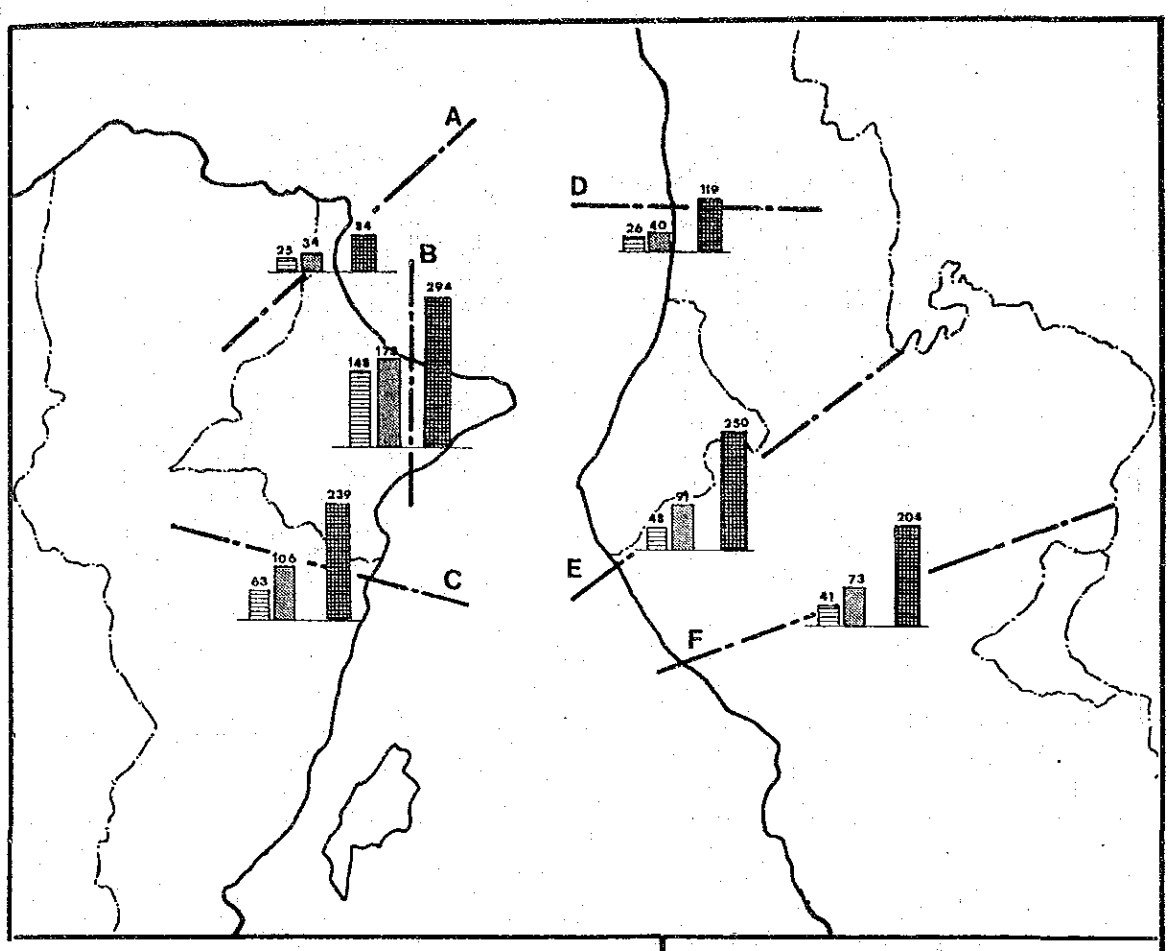


Fig.3.7 Traffic Demand on Major Section

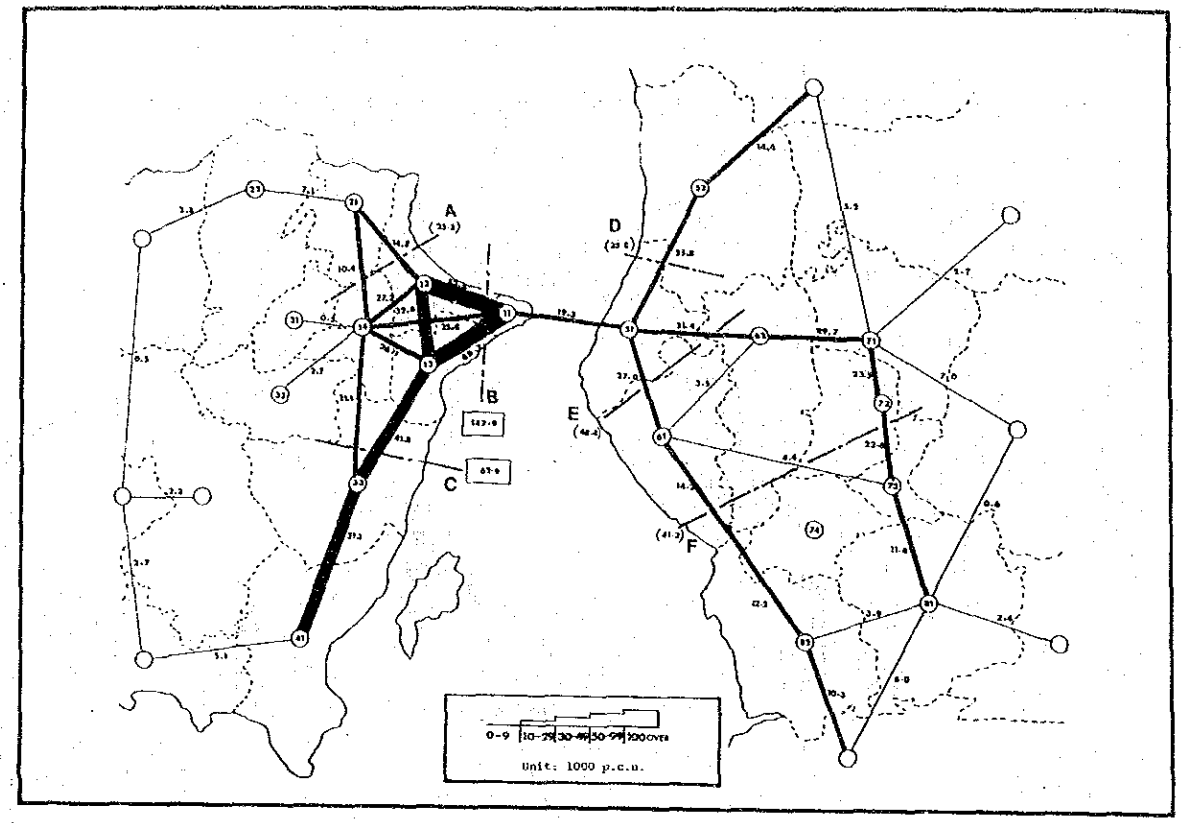


Fig. 3.8 Desired Assignment in 1979

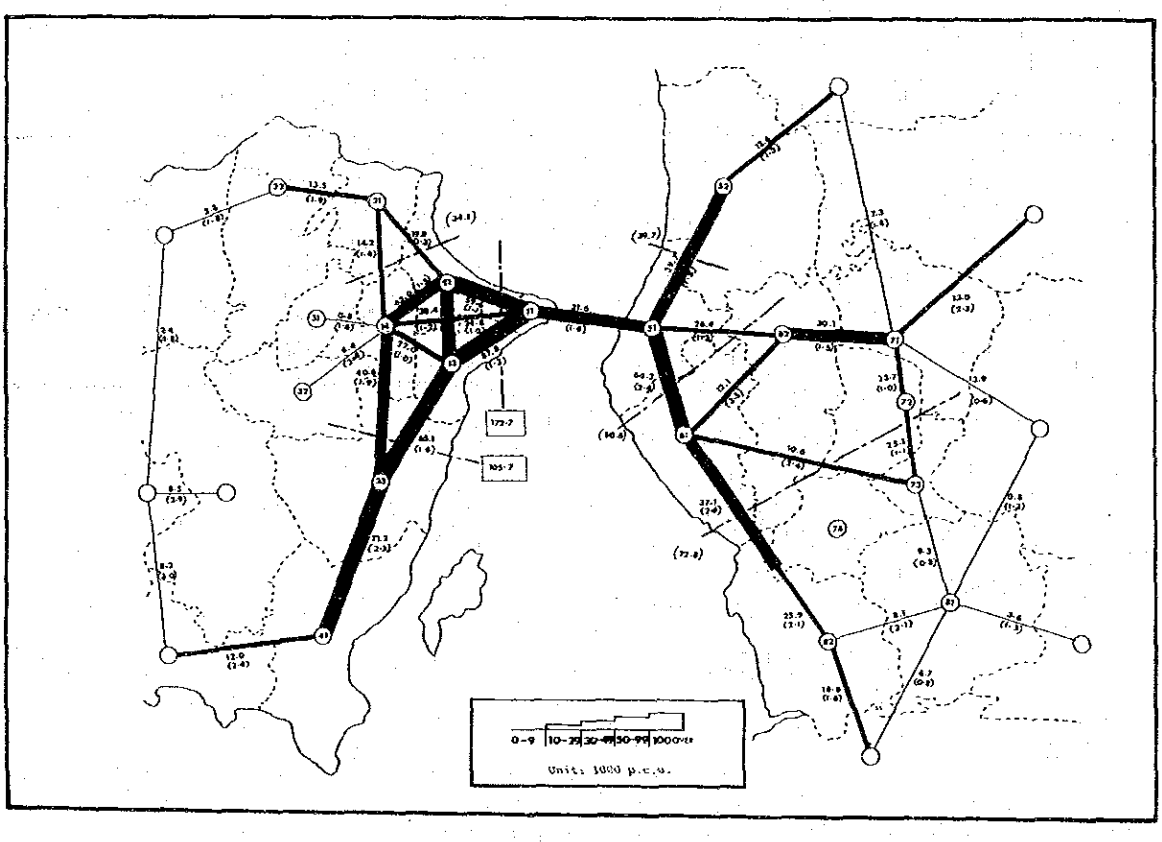


Fig. 3.9 Desired Assignment in 1985

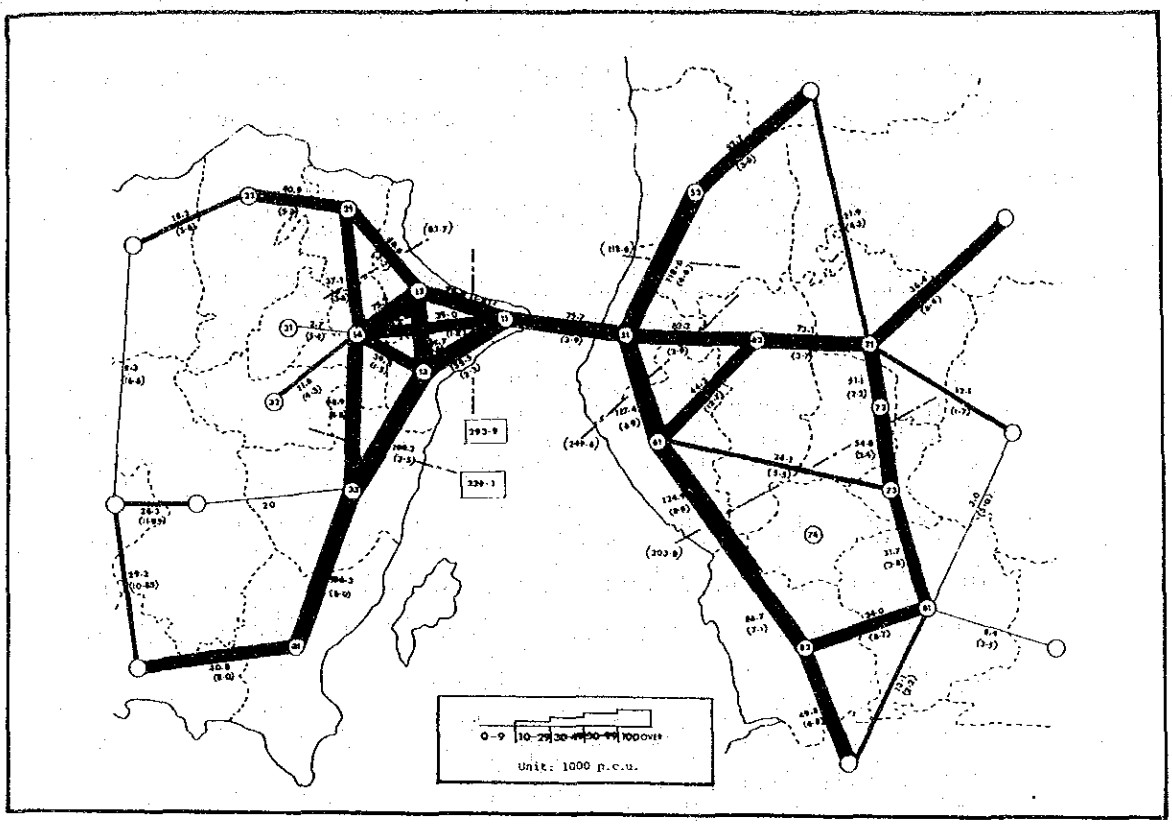


Fig. 3.10 Desired Assignment in 2000

4. Traffic Volume Across the Straits

The traffic volume over the unique section, viz. across the straits is estimated by future O-D tables as follows:

Table 3.11 TRAFFIC VOLUME ACROSS THE STRAITS

(Unit: 1,000 trips, 1,000 p.c.u.)

year	1979	1985	2000
Vehicles (trips)	10.8	19.2	52.9
Motor-cycles (trips)	13.0	14.7	15.8
P.C.U. (p.c.u.)	19.3	31.6	75.7

From the results, the induced trips brought about at the completion of the Penang Bridge can be obtained. In 1985, these trips will total 6,000 p.c.u but by the year 2000 will total 28,000 p.c.u.

From this, we can infer that the effects of the Penang Bridge will be quite considerable.

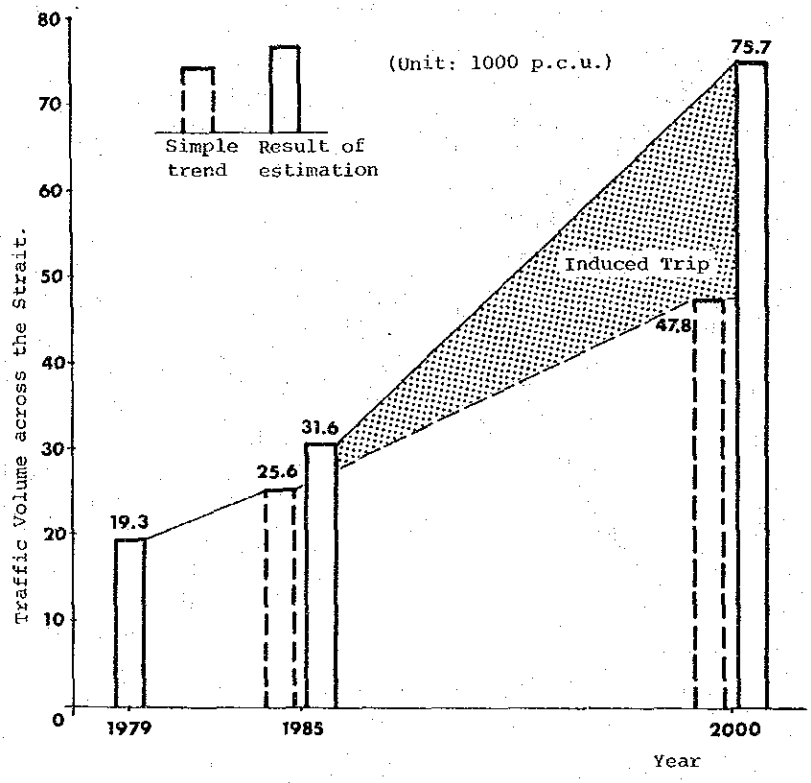


Fig. 3.11 Induced Trip by Linkage

3.4 Estimation of Bus Passenger Demand

3.4.1 Total Demand of Bus Passengers

Firstly the inclination of bus passenger demand is examined from various data obtained. The inclination is indicated as the rate of bus passengers to population (per capita riding). In 1979 there are 256,000 passengers by scheduled buses related to the Study Area, while the population (above 15 years old) is 458,000. Accordingly the per capita riding factor is 0.56, which has been decreasing at an annual rate of 1.3 percent since 1970 in accordance with the increase in car ownership.

This tendency will continue in the future, therefore the per capita riding factor in future and total number of bus passengers are forecasted as follows.

Table 3.12 TOTAL NUMBER OF BUS PASSENGERS

(Unit: 1,000 person)

	per capita riding	No. of bus passengers	annual growth rate
1979	0.56	256.0	-
1985	0.52	279.4	1.3%
2000	0.43	348.8	1.4%

Although the per capita riding decreases year by year, the number of passengers increases at a growth rate of 1.3 to 1.4 percent because of higher population increases.

3.4.2 O-D Pattern of Bus Passengers

In this stage, the total number of bus passengers is first reduced in consideration of transfers. Those linked trips are as follows:

Table 3.13 TOTAL LINKED TRIPS MADE BY BUS PASSENGERS

(Unit: 1,000 trips)

year	Total number of passengers	Total trips made by passengers	Average no. of transfer
1979	256.0	235.8	1.09
1985	279.4	249.1	1.12
2000	348.4	296.4	1.18

The O-D table is forecasted as follows.

Table 3.14 BUS PASSENGER O-D TABLE

(Unit: 1,000 trips)

	O \ D	Internal Area: Penang Island	Internal Area: Province Wellesley	External Area: Penang Island	External Area: Province Wellesley	Total
Study Area	Penang Island	149.2 151.6 157.9	8.3 10.1 13.1	3.4 3.8 4.5	- -	160.9 165.5 175.5
Study Area	Province Wellesley	9.4 10.2 13.3	50.1 57.1 86.9	- -	5.0 5.5 7.2	64.5 72.8 107.4
Outside Study Area	Penang Island	3.6 3.7 4.5		- -	- -	3.6 3.7 4.5
Outside Study Area	Province Wellesley	- - -	5.2 5.5 7.2	- -	1.6 1.6 1.8	6.8 7.1 9.0
						235.8 249.1 296.4

Note: The first figure corresponds to 1975, the second to 1985 and the third to the year 2000.

The O-D distribution of these bus trips is forecasted by means of the gravity method which was already examined by using present data.

3.5 Verification of the Total Traffic Volume

The projection of traffic demand was done by type of transport mode, that is car, lorry, motor-cycle and bus. In this section, simple verification about the total number of trips is conducted by using the person trip method.

The unit of trip production per person is determined to be about 1.0 - 2.0 from person trip surveys. This figure usually does not include trips made on foot.

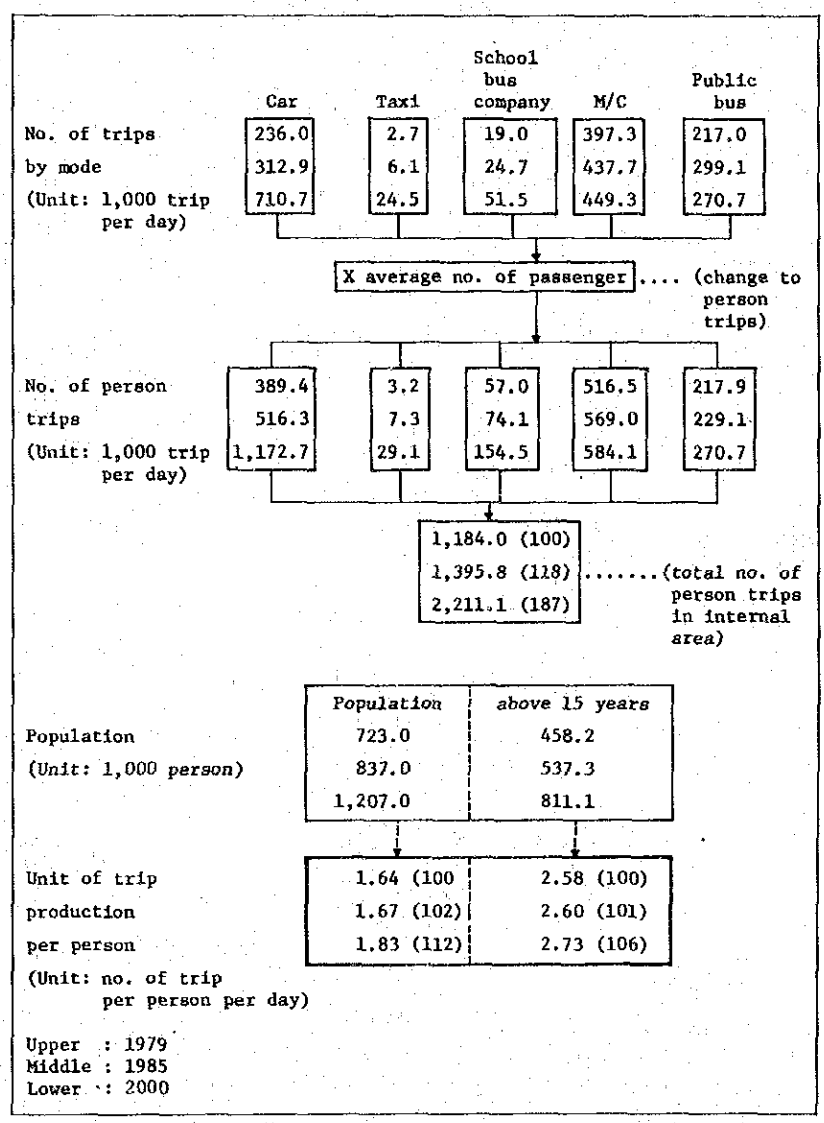
Therefore, by the standard of this result, the unit of trip production in this study is calculated. Firstly, the number of vehicle trips in this study area is converted to number of person trips by multiplying the average number of passengers, and then dividing by the population.

The unit of trip production per person is calculated in this way and the resulting figures are 1.64, 1.68 and 1.83 in 1979, 1985 and the year 2000 respectively with these figures having a range between 1.0 and 2.0 and experiencing increases year by year.

Considering the growth of the economic level, it is accepted that this tendency to increase yearly will continue.

Therefore, it can be said that the projection of traffic demand is neither overestimated or underestimated.

Table 3.15 UNIT OF TRIP PRODUCTION PER PERSON



Note: Above figures use the total number of internal trips in the study area.

4. Alternative Transport Plans

ALTERNATIVE TRANSPORT PLANS

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4. ALTERNATIVE TRANSPORT PLANS

4.1 Planning Goals

4.1.1 Background

By the year 2000 the population of the State of Penang will have increased to about 1.6 million and about 6,000 hectares of land will have been developed for urban activities in the Study Area. This economic growth in the Study Area will result in a large increase in demand for transport whereby there will be twice the present trip trip production. In addition the basic transport structure of the State will be changed after completion of the Penang Bridge Project and the New Federal Route I. Thus, improvements of the transport system are urgently needed to meet future demand.

4.1.2 Policy fot the Improvement of the Transport System

The team identified the following goals for the future transport system:-

To maintain a high quality of urban environment.
To maximize the benefits of the urban and urban transport economy.
To minimize resource consumption.
To provide a safe means of transport.

In order to achieve these goals, the following should be planned:-

The establishement of the future road network.
The improvement of the Public Transport System.
The improvement of Traffic Management and Operations.

The following items should also be taken into account in order to obtain better results.

The preservation of historical places and their environs in George Town itself is seen as part of the maintenance of the good quality of life and urban environment, and the continued preservation of these sites are taken into account.

Future transport systems should correspond to the changes in land use, such as the development of Bayan Lepas and Prai,

as well as to the changes in road network, as in the construction of the Penang Bridge, the traffic dispersal roads and the New Federal Route I.

4.2 Road Network Plan

4.2.1 The Premise

Prior to the formulation of the transport plan, the committed projects within the Study Area are as follows:-

Federal Route No. 1 and two (2) of its related intersections.
Penang Bridge which connects Province Wellesley and Penang Island.
Dispersal Road connecting with the Penang Bridge.

These schemes are totally committed.

4.2.2 Examination of Transport Demand

In order to get the guidelines for road network planning, the results of the land use plan and the traffic demand estimation were reviewed.

The expected changes estimated in the Study Area from 1977 to the year 2000 are summarized as follows:-

A. Change of Urban Structure

The population increase of about 483,000 in the Study Area will be absorbed mainly in Bayan Lepas and the area along the Federal Route I between Butterworth and Bukit Mertajam. Accordingly, in the year 2000, there will be two (2) conurbations i.e. the conurbation of George Town and Bayan Lepas and the conurbation of Butterworth and Bukit Mertajam.

Increase in employed population will be absorbed mainly in Bayan Lepas and Prai. Thus, there will be four (4) major employment areas, while in the C.B.D. of George Town, the population is expected to decline and this will further characterize it as a C.B.D.

B. Change in Transport Demand

Total number of trips will increase to about twice the present number. Especially in Bayan Lepas and Prai, a very large

number of trips will be produced.

Main desired traffic flow will be as follows.

- Between Penang Island and Province Wellesley.
- Between George Town and Bayan Lepas.
- Between the Prai-Butterworth conurbation and the conurbation of Bukit Mertajam.

Corresponding to the expansion of residential areas and urban functions, trips will be longer and the pattern of commuting trips will change to that which is shown in the following figures.

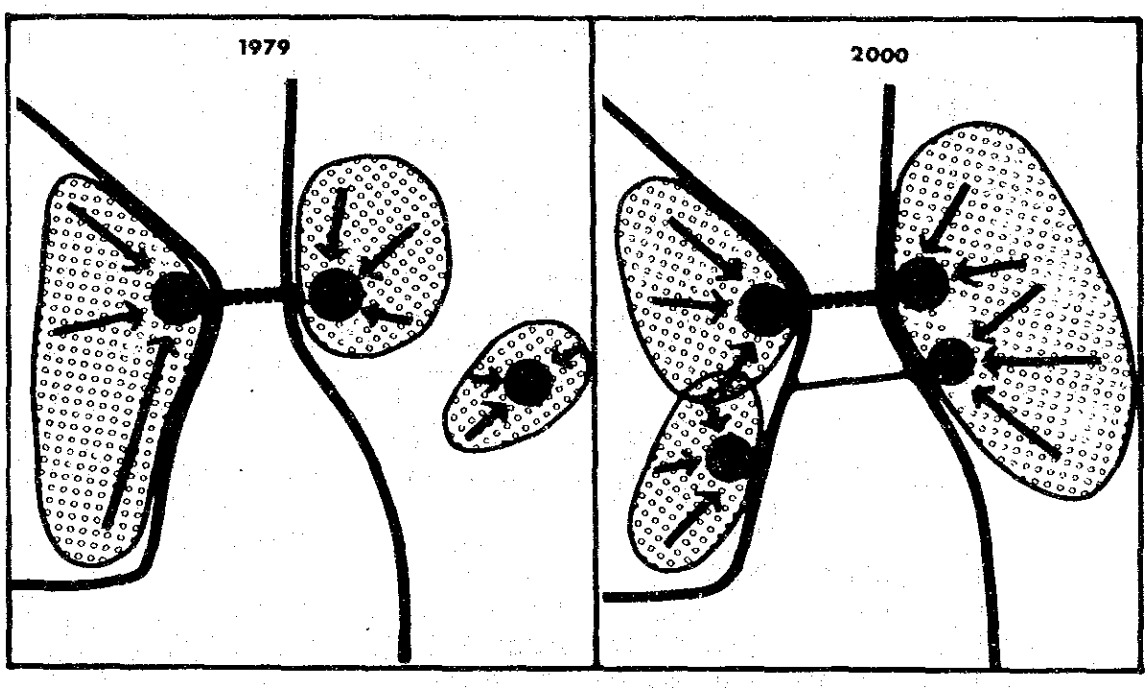
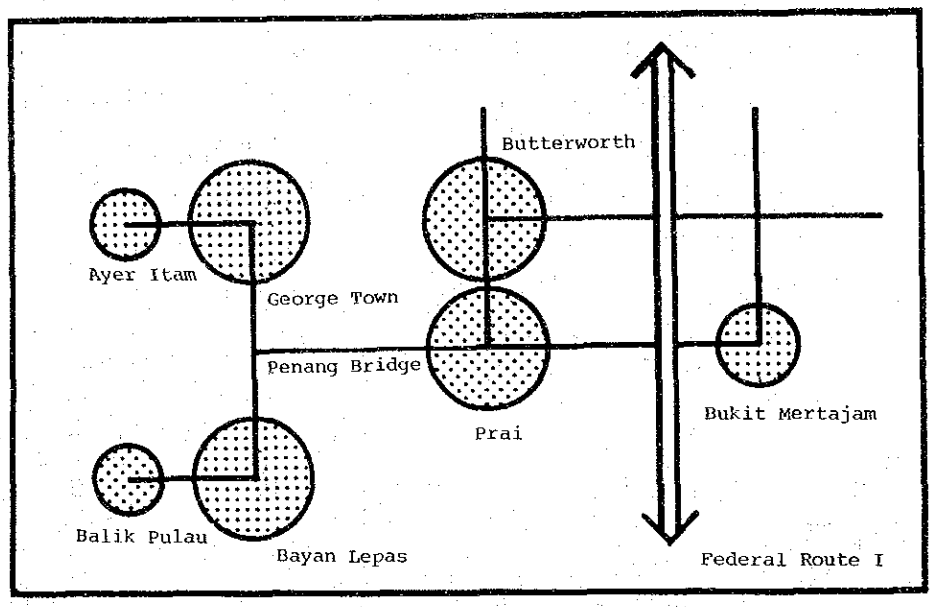


Fig. 4.1 TERRITORY OF COMMUTING TRIPS

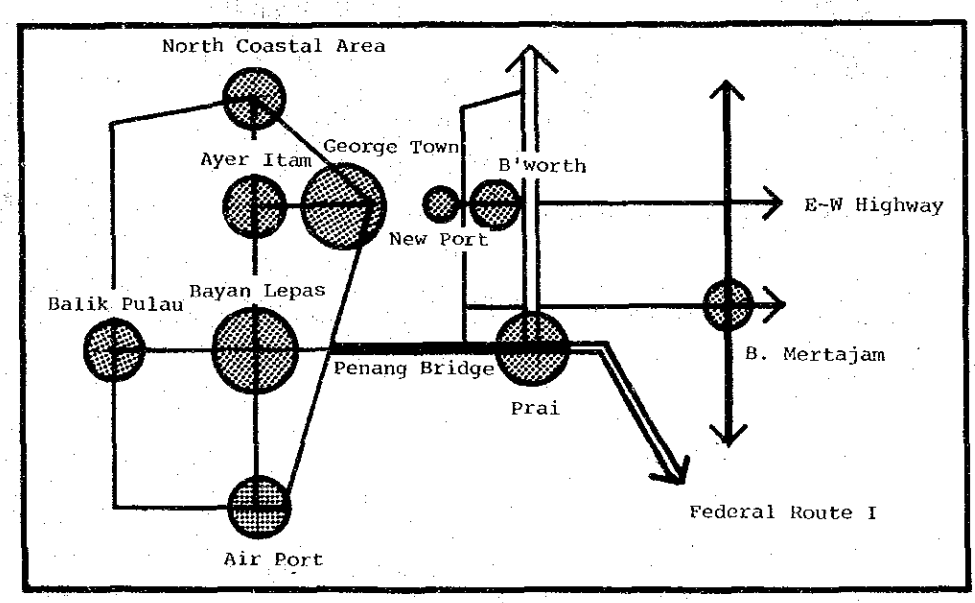
4.2.3 Conceptual Planning

Bearing in mind the policies and the traffic demand characteristics, the conceptual plans for road network were prepared using the following procedures.



Objective of the Plan:-
To connect the major regional cores
To establish the functional Network

Fig. 4.2 CONCEPT PLAN I



Objective of the Plan:-
To identify the basic road network

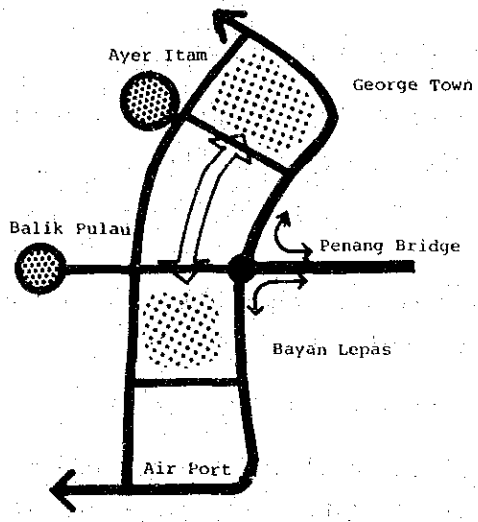
Fig. 4.3 CONCEPT PLAN II

Penang Island

Objectives of the plan: To identify traffic circulation in the Urban Areas.

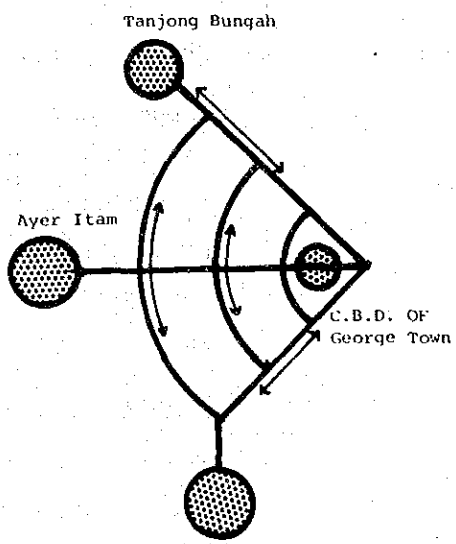
Ladder Pattern

for the East Coastal Corridor



Ring and Radial Pattern

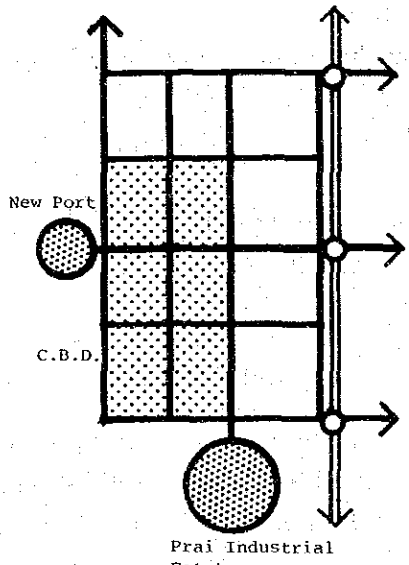
for George Town



CONCEPT PLAN IV

Grid Pattern

for Butterworth



Province Wellesley

Ladder Pattern

Conurbation between Prai and Bukit Mertajam.

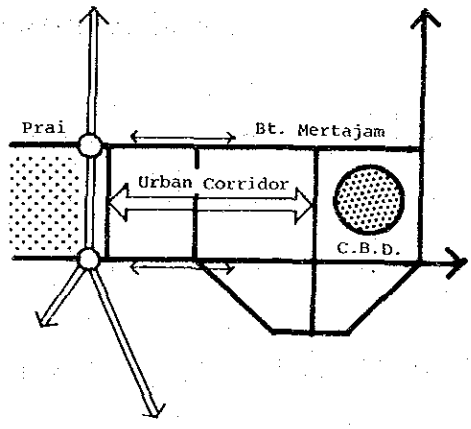


Fig. 4.4 CONCEPT PLAN III
Panang Island

4.2.4 Road Network Plan

Considering the various local conditions, the team prepared the future road network the content of which is described in Chapter 6. With the team proposing mainly primary distributors defined in the following categories of roads.

a) Primary distributors (Concept Plan I and II)

These roads form the primary network for the town as a whole. All long-distance traffic movements to, from and within the town should be channelled to the primary distributions. The primary distributors may be divided into two (2) types; one type between urban area (inter-urban) while the other is in the urban areas (intra-urban).

b) District distributors (Concept Plan III and IV)

These roads distribute traffic within the residential and industrial areas and principal business districts of the town while forming the link between the primary network and the roads within the surrounding areas.

c) Local distributors (Concept Plan III and IV)

These roads distribute traffic within the surrounding areas while forming the link between district distributors and access roads.

d) Access roads

These roads give direct access to buildings and land within the surrounding areas.

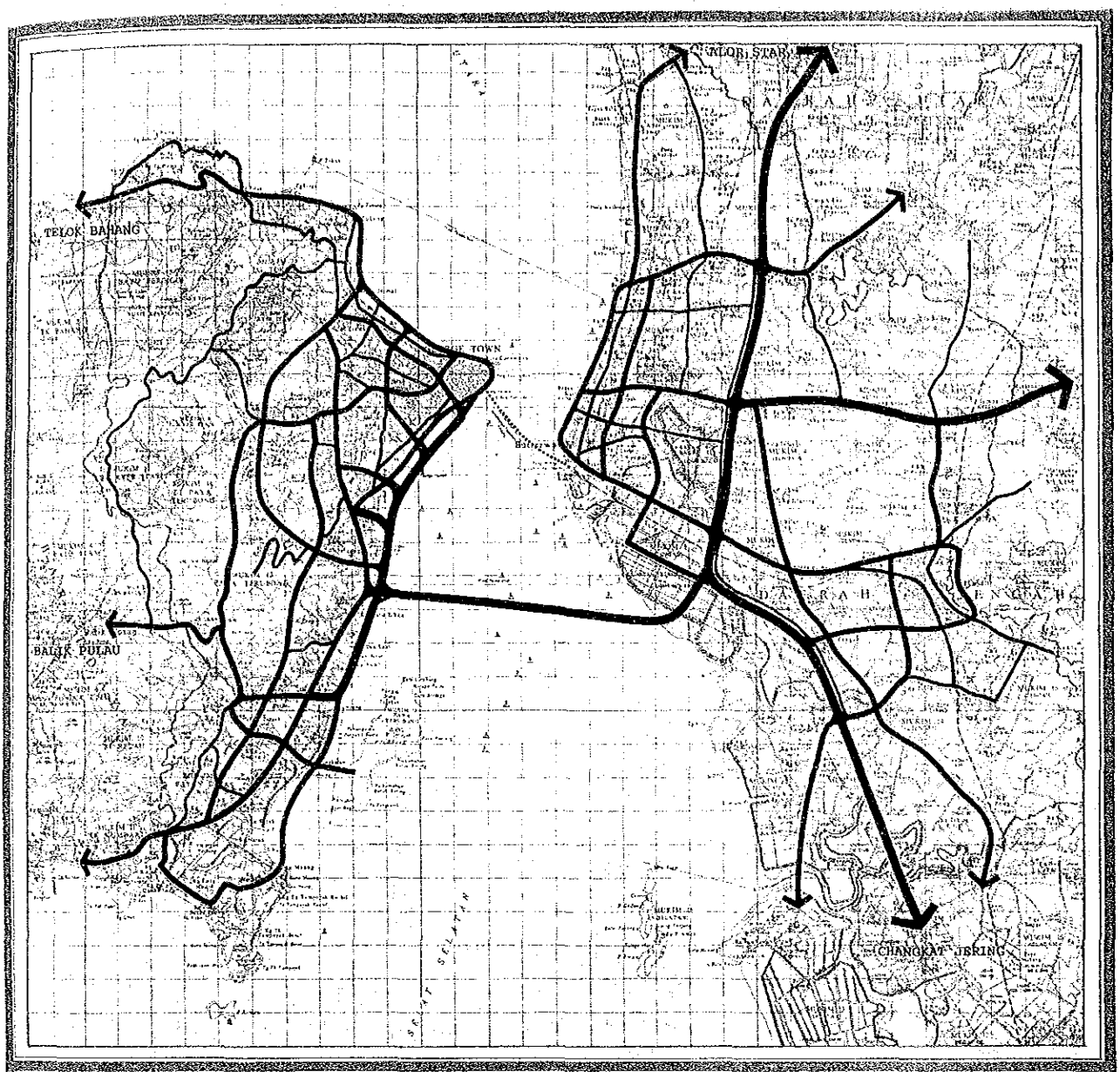


Fig. 4.5 Proposed Road Network

Primary Distributor (Inter-Urban)

Primary Distributor (Intra-Urban)

District Distributor

PENANG URBAN TRANSPORT STUDY

URBAN TRANSPORT STUDY IN GREATER METROPOLITAN AREAS OF GEORGETOWN, BUTTERWORTH AND BUKIT MERTAJAM

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4.3 Alternatives of Transport Strategies

4.3.1 General Considerations

Transport strategies proposed in this chapter are on how to deal with an increase in transport demand in the future. In most large cities it is almost impossible to deal effectively with the increase in traffic volume. Generally speaking, there are two (2) strategies, i.e., to improve the capacity of the transport systems and to reduce the transport demand.

In the Study Area, the projection of future transport demand revealed that not only is it necessary to improve the capacity of the transport system but a reduction of the transport demand will also be necessary.

Major Strategies	To improve Capacity	To reduce demand	Implementation Cost **
Improvement of road network	*		H
Improvement of intersections	*		M
Improvement of system of traffic flow	*		M
Improvement of the present public transport system	*	*	M
Introduction of the new transport system	*	*	H
Intensify parking control		*	L
Introduction of car pooling or road pricing system		*	M
Increasing the cost of owning cars		*	L

** H : assume high cost
M : assume medium cost
L : assume low cost

4.3.2 Transport Strategies

Besides the imporvement of road network which was planned in the previous section, the team prepared the following transport strategies as a major means of coping with the increase of transport demand, with due consideration given to the actual transport conditions of the Study Area and the effects of the strategies. All of these strategies are expected to reduce the traffic volume of vehicles.

1. Public Transport Strategies

Strategies A. Introduction of Exclusive Bus Lane

To assure that the bus service can absorb more commuters, operations should be effective. For this purpose, exclusive bus lanes, where the average speed of the buses is 25 km/hr., are introduced along the following roads.

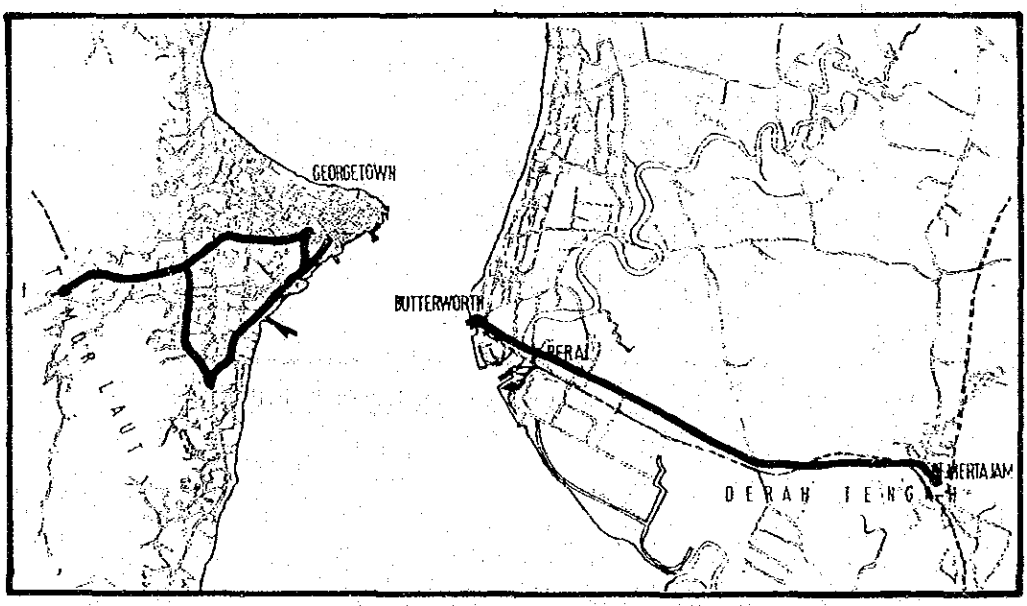

Fig. 4.6 LOCATION OF EXCLUSIVE BUS LANES

Strategy B. Introduction of New Transport System

If a more effective public transport system than the present bus service is necessary, then the new transport system will be introduced. The team proposed the following routes for the New Transport System.

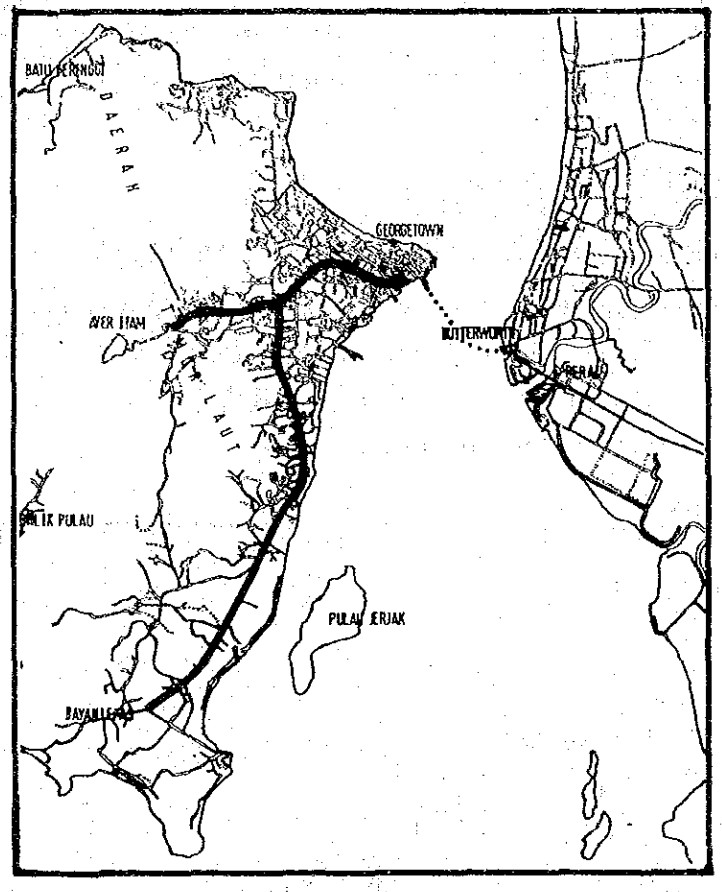

Fig. 4.7 LOCATION OF NEW TRANSPORT ROUTES

2. Demand Control Strategies

Strategy A. Parking Control

Prohibition of on-street parking is mainly aimed at achieving a smooth and safe traffic flow and providing space for sidewalks. However, regarding control of parking capacity in the C.B.D., the team assumed a situation where the total parking capacity in the year 2000 during peak hours in spite of increase in off-street parking due to the sharp decrease of on-street parking capacity.

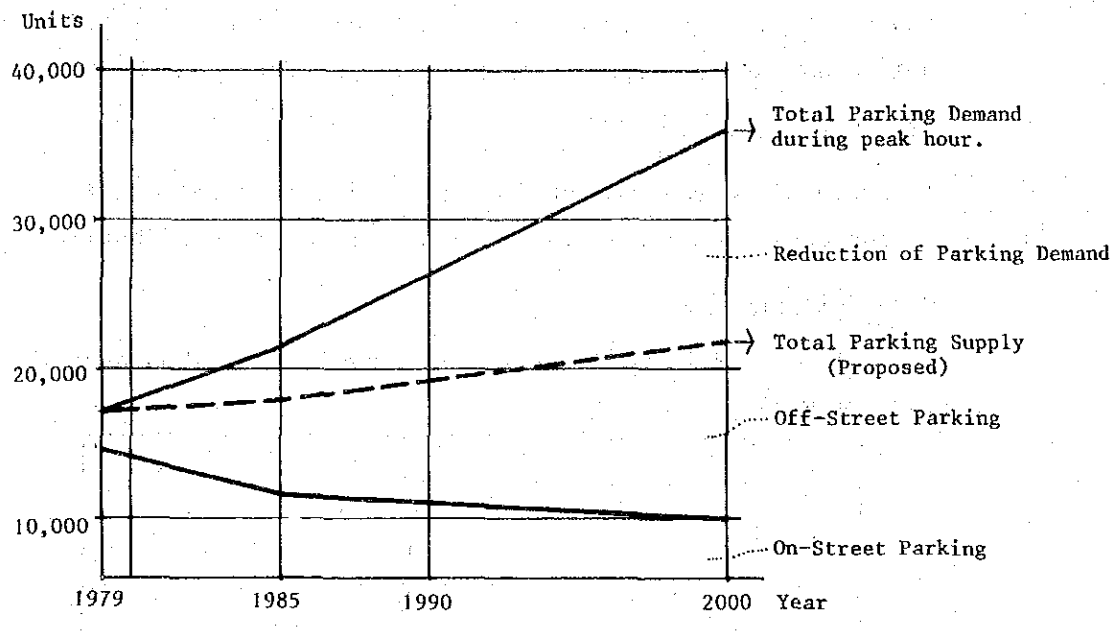

Fig. 4.8 PARKING DEMAND AND SUPPLY

Strategy B. Car Pooling System

The car pooling system is devised in order to prevent traffic congestion caused by private cars entering the C.B.D.

The system as planned by the team is as follows:-

The objective area ---------- the C.B.D. of George Town.
Average number of passengers --- 3 persons including drivers.

4.3.3 Alternatives

Many alternatives are prepared from the combination of the road network and the strategies mentioned earlier. In addition to these combinations, two (2) situations, i.e. the termination of the ferry service after 1985 and the continuation of this service after 1985 are included in the alternatives.

1. Combination Plan for Road Network

Existing road network plan (present)

The road network of this plan is composed of only the existing roads.

Intended road network plan (base case)

The road network of this plan is composed of the existing roads, the Penang Bridge, the New Federal Route I, the traffic dispersal roads and the supporting roads of the East-West Highway.

Plan 1 (on-going)

In addition to the road network plan, the road network is composed of some new roads which have been proposed earlier.

Plan 2 (Proposed)

The following new roads proposed by the team are added to the road network.

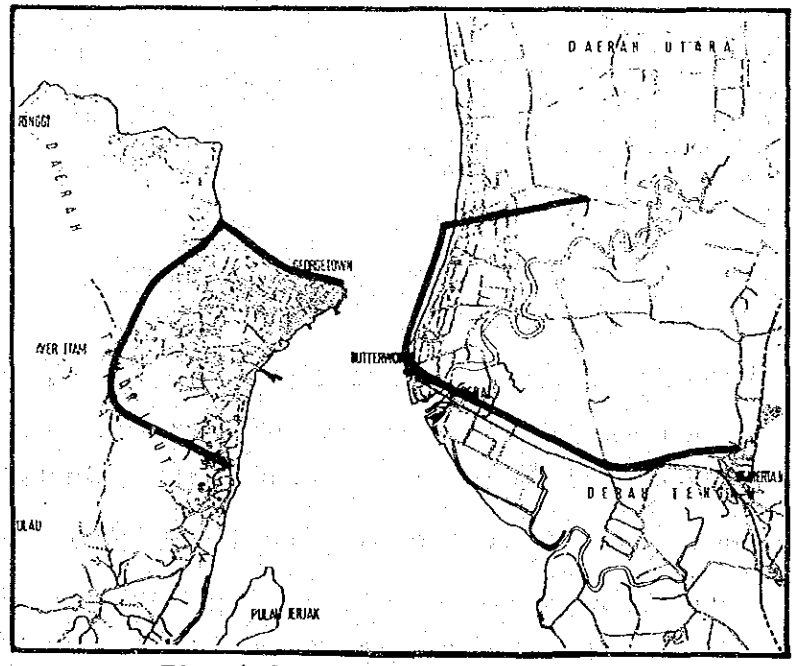

Fig. 4.9 LOCATION OF NEW ROADS

Plan 3 (on-going and proposed)

The road network of this plan consists of Plans 1 and 2.

Plan 4 (Ultimate)

In this road network some roads are added to Plan 2 so as to form the ultimate road network. Besides, this plan is divided into three (3) sub-plans due to the difference in the usage of the ferry service.

Regarding the continuation of the ferry services, Plans 3 and 4 include both cases of with ferry and without ferry.

2. Combination Plan for Demand Control (Public Transport Plan included)

Plan A

No improvements to the public transport and no introduction of demand control.

Plan B

A combination of parking control and exclusive bus lane.

Plan C

A combination of parking control, exclusive bus lane and the introduction of the New Transport System.

Plan D

A combination of parking control and car pooling system.

3. Transport Alternatives

From the combination of the road network plans and demand control stratagies, the alternatives of the future transport system are prepared for evaluations.

Table 4.1 Transport Alternatives

Road Network Plan \ Demand Control Plan	Plan A: Existing Situation	Plan B: Parking Control Exclusive Bus Lane	Plan C: New Transport System Parking Control Exclusive Bus Lane	Plan D: Parking Control Car Pooling
(Present)	(1979)			
Base Case	1985 2000			
Plan 1 Under Planning	1985			
Plan 2 Proposed	1985			
Plan 3 Under Planning & Proposed	1985 2000	1985 2000		
Plan 4 Ultimate	2000	2000	2000	2000

Figures in boxes show the projected years.

In addition, regarding the evaluation of the continued existence or termination of the present ferry system, the following cases are also computed.

1985 With and without ferry system in case of Plan 3 - A

2000 With and without ferry system in case of Plan 4 - B