2.4 Inter-Regional Traffic

The data regarding inter-regional traffic is based on the cordon line survey which was carried out in April 1981 and which documented about 34,500 trips going to, from and through the Irbid City area.

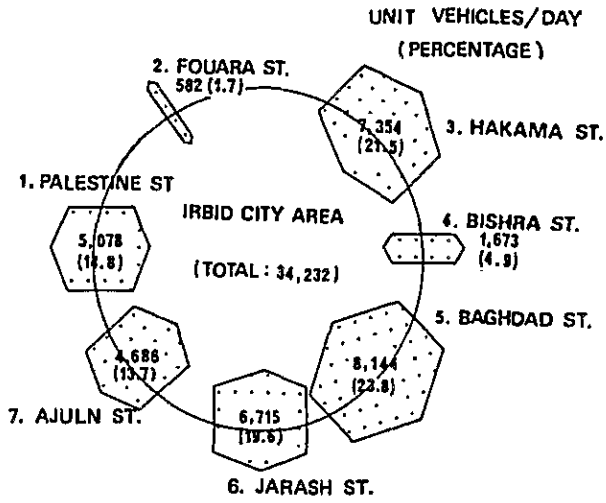
The daily vehicle volume to and from Irbid city is shown in Fig. 2.13 below.

The busiest point was Baghdad St. which registered about 8200 vehicles. The second was Hakama St. which registered about 7400 vehicles.

Through traffic was double counted, so it was adjusted.

Fig. 2.13 Daily Vehicle Volume at Survey Stations

(Unit: Vehicles/Day)



Based on the distribution of licences noted during the survey, over 90% were from the Irbid Region, 37% from Irbid City and 53.6% from other cities in the Irbid Region.

Table 2.21 Distribution of Vehicle Licences

(Unit: %)

Licence	Palestine St.	Fouara St.	Hakama St.	Bishra St.	Baghdad St.	Jarash St.	Ajuln St.	Total No.
Irbid City	34.3	59.6	44.9	22.9	40.5	32.7	30.0	37.0
Irbid Region	58.5	39.1	50.3	72.9	49.0	46.8	65.8	53.6
Subtotal	92.8	98.7	95.2	95.8	89.5	79.5	95.8	90.6
Amman	1.8	0.4	2.3	2.3	2.9	16.2	2.4	5.1
Others	4.9	0.9	2.2	1.7	7.4	3.7	1.8	4.0
Foreign	0.5	-	0.3	0.2	0.2	0.6	-	0.3
Subtotal	7.2	1.3	4.8	4.2	10.5	20.5	4.2	9.4
Total (No.)	5,078	582	7,354	1,673	8,144	6,715	4,686	34,232
(%)	14.8	1.7	21.5	4.9	23.8	19.6	13.7	(100.0)

Source: Survey Team

Table 2.22 shows the breakdown by trips purposes accounting for 85.6% of the total is as follows:

Table 2.22 Major Trip Purposes

(Unit: % of total trips)

Licence	To Work	Business	Home
Irbid City	14.4	8.8	7.1
Irbid Region	25.6	10.5	11.3
Amman	2.1	1.4	1.3
Other Jordan	1.6	0.8	0.9

Table 2.23 Licence - Trip Purpose

Trip purpose / License	To Work	Business	Home	Shopping	For Food	School	Social	Others	Unknown	Total	%
Irbid C	4923	3017	2426	262	189	76	791	287	152	12123	35.4
Irbid R	8754	3580	3870	471	255	238	658	342	330	18498	54.0
Amman	723	469	444	54	36	14	196	55	36	2027	5.9
Others	538	259	302	31	36	12	145	60	53	1436	4.2
Foreign	25	8	15	12	3	0	17	10	0	90	0.3
Unknown	28	19	2	0	0	0	4	3	2	58	0.2
Total	14991	7352	7059	830	519	340	1811	757	573	34232	100.0
%	43.8	21.5	20.6	2.4	1.5	1.0	5.3	2.2	1.7	100.0	

Source : Estimation by Study Team

The breakdown of trip purposes by type of vehicle is shown in Table 2.24. Car trip occupies 41% in all trips.

Table 2.24 Vehicle Type - Trip Purpose

Trip purpose / Veh. type	To Work	Business	Home	Shopping	For Food	School	Social	Others	Un-known	Total	%
Car (1)	4017	3020	4126	364	337	246	1346	379	274	14109	41.2
Bus (2)	450	205	96	32	54	33	32	27	46	975	2.8
Van (3)	1919	1329	1282	243	43	12	203	124	37	5192	15.2
Taxi (6)	5750	1441	813	28	53	44	165	88	154	8536	24.9
1+2+3+6	12136	5995	6317	667	487	335	1746	618	511	28812	84.2
M. Lorry(4)	1317	648	347	115	25	3	37	53	35	2580	7.5
H. Lorry(5)	1185	480	280	45	4	0	27	68	12	2102	6.1
Others (7)	351	230	112	3	2	0	2	21	15	736	2.2
4+5+7	2853	1358	740	163	31	3	66	142	62	5418	15.8
Unknown	0	0	0	0	0	0	0	0	0	0	
Total	14986	7353	7057	830	518	338	1812	760	573	34230	100.0

Source : Estimation by Study Team

Table 2.25 Origin-Trip Purpose

PURPOSE -- / ZONE	TO WORK	BUSINESS	HOME	SHOPPING	FOR FOOD	SCHOOL	SOCIAL	OTHERS	UNKNOWN	TOTAL
1	259	189	398	41	19	5	62	16	8	997
2	368	170	179	41	24	3	44	16	16	861
3	415	331	268	46	27	8	85	23	12	1215
4	288	268	272	10	10	7	54	23	13	945
5	919	486	169	10	5	4	57	32	20	1702
6	160	103	70	14	0	4	45	10	0	406
7	249	143	98	13	7	4	62	6	6	588
8	529	288	338	39	13	4	25	28	21	1285
9	248	213	150	7	41	9	61	15	5	749
10	353	149	151	0	5	0	56	26	26	766
11	259	169	299	11	0	2	22	94	4	860
12	92	41	102	3	6	0	38	2	3	287
13	27	23	7	2	3	0	4	4	7	77
14	307	224	375	11	27	7	53	24	5	1031
15	19	13	3	0	0	0	18	0	4	57
16	168	64	112	2	2	4	3	5	0	360
17	116	85	54	3	0	6	24	14	0	302
99	0	0	0	0	0	0	0	0	0	0
UNKNOWN	10218	4393	4019	577	326	274	1103	420	423	21753
TOTAL	14994	7352	7062	830	515	341	1816	758	573	34241

Source: Estimation by Study Team

Table 2.26 Destination-Trip Purpose

PURPOSE -- / ZONE	TO WORK	BUSINESS	HOME	SHOPPING	FOR FOOD	SCHOOL	SOCIAL	OTHERS	UNKNOWN	TOTAL
1	511	399	135	150	20	39	43	19	60	1376
2	343	217	226	48	3	0	50	16	13	916
3	446	281	226	54	9	6	54	7	19	1096
4	356	225	121	43	45	7	36	21	43	897
5	1564	382	45	9	9	6	23	12	36	2136
6	336	92	63	7	6	15	18	20	5	564
7	563	75	183	22	3	2	31	2	10	891
8	556	154	81	40	14	3	32	4	17	1003
9	364	159	190	20	6	2	84	45	13	823
10	716	149	217	33	12	0	31	8	21	1187
11	383	441	42	13	8	9	22	81	44	1043
12	54	43	37	1	2	0	3	3	5	148
13	22	9	7	3	0	4	3	2	0	50
14	703	314	157	9	32	93	40	27	15	1390
15	59	28	19	0	19	2	0	0	0	127
16	150	49	68	13	3	0	12	7	3	305
17	102	50	40	7	5	0	16	10	2	272
99	0	0	0	0	0	0	0	0	0	0
UNKNOWN	7687	4290	5113	355	321	150	1316	474	296	20002
TOTAL	14989	7357	7054	827	517	338	1814	758	572	34226

Source : Estimation by Study Team

The distribution of trip purposes during the day shown in Table 2.28 indicates very little hourly variation, with the morning peak ratio of 11.2% from 7:00 - 8:00 am and an afternoon peak ratio of 9.7% from 12:00 - 13:00 pm. The distribution of trips by trip purpose for the whole 12-hour survey period was as follows:

Table 2.27

Trip Purpose	%
To Work	45.4
On Business	21.3
Return Home	20.2
Social Visit	5.3
Shopping	2.8
Others	2.3
Entertainment	1.6
To School	1.1

Figure 2.14 shows the composition of traffic by vehicle type during the survey period. Although there is a variation by vehicle type, they are more or less relative to each other as reflected by the fact that few lines cross. Hence, traffic composition is quite stable.

Table 2.28 Distribution of Trip Purposes During Each Hour of the Day

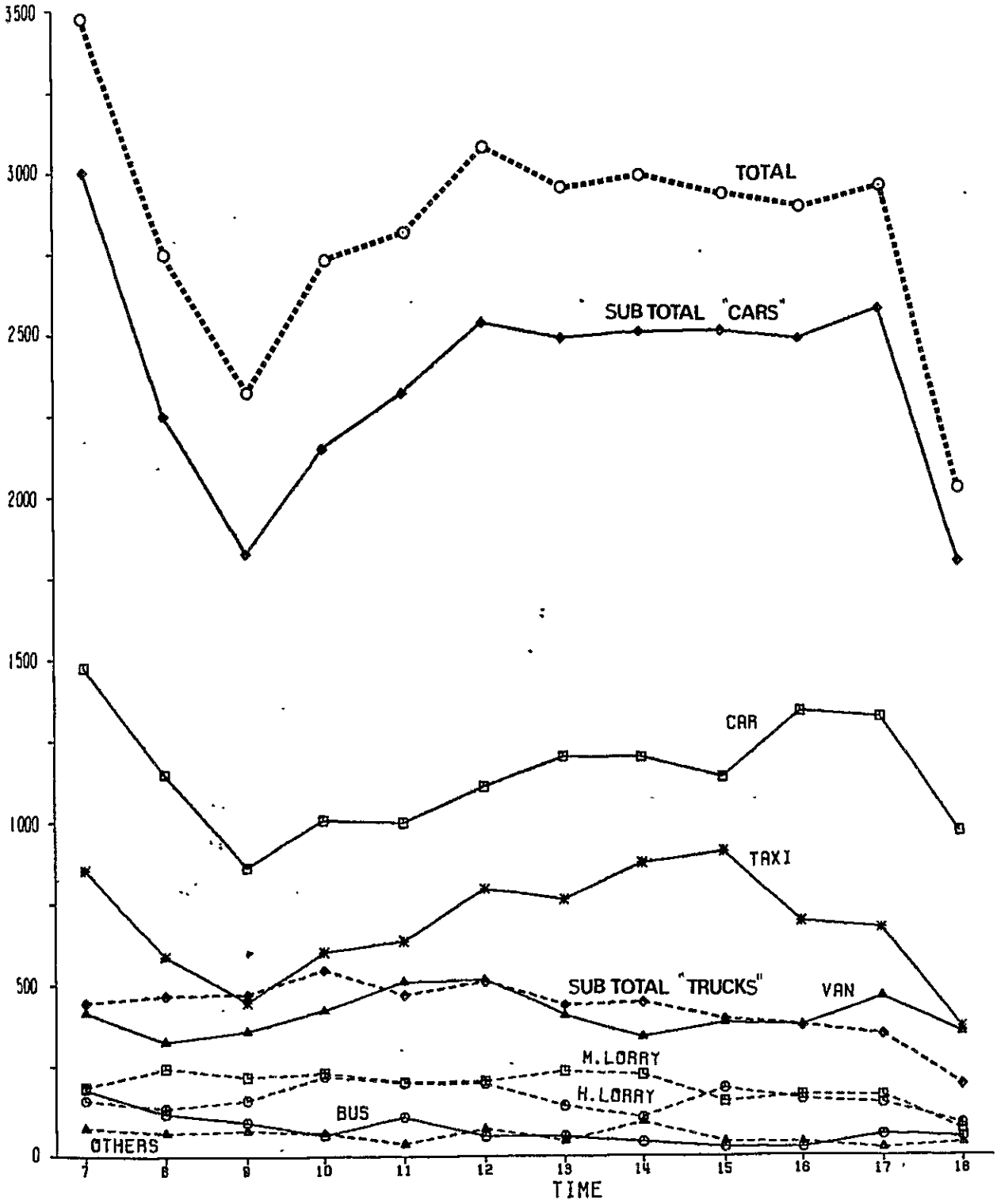
Purpose / Time	To work	On business	Return home	Shopping	Entertainment	To school	Social visit	Others	Total
7-8	2,320	968	65	82	40	155	80	68	(11.2) 3,778
8-9	1,465	755	122	118	36	52	92	95	(8.1) 2,735
9-10	1,252	642	148	117	10	22	100	79	(7.0) 2,370
10-11	1,294	711	259	119	32	25	134	69	(7.8) 2,643
11-12	1,406	600	386	75	45	22	107	66	(8 0) 2,707
12-13	1,544	737	660	101	47	23	112	58	(9 7) 3,282
13-14	1,278	550	703	36	22	22	154	67	(8 4) 2,832
14-15	1,138	534	717	69	39	10	178	66	(8 1) 2,751
15-16	1,207	527	699	69	72	10	208	54	(8 4) 2,846
16-17	1,093	557	929	60	48	2	205	67	(8.7) 2,961
17-18	875	406	1,100	85	101	13	242	57	(8.5) 2,879
18-19	510	236	1,037	28	45	12	169	36	(6 1) 2,073
Total	15,382	(45 4) 7,223	(21.3) 6,825	(20 2) 959	(2.8) 537	(1.6) 368	(1.1) 1,781	(2.3) 782	(100 0) 33,857

Notes. 1 ( )%

2. Unknown data were eliminated

3. Source: Estimation by Study Team

FIG. 2.14 HOURLY TRAFFIC VARIATION IN VEHICLE COMPOSITION



NOTE : "CARS" : —◆— CAR+BUS+VAN+TAXI

"TRUCKS" : ---◆--- M.LORRY+H.LORRY+OTHERS

Table 2.29 Time - Type

Type C / Time	Car (1)	Bus (2)	Van (3)	Taxi (6)	1+2+3+6	M Lorry (4)	H Lorry (5)	Others (7)	4+5+7	Unknown	Total
7:00 –	1500 42.9	206 5.9	441 12.6	879 25.1	3026 86.5	212 6.1	172 4.9	87 2.5	471 13.5	0	3497
8 00 –	1172	133	353	615	2273	271	149	73	493	0	2766
9 00 –	887	106	384	473	1850	244	173	80	497	0	2347
10 00 –	1033	65	449	627	2174	255	245	72	572	0	2746
11.00 –	1026	122	537	662	2347	219	226	40	495	0	2842
12 00 –	1137 36.7	62 2.0	544 17.5	822 26.5	2565 82.7	231 7.4	222 7.2	84 2.7	537 17.3	0	3102
13 00 –	1231	62	435	792	2520	262	155	48	465	0	2985
14 00 –	1229	43	366	902	2540	250	119	104	473	0	3013
15.00 –	1168	27	411	939	2545	169	209	44	422	0	2967
16 00 –	1371	26	402	723	2522	186	174	41	401	0	2923
17:00 –	1355	66	492	704	2617	186	164	25	375	0	2992
18:00 –	1000	58	380	397	1835	82	98	39	219	0	2054
Total	14109	976	5194	8535	28814	2577	2106	737	5420	0	34234

Source : Estimation by Study Team

The loading condition of trucks as shown in Table 2.31 indicates that 99% of the vehicles carried solid cargoes of which about 70% was 2 tons or less. The breakdown by weight or volume is as follows:

Table 2.30

Solid Cargoes (Tonnage)	% Trips
Below 1 ton	26.2
1 - 2 tons	43.8
2 - 4 tons	7.5
5 - 6 tons	12.4
7 - 10 tons	5.0
11 - 20 tons	4.1
Subtotal	99.0

(Gallons)	% Trips
21 - 1000	0.9
1001 - 5000	0.1
Over 5000	-
Subtotal	1.0

Table 2.31 Loading Condition

Capacity / Commodity	Below 1T (Ton)	1–2 (Ton)	3–4 (Ton)	5–6 (Ton)	7–10 (Ton)	11–20 (Ton)	Subtotal 2+3+4+5+6 Ton)	21–1000 (Gallon)	1001–5000 (Gallon)	5001– (Gallon)	Subtotal 8+9+10 (Gallon)	Total
No Lugg.	2642	2749	355	526	220	215	4065	58	0	0	58	6765
Agricul	160	482	51	34	61	82	710	18	0	0	18	888
Animal	51	162	16	9	2	1	190	0	0	0	0	241
Wood	25	259	42	38	5	6	350	0	0	0	0	375
Mineral	65	352	135	521	173	65	1246	14	0	0	14	1325
Machine	25	75	16	16	19	2	128	2	0	0	2	155
Light	64	240	45	34	45	16	380	2	0	0	2	446
Chemical	31	70	28	61	25	9	193	2	0	0	2	226
Miscell	83	487	118	180	42	69	896	3	11	0	14	993
Unknown	0	396	96	67	9	28	596	10	0	0	10	606
Total	3145	5272	902	1486	601	493	11899	109	11	0	120	12020
%	26.2	43.8	7.5	12.4	5.0	4.1	99.0	0.9	0.1	–	1.0	100

Source : Estimation by Study Team

2.5 Movement of Vehicles

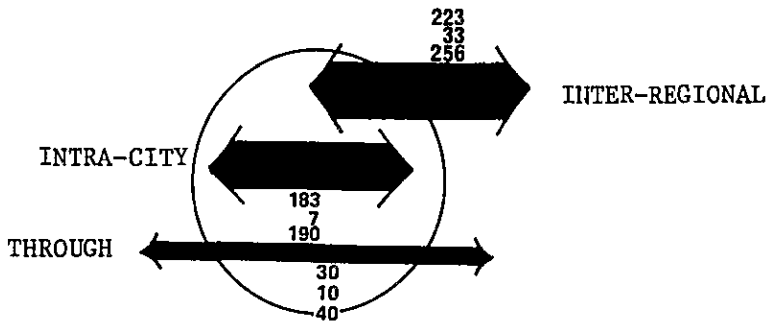
As already mentioned before, the Owner Interview Survey and Cordon Line Survey had different aims. The former aimed at grasping the traffic inside the City Area and the latter, the traffic entering/leaving the City Area.

To make the Origin-Destination Table, the results of above two surveys were combined to make a single O-D table using the results of the Owner Interview Survey for the traffic movement of inside Irbid City Area (ie, traffic between zones 1 ∿ 17 to form the intra-city traffic matrix) and the results of the Cordon Line Survey for the traffic movement of to/from and passing through the City Area, (ie, traffic between zones 22 ∿ 45 to form the inter-city traffic matrix).

The complete O-D table obtained is shown in the following Tables 2.32 for cars, trucks and total vehicles respectively.

Based on the O-D tables, the total vehicle movement in the Irbid City Area is 49,000 trips/day. Of these trips, 39 percent are trips within the City Areas; 53 percent are trips to/from outside the City. The balance of 8 percent are transit trips starting outside the City Area, passing through the City and then ending outside the City Area.

Fig. 2.15 Intra/Inter Regional Traffic Composition



LEGEND
223---CAR
33---TRUCK
256---TOTAL
(Unit: 100 Vehicles)

TABLE 2.32 OD TABLE

CARS(1981)

TRUCKS(1981)

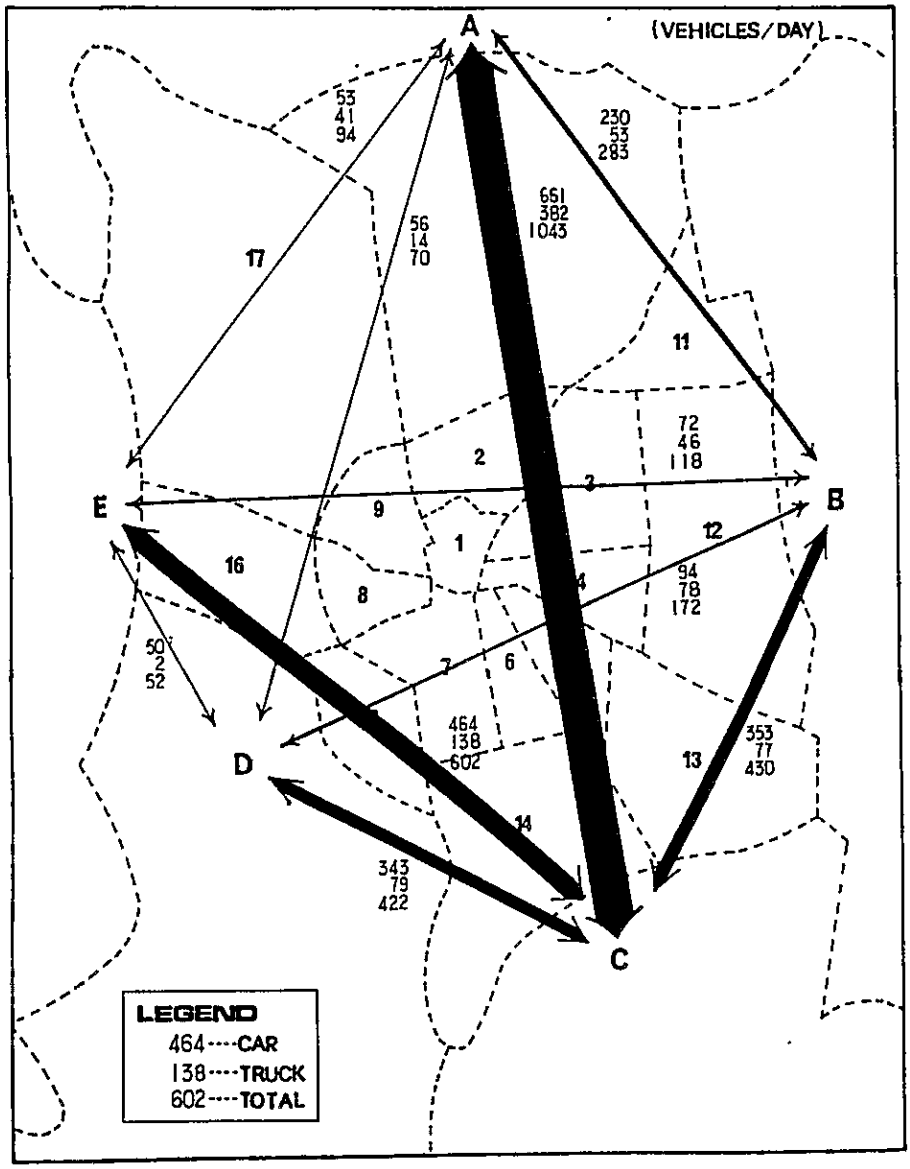
TOTAL(1981)

The pattern of through traffic is shown in Fig. 2.16 North to South trip constitute the greatest portion.

Table 2.33 Composition of Traffic Sectors

Sector	Zones Included
A	22, 27, 28, 34
B	23, 29, 35, 41, 42, 43
C	24, 30, 36, 37, 40, 44
D	25, 31, 38
E	26, 32, 33, 39, 45

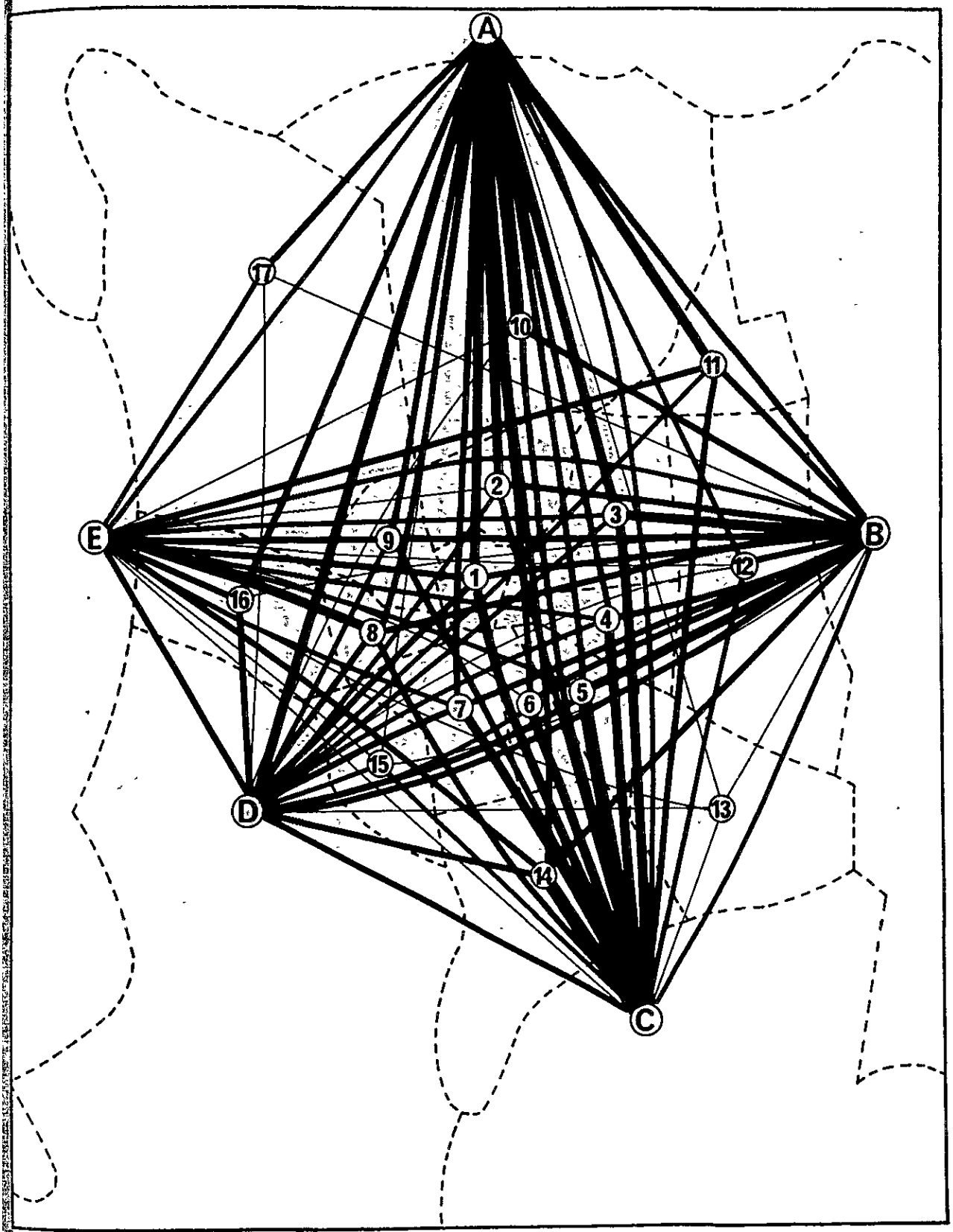
Fig. 2.16 Pattern of through Traffic



Using the total O-D table, desire lines presenting the volume of vehicle movement between each zone origin and zone destination were drawn as shown in Figures 2.17 ∿ 2.19 for cars, trucks and total vehicles respectively. The strength of the line indicates "the desire" of vehicles to go their destination.

(Note: These figures exclude intra-city traffic in order to make the figures legible.)

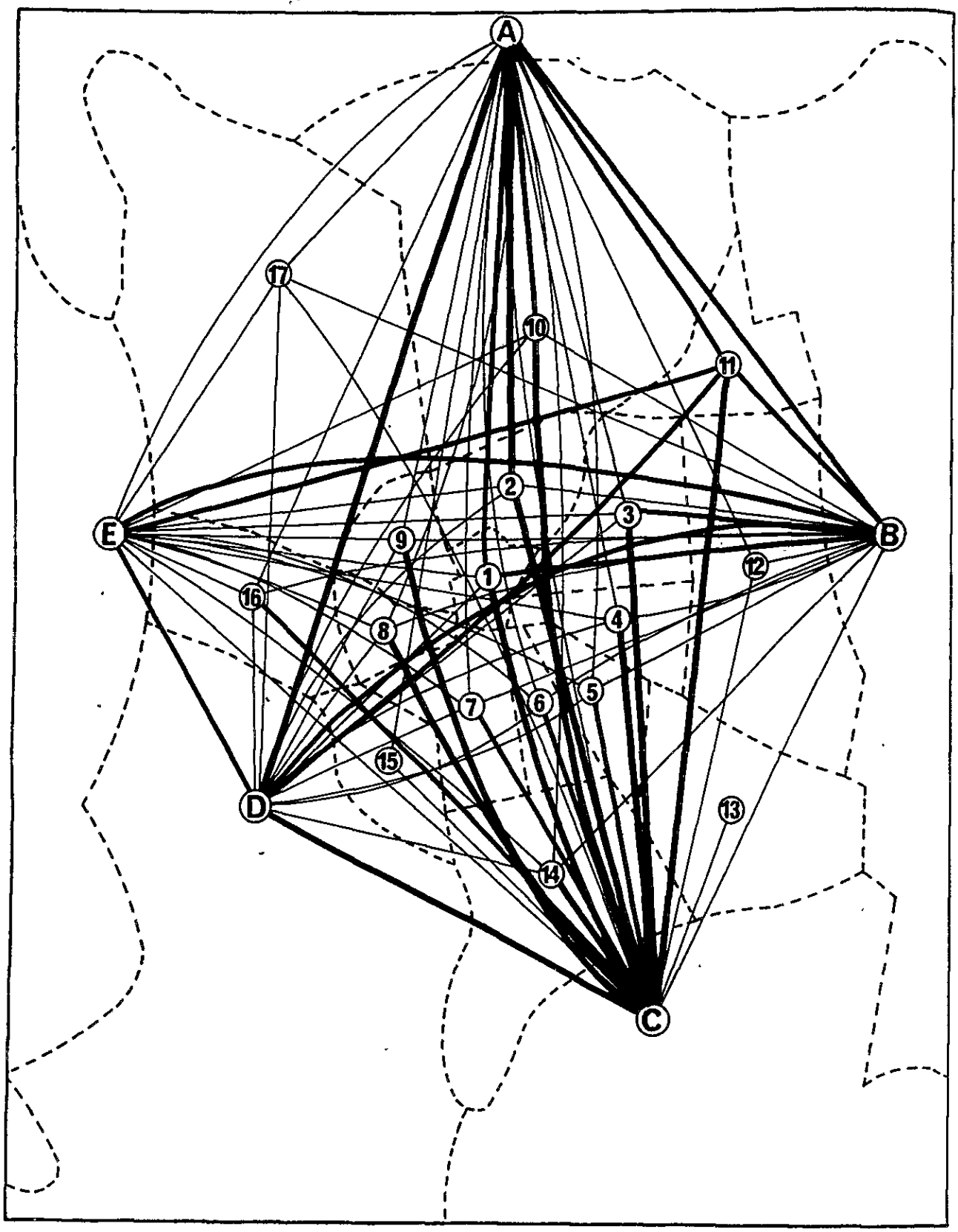
Fig. 2.17 Desire Lines (Cars) 1981



LEGEND

1 000 500 100 50 (Trips/Day excluding intra-city traffic)

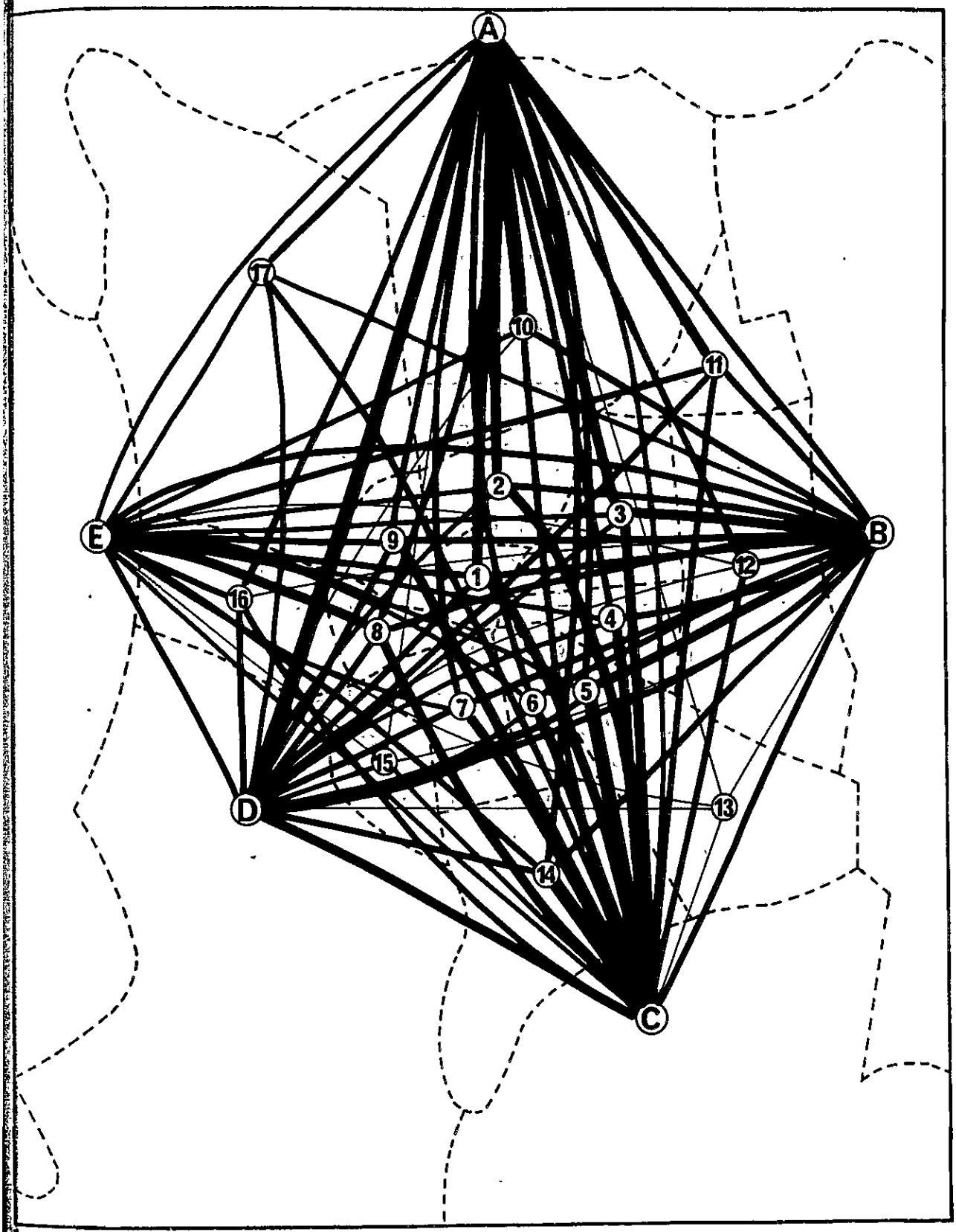
Fig. 2.18 Desire Lines (Trucks) 1981



LEGEND

1 000 500 100 50 (Trips/Day excluding intra-city traffic)

Fig. 2.19 Desire Lines (Total Vehicle) 1981



LEGEND

1 000 500 100 50

(Trips/Day excluding intra-city traffic)

2.6 Traffic Accident

About 20 thousand accidents have occured in the whole country during 1980. Of these, 16.4% (3187 cases) occurred in Irbid, while 57.6% concentrated in Amman.

About 6.3% of accidents in Irbid involved foreign vehicles.

Table 2.34. Total Number of Accidents and Nationality of Vehicles Involved

(Accidents/year)

Area	Amman		Irbid		Others		Total	
Year	1979	1980	1979	1980	1979	1980	1979	1980
Jordanian Vehicles	9914	10942	2432	2988	4047	4634	16393	18564
Foreign Vehicles	430	278	188	199	447	451	1065	928
Total	10344 (59.3%)	11220 (57.6%)	2620 (15.0%)	3187 (16.4%)	4494 (25.7%)	5085 (26.0%)	17458 (100%)	19492 (100%)

Source: Statistics from The Police Headquarters.

More than half of the accidents involved Private Passenger Cars. In Irbid 52.0% of the vehicles involved were Private Passenger Cars, 22.9% were 5 tons Lorries and 9.2% were Public Cars. Other regions in Jordan also showed similar tendencies. About 8 accidents occured every day in Irbid.

Table 2.35 Accidents by Type

(Accidents)

	Amman		Irbid		Others		Total	
	1979	1980	1979	1980	1979	1980	1979	1980
Motor Cycle	127 <1.3>	112 <1.1>	48 <2.0>	63 <2.2>	59 <1.4>	75 <1.6>	234 <1.4>	250 <1.4>
Agriculture) Vehi- Construction) cle	45 <0.5>	36 <0.3>	21 <0.9>	37 <1.3>	52 <1.2>	44 <0.9>	118 <0.7>	117 <0.6>
Passenger Car	6210 <62.3>	6292 <59.5>	1288 <53.1>	1464 <52.0>	1907 <45.7>	2092 <44.5>	9405 <56.8>	9848 <54.4>
5 ton lorry	2451 <24.6>	2508 <23.7>	571 <23.5>	646 <22.9>	1011 <24.2>	1120 <23.8>	4033 <24.4>	4274 <23.6>
2 axes lorry	337 <3.4>	394 <3.7>	120 <4.9>	147 <5.2>	273 <6.5>	288 <6.1>	730 <4.4>	829 <4.6>
Public car	609 <6.1>	625 <5.9>	191 <7.9>	258 <9.2>	492 <11.8>	625 <13.3>	1292 <7.8>	1508 <8.3>
Army vehicle	128 <1.3>	368 <3.5>	160 <6.6>	152 <5.4>	303 <7.3>	350 <7.4>	591 <3.6>	870 <4.8>
Security vehicle	58 <0.6>	238 <2.3>	26 <1.1>	48 <1.7>	74 <1.8>	108 <2.3>	158 <1.0>	394 <2.2>
Total	9965 (60.2)	10573 (58.4)	2425 (14.6)	2815 (15.6)	4171 (25.2)	4702 (26.0)	16561 (100.)	18090 (100.)

Remark: Figures in < > indicate percentages against the total of individual Regions in each year.

Figures in ( ) are percentages against the total of the whole country.

Source: Statistics of the Police Headquarters.

Table 2.36 shows the places of accidents and what kind of action led to the accidents. More than 70% of the accidents occured on straight line sections of road. The second largest number of accidents in Irbid involved left-turning vehicles, "turn" (ie. 9.3%) and the third was largest involved "stopping vehicles" (ie. 7.0%). It can be said that most accidents happened during going straight, turning to the left/right and stopping operation of a vehicle. The latter two cases are related to intersections of roads. As for the causes of accidents, the major ones were "over-speed", "insufficient headways", "wrong way of pulling over" etc. But the largest number of accidents were caused by the carelessness of the driver or the poor driving technique, which is indicated by the figures of "Other faults" and "No faults in driving" in Table 2.36.

Table 2.36 Number of accidents by of action involved

(Accidents)

Region	Amman		Irbid		Others		Total	
Year	79	80	79	80	79	80	1979	1980
Driving straight	6443 (61.5)	7016 (62.0)	1801 (68.2)	2279 (70.1)	2924 (64.2)	3401 (65.4)	11168 (63.2)	12696 (64.2)
Turning to the right	600 (5.7)	529 (4.7)	185 (7.0)	176 (5.4)	286 (6.3)	295 (5.7)	1071 (6.1)	1000 (5.1)
Turning to the left	1127 (10.8)	1098 (9.7)	288 (10.9)	303 (9.3)	583 (12.8)	583 (5.4)	1998 (11.3)	1984 (10.0)
U turning	99 (0.9)	107 (0.9)	26 (1.0)	9 (0.3)	20 (0.4)	36 (0.7)	145 (0.8)	152 (0.8)
Driving slowly	238 (2.3)	311 (2.9)	23 (0.9)	48 (1.5)	62 (1.4)	55 (1.1)	323 (1.8)	484 (2.4)
Stopping on the lane	41 (0.4)	48 (0.4)	12 (0.5)	13 (0.4)	25 (0.5)	24 (0.5)	78 (0.4)	85 (0.4)
Stopping or going to stop	1185 (11.3)	1354 (12.0)	143 (5.4)	228 (7.0)	270 (5.9)	413 (7.9)	1598 (9.0)	1995 (10.1)
Start to move	92 (0.9)	106 (0.6)	17 (0.6)	21 (0.6)	25 (0.5)	46 (0.9)	134 (0.8)	173 (0.9)
Start from the park	61 (0.6)	54 (0.5)	3 (0.1)	6 (0.2)	17 (0.4)	18 (0.3)	81 (0.5)	78 (0.4)
Driving backward	312 (3.0)	362 (3.2)	82 (3.1)	86 (2.6)	167 (3.7)	172 (3.3)	561 (3.2)	620 (3.1)
Overtaking	148 (1.4)	141 (1.2)	48 (1.8)	58 (1.8)	138 (3.0)	137 (2.6)	334 (1.9)	336 (1.7)
Driving in the circle	130 (1.2)	123 (1.1)	13 (0.5)	23 (0.7)	41 (0.9)	24 (0.5)	184 (1.0)	170 (0.9)
Total	10476 (100.0)	11319 (100.0)	2641 (100.0)	3250 (100.0)	4558 (100.0)	5204 (100.0)	17675 (100.0)	19773 (100.0)

Remark : ( ) shows the percentage of total of each region in every year.

Source: Statistics from the Police Headquarters.

Table 2.37 The causes of accidents

(Accidents)

Region	Amman		Irbid		Others		Total	
Year	79	80	79	80	79	80	1979	1980
Over speed	1152 (10.2)	968 (8.0)	585 (19.1)	487 (14.1)	891 (17.0)	681 (11.6)	2628 (13.4)	2136 (10.0)
Overtaking on a hill	12 (0.1)	9 (0.1)	2 (0.1)	2 (0.1)	18 (0.3)	17 (0.3)	32 (0.2)	28 (0.1)
Overtaking on a slope	78 (0.7)	36 (0.3)	13 (0.4)	14 (0.4)	31 (0.6)	41 (0.7)	122 (0.6)	91 (0.4)
Wrong way of overtaking	320 (2.8)	239 (2.0)	95 (3.1)	98 (2.8)	176 (3.4)	198 (3.4)	591 (3.0)	535 (2.5)
Poor road condition	236 (2.1)	247 (2.0)	57 (1.9)	44 (1.3)	127 (2.4)	111 (1.9)	420 (2.1)	402 (1.9)
Not-enough distance between the case	949 (8.4)	927 (7.7)	111 (3.6)	102 (2.9)	241 (4.6)	272 (4.6)	1301 (6.6)	1301 (6.1)
Damaged Signal	42 (0.4)	17 (0.1)	5 (0.2)	2 (0.1)	12 (0.2)	18 (0.3)	59 (0.3)	37 (0.2)
Wrong way of pulling over	626 (5.5)	497 (4.1)	191 (6.2)	167 (4.8)	349 (6.6)	326 (5.6)	1166 (5.9)	990 (4.6)
Traffic light violation	35 (0.3)	41 (0.3)	3 (0.1)	2 (0.1)	1 (0.0)	13 (0.2)	39 (0.2)	56 (0.3)
Traffic Sign violation	77 (0.7)	88 (0.7)	10 (0.3)	6 (0.2)	31 (0.6)	15 (0.3)	118 (0.6)	109 (0.5)
Traffic police violation	39 (0.3)	33 (0.3)	2 (0.1)	- (-)	1 (0.0)	6 (0.1)	42 (0.2)	39 (0.2)
Wrong parking	73 (0.6)	75 (0.6)	32 (0.0)	25 (0.7)	90 (1.7)	82 (1.4)	195 (1.0)	182 (0.9)
Driving without a light	18 (0.2)	14 (0.1)	10 (0.3)	5 (0.1)	13 (0.2)	18 (0.3)	41 (0.2)	37 (0.2)
Other faults	3422 (30.2)	4421 (36.6)	985 (32.2)	1527 (44.1)	1816 (34.6)	2515 (42.9)	6223 (31.7)	8463 (39.5)
No faults in driving	4259 (37.6)	4477 (37.0)	956 (31.3)	979 (28.3)	1454 (27.7)	1543 (26.3)	6669 (33.9)	6999 (32.7)
Total	11338 (100.0)	12089 (100.0)	3057 (100.0)	3460 (100.0)	5251 (100.0)	5856 (100.0)	19646 (100.0)	21405 (100.0)

Remark : ( ) shows the percentage of total of each region in every year.

Source: Statistics from the Police Headquarters.

Some 44% of accidents in Irbid were "hit another car" cases, in which multiple vehicles were involved. About 34% were "hit a pedestrian" cases, which involved casvatties of pedestrians. Accidents involving pedestrians in Irbid amounted to about half the total of Amman Region. This is for too excessive for Irbid in consideration of the proportion of vehicle volumes in these two cities.

Irbid showed a high share of pedestrian involved accidents because Amman had a lower rate of 24.6% and whole Jordan has a still lower rate of 9.4% as far as accidents of such nature is concerned.

Table 2.38 Kinds of accidents

(Accidents)

Region	Amman		Irbid			Others		Total	
Year	79	80	78	79	80	79	80	1979	1980
Hit a car	4039 (64.7)	4282 (63.3)	827 (46.9)	813 (45.4)	973 (44.0)	1389 (45.0)	1605 (46.7)	6241 (56.2)	6860 (55.3)
Turn over	273 4.4)	307 (4.5)	221 (12.5)	236 (13.2)	264 (11.9)	561 (18.2)	591 (17.2)	1070 (9.6)	1162 (9.4)
Hit pedest-rians	1351 (21.7)	1666 (24.6)	657 (37.3)	568 (31.7)	750 (33.9)	858 (27.8)	936 (27.2)	2777 (25.0)	3352 (27.0)
Hit an animal	11 (0.2)	11 (0.2)	7 (0.4)	16 (0.9)	18 (0.8)	33 (1.1)	28 (0.8)	60 (0.5)	57 (0.5)
Hit another object	316 (5.1)	347 (5.1)	51 (2.9)	36 (4.8)	114 (5.2)	180 (5.8)	182 (5.3)	582 (5.2)	643 (5.2)
Other	248 (4.0)	151 (2.2)	- (—)	70 (3.9)	91 (4.1)	65 (2.1)	98 (2.8)	383 (3.4)	340 (2.7)
Total	6238 (100.0)	6764 (100.0)	1763 (100.0)	1789 (100.0)	2210 (100.0)	3086 (100.0)	3440 (100.0)	11113 (100.0)	12414 (100.0)

A study of the above statistics reveals the following impressive facts regarding traffic accidents in Irbid:-

1) The number of accidents, especially those involving pedestrians is excessively large.

2) Many accidents had occured mainly at the straight roads and the intersections.

3) Many accidents were caused mainly by "over speed", "insufficient

headways" and "Wrong way of pulling over".

4) Bearing the above in mind, it is strong recommended that the following consideration be made in planning future development of roadwork system in Irbid area.

   1. Pedestrians crossings on major roads should be clearly marked.
   2. Major intersections should be improved by installing traffic signals for both vehicles and pedestrians.
   3. Intersections between Ring Road and arterial highways, should be channelized as far as possible.

CHAPTER 3 FUTURE SOCIAL, ECONOMIC AND LAND USE PLANNING

3.1 Forecast of Future Population and Employment

(1) Forecast of Future Population

The natural growth rate of population in Jordan is estimated in Table 3.1. The future birth rate will gradually decrease according to the increasing level of education. The death rate will also decrease in accordance with medical progress. As a result, the forecast based on natural growth rates is estimated as shown in Table 3.2.

Income per one family by Governorate is highest in Amman; next highest is Irbid Governorate which is a little lower than the average; other Governorates are lower still.

Assuming that migration into Amman Governorate is 0.3% and that out of Irbid Governorate is -0.1%, the future population of each Governorate is forecast in Table 3.3.

In Irbid Governorate, Irbid District displayed a 1.1% difference in the past growth rate as compared with other districts. Assuming that this difference will continue in the future, the forecast population for Irbid District is shown in Table 3.4.

Within Irbid District, villages excluding Irbid Expanded showed a 0.1% smaller growth rate than the East Bank. Assuming that the same tendency will continue in the future, the forecast population for Irbid Expanded is as shown in Table 3.5.

The population forecast of the Japanese Regional Planning Team is shown in Table 3.6. This forecast seems to be a little high because it was made before the 1979 census results became available.

The increase of population in Irbid Expanded will be 2.3 times between 1980 and 2000.

(2) Employment Population Forecast

In 1975, 19.2% of population of East Bank and 18.9% of that of Irbid Governorate entered the labour force.

The Japanese Regional Planning Team estimated that in the year 2000 the population entering the labour force will be 30%.

The participation of female labourers will gradually increase, so the value will be reasonable.

The same 30% value will be used to estimate the size of the labour force in Irbid Expanded. Since there is no data concerning rate of employment by sector in Irbid Expanded, the rate of employment by sector in Irbid Expanded is estimated based on the ratio of East Bank and Irbid Governorate and hearing of Labour Department of Irbid Governorate.

	1980	2000
Sector I	40%	25%
Sector II	15%	25%
Sector III	45%	50%

Table 3.1. Estimated Crude Birth and Death Rates (Medium Variant)

Period	Av. Crude Birth Rate	Avg. Crude Death Rate	Avg. Natural Growth Rate
1950-55	4.53	2.10	2.43
1955-60	4.68	2.11	2.57
1960-65	4.90	1.83	3.07
1965-70	4.91	1.60	3.31
1970-75	4.82	1.37	3.45

Source : Hanna Rizk, Trends in Family Size, Attidues and Practice of Family Planning in Jordan, 1972

Table 3.2 Forecast Natural Growth Rate

	Birth Rate (%)	Death Rate (%)	Natural Growth Rate (%)
1975-80	4.7	1.3	3.4
1980-85	4.6	1.2	3.4
1985-90	4.4	1.1	3.3
1990-95	4.2	1.0	3.2
1995-2000	4.0	0.9	3.1

Source: Study Team

FIG. 3.1 NATURAL GROWTH RATE OF POPULATION IN JORDAN

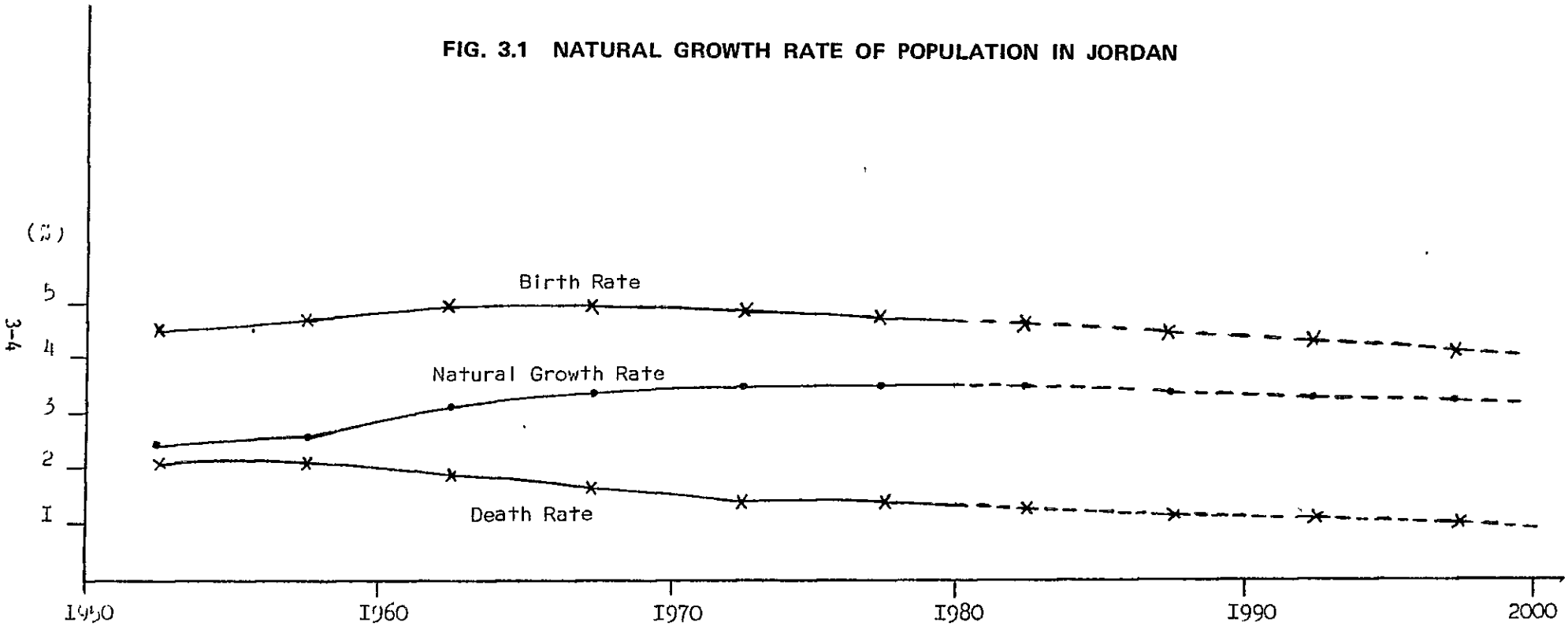


Table 3.3 Forecast Population of East Bank and Governorates

(1000 persons)

Year	East Bank		Ammon Governorate		Irbid Governorate		Others	
	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)
1961	901		434		274		193	
		5.0		5.6		4.6		3.4
1979	2132		1188	3.4+0.3 =3.7	612	3.4-0.1 =3.3	352	3.4-0.8 =2.6
		3.4						
1980	2225		1232	3.4+0.3 =3.7	632	3.4-0.1 =3.3	361	3.4-0.8 =2.6
		3.4						
1985	2630		1477	3.3+0.3 =3.6	743	3.3-0.1 =3.2	410	3.3-0-9 +2.4
		3.3						
1990	3094		1763	3.2+0.3 =3.5	870	3.2-0.1 =3.1	461	3.2-1.0 =2.2
		3.2						
1995	3622		2094	3.1+0.3 =3.4	1013	3.1-0.1 =3.0	515	3.1-1.0 =2.1
		3.1						
2000	4219		2475		1174		570	

Source ; Study Team

FIG. 3.2 FORECAST POPULATION OF EAST BANK AND GOVERNORATES

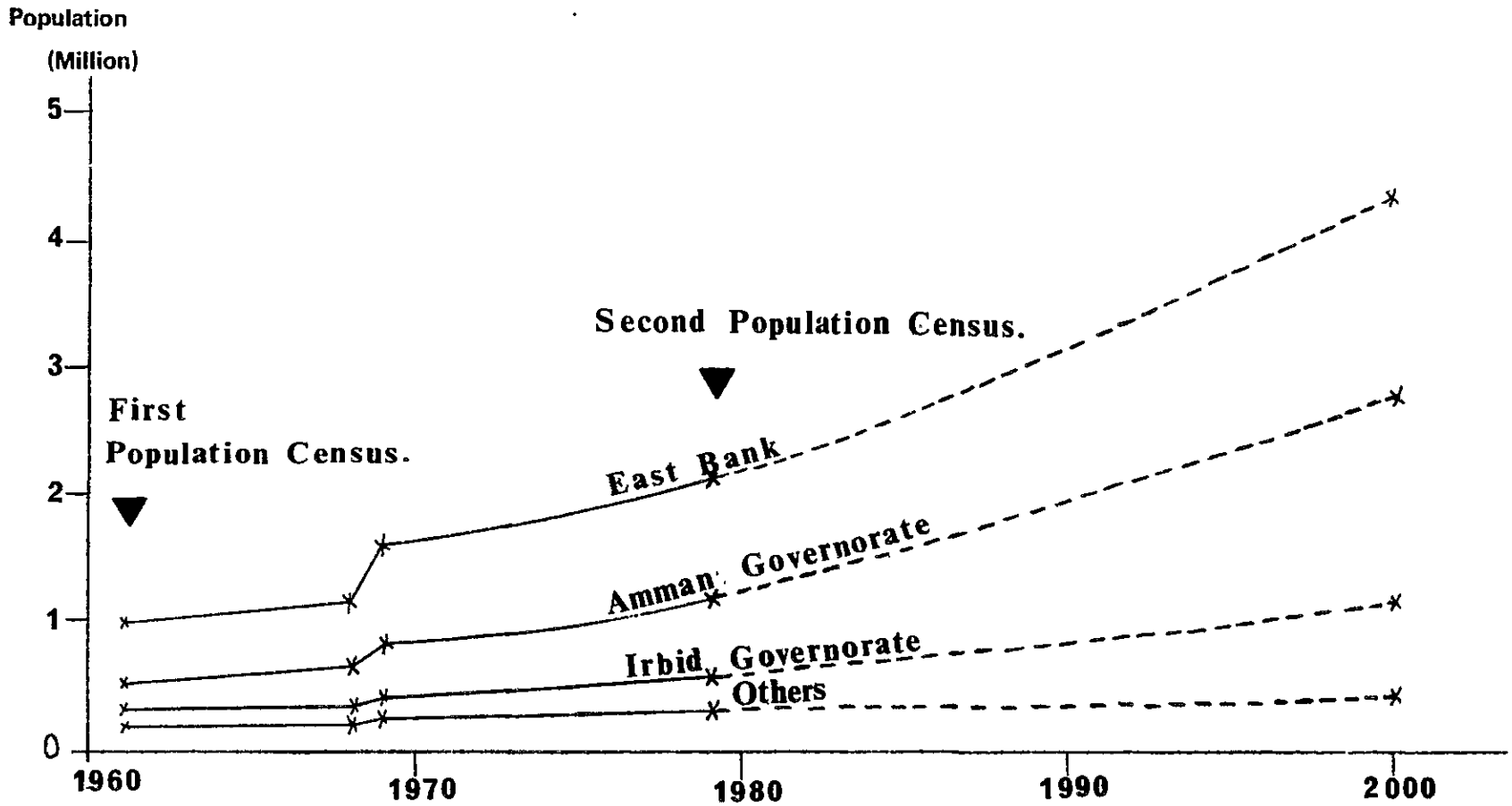


Table 3.4 Forecast Population of Irbid Governorate

(1000 persons)

Year	Irbid Governorate		Irbid District		Other Districts	
	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)
1961	274		132		142	
		4.6		5.1		4.0
1979	612		324	3.4+0.4	288	3.4-0.5
		3.3		=3.8		=2.9
1980	632		336	3.4+0.4	296	
		3.3		=3.8		2.7
1985	743		405	3.3+0.4	339	
		3.2		=3.7		2.6
1990	870		486	3.2+0.4	384	
		3.1		=3.6		2.5
1995	1013		580	3.1+0.4	433	
		3.0		=3.5		2.4
2000	1174		689		485	

Source : Study Team

Table 3.5 Forecast Population of Irbid Expanded

(1000 persons)

Year	Irbid District		Irbid Expanded		Other Areas	
	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)	Population	Average Annual Growth Rate (%)
1961	132		52		80	
		5.1		5.4		4.9
1979	324		133		191	
		3.8		3.4+1.1 = 4.5		3.4-0.1 = 3.3
1980	336		139		197	
		3.8		4.5		3.3
1985	405		173		232	
		3.7		4.3		3.2
1990	486		214		272	
		3.6		4.2		3.1
1995	580		263		317	
		3.5		4.1		3.0
2000	689		322		367	

Source: Study Team

Table 3.6 Population Forecast by Japanese Regional Planning Team

(1000 persons)

	1985	1990	2000
East Bank	2.470	3.239	4.395
Amman Governorate	1.689	2.006	2.827
Irbid Governorate	732	848	1.140
Others	319	385	428
Irbid Expanded	206	N/A	369

3.2 Economic Activity Forecast

(1) Forecast of G.D.P. and N.D.I.

In the first Five Year Plan (1975 - 1980), it was planned that the annual growth rate of G.D.P. be 12%. However, the Plan achieved an 11% increase.

The next Five Year Plan (1981 - 1985) forecasts an annual growth rate of 10.4% of G.D.P.

In Phase II study by the Japanese Team, the annual growth rate of G.D.P. was estimated to be 10% till 1985 and 8% thereafter.

Referring to the above values, the annual growth rate of G.D.P. is assumed to be 10% till 1985, 9% till 1995 and 8% thereafter; thus, the resulting G.D.P. per capita is as shown in Table 3.7.

The ratio between the G.D.P. and the N.D.I. in the past was 1.4 - 1.7. The ratio will decrease when the G.D.P. becomes larger in the future. Assuming that the ratio will be 1.3 in the year 2000, the N.D.I. is forecast as shown in Table 3.7.

(2) Forecast of G.D.P. by Sector

The share of G.D.P. by sector in the past is shown in Table 1.4.

G.D.P. by sector during the Five Year Plan (1981 - 1985) is forecast in Table 3.8.

Referring to the past share of G.D.P. by sector and the new Five Year Plan's forecast, the share by sector is forecast till the year 2000, as shown in Table 3.9.

Using this share, future value of G.D.P. by sector is forecast in Table 3.10. The growth ratios of sectors I and II, that have a correlation to goods traffic, will be 7.7 times their present size by the year 2000.

Table 3.7 Projected GDP Per Capita and NDI Per Capita (East Bank)

Year	GDP at Factor Cost (at 1975 constant Price) (mil.JD)	Average Annual Growth Rate (%)	NDI / GDP	NDI (at 1975 Price) (mil.JD)	Average Annual Growth Rate (%)	Population (thousand) persons)	GDP per Capita (at 1975 constant Price) (JD)	Average Annual Growth Rate (%)	NDI per Capita (at 1975 Price) (JD)	Average Annual Growth Rate (%)
1970	258.7		1.42	367.9		1601	161.6		230	
		) 0.8			) 5.2			) -2.4		) 1.8
1975	269.4		1.76	473.3		1883	143.1		251	
		) 6.7			) 6.5			) 2.4		) 3.0
1979	347.4		1.75	607.9		2152	161.4		282	
		) 10.0			) 10.0			) 6.4		) 6.7
1980	382.1		1.75	668.7		2225	171.7		301	
		) 10.0			) 8.0			) 6.4		) 4.4
1985	615.4		1.60	984.5		2630	234.0		374	
		) 9.0			) 7.6			) 5.5		) 4.2
1990	946.9		1.50	1420.4		3094	306.0		459	
		) 9.0			) 7.5			) 5.6		) 4.2
1995	1456.9		1.40	2039.7		3622	402.2		563	
		) 8.0			) 6.4			) 4.8		) 3.2
2000	2140.7		1.30	2782.9		4219	507.4		660	

Source: Study Team

Table 3.8 G.D.P by sector (East Bank)
(1980 price mil. JD)

	1980 G.D.P (mil JD)	Percent (%)	1985 G.D.P (mil JD)	Percent (%)	Annual growth rate (%)
Sector I	60	8.5	85	7.3	7.0
Sector II	206	29.2	416	36.0	15.1
Sector III	439	62.3	656	56.7	8.4
Total	705	100	1156	100	10.4

Table 3.9 Share of G.D.P by sector (East Bank)

(Unit: %)

	Sector I	Sector II	Sector III
1975	9.0	23.3	67.0
1980	8.5	29.2	62.3
1985	7.3	36.0	56.7
1990	6	40	54
1995	5	44	51
2000	4	47	49

Table 3.10 Forecast of G.D.P by sector (East Bank)
(1980 price mil. JD)

	Sector I		Sector II		Sector III		Total	
	G.D.P	Annual Growth Rate (%)	G.D.P	Annual Growth Rate (%)	G.D.P	Annual Growth Rate (%)	G.D.P	Annual Growth Rate (%)
1980	60		206		439		705	
		7.0		15.1		8.4		10.4
1985	84		416		656		1156	
		5.0		11.3		7.9		9.0
1990	107		712		960		1779	
		5.1		11.1		7.8		9.0
1995	137		1204		1396		2737	
		3.3		9.4		7.1		8.0
2000	161		1890		1971		4022	

3.3 Forecast of Car Ownership

There is a high correlation between National Disposable Income (N.D.I.) per capita (x) and the rate of car ownership (Y) in the countries of the world.

By plotting these values from many countries on logarithmic paper, a linear relation is obtained between log x and log Y, which is : $Y = a\ x^{b}$. It is clear that car ownership in Jordan in recent years is at a higher level than the international average.

Assuming that the future tendency of the growth rate of car ownership in Jordan is equal to the international average, the future rate of car ownership can be forecast based upon the estimated future N.D.I. per capita.

Table 3.13 shows the forecast number of cars by governorate.

Number of cars in Irbid Governorate is forecast to grow 5.5 times between 1980 and 2000.

Table 3.11 NDI per Capita and Rate of Car Ownership in many countries (1975)

Country	1/ NDI per Capita (x) (US$)	2/ Population (1,000 Persons)	1/ Number of Cars (1,000 Cars)	Number of Cars/1,000 Persons (Y)
Egypt	347	37,233	274	7.4
Kenya	217	13,399	166	12.4
Morocco	426	17,305	447	25.8
South Africa	1,177	25,501	2,917	114
Canada	6,317	22,727	10,869	478
U.S.A.	6,265	213,559	130,917	613
Chile	628	10,253	424	41.5
Colombia	509	23,542	465	19.8
Ecuador	570	6,733	129	19.2
Mexico	1,206	60,145	3,289	54.7
Peru	520	15,615	129	8.3
Venezuela	2,115	11,993	1,325	110
Iraq	1,118	11,124	173	15.6
India	137	600,763	1,338	2.2
Japan	3,855	111,573	27,551	247
Korea	525	35,281	189	5.4
Philippines	339	42,071	657	15.6
Thailand	325	41,869	533	12.7
Belgium	5,830	9,801	2,906	297
Denmark	6,775	5,060	1,539	304
France	5,197	52,705	17,434	331
Germany	5,898	61,832	19,239	311
Italy	2,807	55,830	16,673	299
United Kingdom	3,618	55,890	15,826	283
Austria	4,370	7,520	2,166	288
Norway	5,956	4,007	1,100	275
Sweden	7,488	8,193	2,918	356
Switzerland	7,721	6,403	1,946	304
Greece	2,284	9,047	650	72.0
Spain	2,677	35,596	5,847	164
Australia	6,245	13,771	6,213	451
New Zealand	4,027	3,087	1,355	439

Source 1/ UN Statistical Yearbook
2/ UN Demographic Yearbook

N.D.I = National Disposable Income

FIG. 3.3 CORRELATION BETWEEN NDI PER CAPITA AND RATE OF CAR OWNERSHIP

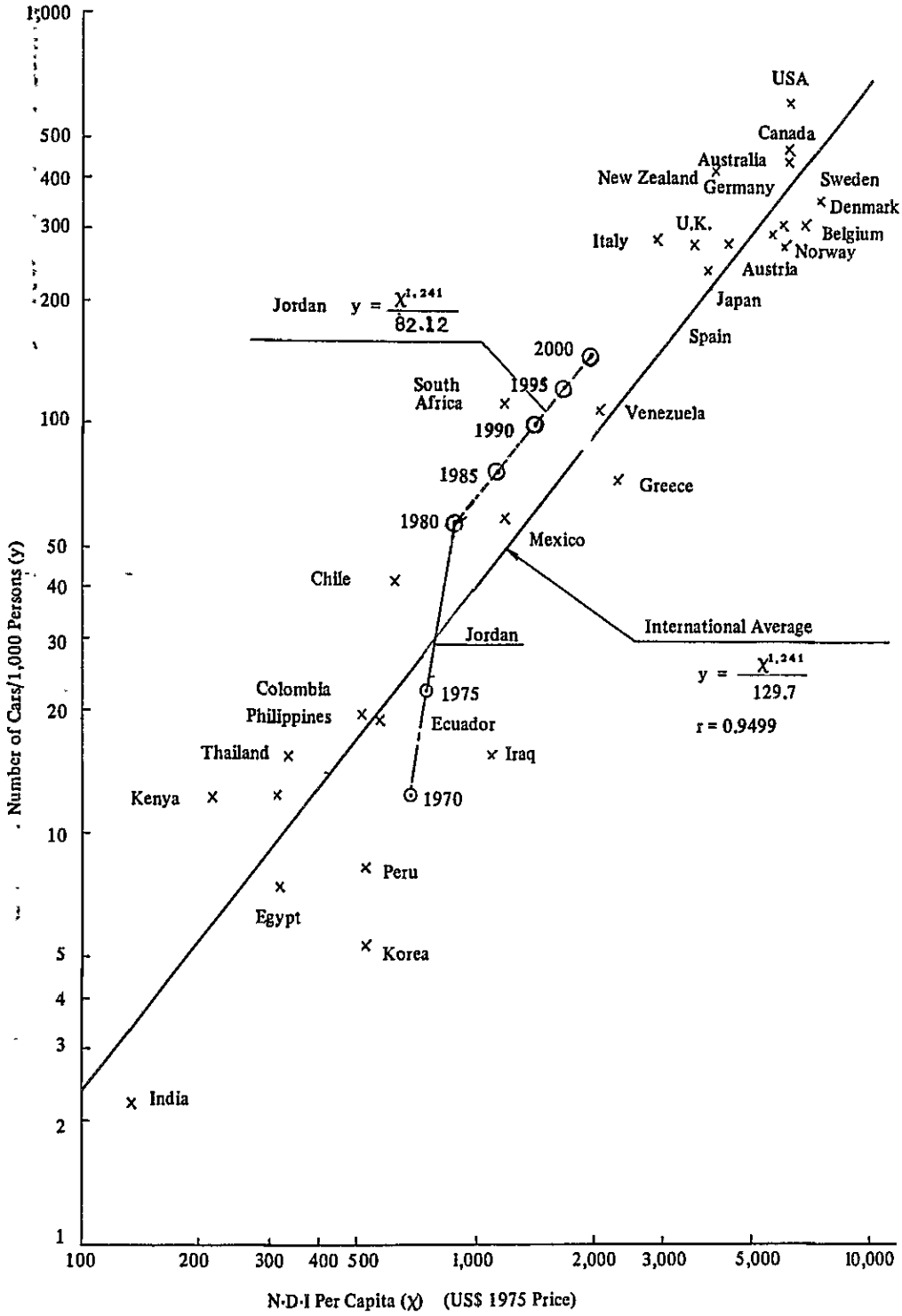


Table 3.12 Future Number of Cars (East Bank)

Year	NDI per Capita (1975 Price)		1/ Number of Cars/(1,000 Persons	Population (1,000 Persons)	Number of Cars (1,000 Cars)
	JD	US$			
1980	304	903	56.7	2,225	126.1
1985	374	1,122	74.2	2,630	195.1
1990	459	1,377	95.7	3,094	296.1
1995	563	1,684	123.3	3,622	446.6
2000	660	1,980	150.2	4,219	633.7

Note: 1/ The value is obtained from the graph in Fig. 3.3.
Tractors, motorcycles and construction vehicles are not included.

Table 3.13 Forecast Number of Cars by Governorate

Year	East Bank		Amman Governorate		Irbid Governorate		Others	
	Number of Cars (1,000 Cars)	Annual Growth Ratio (%)	Number of Cars (1,000 Cars)	Annual Growth Ratio (%)	Number of Cars (1,000 Cars)	Annual Growth Ratio (%)	Number of Cars (1,000 Cars)	Annual Growth Ratio (%)
1970	19.9		18.3		1.7		-	
		17.3		17.3		16.8		
1975	44.2		40.5		3.7		-	
		23.3		22.2		31.2		39.5
1980	126.1		110.2		14.4		1.5	
		9.1		8.5		9.6		32.0
1985	195.1		166.3		22.8		6.0	
		8.7		8.2		9.1		18.8
1990	296.1		246.6		35.3		14.2	
		8.6		8.0		9.0		15.7
1995	446.6		362.8		54.4		29.4	
		7.2		6.7		7.7		12.1
2000	633.7		502.7		78.9		52.1	

Note: Tractors, motorcycles and construction vehicles are not included.

3.4 Desirable Land Use Planning

(1) The Ideal of City Planning

To minimize traffic is one of the ideals of city planning. Hence, commercial and business areas, industrial area and recreational area should be connected around the residential area, so that residence and work places are arranged close together, and so residential and recreational areas are arranged close to each other. By this arrangement of a human settlement unit, people can live with minimum traffic demand.

For one group of residential area, it is most desirable to adopt the "district" composed of approximately four neighbourhoods where one neighbourhood equals one primary school zone. Thus the needs of children are filled within the zone till they finish middle school or until high school.

Since the suitable average population of one neighbourhood is between 8,000 - 10,000, the population of one district would be 30,000 - 40,000. The size of the neighbourhood area would be approximately 0.9 x 0.9 $\sim$ 1 km x 1 km based on low rise housing which is the most suitable for raising children. Accordingly, the size of one district area would be approximately 1.8 x 1.8 $\sim$ 2 km x 2 km.

Fig. 3.4 shows the physical plan of a human settlement unit.

Un urban unit (one core city) is established by concentrating commercial and business areas of the human settlement unit in the place where people gather. Assuming that approximately 20% of the urban population live in commercial and industrial areas, the population of urban unit would be 250,000 - 300,000. The diameter of an urban unit would be about 6 km (Fig. 3.5). Here, the residential area should be zoned for residential use only, and mainly low rise housing should be arranged.

Commercial and business area should be made rich in variety by mixing apartment housing throughout. In any industrial area, only urban industry which does not cause environmental pollution should be permitted to be located. The utilities and the distribution center should also be located inside the area.

In a recreation area (green area), general park, sport park, urban forest, play land, cemetery, university and so on should be located.

In the urban unit, the land use ratio is divided between residential area, commercial & business area, industrial area and recreational area as follows: 6:1:1:1. This orderly proportion has already been examined by standard land use basic value. Moreover, an ideal multi-core city can be formed by combining urban units (Fig. 3.6).

In an urban unit (one core city) and in multi-core city also, residence and work places are arranged close together, and the same for residence and recreation areas. With this arrangement, people can live with minimum demand for traffic which is the main goal of urban planning.

When a one-core city has a population increase that exceeds 300,000, it should be upgrade to a multi-core city.

FIG. 3.4 HUMAN SETTLEMENT UNIT

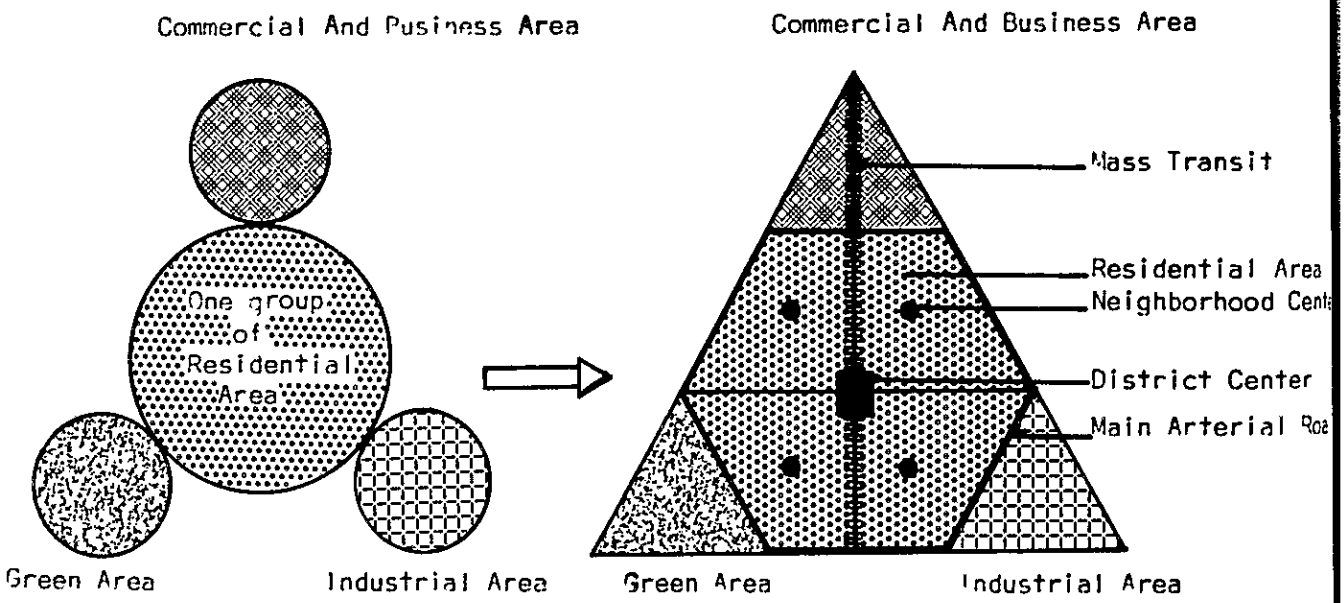


FIG. 3.5 URBAN UNIT

(Population 250-300,000)

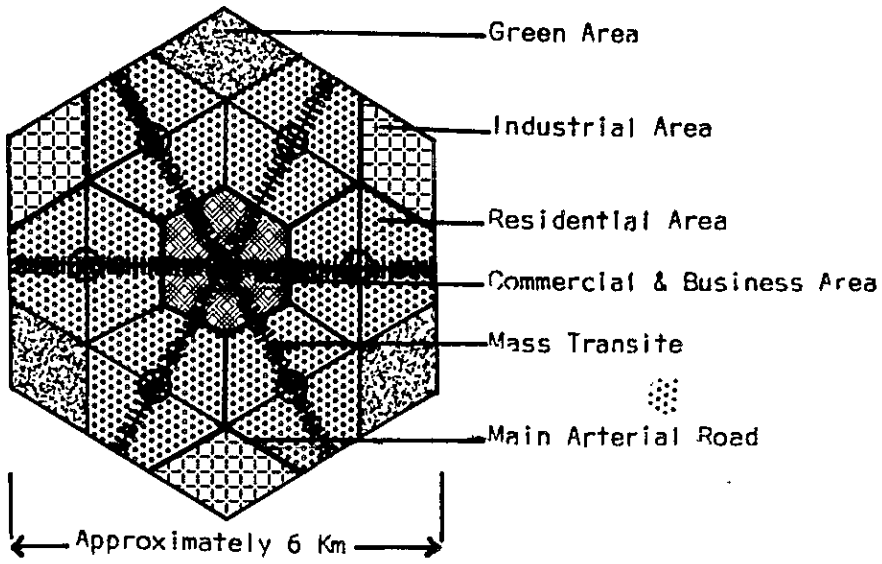
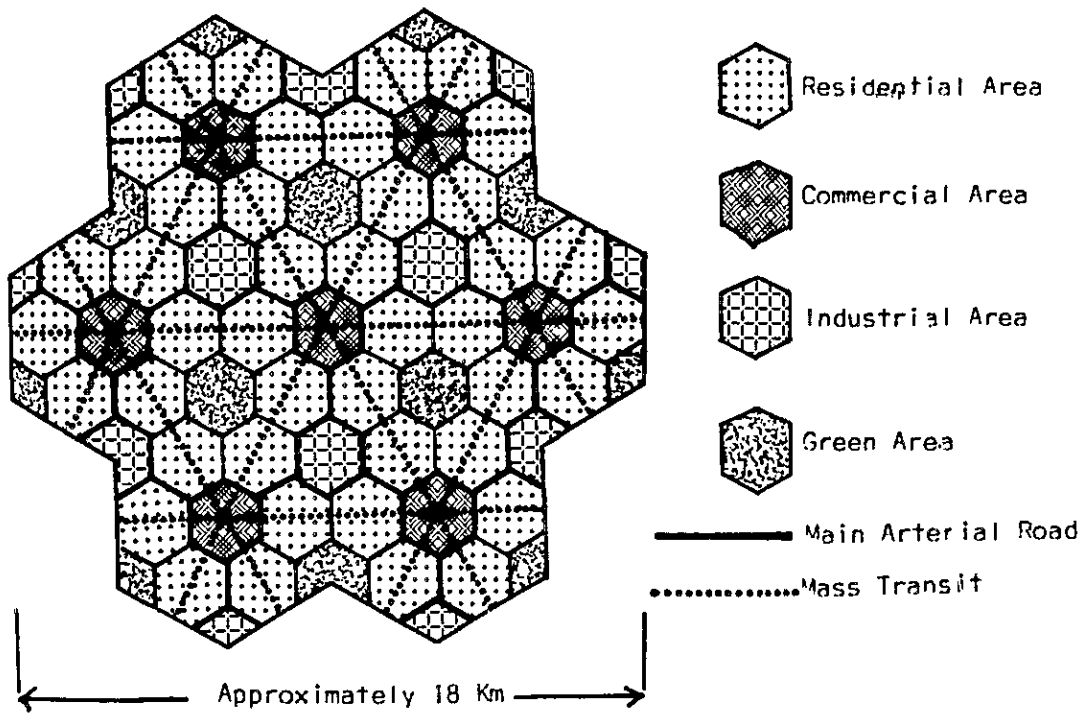


FIG. 3.6 IDEAL MULTI-CORE TYPE CITY

(Example:Population 2 million)



Source: "Planning of Comfortable housing"
H. SAKAI, Ohme Co., Ltd.
(Fig. 3.4 ∿ Fig. 3 6)

(2) Desirable Land Use Plan of Irbid City

Referring to the ideal of urban planning and considering the topography and the developing situation of Irbid City, the desirable land use plan of the city is outlined below.

The commercial area in the center of the city should be assigned as a commercial and business area.

Most of the area inside the Inner Ring Road should be assigned as a mixed area of linear commercial area and residential area.

In Irbid City, the wind blows from the west all through the year, so it is quite reasonable to locate the industrial area at the northeast fringe of the city. Inside the area, a distribution center for Sector II is recommended to be located.

If the industrial area is concentrated in one place, traffic also will be concentrated, so a simple service industry is better located in the existing sub-station area and along Fouara Street.

The existing central market place is very suitable for the distribution center of Sector I, since it is located along the Inner Ring Road, which connects Palestine Road and Baghdad Road.

A large scale green area (Recreation Area) should be located in the northern and eastern boundary areas. The value of recreation areas will be increased as urbanization proceeds and as the standard of living level rises. The hill area of the city cente should be developed as a green park.

A residential area will be located in the other areas. Residential areas should be arranged on a "District" scale. In the center of the district, along the Boundary Ring Road, a district center (Commercial area) should be arranged.

It should be noted that it is very important to promote district centers in Irbid City, since they are very effective in preventing the concentration of the traffic flow to the city center.

Since the size of an ideal neighbourhood is approximately 1 km x 1 km, it is desirable to arrange the Boundary Ring Road and Outer Ring Road at 1 km intervals from the Inner Ring Road. This is also clear from urban unit drawing (Figure 3.5).

As the development on the western side of the city is prevented by Wadi Elghafar, it seems to be not so imported to arrange the Boudary Ring Road in the western area from the land use point of view. But, if the capacity of the Inner Ring Road is insufficient to handle the future traffic, the Boundary Ring Road will be necessary at that section.

In conclusion, desirable land-use and the ring roads network concept is as shown in Figure 3.8.

The ring road network in Figure 3.8 is the ideal figure. In reality, housing is under developed in some areas, local topographic controls exist in some places and the land readjustment process is proceeding in some areas. Accordingly, it is permissible to amend the ring road corridor, as discussed in Chapter 7.

It is very important to improve the Inner Ring Road as a smooth circle, in order to solve the present congestion of traffic in the city center. After the Inner Ring Road is improved in a smooth circle, it is necessary to prohibit through traffic inside the Inner Ring Road.

After the population of Irbid Expanded exceeds 250,000, a sub-center should be developed and Irbid Expanded should be upgrade to a multi-core city.

The desirable position of the sub-center is on Baghdad Street, approximately 6 km from the existing urban center. (Figure 3.7)

FIG. 3.7 THE POSITION OF SUB CENTER

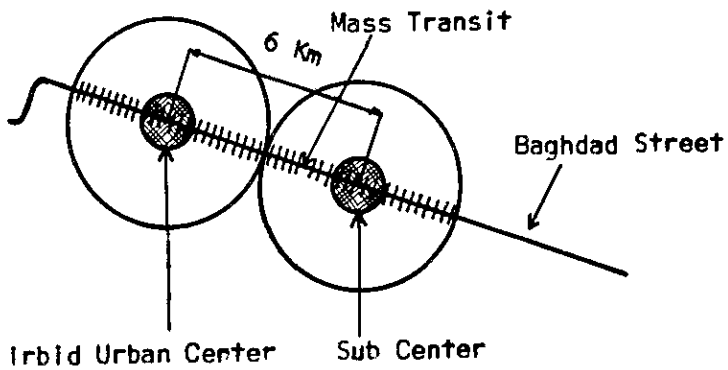
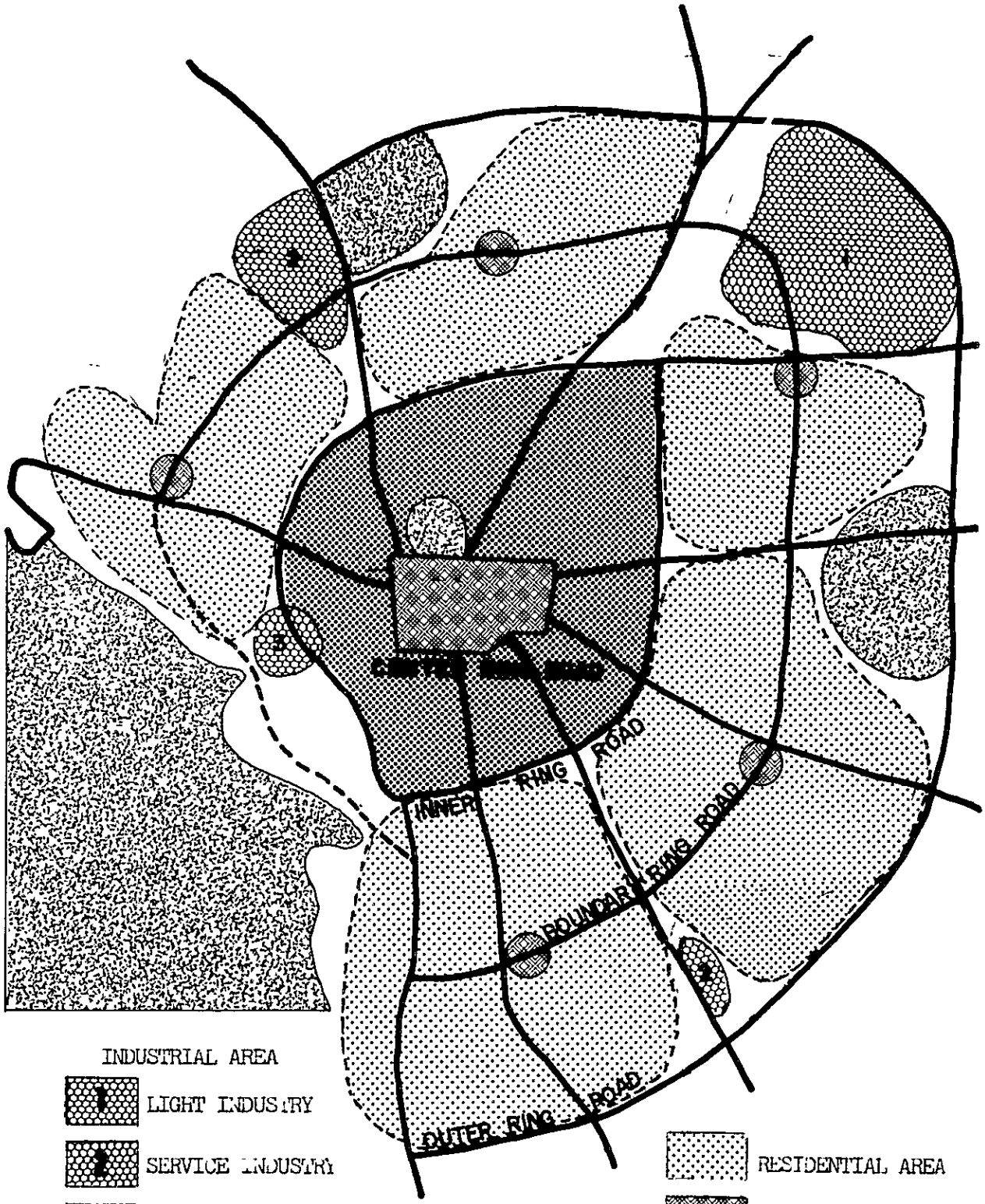


FIG. 3.8 CONCEPT OF LAND USE AND RING ROAD PLAN IN IRBID EXPANDED



(3) Desirable Urban Traffic System in Irbid City

The basic means of urban movement is walking. But in Irbid City there are few comfortable pedestrian ways. It is important to make a network of pedestrian ways inside the city by arranging sidewalks and pedestrian ways.

In order to make the city center comfortable, it is recommended to arrange Center Ring Road inside Inner Ring Road mainly using existing road, and to adopt a traffic cell system inside it (Fig. 3.9).

Baghdad Street and Jarash Street inside the Center Ring Road should be changed to pedestrian ways (Transit mall). By the pedestrian ways, the inside area can be divided into four traffic cell; vehicle traffic between cells would be prohibited. A vehicle which enters one cell will exit from the same cell.

At present few bicycles are used in Irbid City. However, it is recommended to use bicycles since they cause no pollution and since the topography of Irbid City is almost flat. As bicycle traffic increases, bicycle lane should gradually be increased.

The space for traffic in the urban area is limited. Accordingly, private cars cannot be relied upon as the main means of transportation in the urban area.

To constrain the use of private cars, a public car system should be promoted.

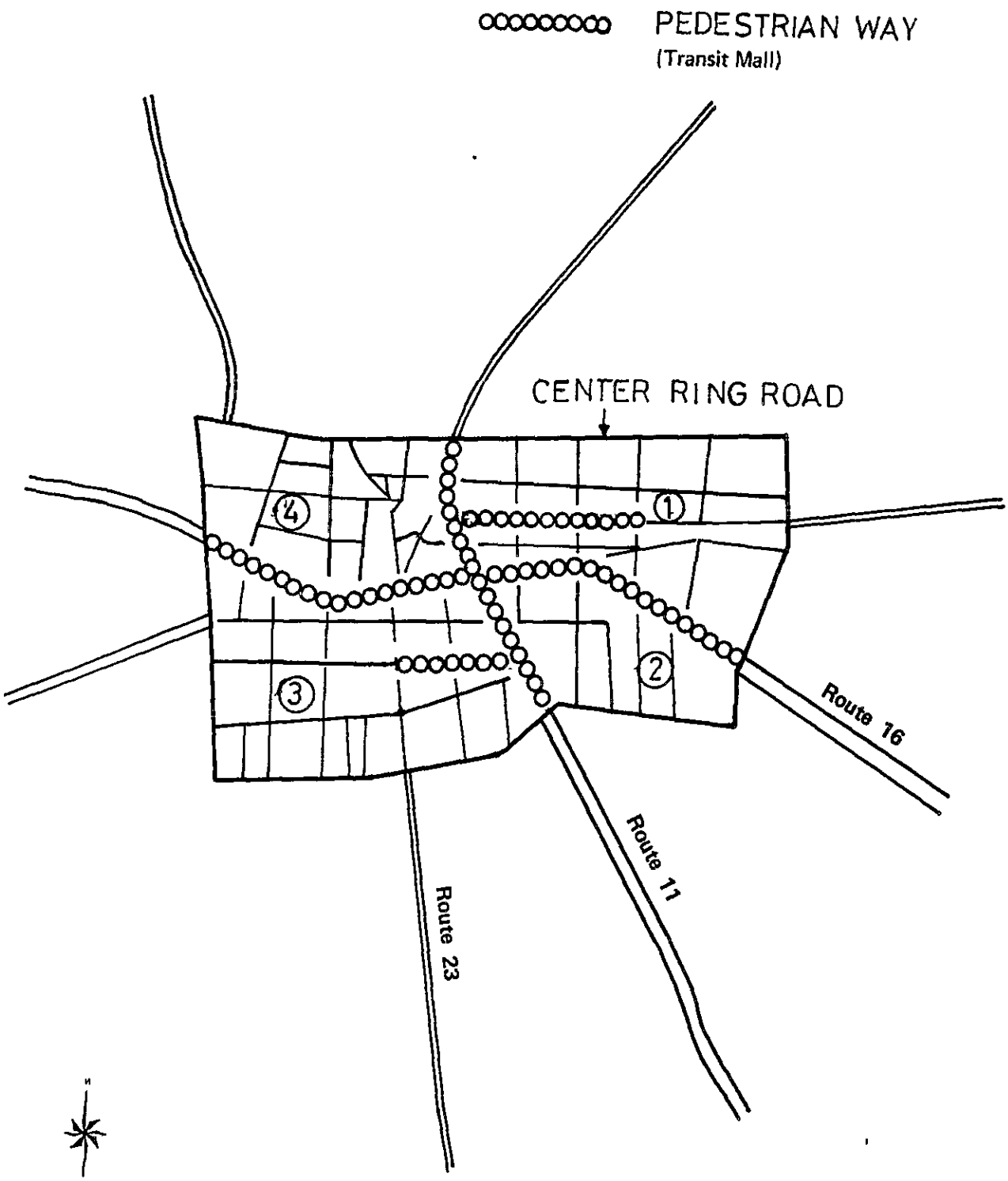
A high rate tax equivalent to social cost should be levied on private car owners. It is desirable to make the use of private cars difficult by increasing parking prohibitions in the central area of the city.

On the other hand, taxi, service taxi, mini bus and bus networks should be developed.

It is desirable that people can use public cars with low fares to go everywhere in the city.

When Irbid Expanded is shifted to multi core city, it is recommended that mass transit will be applied between existing urban center and new sub-center.

FIG. 3.9 TRAFFIC CELL SYSTEM



3.5 Future Framework of Land-Use in Irbid Expanded

(1) Irbid Expanded

The desirable density of the residential area is between 80 ∿ 130 person/ha, average 100 persons/ha based on low rise housing which are most suitable for raising children. Therefore the density of the residential area in year 2000 is assumed to be 100 persons/ha. It is also assumed that 80 percent of the urban population live in the residential area and the rest live in the commercial and industrial areas. These are common tendencies. Based on both assumptions, the required residential land area for the future are calculated.

For the commercial area, approximately net 10 m^2 per one person is necessary based on Japanese and Amercian urban examples. Accordingly gross 13 m^2 per one person in year 2000 is adopted.

The required industrial area per worker is estimated to be as follows by Japanese Regional Planning team.

(m^2/person)

	1985	1986 ∿ 1990	1991 ∿ 2000
Net land demand	70	77	84
Gross land demand	100	110	120

The total required industrial area is calculated to have a gross density of 85 persons/ha in 2000.

Large-scale green area is necessary in the amount of at least net 10 m^2 per urban person. Large-scale green area is adopted as gross 11 m^2 per urban person in 2000.

Based on above mentioned assumptions, the future urban area is calculated as shown in Table 3.14.

Taking topography into consideration for the urban planning and future development plans, the future urban area is drawn as Fig. 3.10.

Fig. 3.11 shows desirable land use plan for the year 2000.

Table 3.14 Estimated Framework of Future Land-Use in Irbid Expanded

	1980	1985	2000
Population (1,000 persons)	139	173	322
Population in Residential Area (1,000 persons)	111	138	258
Employed Population (1,000 persons)	27.8 (20%)	38.9 (22.5%)	96.6 (30%)
Sector II Population (1,000 persons)	4.2 (15%)	7.0 (18%)	24.2 (25%)
Residential Area (ha) Gross Density	967 (115 persons/ha)	1,247 (111 persons/ha)	2,576 (100 persons/ha)
Commercial & Business Area (ha) Gross	139 (10 m^2/ person)	190 (11 m^2/person)	419 (13 m^2/person)
Industrial Area (ha) Gross Density of Workers	42 (100 persons/ha)	73 (96 persons/ha)	284 (85 persons/ha)
Large-scale Green (ha) Gross Area Required	69 (5.0 m^2/person)	111 (6.4 m^2/person)	354 (11 m^2/person)
Urban Area (ha)	1,217	1,654	3,637
Density (person/ha)	114	106	89

Table 3.15 Forecast Urban Area in Irbid Expanded

(ha)

	1979	1985	2000
Irbid City	882.7	1,245	2,385
Beit Ras	48.5	101	250
Hakama	39.4	56	125
Bishra	56.3	73	275
Hawara	46.9	69	165
Aidun	79.7	110	437
Irbid Expanded	1,153.5	1,654	3,637

FIG. 3.10 FUTURE URBAN AREA IN IRBID EXPANDED

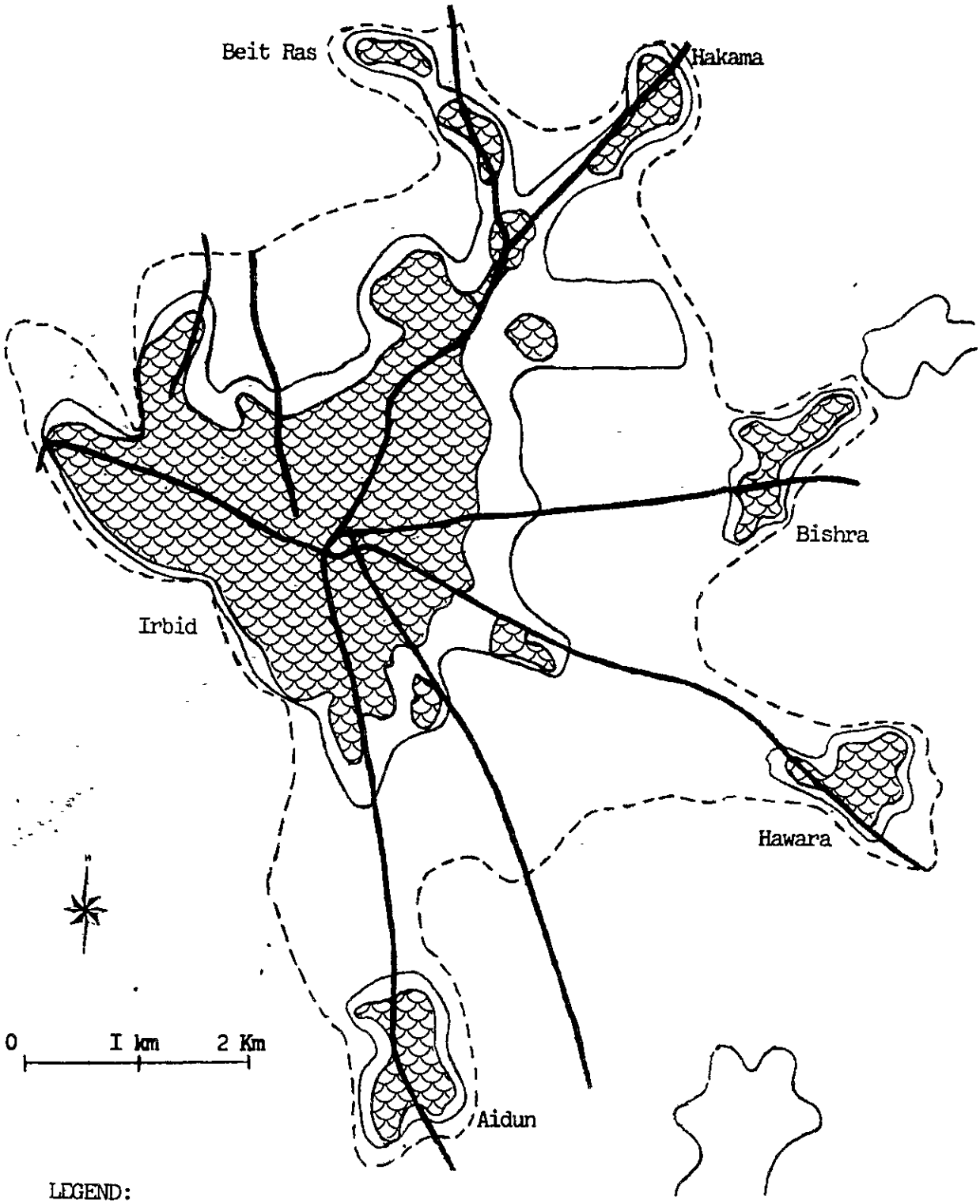
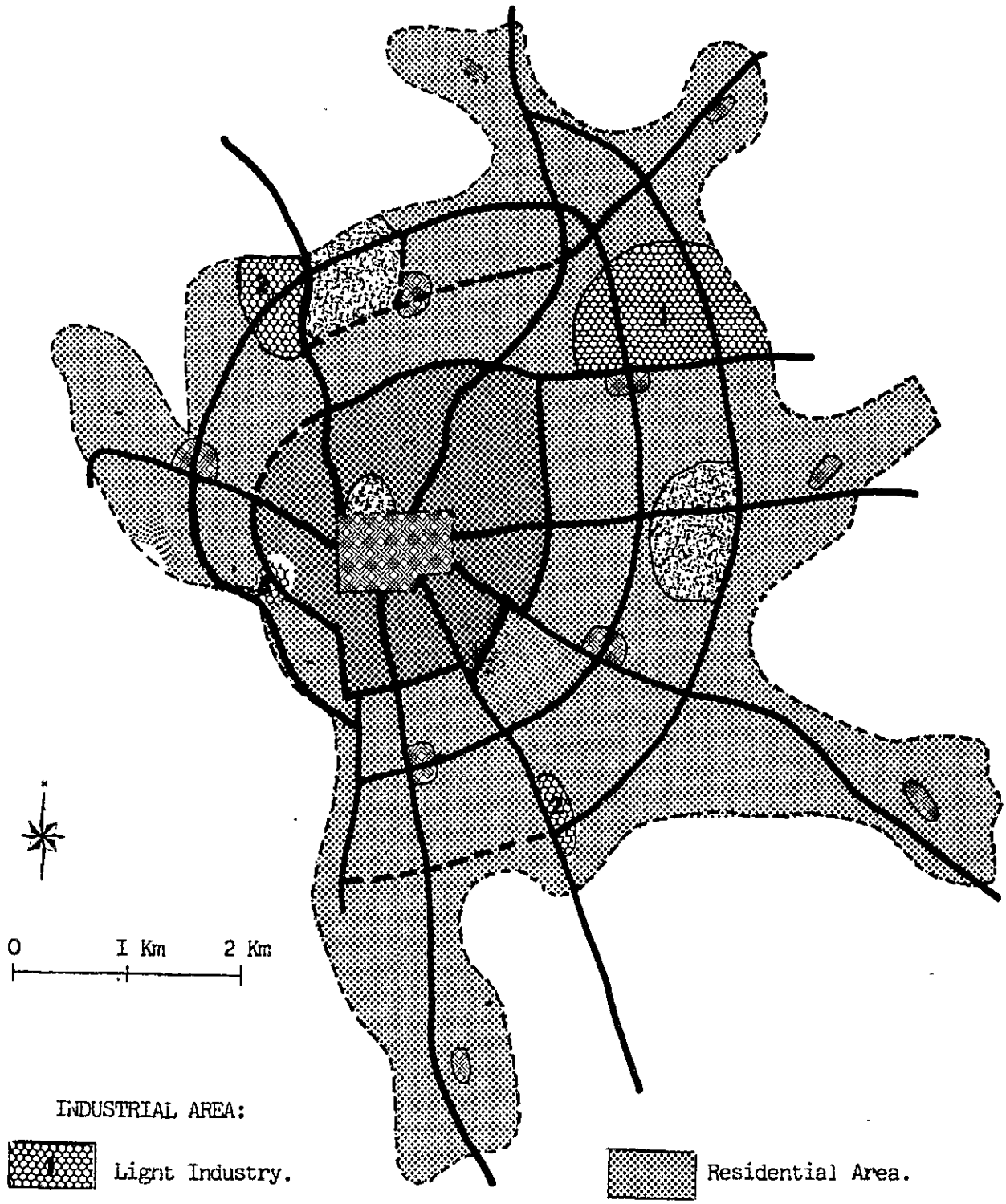


FIG. 3.11 LAND USE PLAN IN IRBID EXPANDED (in 2000)

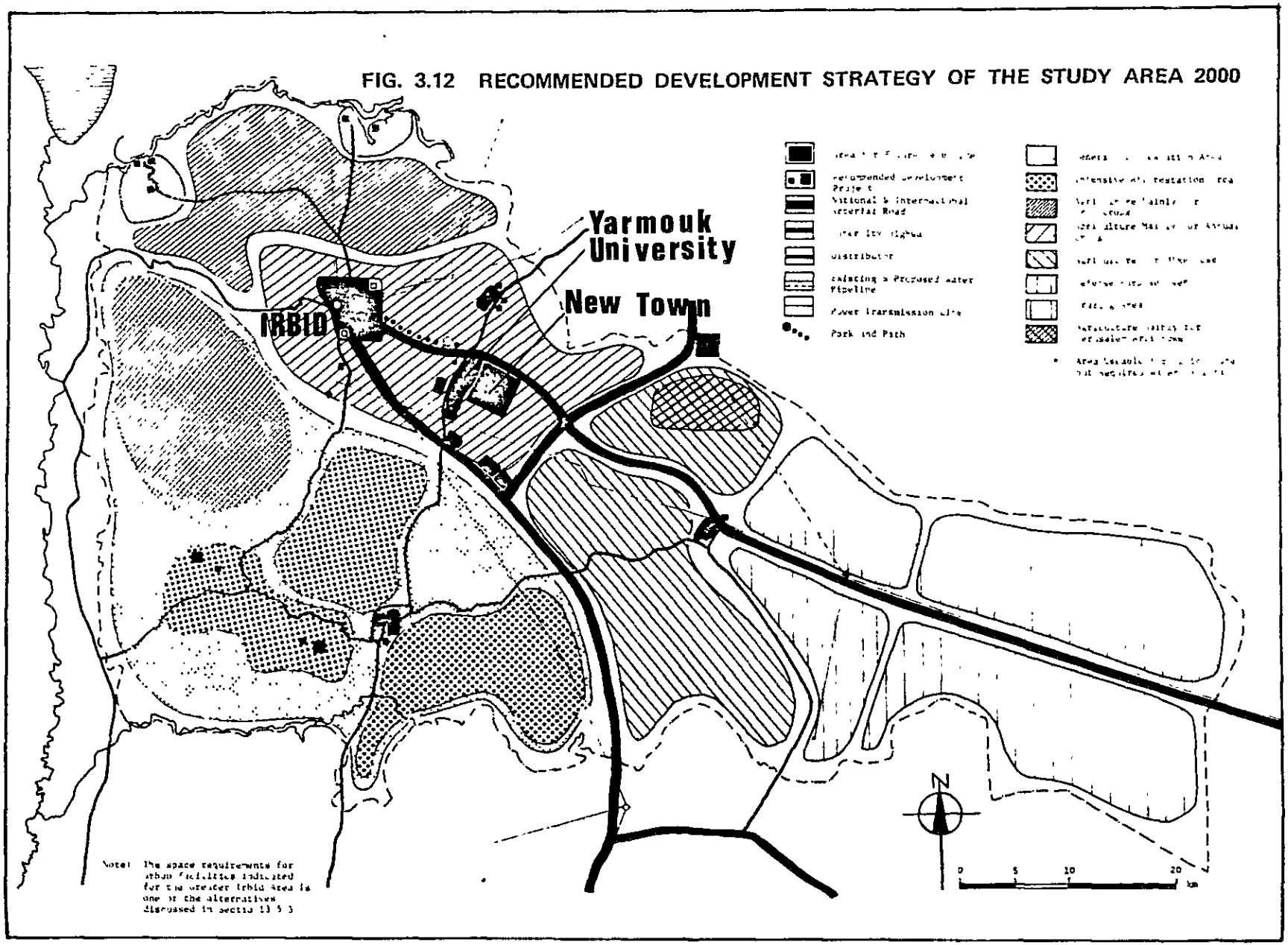


(2) Irbid Region

The development plan of the Irbid Region is proposed by Japanese Regional Planning Team as shown in Fig. 3.12. A new town is planned beside the Yarmouk University premises.

The development plan of Yarmouk University is as follows.

Students will begin to move to the new site from 1985 and moving of the total university facilities will be completed after 10 years. At that time, the number of students should reach 20,000, with University staff numbering about 1,600.



Source : Integrated Regional Development Study of Northern Jordan, Final Report, Volume 2

3.6 Forecast Indices by Zone

Indices by zone, that are the bases of forecasting future traffic volumes, are as follows:

(1) Land-Use Area by Zone (in Irbid Expanded)

The future urban area by zone is measured based on the future urban area in Irbid Expanded (See Figure 3.13).

Components of land-use, that is residential area, commercial, business, industrial and large scale green areas by zone can be measured using future land-use plan (Figure 3.11). This index is an approximate value, which shows the tendency by zone.

(2) Residential Population by Zone

Residential population by zone in 1979 is obtained through the Population Census.

Future residential population by zone is forecasted as follows:

i) In Irbid Expanded

Based upon present population density by zone, future population density can be forecast based on future land-use by zone.

Future residential population is calculated by multiplying the future urban area of each zone with the future population density of each zone.

ii) Other Areas in Jordan

Future residential population of other areas in Jordan can be obtained by forecasting the average annual growth rate, as shown in Table 3.18 referring to Section 3.1.

Students at Yarmouk University will be moved to the new site from 1985. Accordingly, the population of the new town will increase thereafter. It is forecasted that the population of the new town will be 30,000 in the year 2000.

iii) Neighbouring Countries

The population of neighbouring countries can be calculated using future annual growth rate which is forecasted by the past tendency.

(3) Work Places of Sector III and Sector II by Zone (In Irbid Expanded)

The work places of Sectors III and II can be calculated using the commercial & business and industrial areas by zone and the estimated density of workers respectively.

This index is also an approximate value, which shows the tendency by zone.

FIG. 3.13 FUTURE URBAN AREA IN IRBID EXPANDED

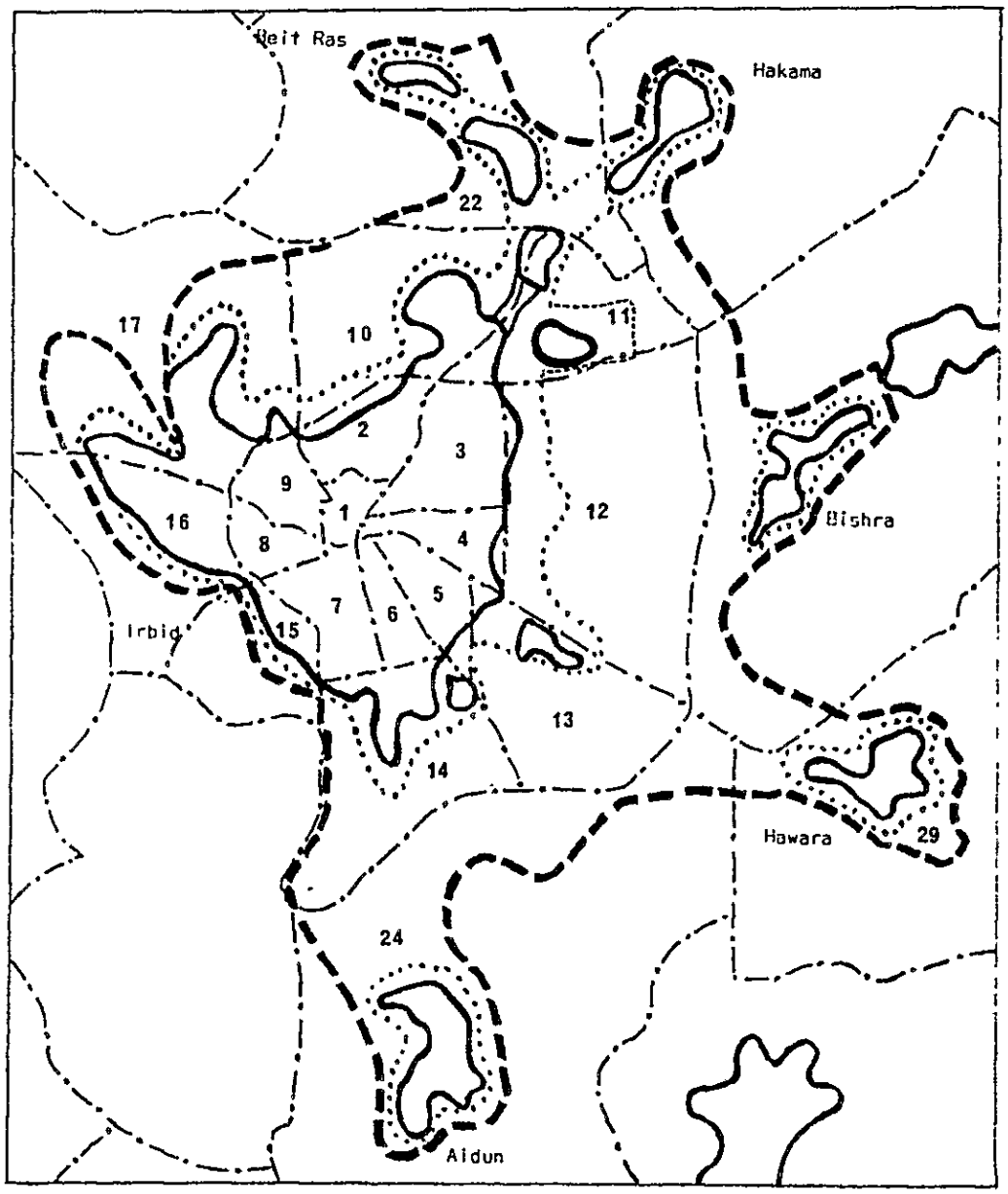


Table 3.16 Land-Use Area by Zone (ha) in Irbid Expanded

	1979					1985					2000				
Zone	R	C	I	G	T	R	C	I	G	T	R	C	I	G	T
1	8	14	0	2	24	6	15	0	4	25	2	17	0	6	25
2	63	0	0	4	67	70	1	0	4	75	64	10	0	1	75
3	67	22	4	6	99	69	27	7	5	108	40	50	15	33	108
4	30	13	1	3	47	35	17	1	3	56	25	27	3	1	56
5	22	12	1	8	43	27	15	1	7	50	18	25	3	4	50
6	36	10	1	1	48	32	14	1	1	48	21	23	3	1	48
7	42	18	5	2	67	46	20	6	2	75	38	25	10	2	75
8	20	4	3	2	29	29	6	4	2	41	21	10	8	1	40
9	36	5	3	1	45	39	7	4	1	51	28	15	7	1	51
10	75	3	1	4	83	97	5	2	10	114	164	25	5	90	284
11	20	2	16	4	42	37	3	28	7	75	54	7	100	10	171
12	23	0	0	10	33	58	10	0	20	88	291	50	2	120	463
13	16	0	3	3	22	35	0	5	10	50	181	7	10	30	228
14	38	2	0	4	44	91	5	0	7	103	214	25	2	15	256
15	31	0	0	3	34	30	0	1	3	34	30	3	5	2	40
16	61	0	1	2	64	104	0	2	2	108	112	5	6	2	125
17	80	5	3	3	91	122	10	9	3	144	216	25	29	20	290
Sub-total (Irbid City)	688	110	42	62	882	928	155	71	91	1245	519	349	208	309	2385
22	43	5	0	1	49	90	7	1	3	101	204	15	22	9	250
Bishra	50	5	0	1	56	62	7	0	4	73	299	15	2	9	275
24	73	6	0	1	80	94	9	0	7	110	394	20	10	13	437
Hakama	33	5	0	1	39	46	6	1	3	56	68	10	40	7	125
29	42	4	0	1	47	60	6	0	3	69	146	10	2	7	165
Total (Irbid Expanded)	909	135	42	67	1153	1280	190	73	111	1654	2580	419	284	354	3637

Notes : R : Residential Area C : Commercial & business Area
I : Industrial Area G : Large Scale Green Area
T : Total Area

Table 3.17 Population by Zone in Irbid Expanded

Zone	1979			1985			2000		
	Urban Area (ha)	Density (Persons/ha)	Population (Persons)	Urban Area (ha)	Density (Persons/ha)	Population (Persons)	Urban Area (ha)	Density (Persons/ha)	Population (Persons)
1	24	124.3	3,021	25	120	3,000	25	110	2,800
2	67	365.5	24,597	75	350	26,200	75	210	15,700
3	99	142.2	14,017	108	140	15,100	108	130	14,000
4	47	55.6	2,630	56	60	3,400	56	95	5,300
5	43	40.5	1,753	50	45	2,300	50	85	4,200
6	48	75.4	3,651	48	75	3,700	48	85	4,200
7	67	200.6	13,340	75	190	14,300	75	160	12,000
8	29	198.1	5,724	41	190	7,600	40	160	6,400
9	45	292.4	10,813	51	230	11,800	51	180	9,200
10	83	99.6	7,986	114	90	10,200	284	60	17,100
11	42	97.2	1,992	75	45	3,400	171	40	6,800
12	33	19.4	637	88	25	2,200	463	60	27,200
13	22	34.6	775	50	40	2,000	228	70	16,000
14	44	46.7	2,060	103	50	5,100	257	80	20,800
15	34	40.4	1,352	34	45	1,500	40	100	4,000
16	64	149.4	9,564	108	142	15,400	125	125	16,200
17	91	102.0	9,057	144	100	14,400	290	120	34,800
Sub-total (Irbid city)	882.3	128.0	112,969	1,245	113.8	141,600	2,385	90.8	216,700
22	49	95.5	4,630	101	90	9,200	250	88	22,000
Bishra	56	70.9	3,992	73	71	5,200	275	85	23,400
24	80	58.9	4,697	110	60	6,700	437	80	35,000
Hakama	39	56.0	2,208	56	60	3,400	125	80	10,000
29	47	107.5	5,043	69	100	6,900	165	90	14,900
Total (Irbid Expanded)	1,153	115.8	133,539	1,654	104.6	173,000	3,637	88.5	322,000

Table 3.18 Population by Zone in Irbid Governorate

Zone	1979 Population (Persons)	Annual Growth Rate (%)	1985 Population (Persons)	Annual Growth Rate (%)	2000 Population (Persons)
Irbid City	112,960	-	141,600	-	216,700
22	4,630	-	9,200	-	22,000
24	4,697	-	6,700	-	35,000
29	5,043	-	6,900	-	14,900
Bishra	3,992	-	5,200	-	23,400
23 Others	3,256	3.7	4,000	3.1	6,300
Total	7,248	-	9,200	-	29,700
25	1,552	3.7	5,200	3.1	3,000
26	4,158	3.7	5,200	3.1	8,200
27	6,560	3.7	8,200	3.1	13,000
Hakama	2,208	-	3,400	-	10,000
28 Others	15,169	3.7	18,900	3.1	29,900
Total	17,377	-	22,300	-	39,800
30	35,790	3.7	44,500	3.1	70,300
31	16,108	3.7	20,000	3.1	31,600
32	10,196	3.7	12,700	3.1	20,100
33	39,106	2.8	46,200	2.3	65,000
34	29,775	2.8	34,100	2.3	49,900
New Town	0	-	0	-	30,000
35 Others	47,980	2.8	56,600	2.3	79,600
Total	47,980	-	56,500	-	109,600
36	73,241	2.8	86,300	2.3	121,400
37	66,835	2.8	78,900	2.3	111,000
38	75,291	2.8	88,000	2.3	125,000
39	53,100	2.8	62,700	2.3	88,200
Irbid Governorate	611,658	3.3	743,000	3.1	1,174,000

Table 3.19 Zone 40 (Jordan Excluding Irbid Governorate)

Year	1979	1985	2000
Population (1,000 Persons)	1,540	1,887	1,3045

Table 3.20 Annual Population Growth Rate in Neighbouring Countries

		Syria	Iraq	Saudi Arabia	Egypt	East Bank
1/ Actual	1950-55	2.4	2.7	1.9	2.3	
	1955-60	2.8	2.9	2.7	2.4	
	1960-65	3.2	3.1	2.4	2.5	
	1965-70	3.2	3.4	2.7	2.3	1.9
	1970-75	3.4	3.4	3.3	2.2	1.9
	1975-79	3.4	3.4	6.1	2.7	1.2
Estimate	1980-85	3.4	3.4	3.4	2.6	1.1
	1985-90	3.3	3.3	3.8	2.5	1.1
	1990-95	3.2	3.3	3.7	2.4	1.0
	1995-2000	3.1	3.2	3.6	2.3	1.0

Note : 1/ Source U N . Population Census

Table 3.21 Forecast Population of Neighbouring Countries (1,000 Persons) (Aveg. Annual Growth Rate)

Zone Year	41 Syria	42 Iraw	43 Saudi Arabia	44 Egypt	45 West Bank
1979	8,506	12,908	9,292	40,993	729
	3.4	3.4	3.8	2.6	1.2
1980	8,795	13,347	9,645	42,059	738
	3.4	3.8	3.8	2.6	1.1
1985	10,395	15,776	11,622	47,818	779
	3.3	3.3	3.8	2.5	1.1
1990	12,227	18,557	14,005	54,102	823
	3.2	3.3	3.7	2.4	1.0
1995	14,312	21,828	16,795	60,913	865
	3.1	3.1	3.6	2.3	1.0
2000	16,671	25,551	20,044	68,248	909

Table 3.22 Work Place of Sector II and Sector III by Zone in Irbid Expanded

Zone	Sector II			Sector III		
	1979 Workers (Persons)	1985 Workers (Persons)	2000 Workers (Persons)	1979 Workers (Persons)	1985 Workers (Persons)	2000 Workers (Persons)
1				1,400	1,570	2,210
2					110	1,300
3	470	810	1,650	2,200	2,830	6,500
4	120	120	330	1,300	1,790	3,510
5	120	120	330	1,200	1,570	3,250
6	120	120	330	1,000	1,470	2,990
7	580	690	1,100	1,800	2,100	3,250
8	350	460	880	400	630	1,300
9	350	460	770	500	730	1,950
10	90	170	400	200	380	2,540
11	1,390	2,410	8,000	120	220	710
12			160		750	5,080
13	260	420	800			710
14			160	130	370	2,540
15		90	410			300
16	90	170	480			500
17	260	770	2,320	340	750	2,540
Total (Irbid City)	4,200	6,820	18,120	10,600	15,270	41,180
22		90	1,760	340	530	1,520
Bishra			160	340	530	1,520
24			800	410	670	2,030
Hakama		90	3,200	340	450	1,020
29			160	270	450	1,020
Total (Irbid Expanded)	4,200	7,000	24,200	12,300	17,900	48,290

CHAPTER 4 FUTURE TRAFFIC DEMAND FORECAST

4.1 General

4.1.1 Introduction

At the present time, Irbid is not only the administrative centre of the northern region, but also serves as the centre for diversified economic activites and education.

Therefore, traffic movement involves various different social and economic structures which should be examined in the process of building a forecasting model.

The basic socio-economic data for forecasting future traffic volumes have already been presented in Chapter 3. All such socio-economic data have been checked and taken into consideration for the census, 5-year development plan and related material.

The bases or assumptions used in the forecasting of traffic demand for the proposed Ring Road include the following:

a. Population was studied by the Study Team and presented in Chapter 3.

b. The study area was divided into 41 traffic zones, which were smaller along the proposed ring road and centre of Irbid. The Irbid City area was divided into 17 traffic zones, which all based upon the zoning of the population census.

   Irbid Region excluding Irbid City areas such as Beit Ras, Bishra, Adiun, Hawara, etc. was divided into 12 traffic zones, or areas external to the study area.

   The other regions, such as Ramtha, Jarash, Amman, the southern part of Jordan and so on, were divided into 7 traffic zones. Neighbouring countries outside Jordan were divided into 5 traffic zones, which were based upon the road network and the traffic flow direction.

c. Target years were set as 1985 and 2000.

4.1.2 Traffic Zones and Sectors

The study area was sub-divided into 17 traffic zones. The area external to it was divided into 24 traffic zones.

Traffic zones which were used in the forecasting of this report are shown in the Chapter 2.

For the purpose of ease in the planning and traffic analysis, the external zones were combined into 5 traffic sectors. The traffic zones included in each traffic sector are shown in Table 4.1.

Table 4.1 Composition of Traffic Sectors

Sector	Zones Included
R1	22, 27, 28, 34
R2	23, 29, 35, 41, 42, 43
R3	24, 30, 36, 37, 40, 44
R4	25, 31, 38
R5	26, 32, 33, 39, 45

4.1.3 Target Years

The target years for forecasting were set as 1985 and 2000.

By the year 1985, it is expected that the construction of the Ring Road will be finished and will be operational. 1985 is also the final year of the present 5-year plan.

Therefore, it is feasible that the Ring Road be taken into consideration for the road network planning in the next 5-year plan.

The year 2000 is considered as the future traffic condition and situation in the more long term. Generally, about 20 years is used to measure of change for traffic conditions in the future.

4.1.4 Classification of Vehicle

In order to make the forecasting of the future traffic demand simple, the kinds of vehicles were aggregated into two groups. One was called "CARS", which consisted of (1) passenger cars, (2) vans and pick-ups (3) buses and (4) taxis.

The other was called "TRUCKS", which consisted of (1) medium trucks, (2) large trucks and (3) other vehicles.

All the forecasting steps, the trip generation/attraction, trip distribution (O-D Table) and the traffic assignment were carried out according to these two categories.

4.2 Forecasting procedure

Forecasting the future traffic demand in Irbid City Area consists of 3 main steps using mathematical estimating models. Models for each step have relationships reflecting the most likely behavioural response to specific conditions of vehicle use.

These relationships were established from the analysis of existing vehicle traffic movement patterns, which were obtained from the surveys carried out in April, 1981 in Irbid. The techniques involved in the traffic demand models have emerged from similar studies of major cities in the world. The main aspect of the model are described in this report.

The basic approach of traffic forecasting by mathematical model in this study is the most typical type of traffic planning technology. The demand for vehicile traffic was determined by the land-use types and potentials. The type of road was chosen according to the relative advantage of using competing road conditions.

The socio-economic indicators which affect the trip generation and attraction have already been presented in Chapter 3.

Efforts were made to study some of the major inputs to estimate traffic demand, such as population, numbers of employees, households and students, but no precise data except population could be obtained. Other statistical data, such as the characteristics of vehicle traffic behaviour or the elements of the traffic movement for estimating purposes, was obtained from the results of the traffic survey in April, 1981 in Irbid.

The procedure used in the traffic forecasting for this report is summarised in the following paragraphs.

(1) Trip Generation

The trip generation demand for each zone was determined by regression models. Such regression models were built from correlated factors.

Generally, trip-ends and socio-economic factors of each zone are examined by multiple correlation using a correlation

coefficient examined in the trial of many kinds of functions using present data of each zone, for example, a linear type, an exponential type and a logarithmic type of function, etc.

Socio-economic factors are usually based on population, industrial products, commercial activity, enterprises, employers, car ownership, income and so on.

However, except for population, it was very difficult to obtain such data, because the data should be divided by zone and furthermore should be able to produce a forecast of future values.

(2) Trip Attraction

The trip attraction in each zone was determined by the urban activities reflecting the potential of each zone.

Since the characteristics of vehicle movement is to return to the place of origin, from the view point of a zone, one vehicle movement has two trips. Hence, trip generation is equal to trip attraction.

Therefore, in this report, trip generation and trip attraction are dealt with as having the same volume and value.

Trip attraction was considered included in the number of generated-attracted trips.

(3) The Total Number of Generated/Attracted Trips

The total number of trip-ends (equal to twice the total number of generated/attracted trips) was separately forecast from generated/attracted trips by zone.

This total number of trip ends was used as a control total for the future forecast O-D Table.

This total number of trip-ends corresponds with the number of the Master Road Plan of Jordan.

(4) Trip Distribution

The future O-D Table was built by trip distribution using the "gravity model". This gravity model incorporated potential factors in each zone and the distance between

origin and destination zones, i and j.

The volume of O-D traffic between i and j zone is proportional to the potential of i and j zone, and inversely proportional to the distance between i and j zone.

In this study, the potential of each zone was assumed as the number of trip-ends by zone.

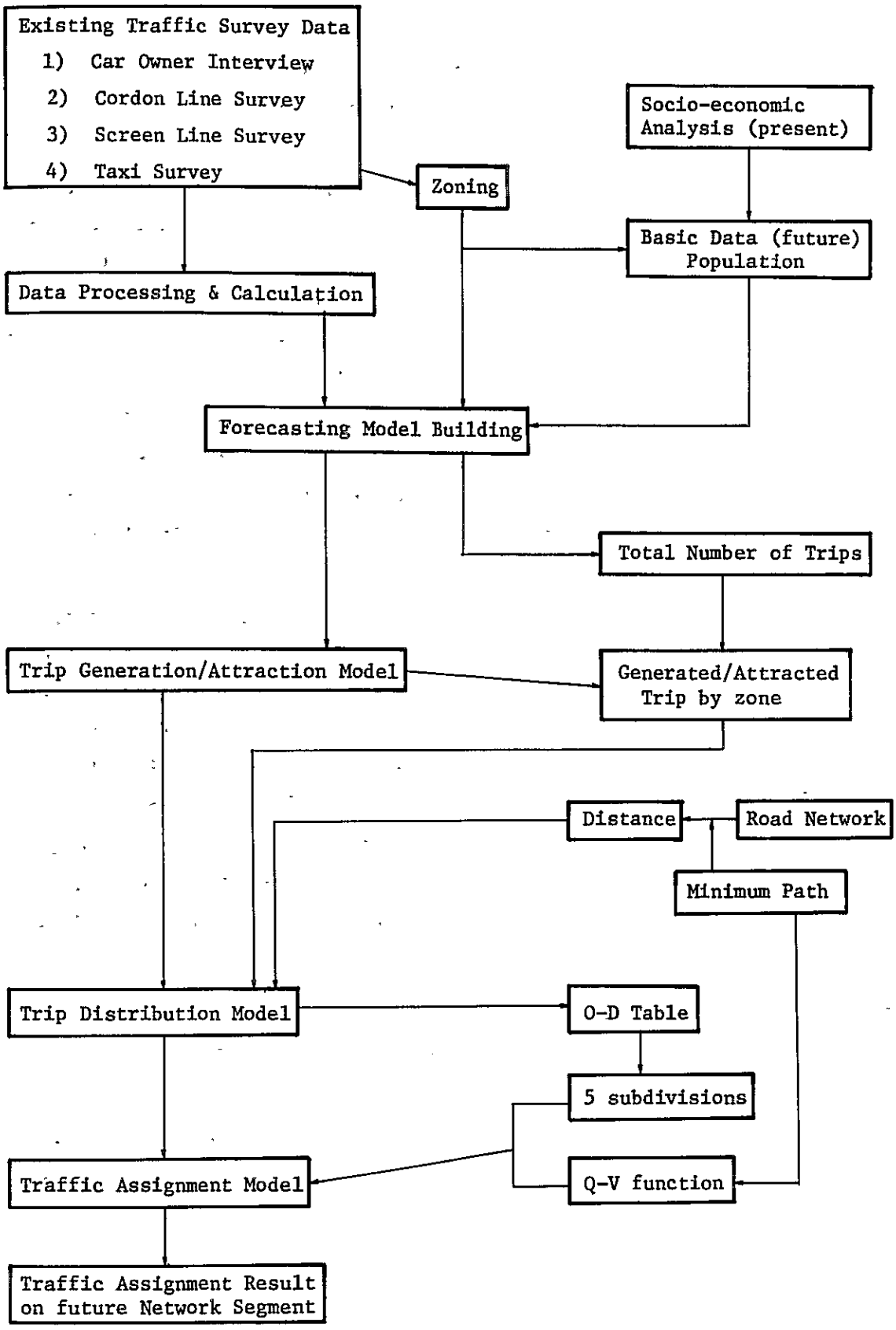
(5) Traffic Assignment

Trips were assigned by network simulation. The minimum time path from the origin of movement to the destination was searched by computer to allocate traffic movements in each network segment. The resulting O-D Table was divided into 5 parts. Traffic assignment was carried out 5 times for each subdivision of the O-D Table.

In every traffic assignment, the travel speed of a vehicle on each network segment was calculated by relation to the traffic volume.

The forecasting procedures is outlined in the following Figure 4.1.

Figure 4.1 Flow Chart of Forecasting Procedure



4.3 Total Traffic Demand

4.3.1 Forecasting Considerations

In this section, the total traffic demand of the whole study area is forecast, in other words, an estimate is made of the total trip-ends of the O-D Table.

The O-D Table consists of intra-city traffic within Irbid and inter-city traffic between Irbid and other cities. Therefore, two different kinds of traffic flow were taken into consideration. Intra-city traffic mainly depends on the growth of city activities inside Irbid. Inter-city traffic is mainly related to the growth of other neighboring cities.

Generally speaking, the process of motorization involves: (1) increase in the rate of vehicle ownership, (2) decrease in the rate of trips per vehicle, (3) increase in the trip length per vehicle. These tendencies have been observed in most developed countries in their progress of motorization.

These three tendencies are considered in forecasting vehicle trips. However, since it is very difficult to estimate each tendency independently owing to the lack of traffic data from the past, the Master Road Plan for the whole country was used. In this report, the number of vehicle-kilometers and trips in the year 2000 were forecast. This Road Master Plan dealt mainly with inter-regional traffic flow.

The estimate of the total number of trip-ends is based on the estimated values of the Master Road Plan for Jordan. The growth rate of external traffic zones to Irbid correspond with the Master Road Plan's estimation.

4.3.2 Forecasting Method

The future total number of trip-ends is usually defined by the following equation:

$$\overline{T.E.} = \left\{ \alpha \left(\frac{\sum_i {}_kTI_i}{\sum_i {}_kMi} \right) \cdot \sum_i {}_k\overline{M}_i \right\} \left\{ \frac{\sum_i ({}_kTI_i + {}_kTO_i)}{\sum_i {}_kTI_i} \right\}$$

T.E. : Total number of trip-ends

TI : Trip-ends of inside Study Area

TO : Trip-ends of outside Study Area

Mi : Car Ownership by i zone

i	:	i zone
K	:	Kind of vehicle
—	:	Future estimated value
α	:	Rate of change for trips per vehicle

In this study the equation was expanded to give more detail. The growth rate of trip-ends was used in forecasting the future total trip-ends that can be produced.

The growth rate of trip-ends was based on the growth of vehicle-kilometers and growth of trip lengths as follows:

$$\text{The growth rate of trip-ends} = \left(\text{Growth of Vehicle-kilometers}\right) \Big/ \left(\text{Growth of trip-lengths}\right)$$

$$= \frac{\text{Vehicle-kilometers in 2000}}{\text{Vehicle-kilometers in 1981}} \Big/ \frac{\text{trip lengths in 2000}}{\text{trip lengths in 1981}}$$

The growth of vehicle-kilometers was based on several factors as follows:

$$\text{Growth rate of Vehicle-Kilometers} = \frac{\text{No. of registered Veh. (2000)}}{\text{No. of registered Veh. (1981)}} \cdot \frac{\text{No. of trips per Veh. (2000)}}{\text{No. of trips per veh.(1981)}} \cdot \frac{\text{Trip-length per Veh.(2000)}}{\text{Trip-length per Veh.(1981)}}$$

Thus, the growth of trip-ends was obtained by the growth rate of vehicle-kilometers divided by the growth of trip-lengths.

Since the O-D Table consists of intra- and inter-city trips, it is necessary to refer to the growth of these different traffic flows, the growth of potential in Irbid and other outside cities, respectively.

The growth of total No. of trip-ends was forecast using the following equation:

$$GRT = \left(\text{Growth of Vehicle-kilometers}\right) \Big/ \left(\text{Growth of Trip-Lengths}\right)$$

$$= \left(\frac{VF}{VP} \times \frac{TVF}{TVP} \times \frac{TLF}{TLP}\right) \Big/ \left(\frac{TLF}{TLP}\right)$$

$$= S1\left(\frac{CVF}{CVP} \times \frac{TVF1}{TVP1}\right) + S2\left(\frac{IVF}{IVP} \times \frac{TVF2}{TVP2}\right) \quad (4)$$

Where	GRT	:	Growth rate of total trip-ends
	VF	:	Number of Registered Veh. in the future

VP : Number of Registered Veh. at present

TVF : Trip per veh. (future)

TVP : Trip per veh. (present)

TLF : Trip length per veh. (future)

TLP : Trip length per veh. (present)

S1 : Rate of inter-regional traffic

S2 : Rate of intra-regional traffic

CVF : No. of Registered Veh. in whole country (future)

CVP : No. of Registered Veh. in whole country (present)

TVFI : No. of inter-regional trip per veh. (future)

TVPI : No. of inter-regional trip per veh. (present)

IVF : No. of Registered Veh. in Irbid (future)

IVP : No. of Registered Veh. in Irbid (present)

TVF2 : No. of intra-city trip in Irbid per veh. (future)

TVP2 : No. of intra-city trip in Irbid per veh. (present)

The future inter-regional traffic over the whole country was forecast in the Master Road Plan Report (1978-82) by Wilbur Smith and Associates.

In this Master Road Plan, the vehicle-kilometers, average trip lengh and number of trips per passenger car were presented as in Table 4.2.

This data indicates that the total vehicle-kilometers of inter-regional traffic in the whole country will grow 1.644 times from 1982 to 2000. Especially private passenger cars will grow about 2.1 times in this period. Light and heavy trucks will grow about 1.5 times.

TLF : Average Trip Length of inter-regional traffic in the whole country will increase only about 0.6%.
The number of private passenger cars will decrease about 0.1%. Heavy trucks will increase about 17% of their 1982 trip-length.

TVF : Number of trips per passenger car will dramatically decrease to 40% of their 1982 level.

Table 4.2 The Estimated Trip Values in Master Road Plan

Vehicle-kilometers (x 1000)	1982	2000	2000/1982
Private passenger cars	1557.2	3255.1	2.090
Bus/Taxi	1249.2	1575.2	1.261
Light Trucks	638.6	934.5	1.465
Heavy Trucks	1472.7	2319.4	1.575
Total	4917.7	8084.2	1.644
Average Trip Length (Km)			
Private Passenger Cars	27.17	27.15	0.999
Bus/Taxi	30.93	31.77	1.027
Light Trucks	35.19	37.01	1.052
Heavy Trucks	76.35	89.13	1.167
Total	36.39	36.82	1.006
No. of Trips Per Day			
Private Passenger Cars	57,305	119,881	2.092
Bus/Taxi	40,384	49,582	1.228
Light Trucks	18,146	25,253	1.392
Heavy Trucks	19,288	26,023	1.349
Total	135,123	220,739	1.634
No. of Trips per Passenger Car	0.783	0.309	0.395

Source: Master Road Plan

Those estimated trip values of the Master Road Plan were for inter-regional trips. However, with regard to intra-city traffic, it can be said that the activities of the city will grow more complicated corresponding to the urbanization.

At the same time, the movement of vehicles will increase as a whole, but the increase in registered cars will exceed this.

Therefore, the number of trips per car in the city will also decrease to a certain extent. However, it will be a smaller decrease than the decrease of inter-regional traffic.

The number of trips per passenger car in 1981 is given in Table 4.3. The decrease of trips/passenger car from 1981 to 2000 for the inter-regional traffic was 0.33 in the Master Road Plan.

Table 4.3 Decrease of Trips Per Car

Private Passenger Car	1976	2000	2000/1976	Annual Growth Rate (%)
Trips/day	38,014	119,881	3.15	4.9
No. of registered Cars	29,478	387,753	13.15	11.3
Trips per Car	1.29	0.31	0.24	
	1981	2000	2000/1981	
Trips/day	48,280	119,881	2.48	
No. of registered Cars	50,350	387,753	7.70	
Trips per Car	0.95	0.31	0.33	

Source: Master Road Plan (1978 - 1982)

Table 4.4 The Composition of Intra- and Inter-Regional Traffic

		1976	1985	2000
Passenger Cars	Inter	32	32	31
	Intra	68	68	69
Trucks	Inter	41	37	37
	Intra	59	63	63
Total Vehicles	Inter	35	33	33
	Intra	65	67	67

Source: Integrated Regional Development Study of Northern Jordan (Final Report, Volume 6, part 111)

This study assumed that the decrease of trips/one passenger car for the inter-regional traffic will be 0.4 from 1981 to 2000, and also intra-regional traffic will be 0.8.

S1, S2 : The rate of inter/intra city traffic was taken from "The Integrated Regional Development Study of Northern Jordan". It is shown in Table 4.4 and assumed to be a 30% share of the total inter-regional (city) traffic. Thus the share of intra-city traffic was about 70% of all traffic (S1 = 0.3, S2 = 0.7).

CVF : The total number of vehicles in Jordan was estimated in Chapter 3 as follows:

Table 4.5 Future Number of Vehicles

Year	East Bank (1000)	Irbid Governorate (1000)
1975	44.2	2.7
1980	126.1	14.4
1981	150.0	17.8
1985	195.0	22.8
1990	296.1	35.3
1995	446.6	54.4
2000	633.7	78.9

Source : Study Team

The estimated number covers all types of vehicles. It was assumed that the split by kind of vehicle could be made using the share of each kind of vehicle in the Master Road Plan.

Table 4.6 Future Number of Vehicles (thousands)

Year	East Bank		Irbid Governorate	
	Car	Truck	Car	Truck
1981	105.0	45.0	12.5	5.3
1985	136.6	53.5	16.0	6.8
2000	473.5	158.4	59.2	19.7

Source : Study Team

GRT : The growth rate in the total number of trip-ends was forecast using the above mentioned equation (4). The result of the forecasting were as follows:

Table 4.7 Growth of Total Trip-Ends

	1985/1981	2000/1981
Car	1,300	3,196
Truck	1,280	2,504

4.3.3 Number of Trips to Irbid Industrial Estate

As one of the main projects in Irbid, the Irbid Industrial Estate was planned and identified by "The Integrated Regional Development Study of the Northern Region".

This Irbid Industrial Estate (IIE) Project will be implemented in accordance with the recommendations of the report on "Feasibility Study of Irbid Industrial Estate" which recommended that the site location of the industrial estate be the adjacent area in the east of the existing municipal industrial area. The Boundary and Outer Ring Roads have a close relationship to this project. The IIE Project should be fully supported by the road network. Furthermore, in this study, the traffic forecasting should take the traffic of the IIE into consideration.

It was estimated that the daily traffic volume of the IIE will be about 1,910 vehicles/day as shown below.

Table 4.8 Estimated Daily Traffic Volume of IIE

Activities	Kind of Vehicle	Vehicle Volume	Passenger Volume (%)
Produce	Truck/5 ton	480	480 (8)
Business	Passenger Car	280	280 (5)
Administrative	Passenger Car	200	200 (4)
Commuting	Passenger Car	750	750 (13)
"	Bus	200	4,000 (70)
Total		1,910	5,710(100)

Source: "Feasibility Study of IIE"

As shown in Table 4.8 it was assumed that about 70% workers would use the bus (20 persons/bus).

It will be a reasonable assumption to use buses for the workers of the IIE. However, in order to make a traffic assignment, it is better to convert to passenger car units (PCU). This can also be said about trucks.

Thus, the number of buses was converted to PCU as shown in Table 4.9. In the procedure of making an O-D Table, it was actually only made for buses.

Table 4.9 Traffic Volume in PCU

Passenger Car	1230 (PCU)	(80%)
Bus	300	(20%)
Total Passenger Cars Units	1530	(100%)

Note: PCU for bus is 1.5.

The main use for passenger car use was assumed to be commuting (about 60% of the total). This trip pattern is dependent upon the distribution of population.

On the other hand, the business and administrative use of passenger car is dependent upon city activities. Those trip patterns can be assumed to correspond to the pattern of passenger car movements.

The O-D Table of trucks was based on the activities of production of IIE such as the transport of raw materials and products.

Since such traffic movements are not reported in detail, it was supposed that the number of trip-ends of those truck movements would be distributed in proportion to the number of trips generated/attracted.

4.4 Trip Generation/Attraction

4.4.1 General

Trip generation models have been established using the socio-economic data related to trip generation. There are many factors which influence the potential in each zone that generate the trips.

Trip attractions are also related to land use, economic and social activities of the urban area.

The forecasting model was based on generated and attracted trips in each zone.

4.4.2 Model Formulation

Although there are many factors which could be considered in trip generation/attraction, only exact data by zone for population was known and therefore only population was used in the analysis.

Based on the relationship between the number of trip-ends by zone and population by zone, the forecasting equation could be one of the following types:

$$\text{Type - 1 :} \quad Ti = \alpha x_i + \beta$$

$$\text{Type - 2 :} \quad Ti = \alpha x_i^{\beta}$$

$$\text{Type - 3 :} \quad Ti = e^{\alpha x_i + \beta}$$

$$\text{Type - 4 :} \quad Ti = \alpha e^{\beta x_i^2 + \gamma x_i}$$

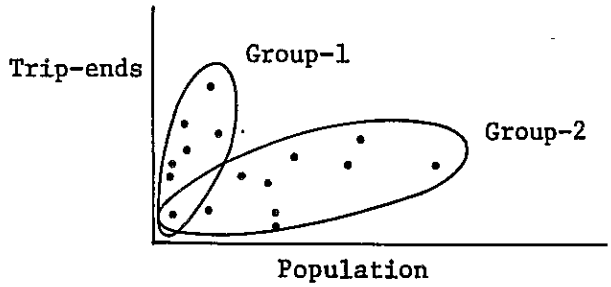
Ti : Trip-end in i zone
Xi : Population in i zone
$\alpha.\beta.\gamma$: Parameters

The equation which had the best correlation was chosen for each zone separately as discussed in the subsequent paragraphs.

In all equations, the relation between the number of trip-ends and population by zone was scattered and thus the multiple correlation coefficient was too low to be used. Therefore, dividing the zones into two groups was considered as shown in Figure 4.2. Generally speaking, it is better to deal with the data as a whole, because no study was made regarding the reasons why each zone was distributed as shown. Nevertheless, it was assumed that whatever the reasons, the future situation would also reflect them.

Furthermore there will be no structural change on each zone in Irbid except the zone of IIE where a future development plan existed. The centre of the Irbid City will also fulfill its function equally in the future. Thus the tr p generation/attraction model was applied to the divided two groups.

Figure 4.2 ZONES divided into two groups



The results of regression calculation are shown in Tables 4.10 and 4.11. The types of regression equations were referred to in the above paragraph. The cases considered were divided by the independent variables as follows:

CASE-1 : The independent variables were distributed by population. The data of trip-end and population by zone was used for all zones.

CASE-2 : The independent variables were distributed by population. The data of trip-end and population was divided into two groups. This case concerns Group-1 shown in Figure 4.2 and consists of zones 1, 4, 5, 11, 12, 13, 14 and 15.

CASE-3 : The independent variables were distributed by population. The data of trip-end and population were based on Group-2 zones which included zones 2, 3, 6, 7, 8, 9, 10, 11, 15, 16 and 17.

CASE-4 : The independent variable were distibuted by the data on population and (commercial + industrial area)/urban area in each zone.
This case used the data for all zones.

CASE-5 : The independent variables were distributed by the data on population and employee by zone.
This case also used the data for all zones.

Table 4.10 Results of Regression Analysis (Cars)

Type 1/	Parameters α	Parameters β	Parameters γ	Correlation Coefficient
CASE-1 $Ti=e^{\alpha x_i+\beta}$	0.000026	7.7326	-	0.2075
CASE-2 1. $Ti=\alpha x_i+\beta$	2.8995	-1429.31	-	0.9130
2. $Ti=\alpha x_i^{\beta}$	1.7466	5.0351	-	0.8898
3. $Ti=e^{\alpha x_i+\beta}$	0.00115	5.7722	-	0.8827
4. $Ti=\alpha e^{\beta x_i^2+\gamma x_i}$	4.8789	0.3401 E-6	0.00240	0.9046
CASE-3 1. $Ti=\alpha x_i+\beta$	0.13254	1479.84	-	0.5544
2. $Ti=\alpha x_i^{\beta}$	0.53602	3.0320	-	0.8078
3. $Ti=e^{\alpha x_i+\beta}$	0.000073	7.0087	-	0.6364
4. $Ti=\alpha e^{\beta x_i^2+\gamma x_i}$	6.4903	0.6572 E-8	0.000222	0.8048
CASE-4 2/ $Ti=\alpha x_i+\beta N_i+\gamma$	0.05430	8350.88	1530.51	0.6865
CASE-5 2/ $Ti=\alpha x_i+\beta M_i+\gamma$	0.01138	1.38321	2334.33	0.5620

Notes: 1/ CASE-1 All zones

CASE-2 ZONES 1,4,5,11,12,13,14 and 15

CASE-3 ZONES 2,3,6,7,8,9,10,12,13,15,16 and 17

CASE-4 All zones

CASE-5 All zones

2/ CASE 4 Xi = Population, $Ni = \frac{\text{(Commercial+Industrial area)}}{\text{Urban Area}}$

CASE-5 Xi = Population, Mi = Employees

Table 4.11 Results of Regression Analysis (Trucks)

Type [1]	Parameters			Correlation Coefficient
	α	β	γ	
CASE-1 $Ti=e^{\alpha x_i+\beta}$	0.0000579	4.8948	-	0.3553
CASE 2				
1. $Ti=\alpha x_i+\beta$	0.23142	129.6	-	0.7808
2. $Ti=\alpha x_i^{\beta}$	9.9068	2.0265	-	0.7904
3. $Ti=e^{\alpha x_i+\beta}$	0.00136	2.5955	-	0.7962
4. $Ti=\alpha e^{\beta x_i^2+\gamma x_i}$	1.71113	0.3466 E-6	0.00259	0.8102
CASE-3				
1. $Ti=\alpha x_i+\beta$	1.59687	81.914	-	0.7326
2. $Ti=\alpha x_i^{\beta}$	1.69309	0.7796	-	0.8491
3. $Ti=e^{\alpha x_i+\beta}$	0.000113	4.0336	-	0.7130
4. $Ti=\alpha e^{\beta x_i^2+\gamma x_i}$	3.43515	0.7704 E-8	0.000288	0.8261
CASE-4 [2] $Ti=\alpha x_i+\beta N_i+\gamma$	0.00905	611.983	103.964	0.5885
CASE-5 [2] $Ti=\alpha x_i+\beta M_i+\gamma$	0.00505	0.05199	200.49	0.3091

Notes: [1] CASE-1 All zones

CASE-2 ZONES 1,4,5,11,12,13,14 and 15

CASE-3 ZONES 2,3,6,7,8,9,10,12,13,15,16 and 17

CASE-4 All zones

CASE-5 All zones

[2] CASE-4 Xi = Population, $Ni = \frac{\text{(Commercial+Industrial Area)}}{\text{Urban Area}}$

CASE-5 Xi = Population, Mi = Employees

4.4.3 Forecasting Model

After detailed examination of the results of regression, it was decided to use the following models for future forecasting.

Table 4.12 Forecasting Model

Cars

Group-1 (ZONES 1, 4, 5 and 14)

$Ti = 2.89954\ Xi - 1429.31$

Where Xi : Population by i zone

Multiple corr. coefficient	:	0.9130
Coefficient of Determination	:	0.8336
Standard Error of Regression	:	1.29651
F value	:	30.056
T value	:	2.2364
Durbin - Watson Ratio	:	2.058

Group-2 (ZONES 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16 and 17)

$Ti = 0.53602\ Xi^{3.0230}$

Where Xi : Population by i zone

Multiple corr. coefficient	:	0.8078
Coefficient of Determination	:	0.6526
Standard Error of Regression	:	0.2098
F value	:	18.783
T value	:	2.5545
Durbin - Watson Ratio	:	0.795

Table 4.12 (Continued)

Trucks

Group-1 (ZONES 1, 4, 5, 11 and 14)

$Ti = 0.23142\ Xi - 129.608$

Where Xi : Population by i zone

Multiple corr. coefficient	:	0.7808
Coefficient of Determination	:	0.6097
Standard Error of Regression	:	0.1210
F value	:	9.372
T value	:	1.9126
Durbin - Watson Ratio	:	2.186

Group-2 (ZONES 2, 3, 6, 7, 8, 9, 10, 12, 13, 15, 16 and 17)

$Ti = 1.6930\ Xi^{0.77963}$

Where Xi : Population by i zone

Multiple corr. coefficient	:	0.8491
Coefficient of Determination	:	0.7209
Standard Error of Regression	:	0.29037
F value	:	25.851
T value	:	2.68498
Durbin - Watson Ratio	:	1.380

These models were mainly used to obtain the future volume of vehicle movement in each zone, such as generating/attracting trip-ends. The forecasted volume of a few zones were adjusted by other forecasting models, because the forecast volumes were too large or too small from other viewpoints such as land use of socio economic development.

Those forecasted volumes were amended mainly in the model using the factor of land-use as in Case-4.

4.4.4 Future Trip End by Zone

The finally forecast values for the trip-ends for each zone are shown in the Table 4.13 and 4.14. These forecast values have already been adjusted by the control total which was obtained in 4.3.

The results also contain the traffic volume ralating to the Irbid Industrial Estate (IIE).

Table 4.13 Forecast Trip-ends in 1985 and 2000

	1985		2000	
ZONE	CARS	TRUCKS	CARS	TRUCKS
1	7696	635	12065	620
2	3517	575	5727	598
3	5718	374	11995	1376
4	9676	372	22845	574
5	6016	360	18093	581
6	1930	125	2834	139
7	5975	358	9968	596
8	4570	362	9237	523
9	4563	385	9225	539
10	3420	316	10165	456
11	5928	738	11681	1727
12	1460	84	7352	1411
13	1388	75	6677	483
14	5111	590	33752	2939
15	1189	62	2822	141
16	4144	380	6079	421
17	4017	364	14567	769
22	2101	309	4727	518
23	1139	153	2563	257
24	3158	212	7106	356
25	98	33	218	55
26	627	270	1411	454
27	596	127	1341	214
28	3519	478	7918	903
29	2453	294	5520	493
30	5168	1664	11634	2793
31	731	111	1646	187
32	338	53	759	90
33	1507	206	3409	346
34	2575	410	5796	690
35	2724	373	6576	671
36	2141	329	5166	590
37	719	139	1532	233
38	2770	503	5907	843
39	1201	200	3047	335
40	3406	739	7320	1185
41	65	111	144	180
42	18	27	38	41
43	11	9	20	11
44	1	7	3	8
45	6	2	10	2
Total	113,390	12,914	283,734	26,193

Table 4.14 Growth Rate of Trip Ends

ZONE	1985/1981		2000/1981		2000/1985	
	CAR	TRUCK	CAR	TRUCK	CAR	TRUCK
1	1.153	1.000	1.808	0.976	1.568	0.976
2	1.157	1.359	1.885	1.414	1.628	1.040
3	1.159	1.090	2.432	4.012	2.098	3.679
4	1.473	1.617	3.477	2.496	2.361	1.543
5	1.071	1.513	3.222	2.441	3.007	1.614
6	1.024	1.042	1.504	1.158	1.468	1.112
7	1.556	1.764	2.595	2.936	1.668	1.665
8	0.998	1.058	2.017	1.529	2.021	1.445
9	0.974	1.013	1.969	1.418	2.022	1.400
10	1.046	0.829	3.110	1.197	2.972	1.433
11	1.560	1.304	3.074	3.051	1.970	2.340
12	1.653	1.235	8.326	20.750	5.036	16.798
13	2.874	4.688	13.824	30.188	4.811	6.440
14	1.022	1.242	6.752	6.187	6.604	4.981
15	1.536	2.385	3.646	5.423	2.373	2.274
16	2.772	1.939	4.066	2.148	1.467	1.108
17	2.978	3.434	10.798	7.255	3.626	2.113
22	1.293	1.266	2.909	2.123	2.250	1.676
23	1.293	1.264	2.909	2.124	2.250	1.680
24	1.348	1.262	3.033	2.119	2.250	1.679
25	1.307	1.269	2.970	2.115	2.224	1.667
26	1.293	1.262	2.909	2.121	2.250	1.681
27	1.293	1.257	2.909	2.119	2.250	1.685
28	1.293	1.265	2.909	2.389	2.250	1.889
29	1.292	1.262	2.908	2.124	2.250	1.684
30	1.292	1.264	2.909	2.122	2.251	1.678
31	1.292	1.261	2.908	2.125	2.252	1.685
32	1.295	1.262	2.908	2.143	2.246	1.698
33	1.301	1.280	2.944	2.149	2.262	1.680
34	1.293	1.262	2.910	2.123	2.251	1.683
35	1.327	1.300	3.203	2.338	2.414	1,799
36	1.327	1.300	3.203	2.332	2.413	1.793
37	1.367	1.264	2.913	2.118	2.131	1.676
38	1.366	1.267	2.913	2.123	2.132	1.676
39	1.366	1.266	3.466	2.120	2.537	1.675
40	1.277	1.248	2.744	2.002	2.149	1.604
41	1.275	1.261	2.824	2.045	2.215	1.622
42	1.200	1.227	2.533	1.864	2.111	1.519
43	1.222	1.286	2.222	1.571	1.818	1.222
44	1.000	1.400	3.000	1.600	3.000	1.143
45	1.200	1.000	2.000	1.000	1.667	1.000

4.5 Trip Distribution

4.5.1 General

In this section the future spatial linking pattern of trip generation (origin) with trip attraction (destination) for vehicle movements is determined.

Normally, the gravity-type model or the opportunity-type model will be used for forecasting purposes.

For determining the trip distribution pattern, the gravity-type model is generally the most practical method. Hence, the trip distribution model for conducting the inter-zonal trip flow pattern adopts the gravity-type model here.

The general flow chart of this procedure is shown in Figure 4.3.

4.5.2 Gravity Model

The fundamental Gravity Model equation is as follows:

$$Tij = K \frac{GTi \cdot ATj}{Dij^{\alpha}} \qquad (5)$$

Tij : Trip from i zone to j zone
GTi : The number of trip generation in i zone
ATj : The number of trip attraction in j zone
Dij : Distance between i and j zone
K, α : Constant and parameter

In this equation the trips from i zone to j zone is either proportional to the number of trip generation/attraction in i and j zone or inversely proportional to the distance between i and j zones.

The number of trips increase proportionally with the decrease in trip length since they are a function of distance. At the same time, number of trips is weighted to the volume of trip-ends by the potentials of zones i and j.

This model consists of the following two effects:

(1) The potential of each zone induces the volume of the trips from i zone to j zone.

(2) Distance function produces the trip distribution pattern.

In this study, the gravity model for trip distribution is based on the following equation:

$$Tij = \frac{k \cdot GTi^{\beta} \cdot ATj^{\gamma}}{Dij^{\alpha}} \qquad (6)$$

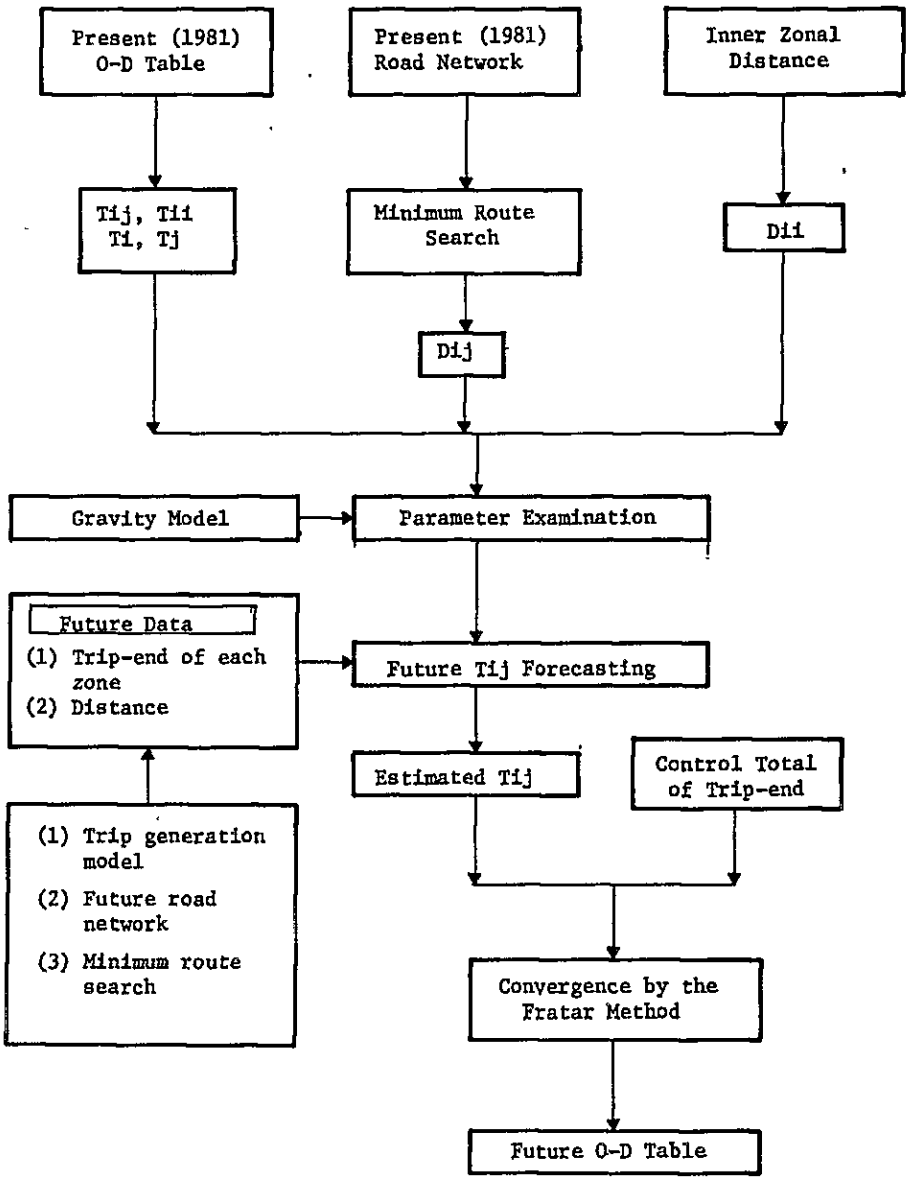
Tij : Trip from i zone to j zone
GTi : The number of trips generated in i zone
ATi : The number of trips attracted in j zone
Dij : Distance between i and j zone
$\kappa, \alpha, \beta, \gamma$: Parameters

It is necessary to calculate the parameters using the existing O-D Table in order to forecast the future values. In this procedure, the least squares method is used for the estimation of the

parameter. The distance between i and j zone is calculated by minimum route search on the present road network for the sake of compiling data as input to the least squares method.

At the same time, the distance of internal movements in i zone is calculated based on the assumption that each zone is a circle of the same size.

Fig. 4.3 Trip Distribution Procedure



The results of the parameter estimation by the least square method are as follows:

Table 4.15 Parameters of the Gravity Model

Equation : $Tij = \frac{k \cdot GT^{\beta} \cdot Ati^{\gamma}}{Dij^{\alpha}}$

where

	Cars	Trucks
α :	0.83971	0.01357
β :	0.86615	0.52660
γ :	0.71688	0.52752
k :	0.0002595	0.2451
Multiple Correlation Coefficient :	0.7942	0.5819
Coefficient of Determination:	0.6308	0.3386

When the gravity model estimated the number of inter-zonal trips, the sum of the estimated trips by zone (trip-end) was unequal to the estimated number of trip generation/attraction in each zone, also the total for the sum of trips by zone was unequal to the control total, which was forecast in Section 4.3.

Therefore, the sum of the estimated trips by the gravity model should be adjusted so that it equals to the already given number of trip-ends and control total.

The Fratar method was adopted in such cases. The Fratar method adjusts the estimated number by the gravity model to the trip-end on each zone and the control total by iteratively repeating the calculation until it equals the control total.

The first adjustment:

$$\widehat{Tij}^{(1)} = tij \cdot \frac{Ti^* \cdot Tj^* \cdot \sum_{j=1}^{n} Tij}{Ti. \cdot Tij \cdot \sum_{j=1}^{n} \left(\frac{Tj^*}{T.j} \right) Tij}$$

$$Ti. = \sum_{j=1}^{n} Tij$$

$$T.j = \sum_{i=1}^{n} Tij$$

Notes: Ti* : Control total of i zone

Tj* : Control total of j zone

Tij : Estimated trips by Gravity Model

The m^{th} adjustment:

$$\widehat{Tij}^{(m)} = \widehat{Tij}^{(m-1)} \cdot \frac{Ti^*}{\widehat{Ti.}^{(m-1)}} \cdot \frac{Tj^*}{T.j^{(m-1)}} \cdot \frac{\sum_{j=1}^{n} \widehat{Tij}^{(m-1)}}{\sum_{j=1}^{n} \left(\frac{Ti^*}{\widehat{T.j}^{(m-1)}}\right) \widehat{Tij}^{(m-1)}}$$

$$\widehat{Ti.}^{(m-1)} = \sum_{j=1}^{n} \widehat{Tij}^{(m-1)}$$

$$\widehat{T.j}^{(m-1)} = \sum_{i=1}^{n} \widehat{Tij}^{(m-1)}$$

The calculation is stopped when the adjustment obtains the following results:

$$\sum_{j=1}^{n} \widehat{Tij}^{(n)} \fallingdotseq Ti^*$$

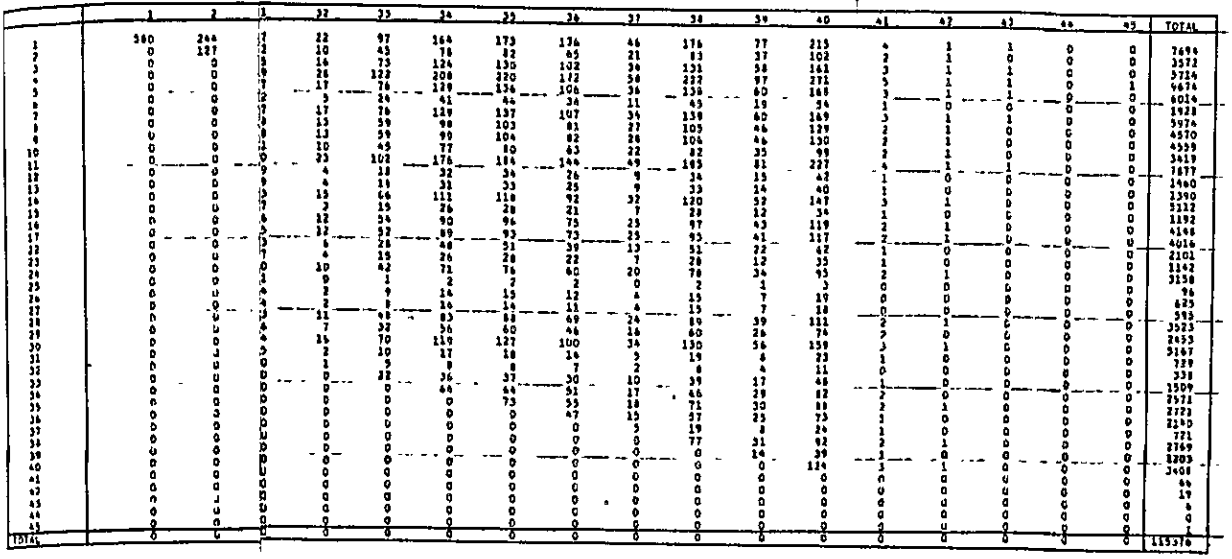
$$\sum_{i=1}^{n} \widehat{Tij}^{(n)} \fallingdotseq Tj^*$$

4.5.3 The Future O-D Table

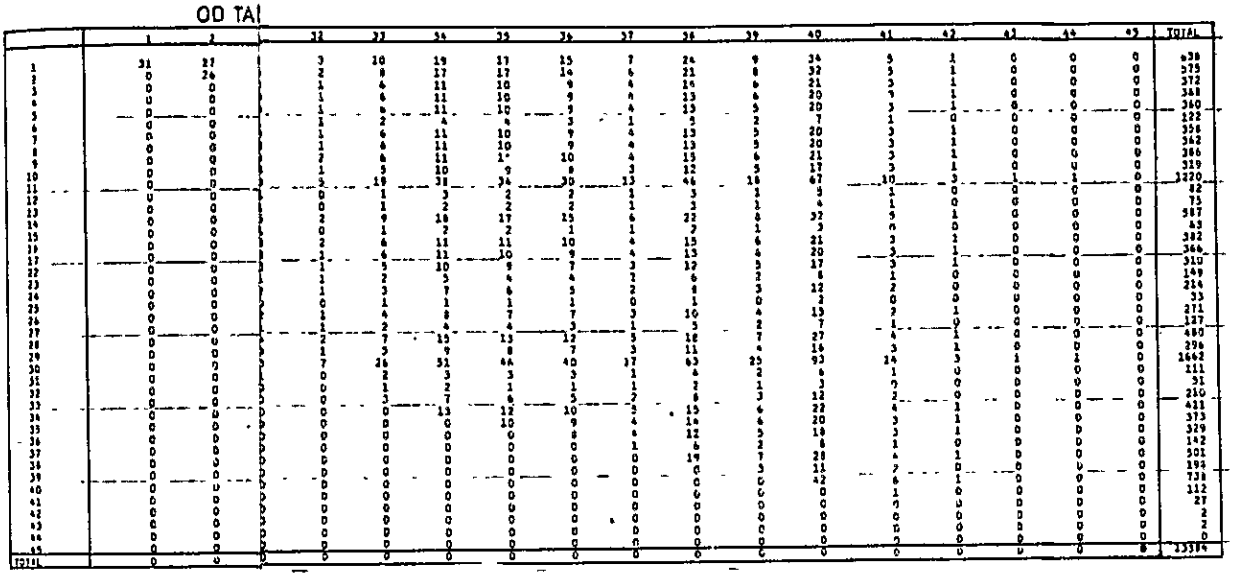
After these procedures, shown in 4.5, the future forecast Origin and Destination tables were constructed as follows:

Table 4

OD TAB



OD TAI



OD TAB

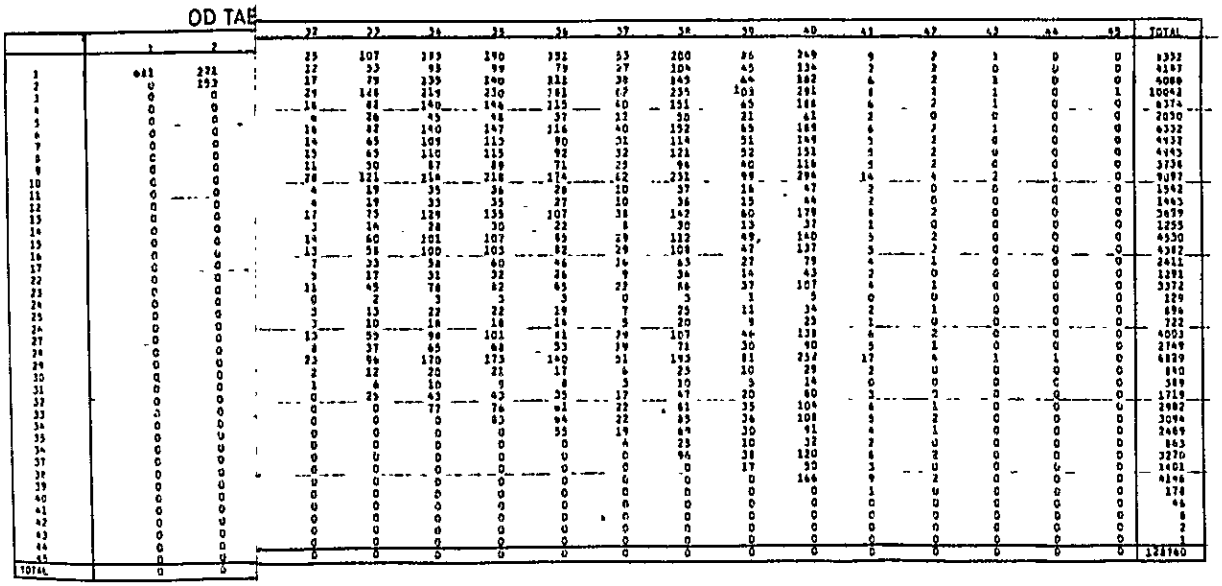
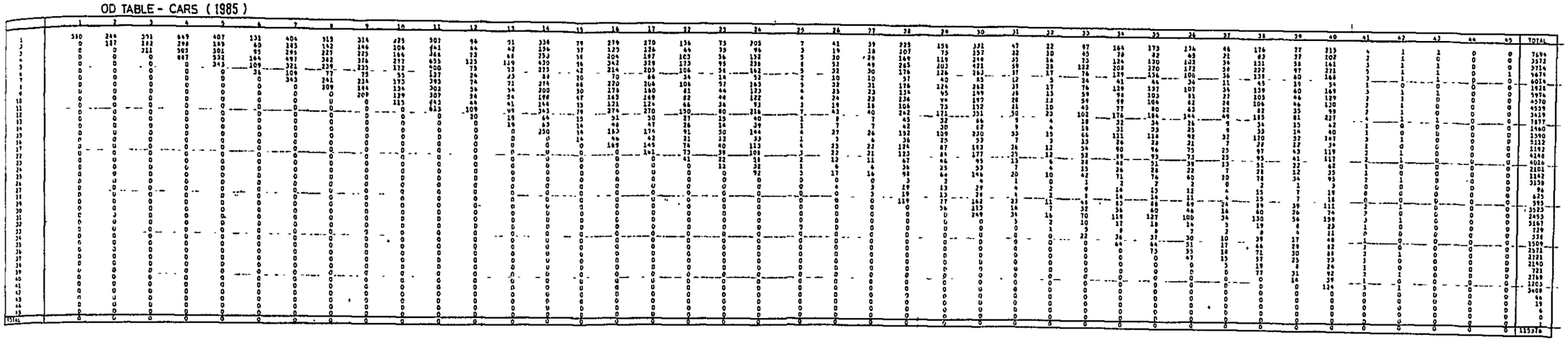
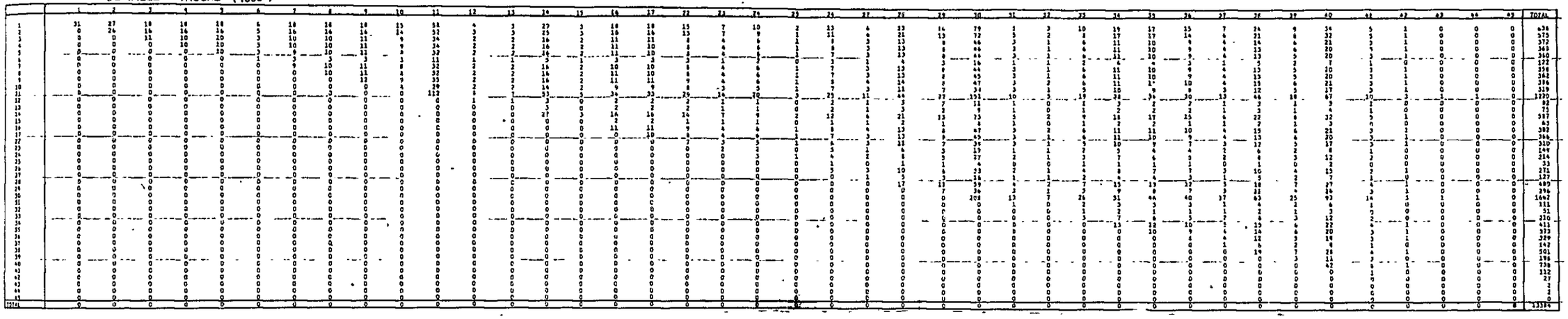


Table 4.16

OD TABLE - CARS (1985)



OD TABLE - TRUCKS (1985)



OD TABLE - TOTAL (1985)

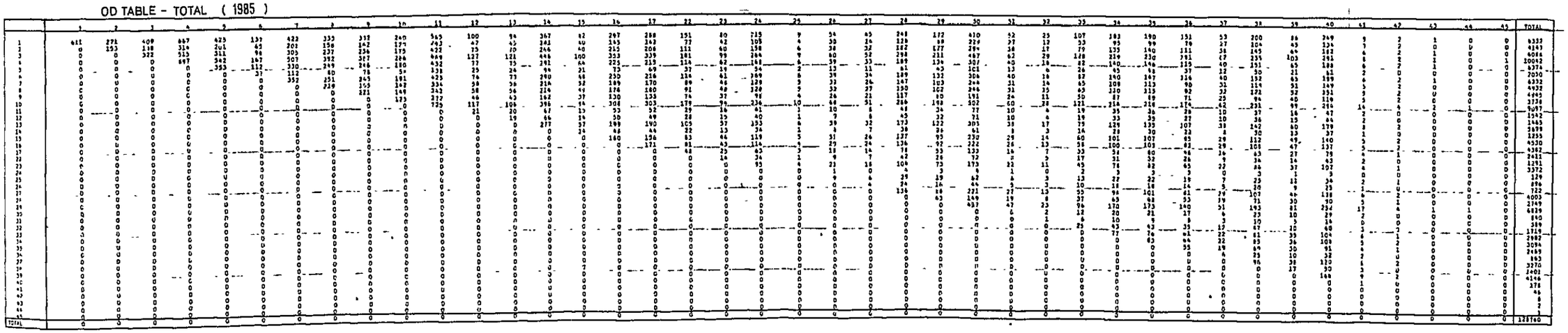
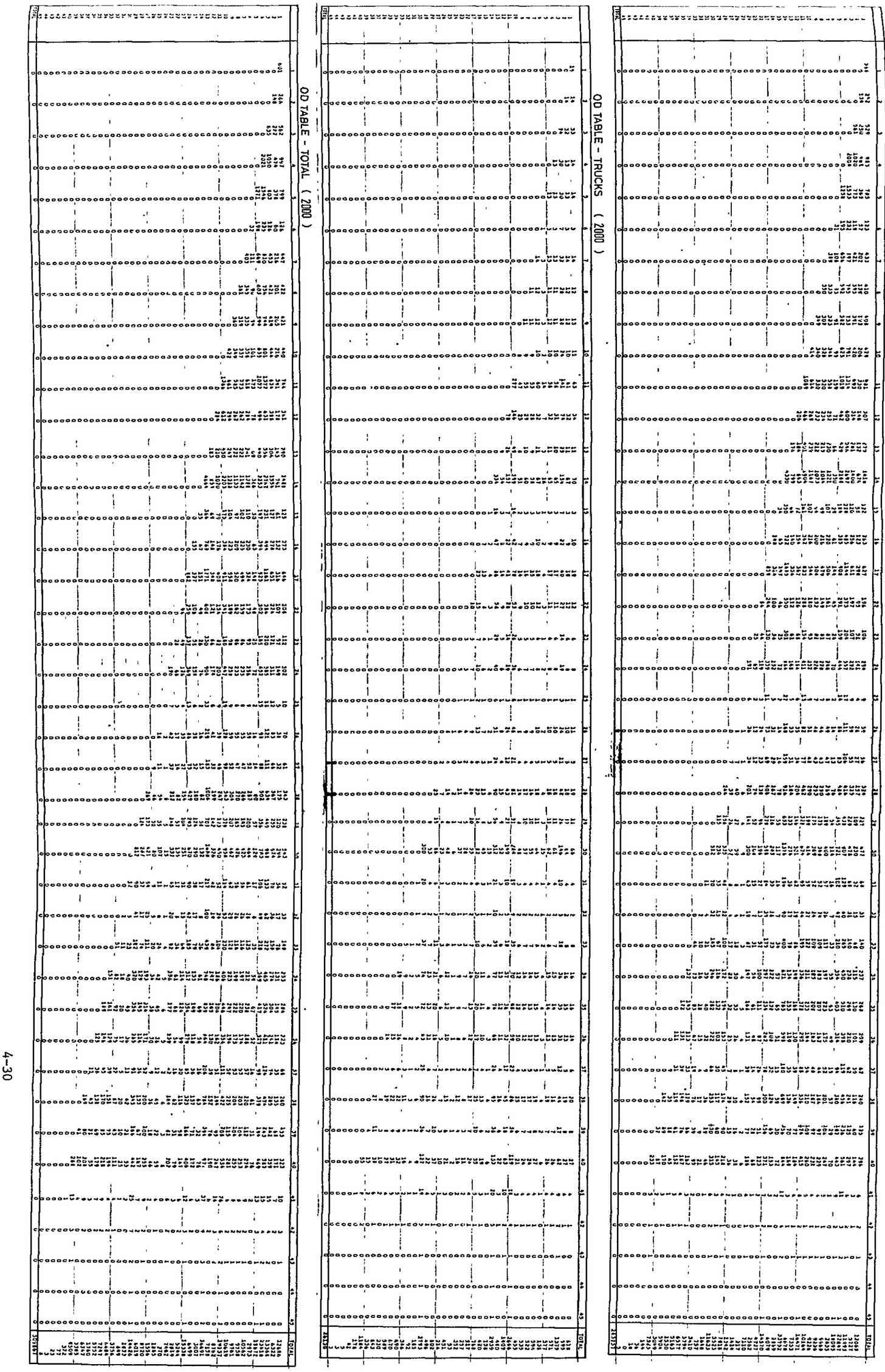


Table 4.17

OD TABLE - CARS (2000)



OD TABLE - TRUCKS (2000)

OD TABLE - TOTAL (2000)

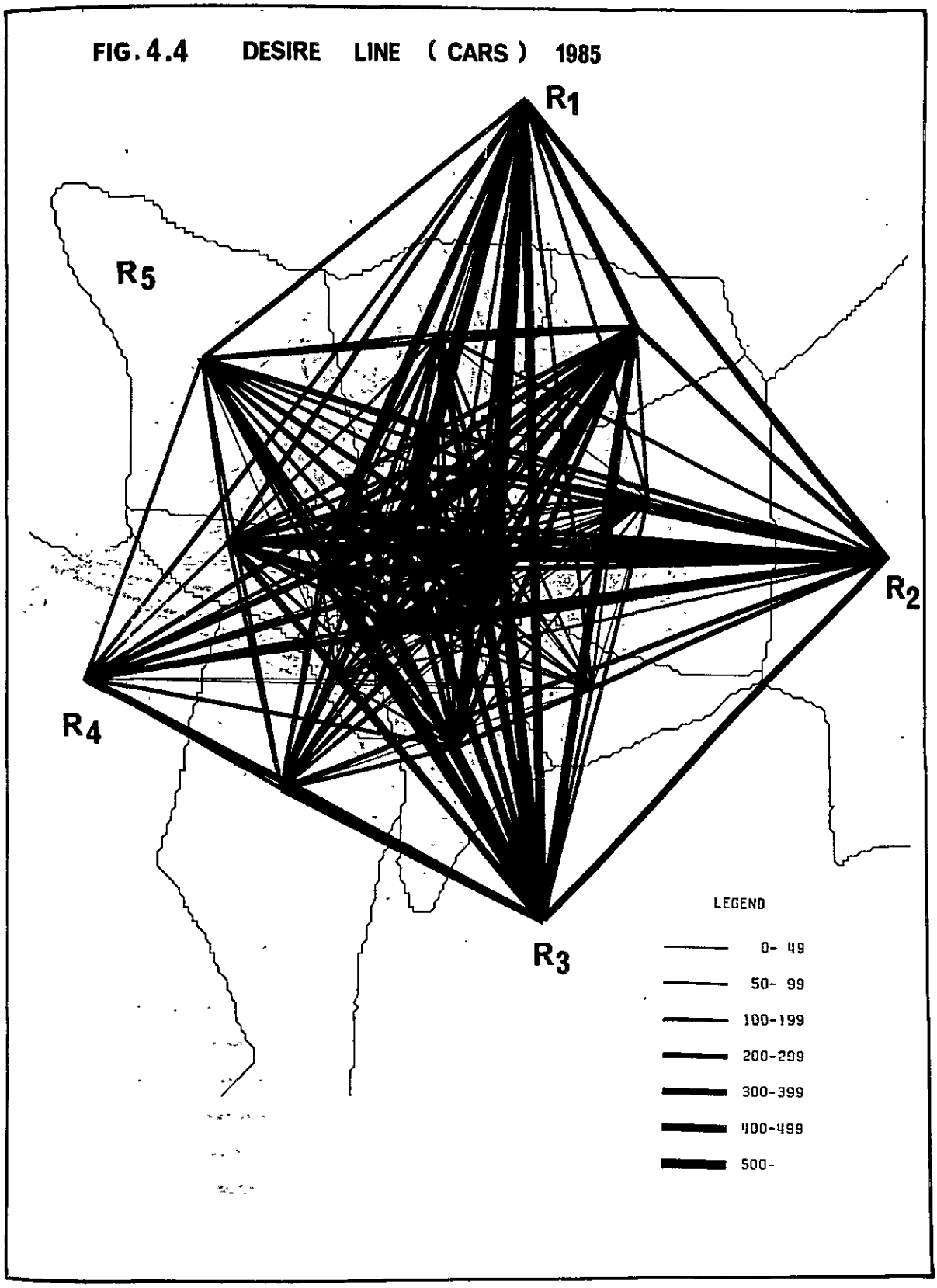


FIG. 4.4 DESIRE LINE (CARS) 1985
R1
R2
R3
R4
R5
LEGEND
0- 49
50- 99
100-199
200-299
300-399
400-499
500-

FIG. 4.5 DESIRE LINE (TRUCKS) 1985

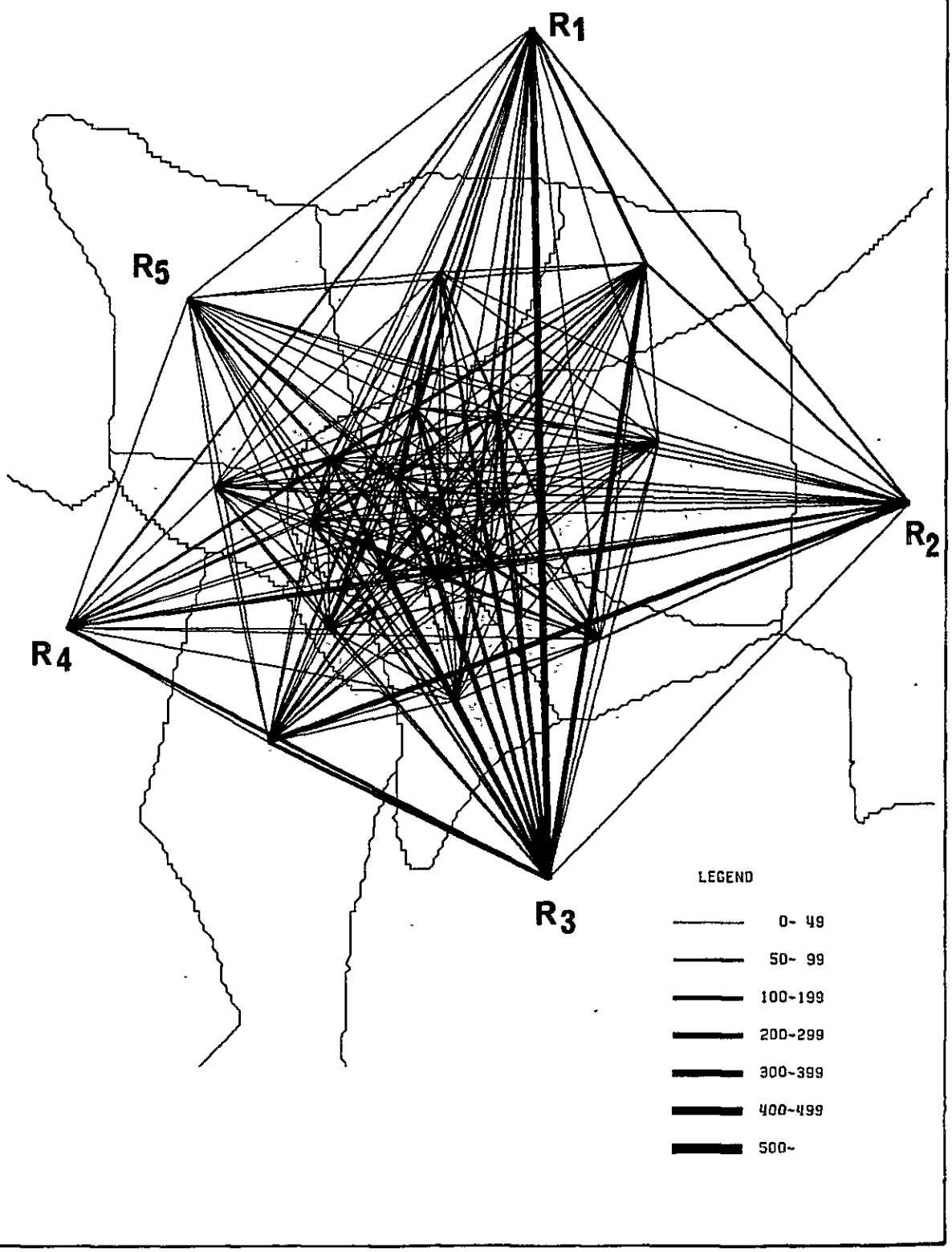


FIG. 4.6 DESIRE LINE (TOTAL) 1985

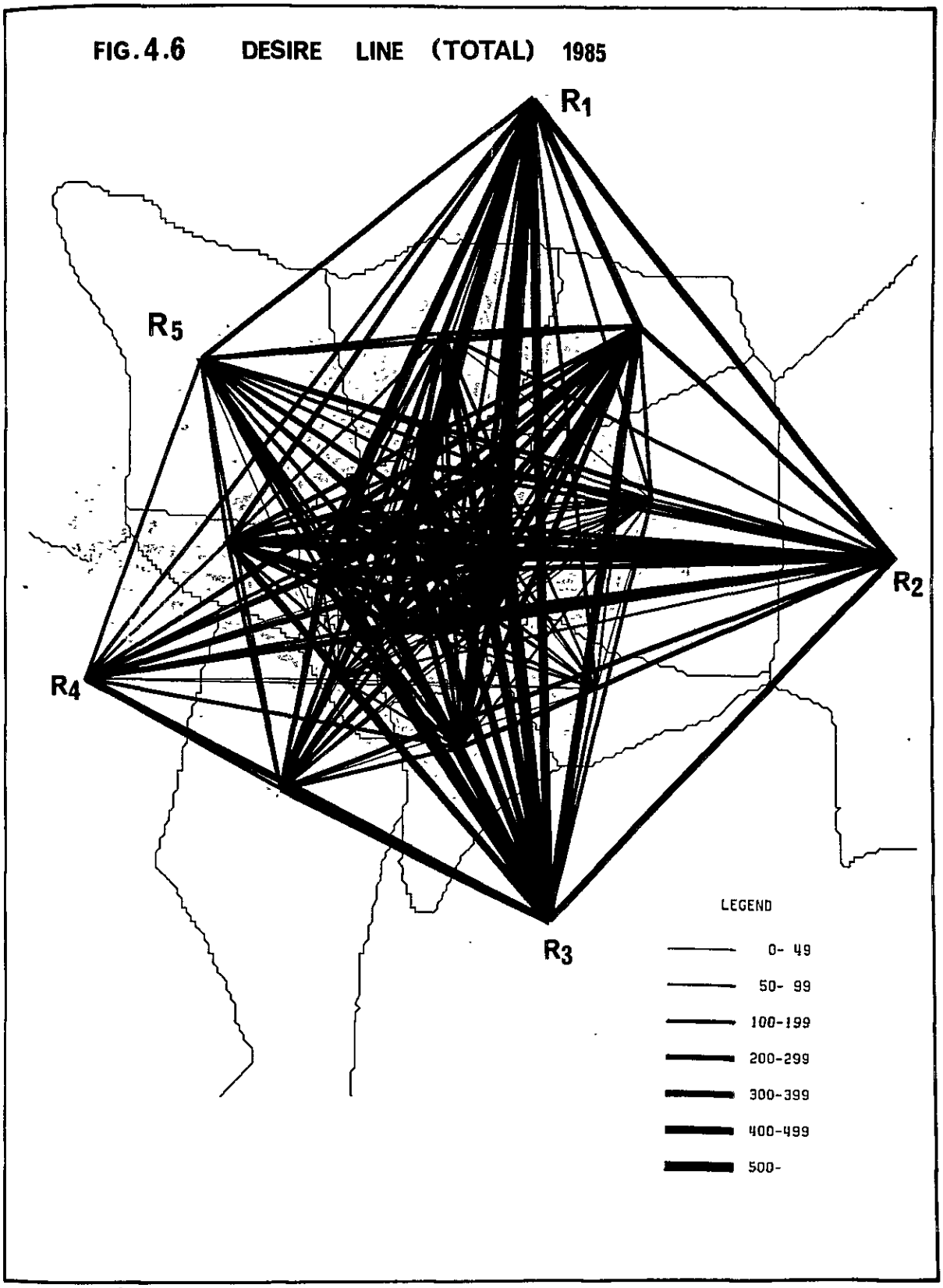


FIG. 4.7 DESIRE LINE (CARS) 2000

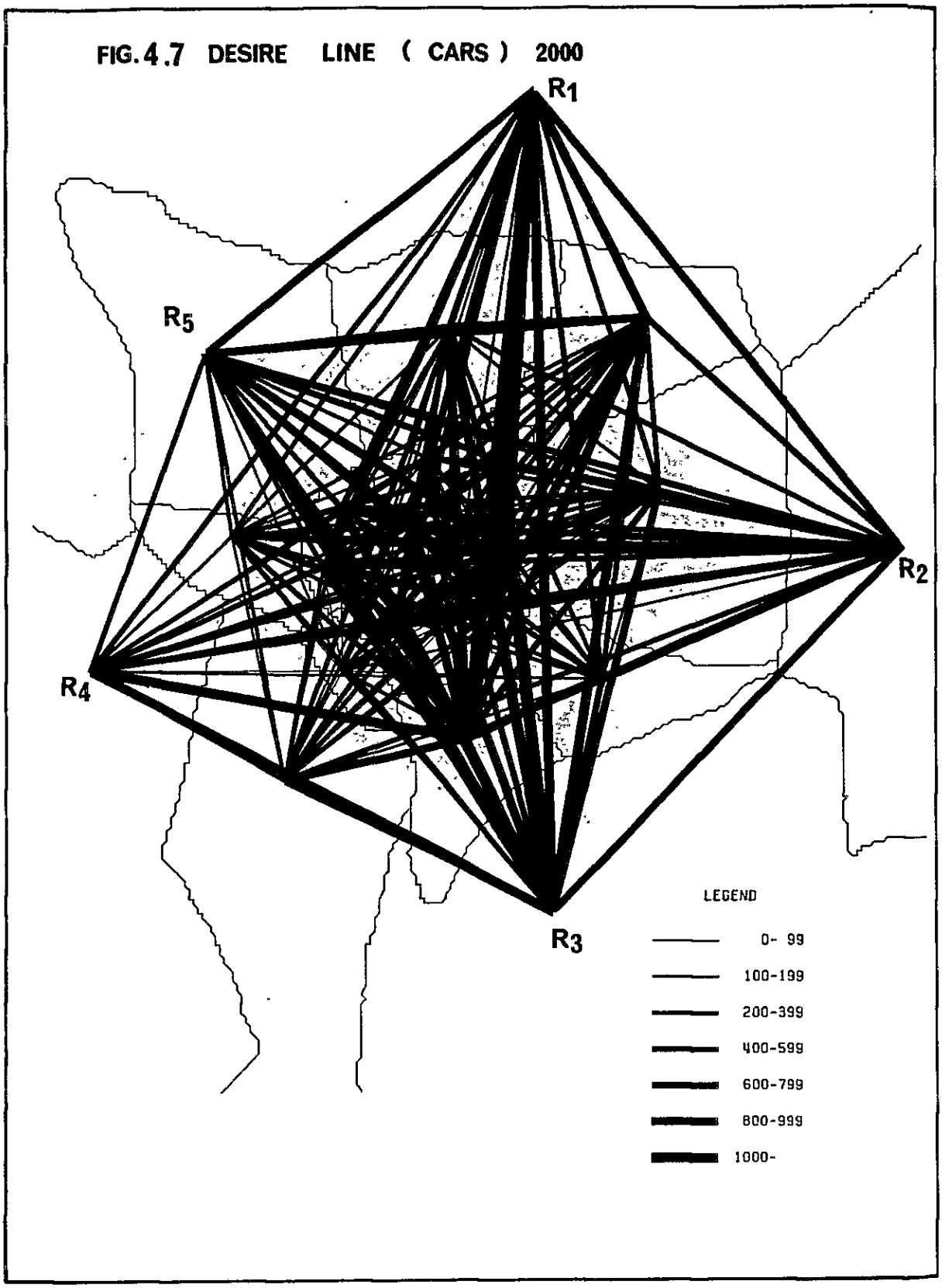


FIG.4.8 DESIRE LINE (TRUCKS) 2000

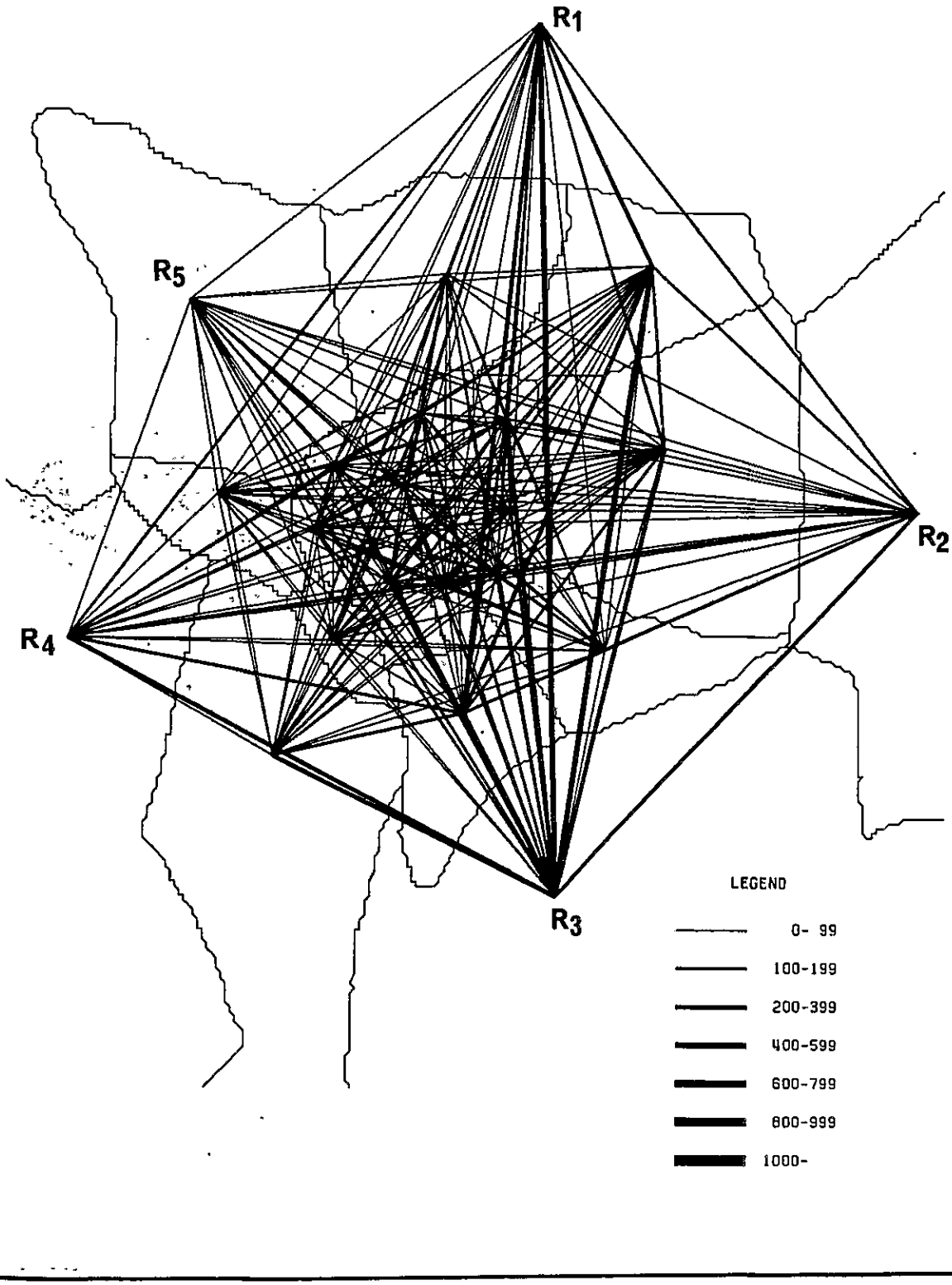
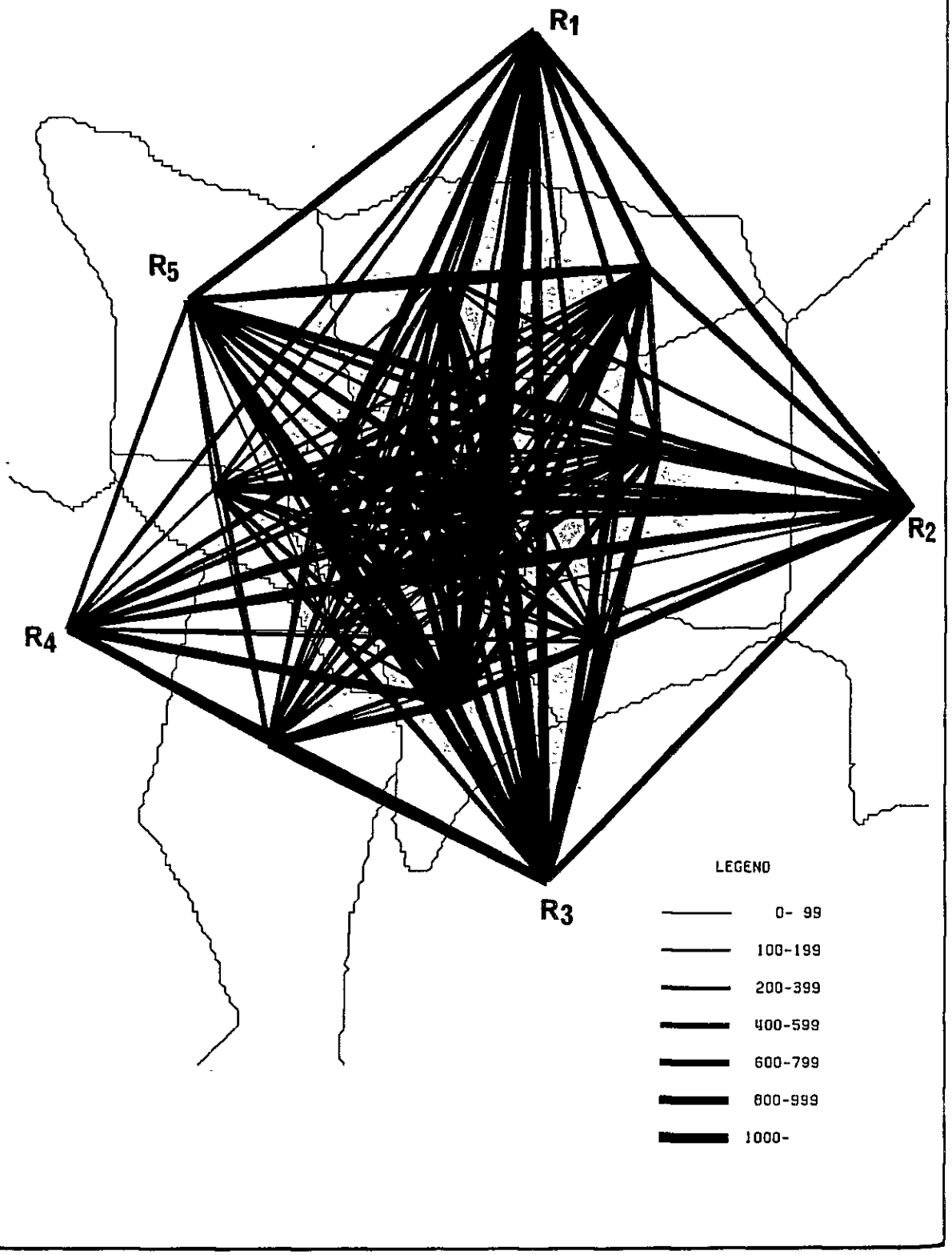


FIG.4.9 DESIRE LINE (TOTAL) 2000



4.6 Traffic Assignment

4.6.1 General

The purpose of traffic assignment is to allocate trips representing the zone-to-zone travel demands for each segment of the road network in the future.

The traffic assignment procedure involves capacity restraint simulation which effectively measures the impact of congestion and accounts for the free choice of drivers to alter their route to avoid congestion.

The capacity restraint technique assigns zone-to-zone travel demands to the road network in 5 incremental steps for the divided O-D Table. The general flow chart of this procedure is shown in Fig. 4.10.

4.6.2 The Capacity Restraint Assignment

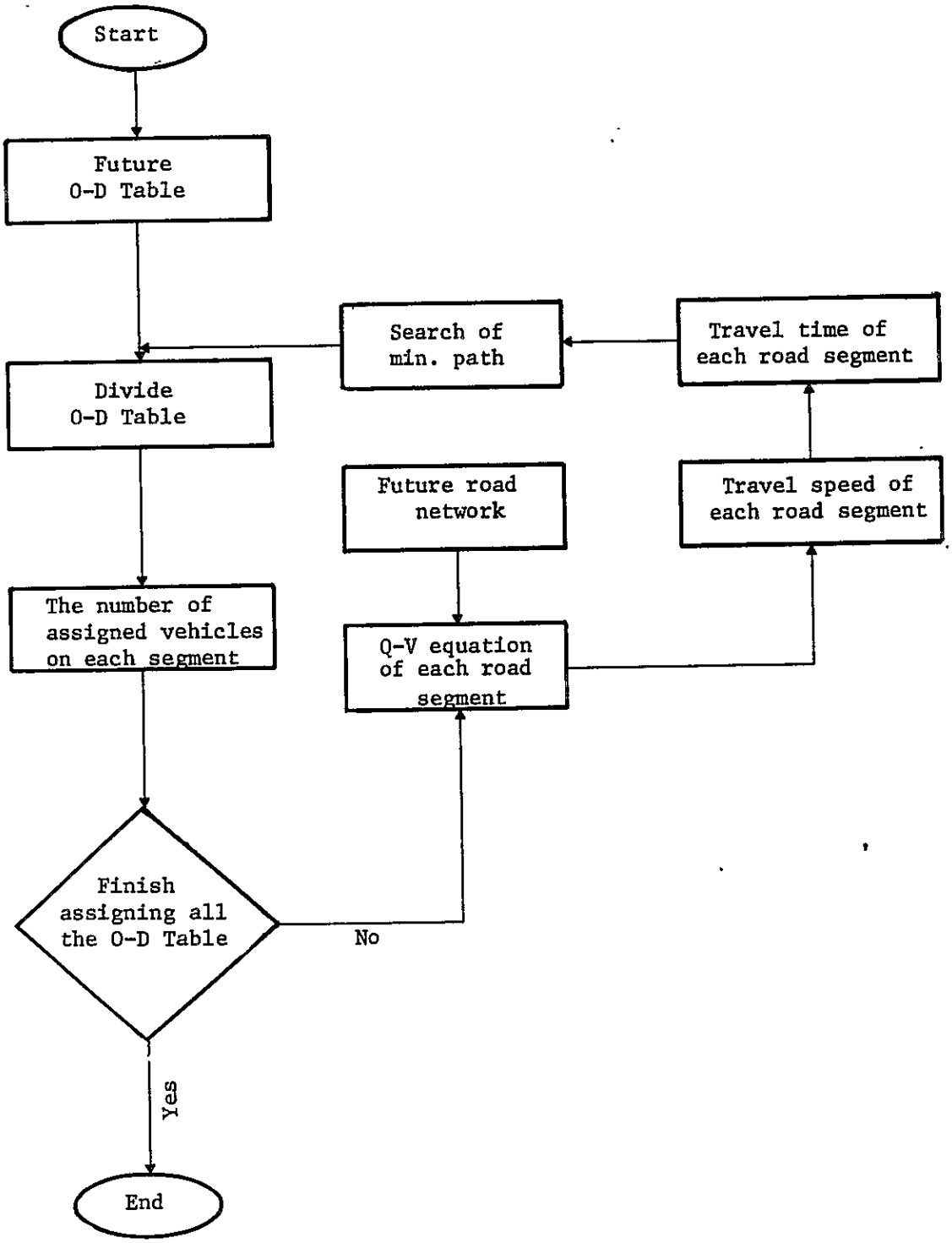
This method assigns 1/N of the O-D Table (if the O-D Table is divided N times) to the minimum route of each trip. By such a process, the travel speed of each link (ie. each segment of the road network) is calculated by Q-V (Quantity-Velocity) equation. The Q-V equation shows the relationship between the traffic volume and travel speed. The next assignment of 1/N of the O-D Table uses the modified running speed by the Q-V equation. This process of assignment continues N times until all the zone-to-zone traffic demand is assigned.

The information which is necessary to assign the trips is shown as follows:

1) Future O-D Table
2) Road network, distance of links
3) The number of lanes (width of road)
4) Standard of road
5) Q-V equation (the planned running speed)

Trip assignment is described in detail for each of the above items as follows:

Fig. 4.10 Traffic Assignment Procedure

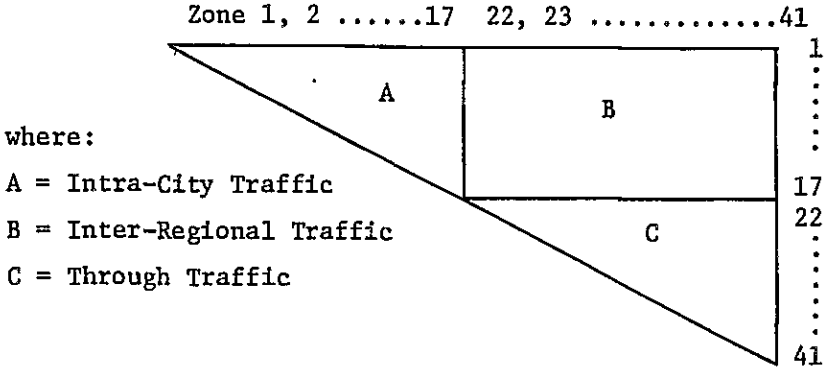


Future O-D Table

The future O-D Table was forecast in Section 4.5. For the purpose of traffic assignment, the future O-D Table was divided into 5 parts.

The O-D Table consists of 3 main parts, which are shown in Fig. 4.11 .

Fig. 4.11 Components of O-D Table



where:

A = Intra-City Traffic

B = Inter-Regional Traffic

C = Through Traffic

After the O-D Table was divided into these 3 components, the traffic movement inside the Irbid City Area (part "A" of the O-D Table) was sub divided into 3 approximately equal parts. Thus, a total of 5 divisions were made. The traffic assignment was conducted 5 times consecutively as follows:

(1) First assignment: 1/3 of traffic inside Irbid (A)
(2) Second assignment: 1/3 of traffic inside Irbid (A)
(3) Third assignment: 1/3 of traffic inside Irbid (A)
(4) Fourth assignment: Inter-regional traffic of Irbid (B)
(5) Fifth assignment: Traffic passing through Irbid (C)

During the first assignment, the traffic demand was 1/3 of the traffic inside Irbid (ie, 1/3 of Part A in the O-D Table) which was assigned to the route selected by the minimum time path.

During the second assignment, the traffic demand was an additional 1/3 of part "A" in the O-D Table. Routes were selected in the same manner for minimum paths, but the route searching was a little different from the first assignment. The route searching was affected by the Q-V curve (i,e, Quantity-Velocity curve).

The travel speed was selected by the relation with the traffic volume on the links according to the Q-V curve. For example, if a certain link was over the capacity in the first assignment of 1/3 of part "A" in the O-D Table, the travel speed decreased in proportion as the Q-V curve at the second assignment.

This procedure continued 5 times for each kind of vehicle until the fifth assignment. The total demand on the links was obtained from the results of the last assignment.

Road Network

The road network in the future was the only a single variable. However, various cases concerning the ring road project should be considered. Therefore, the variation was assumed to correspond to alternatives in the years of implementation.

Traffic demand was forecast for the two alternatives. In Alternative I, the Boundary Ring Road (2 lanes) and the Outer Ring Road (2 lanes) will be constructed in 1985, and then in 1995 the Section 1 of the Boundary Ring Road will be widened to 4 lanes.

In Alternative II, Section 1 & 3 of the Boundary Ring Road (2 lanes) and the Outer Ring Road (2 lanes) will be constructed in 1985; then in 1990, Section 2 of Boundary Ring Road (2 lanes) will be constructed, followed in 1995 by the widening of Section 1 of the Boundary Ring Road to 4 lanes.

The variations of the network are shown in the next Table 4.18 and Fig. 4.12, 4.13 and 4.14.

Table 4.18 Road Network Alternatives by Completion Year

Road Section	Capacity	Alternative I	Alternative II
BRR - Section 1	2-lanes 4-lanes	1985 1995	1985 1995
- Section 2	2-lanes	1985	1990
- Section 3 and ORR	2-lanes	1985	1985

Distance of Links

Link distance is basic information for the minimum time path searching. The distance of each link (segment of road) was measured by curvimeter on the maps of 1/10,000 and 1/50,000.

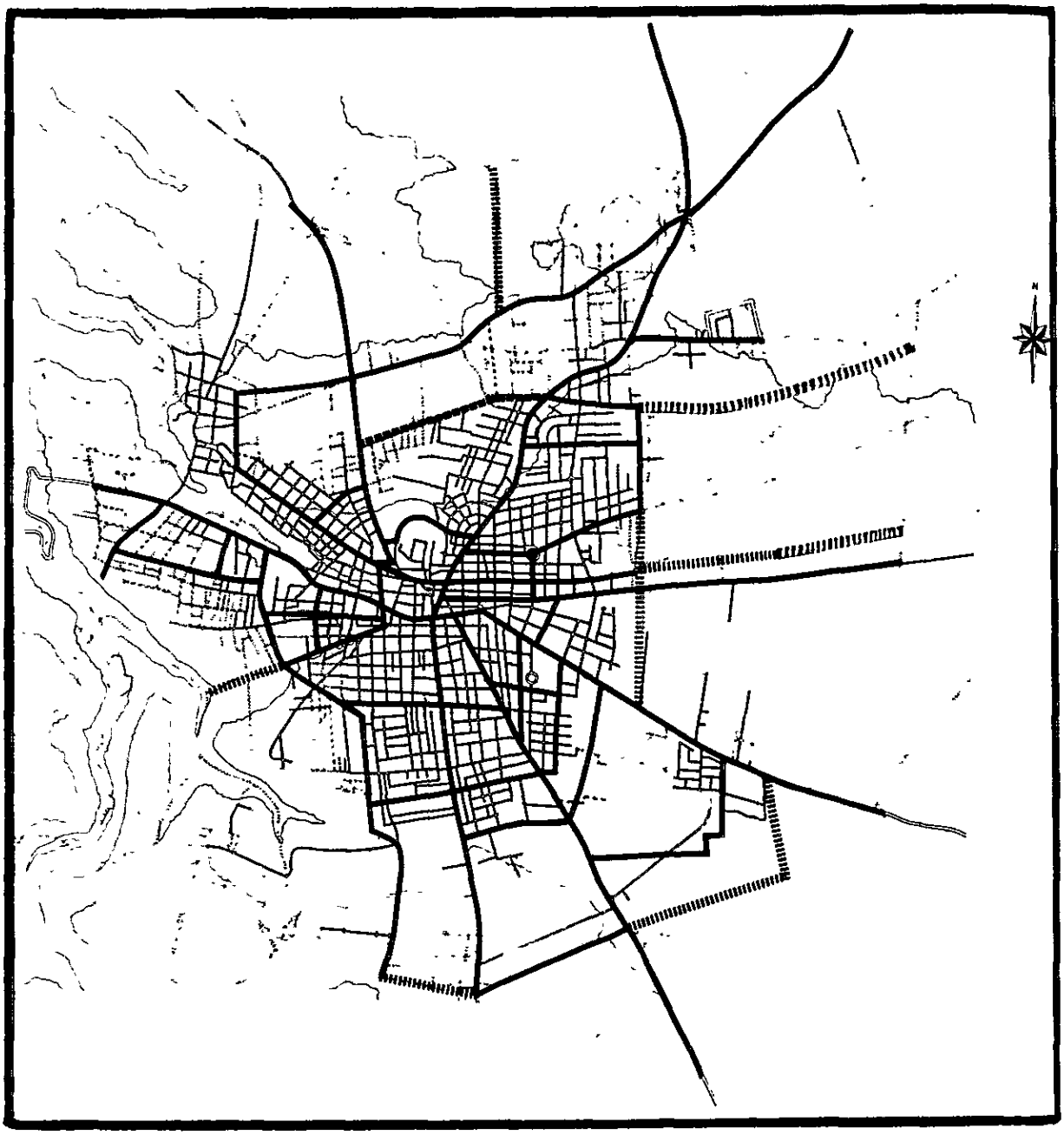
The Number of Lanes

The Q-V curve was formulated depending on the number of lanes which determine traffic capacity and velocity.

The Classification of Roads

The classification of roads was also used to formulate the type of Q-V curve. The national roads are classified by the Ministry of Public Works as: (1) primary arterial, (2) secondary arterial, (3) collector and (4) local.

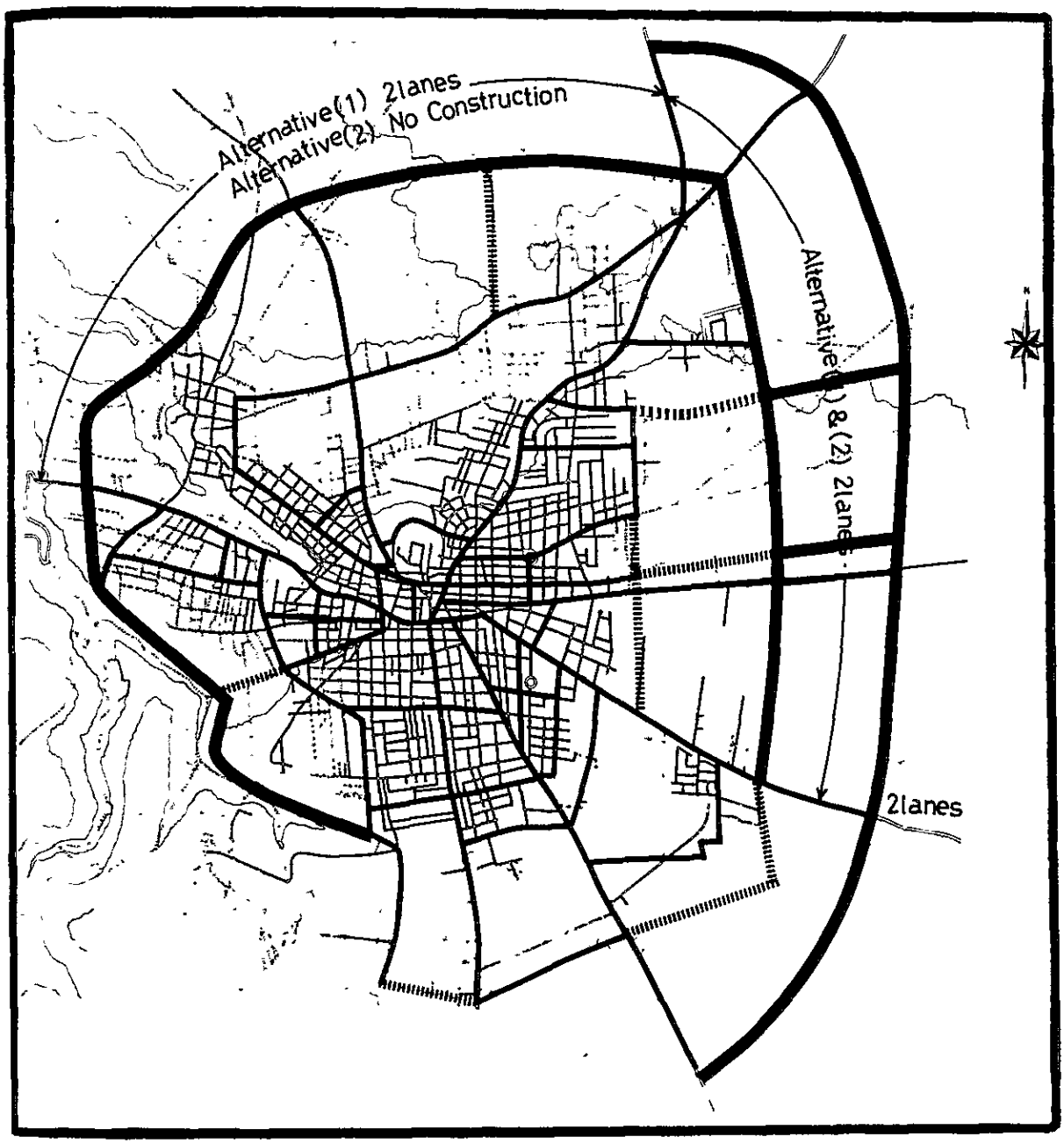
Fig. 4.12 ROAD NETWORK (Without Project)



LEGEND :

- Existing Road
- Roads Constructed By 1985
- Roads Constructed Between 1985 and 2000

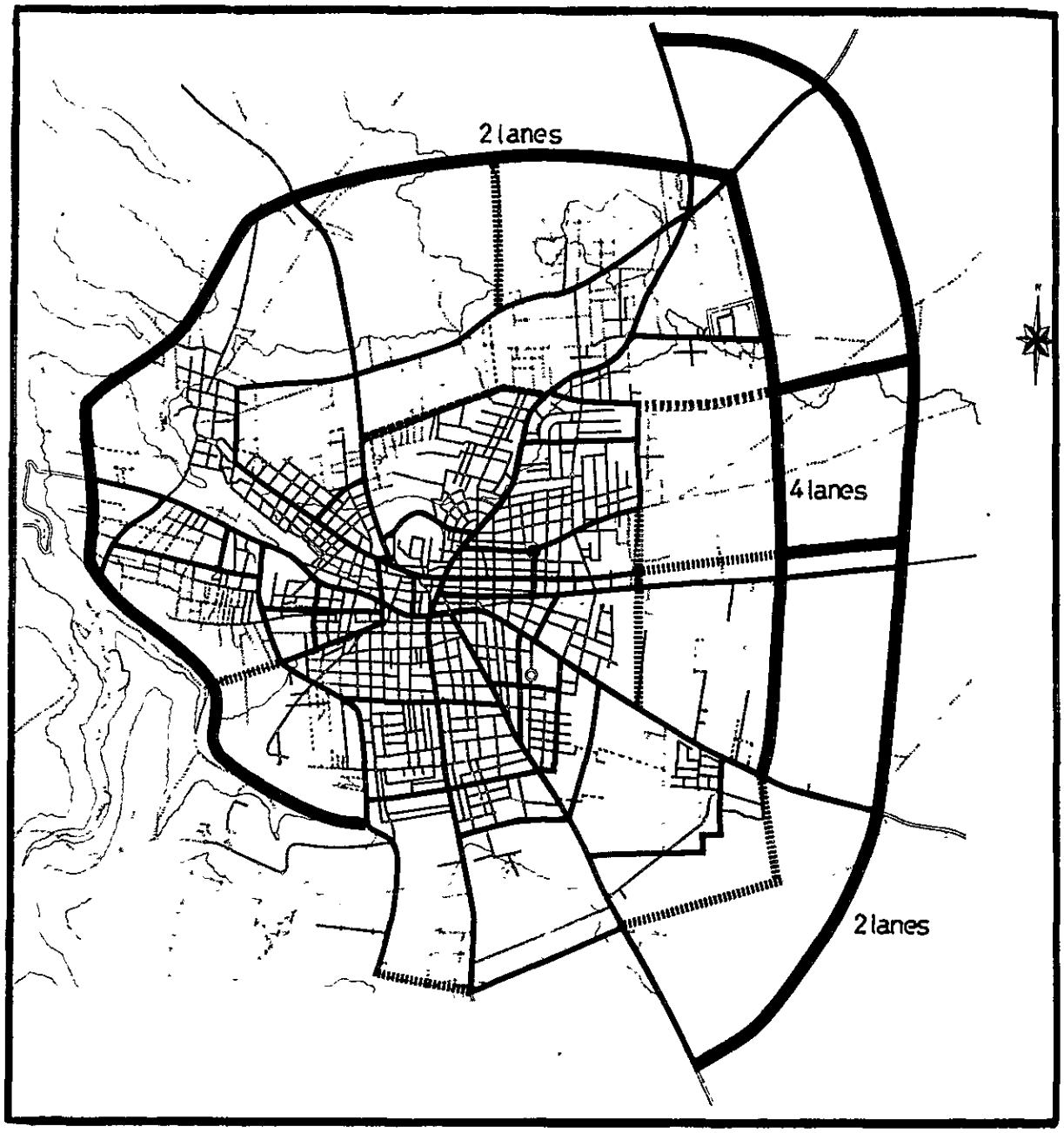
Fig. 4.13 ROAD NETWORK (In 1985 with Project)



LEGEND :

- Existing Road
- Roads Constructed By 1985
- Proposed Ring Road

Fig. 4.14 ROAD NETWORK (In 2000 with Project)



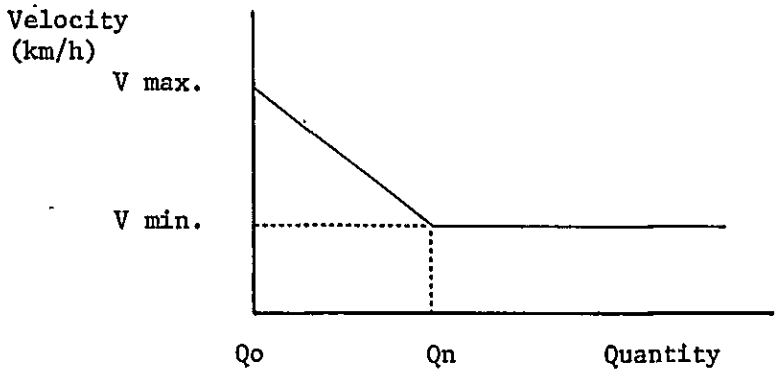
LEGEND

- Existing Road
- Roads Constructed By 1985
- Roads Constructed Between 1985 and 2000
- Proposed Ring Roads

The Q-V Curve

The Q-V curve expresses the relation between the traffic volume and travel speed. The Q-V values varied in terms of the classification of roads, the number of lanes and the surrounding land-use. A simplified Q-V relationship is shown in Fig. 4.15.

Fig. 4.15 Simplified Q-V Curve



In Fig. 4.16, V max. is the maximum speed of a road link which has no loading. V min. is the speed when the traffic volume has reached its capacity.

At the speed between V max. and V min., an increase in traffic volume will decrease to the travel speed corresponding to the Q-V function. Once over-capacity is reached, the travel speed is assumed to be constant.

Although there are many possible variations in this relationship, this study used 11 kinds of Q-V curves. They are shown in Table 4.19.

Table 4.19 Q-V Curve

Q-V Code	No. of Lanes (lanes)	Design Speed V Max. (km/h)	Capacity Q1 (veh/day)	Street Name to Apply
1	4	80	48,000	BRR (Eastern Part) Connecting road B
2	2	80	14,000	BRR (Northern Part) ORR Connecting Road A
3	4	60	48,000	Baghdad St. (outside BRR)
4	2	60	16,000	Al-Jarash St. (outside BRR)
5	2	60	12,000	BRR (Western Part) Hakama St. (outside BRR)
6	4	40	40,000	Palestine St. Baghdad St.
7	2	40	13,000	Al-Jarash St. Bab-Al-Wadd St.
8	2	40	12,000	Fouara St. Bishra St. (outside BRR)
9	2	40	10,000	Hakama St. Bishra St.
10	2	40	8,000	Inner Ring Road
11	2	30	6,000	Other Roads

Source: Study Team

Note: (1) BRR: Boundary Ring Road

(2) ORR: Outer Ring Road

4.6.3 Results of Traffic Assignment

The results of traffic assignment on the network for 1985 and the year 2000 are shown in the following Fig. 4.16 and Fig. 4.17.

In 1985, Alternative I, about 3000 ∿ 7000 vehicles were estimated on section 1 of the Boundary Ring Road. Section 2 was about 2000 vehicles. The demand of the Outer Ring Road was 3000 ∿ 5000 vehicles/day.

In 1985, Alternative II, the traffic demand of the Boundary and the Outer Ring Roads were estimated to be nearly the same number of vehicles.

A remarkable change was shown for Palestine St. (which increased to maximum 1700 vehicles compared with an increase in Alternative I) and Hakama St. (which increased to about 1000 vehicles).

In the year 2000, the network will be compretely finished. The largest traffic demands were on Section 1 of the Boundary Ring Road (about 22,300 vehicles); Section 2 was about 10,000 vehicles and Section 3 was about 900 vehicles. The Outer Ring Road traffic demand was estimated to be about 16,000 vehicles.

The largest effect of the Ring Road for the center area in Irbid in the year 2000 is shown at the cross point between Palestine St. and Baghdad St. in Table 4.20 to be about 30% decrease compared with the case of without project. Thus, it can be considered that the effect of the Ring Road will be very strongly-felt for the road network system in Irbid.

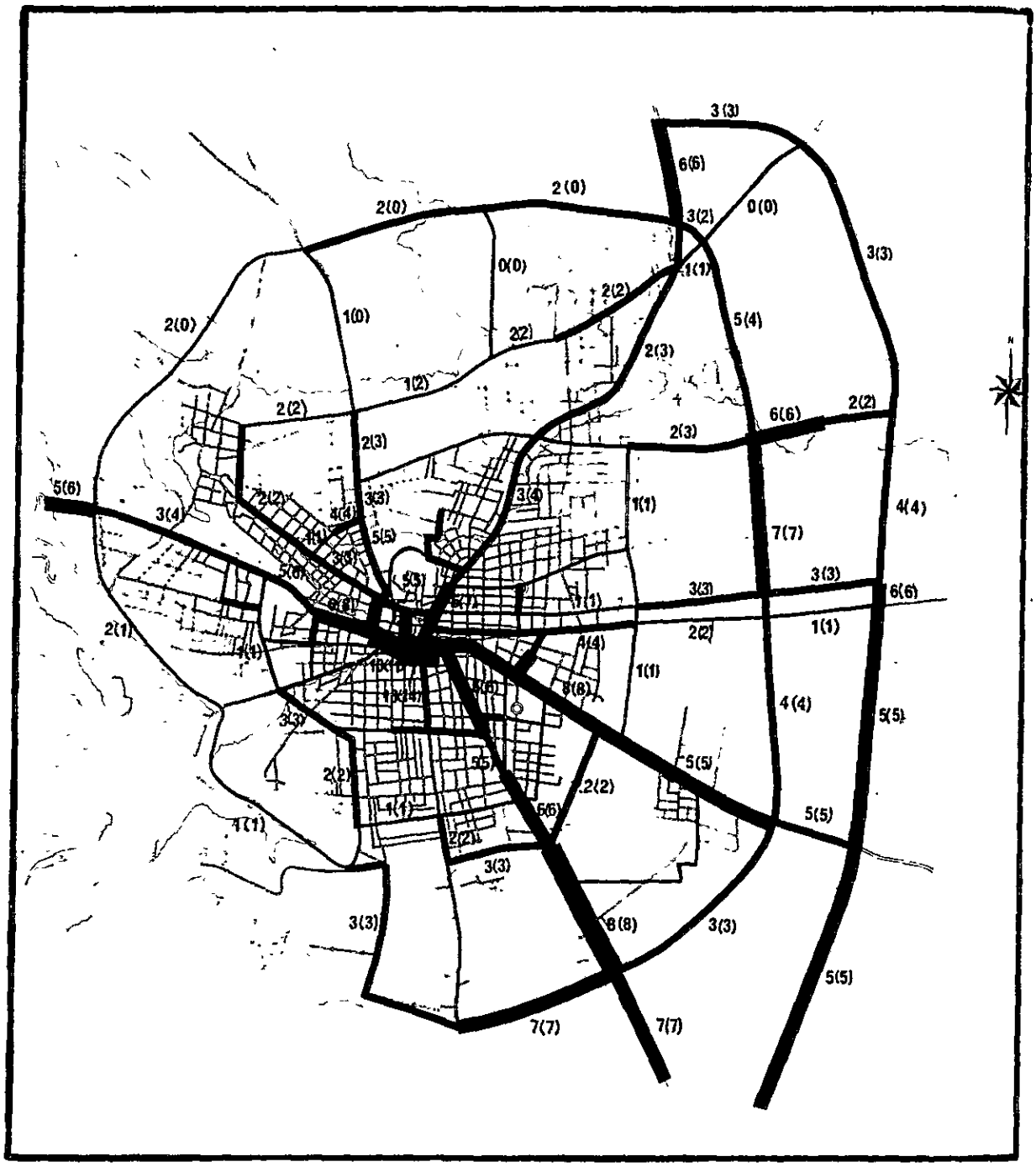
Table 4.20 Effects of Ring Road Construction (2000)

Location	Segment	With Project (Veh.)	Without Project (Veh.)	Decrease (%)
Hakama St. Ⓐ Ⓒ Ⓑ Palestine St. Baghdad St.	A	10811	21454	Δ50%
	B	21994	32994	Δ33%
	C	22451	32522	Δ31%

Actually, the construction of the Ring Roads have a large effect on reducing the traffic volume in the center area of Irbid City. However, it can be said that certain fundamental traffic related problems still remain concerning the central area in Irbid, such as traffic safety, vehicle parking, pedestrians pathways, the mixed and disordered traffic flow and the traffic congestion on limited road-segments.

Therefore, in order to solve the overall urban traffic problems in Irbid City Area, it will be necessary to make up a master traffic plan in Irbid. This master traffic plan should include urban transportation planning with particular emphasis on planning concerning public transporation, traffic control and regulation, road/street network planning.

FIG. 4.16. RESULT OF TRAFFIC ASSIGNMENT (1985)



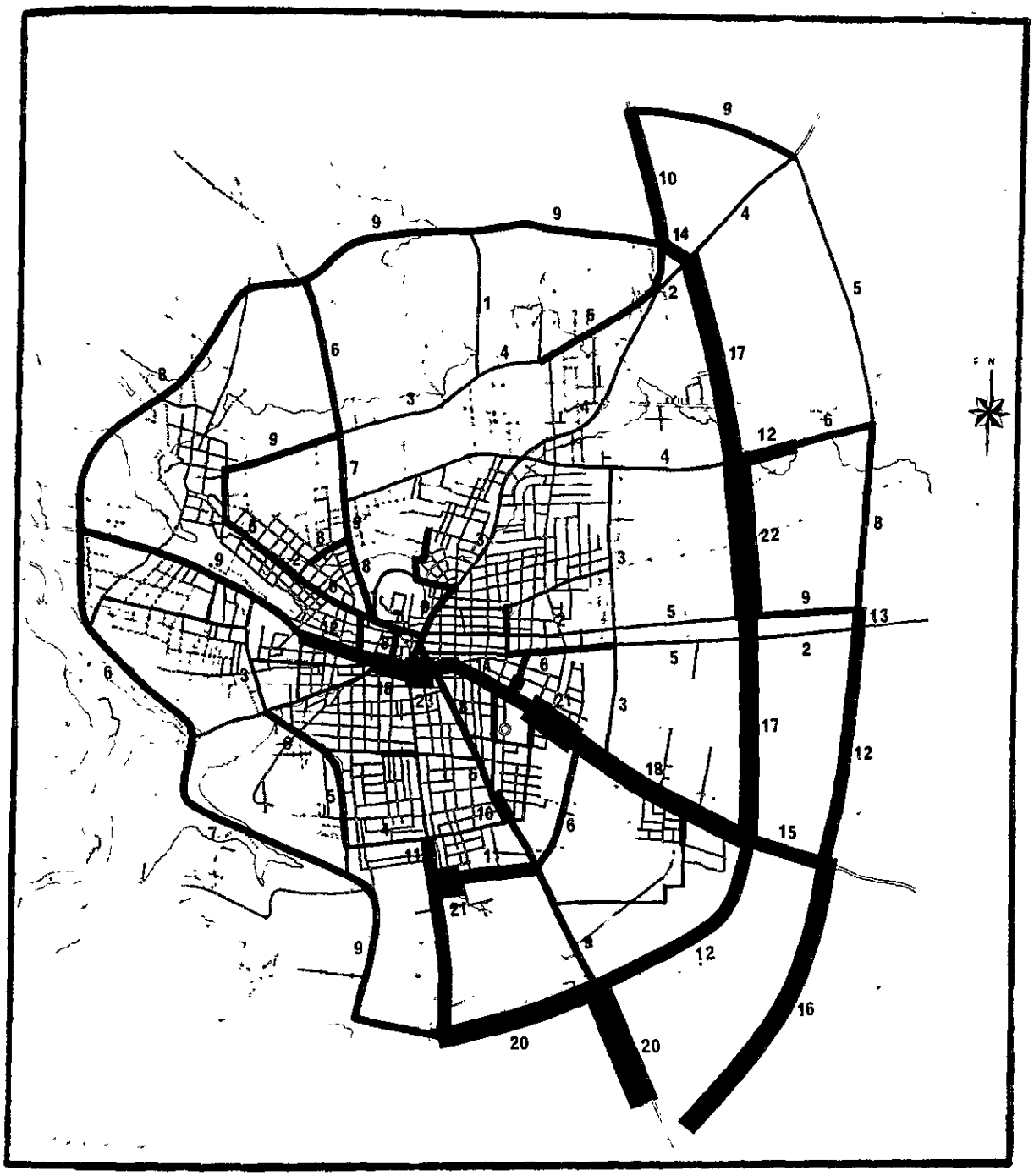
LEGEND ;

1. RING ROAD TRAFFIC VOLUME (1000 VEHICLES / DAY) 7(6) — ALTERNATIVE (2) / ALTERNATIVE (1)

2. 10000 8000 5000 2000 (VEHICLES / DAY)

FIG. 4.17. RESULT OF TRAFFIC ASSIGNMENT

2000 (WITH)



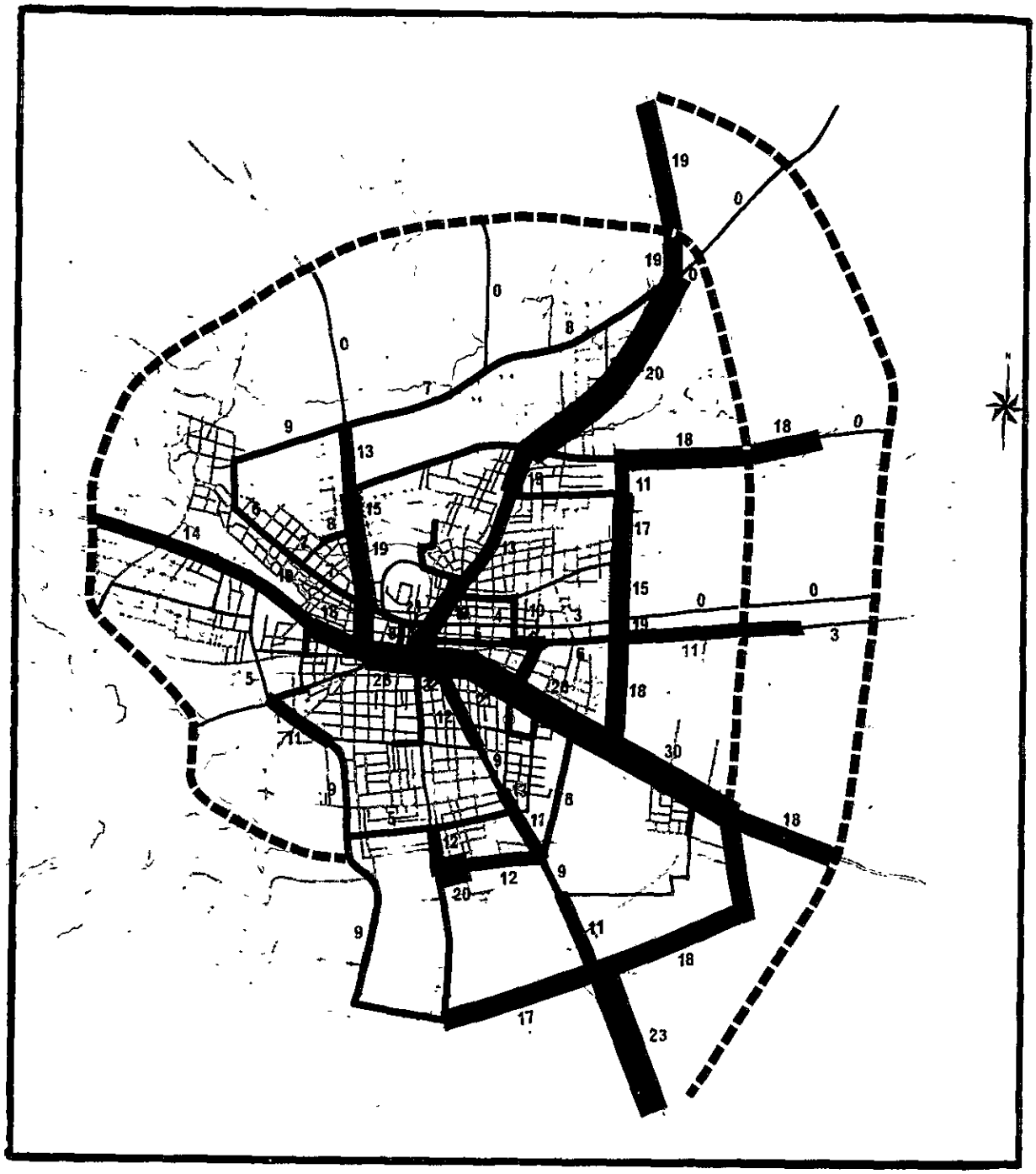
LEGEND ;

1. RING ROAD TRAFFIC VOLUME (1000 VEHICLES / DAY)

2. 20 000 15 000 10 000 5 000 (VEHICLES / DAY)

FIG. 4.18 : RESULT OF TRAFFIC ASSIGNMENT

2000 (WITHOUT)



LEGEND;

1. RING ROAD TRAFFIC VOLUME (1000 VEHICLES / DAY)

2. 20 000 15 000 10 000 5 000
(VEHICLES / DAY)

3. PROPOSED RING ROAD

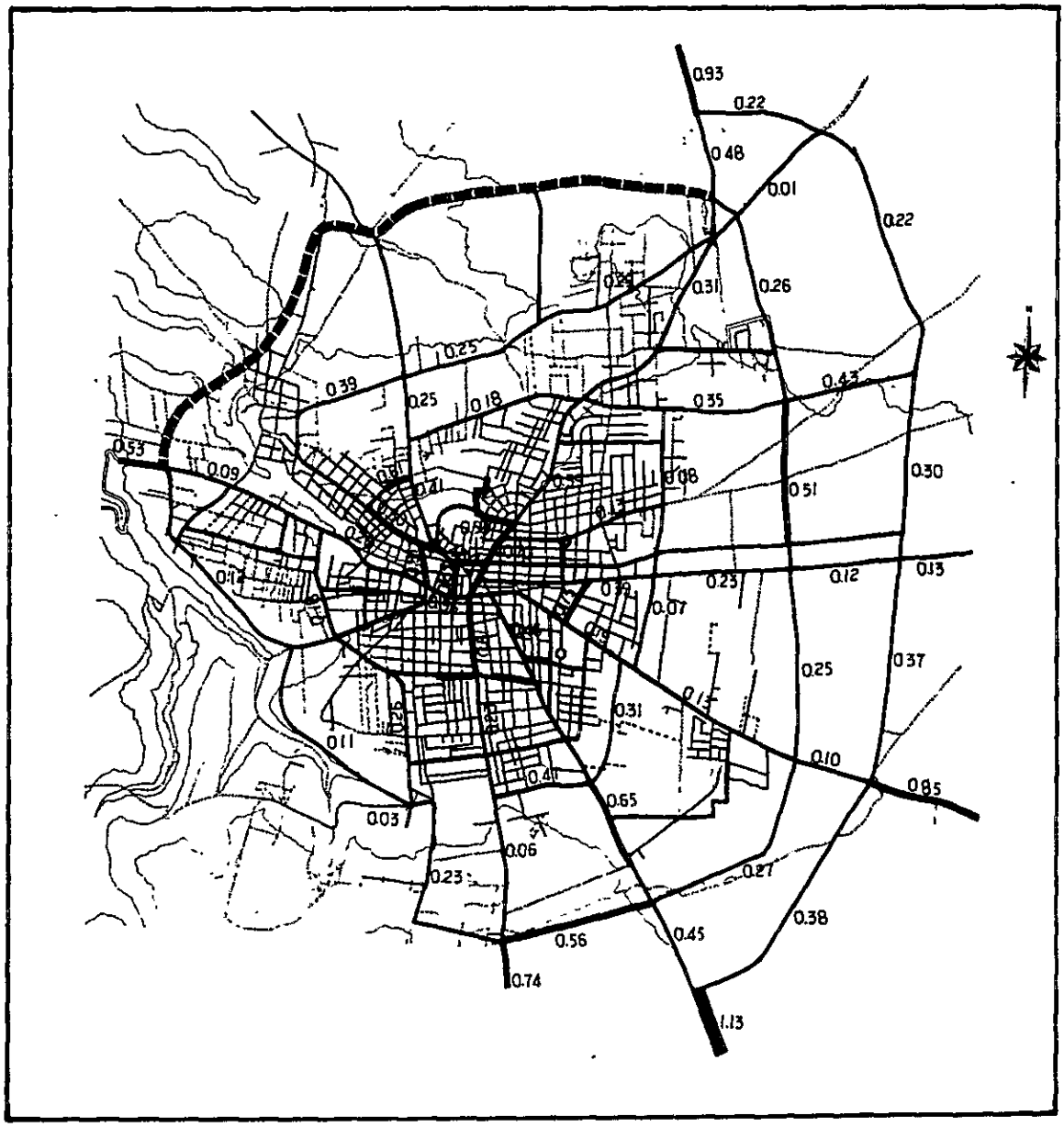
The ratio of traffic volume/capacity shows a level of congestion on each road segment. In 1985 this ratio indicated less than 1.00 on almost all the road segments. This is because the increase of traffic volume is only 30% after the year 1981, and also because Furthermore, the Ring Road will fulfill its function in distributing the traffic passing through the center of the city.

In 2000, the case "with project" which means the Ring Road will be completely finished, this ratio of the Boundary Ring Road shows 0.97 at the southern part of it, 0.62 at the eastern part, 0.68 at the northern part and 0.59 at the western part.

At the nearest segment to the beginning point of the Outer Ring Road, this ratio shows 1.11 and is the only segment of this road having a greater ratio than 1.00. About 10 segments in the center of the city have greater ratio than 1.00.

But, in the case of without project, about 40 segments shows more than 1.00, and such segments appear around the western part and the northern part of the city. Through comparison between these two cases, it is clear that a beneficial inpact will be given by the construction of Ring Road.

FIG. 4.19. THE RATIO OF TRAFFIC VOLUME/CAPACITY 1985 (ALTERNATIV 2)

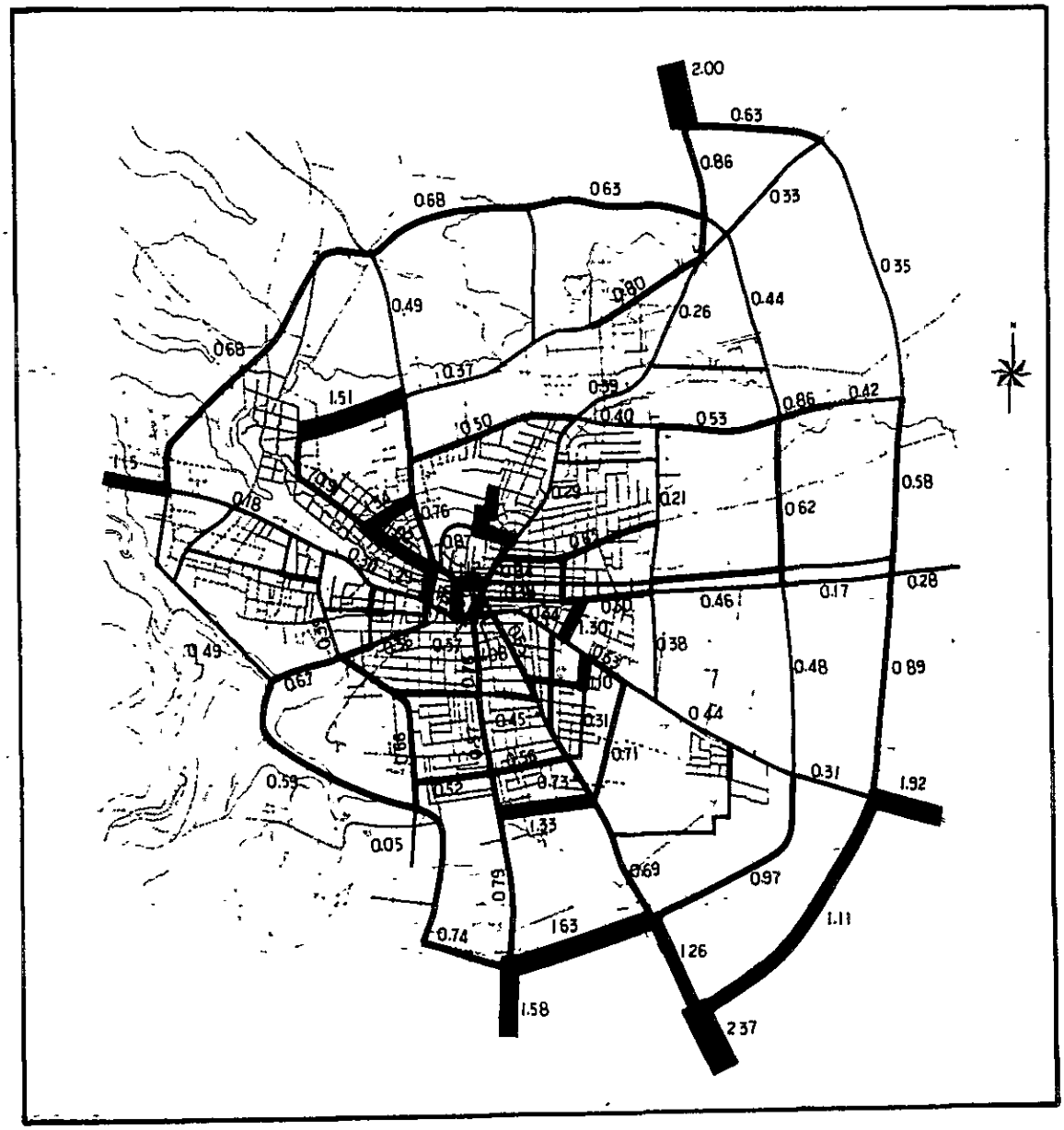


LEGEND;

1 ~2·0 1·5 1·0 0·5~

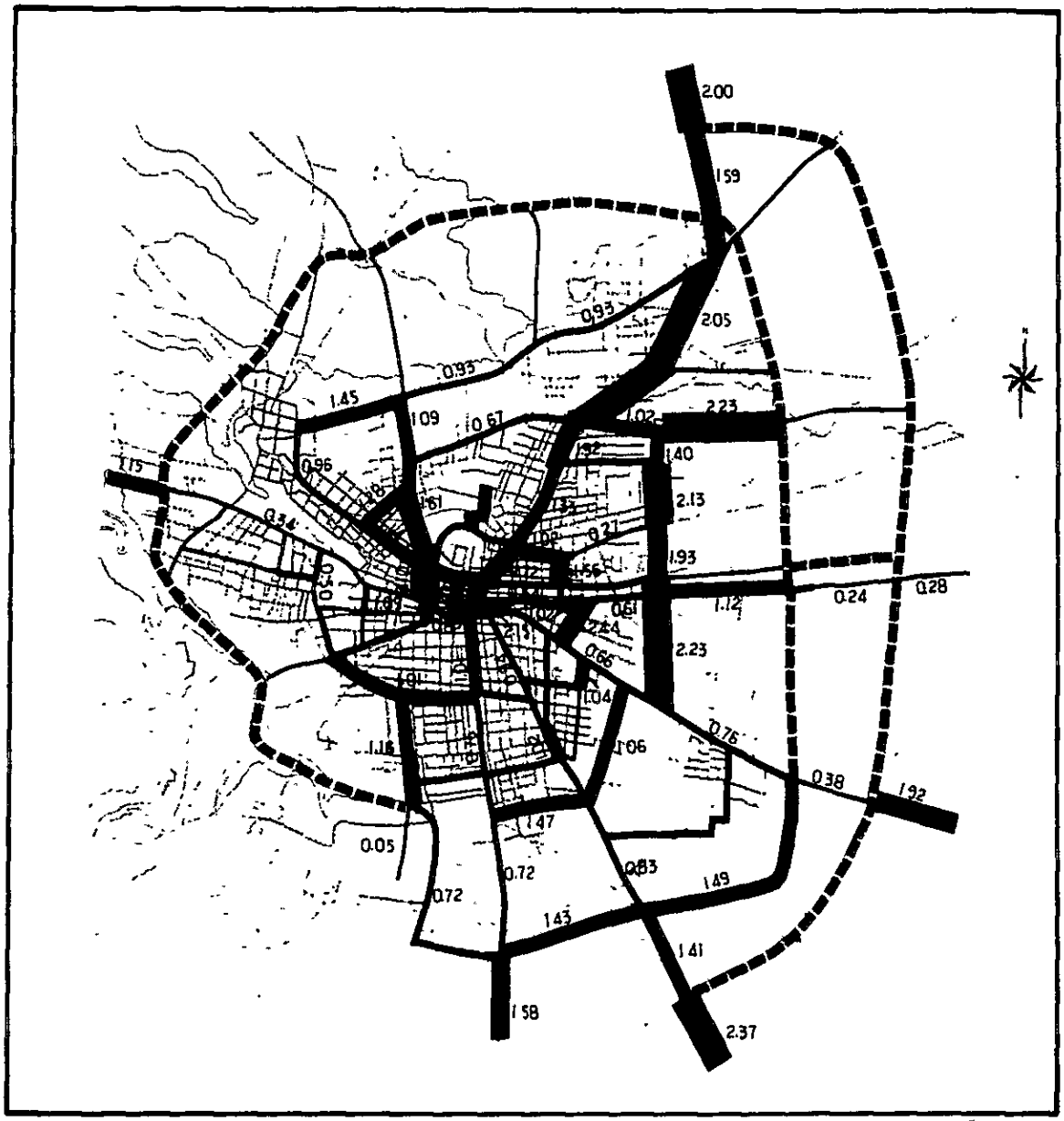
2 **Proposed Ring Road Project**

FIG. 4.20. THE RATIO OF TRAFFIC VOLUME/CAPACITY 2000 (WITH PROJECT)



LEGEND;

FIG. 4.21. THE RATIO OF TRAFFIC VOLUME/CAPACITY 2000 (WITHOUT PROJECT)



LEGEND;

1 ~2·0 1·5 1·0 0·5~

2 **Proposed Ring Road Project**

CHAPTER 5 PROJECT BENEFITS

It is clear that the most important economic benefits derived from the construction of a road are as follows:-

(1) Promotion of economic productivity

(2) Reduced operating expenses, obtained from reducing traffic congestion and increasing the vehicle operating speed

(3) Time savings

(4) Reduced accident rate

(5) Increased comfort and convenience etc.

For the purpose of this study and to satisfy the main objective of the work, road user benefits (i.e. mainly the benefits of items (2) and (3) described above) were calculated. These benefits were calculated from the traffic conditions forecast in the previous chapter.

The vehicle operating cost and the value of time are mentioned below.

5.1 Vehicle Operating Costs

Vehicle operating costs are composed of fuel consumption, lubricating oil consumption, parts consumption, maintenance - labour hours, tyre consumption, depreciation, crew hours and standing costs. These costs should be calculated by type of vehicle and then put together into two categories: i.e. cars (including private passenger cars, taxis and vans) and trucks. The purpose of this classification is to fit the kind of vehicles with those dealt with in forecasting the traffic demand.

In computing these costs, the consumption ratios by varying vehicle operating speed were based on the previous feasibility study published by the Ministry of Public Works.[1]

These consumption ratios are based on the tables and graphs from a report in the U.S.A.[2] and are modified for Jordanian conditions.

The unit prices indicated in Table 5.1, 5.2 were obtained from the Ministry of Public Works and used for calculating the costs.

Table 5.1 : Base Prices Related to Vehicle Operating Cost Elements

(Based on May 1981 Values)

Kind of Vehicle	Passenger Car	Taxi	Van	Medium Truck	Heavy Truck
Definition	50% Mercedes 200 50% Japanese & European Small Cars	Mercedes 200	Japanese Cars & Land Cruiser	Mercedes 608	Mercedes 1924
Depreciation Years	12	12	12	15	15
Annual Kilometers (Km)	21,000	65,000	45,000	45,000	72,000
Vehicle Price (JD) (economic cost)	1,900	3,360	2,990	5,500	25,000
Tyre Cost per Tyre (JD) (economic cost)	12,415	13,470	22,100	80,961	89,660
Type of Fuel	Gasoline			Diesel	
Maintenance Labour Cost (JD per hour)	0.420	0.420	0.445	0.528	0.528
Crew Cost (JD per hour)	0.000	0.385	0.490	0.517	0.640

Source: MMRAE Southern Region Project, Infrastructure Group Wadi Yutum/Wadi 2 Back Road Economic Feasibility Study (unpublished)

Note: 1/ Ministry of Public Works, Amman-Amman International Airport Highway Project, Feasibility Study and Preliminary Engineering, August 1976.

2/ Jan de Weille, Quantification of Road User Savings, World Bank Staff Occasional Paper No.2, 1966.

Table 5.2 Fuel Cost (in JD per litre)

(Economic Cost)

Regular Gasoline	0.150
Super Gasoline	0.180
Combination (80% regular + 20% super)	0.156
Diesel	0.050
Oil	0.570

Source: MMRAE Southern Region Project Infrastructure Group Wadi Yutum - Wadi 2 Back Road Economic Feasibility Study (unpublished)

5.1.1 Fuel Consumption Costs

Fuel consumption rates vary with the category of vehicle, travel speed, geometric features and road surface conditions.

In Irbid City, there are few hills and great stretches of all roads are paved. Therefore, the fuel consumption rate on paved roads in a flat area was adopted from the reference 1/.

Note: 1/ Ministry of Public Works as for Source following Table

Fuel consumption rates by differing speeds are shown below in Table 5.3.

Table 5.3 Fuel Consumption Rate (litre per km)

	Travel Speed (km/hr.)			
	20	40	60	80
Passenger Cars Vans & Taxis	0.099	0.080	0.078	0.092
Trucks	0.366	0.268	0.254	0.283

Source: Ministry of Public Works
Amman-Amman International Airport Highway
Project, Feasibility Study and Preliminary
Engineering
August, 1976

It is assumed that passenger cars, vans and taxis use a combination gasoline and trucks use diesel gasoline, Fuel consumption costs are as shown in Table 5.4.

Table 5.4 Fuel Consumption Costs (JD per 1000 km)
(Economic Cost)

	Travel Speed (km/hr.)			
	20	40	60	80
Passenger Cars, Vans & Taxis	15.44	12.48	12.17	14.35
Trucks	18.30	13.40	12.70	14.15

Source: Study Team

5.1.2 Oil Consumption Costs

Similar to fuel consumption, the oil consumption rate and oil consumption costs are as shown in Tables 5.5 and 5.6 respectively.

Table 5.5 Oil Consumption Rate (litre per km)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars, Vans & Taxis	0.0022	0.00098	0.00078	0.00066
Trucks	0.0031	0.0024	0.0019	0.0017

Source : Ministry of Public Works
Amman-Amman International Airport Highway
Project, Feasibility Study and Preliminary
Engineering
August, 1976

Table 5.6 Oil Consumption Costs (JD per 1000 km)
(Economic Cost)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars, Vans & Taxis	0.70	0.56	0.44	0.38
Trucks	1.77	1.37	1.08	0.97

Source: Study Team

5.1.3 Vehicle Maintenance Costs

Vehicle maintenance costs include the economic cost of parts and labour used in the regular maintenance over the whole life of the vehicle.

The cost of parts is described as the percentage per 1000 km of the depreciable value of the vehicle.

Vehicle maintenance cost units are shown in Table 5.7 below. The cost of parts was calculated using the economic price of the vehicle without tyres, because tyre costs are calculated separately. As a result, vehicle maintenance costs are shown in Table 5.8.

Table 5.7 Vehicle Maintenance Cost Units

	Travel Speed (km/hr)			
	20	40	60	80
Parts : (% per 1000 km of the depreciable value of the vehicle)				
Passenger Cars, Vans & Taxis	0.069	0.081	0.094	0.106
Trucks	0.167	0.190	0.227	0.279
Labour : (hours per 1000 km)				
Passenger Cars, Vans & Taxis	0.44	0.50	0.57	0.65
Trucks	1.75	1.90	2.35	2.85

Source: Ministry of Public Works
Amman-Amman International Airport Highway Project, Feasibility Study and Preliminary Engineering
August, 1976

Table 5.8 Vehicle Maintenance Costs (JD per 1000 km)
(Economic Cost)

	Travel Speed (km/hr)			
	20	40	60	80
Parts :				
Passenger Cars	1.28	1.50	1.74	1.96
Vans	2.00	2.35	2.73	3.08
Taxis	2.28	2.67	3.10	3.50
Medium Trucks	8.64	9.83	11.75	14.44
Heavy Trucks	41.15	46.82	55.94	68.75
Labour :				
Passenger Cars	0.18	0.21	0.24	0.27
Vans	0.20	0.22	0.25	0.29
Taxis	0.18	0.21	0.24	0.27
Medium Trucks	0.92	1.00	1.24	1.50
Heavy Trucks	0.92	1.00	1.24	1.50

Source : Study Team

5.1.4 Tyre Wear Costs

Tyre wear is expressed as the percentage wear of one tyre per 1,000 km, as shown in Table 5.9.

Using the economic price per tyre shown in Table 5.1., tyre wear costs were calculated as shown in Table 5.10.

Table 5.9 Tyre Wear Rate (% of Wear of one Tyre per km)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars, Vans & Taxis	0.0015	0.0026	0.0044	0.0070
Trucks	0.0020	0.0038	0.0065	0.0120

Source : Ministry of Public Works
Amman-Amman International Airport Highway
Project, Feasibility Study and Preliminary
Engineering
August, 1976

Table 5.10 Tyre Wear Costs (JD per 1000 km) (Economic Cost)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars	0.19	0.32	0.55	0.87
Vans	0.33	0.57	0.97	1.55
Taxis	0.20	0.35	0.59	0.94
Medium Trucks	1.62	3.08	5.26	9.72
Heavy Trucks	1.79	3.41	5.83	10.76

Source : Study Team

5.1.5 Depreciation

Speed affects depreciation cost in a complex manner, According to the reference 1/, the depreciation percentage per 100 kms is expressed by the following formula :

Note: 1/ Ministry of Public Works
Amman-Amman International Airport Highway
Project, Feasibility Study and Preliminary
Engineering
August, 1976

$$d = 1/at$$

where d = depreciation percentage per 1,000 kms

a = s (AM/AS) where a = annual mileage

s = specific speed of vehicle km/hr

AM = average annual mileage (in thousand kms)

AS = average year round speed

cars = 60 km/hr
trucks = 35 km/hr

$$t = ((AM) \quad (1/3) \quad (SL) \quad / a) \quad + 2/3 \quad (SL)$$

SL = average service life of vehicle in years

1/3 = proportion of distance depreciation

2/3 = proportion of time depreciation

If the scrap value of the vehicle is assumed to be zero, the depreciable value is equal to the economic cost of the vehicle without tyres.

Other values are shown in Table 5.1, also. Using these values, the depreciation of each vehicle is calculated as shown in Table 5.11.

Table 5.11 Depreciation Costs (JD per 1000 km) (Economic Cost)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars	13.21	9.44	7.34	6.01
Vans	9.66	6.91	5.37	4.40
Taxis	7.62	5.45	4.22	3.47
Medium Trucks	10.74	7.00	5.20	4.13
Heavy Trucks	31.93	20.83	15.45	12.29

Source : Study Team

5.1.6 Crew Costs

The cost of the drivers operating taxis, vans and trucks is included in the operating costs as crew cost. The cost of a driver of a private passenger car is not included in the operating cost. If is taken into account in time savings item, because a driver of a private passenger car does not earn his livelihood by operating cars.

Crew costs were calculated as in Table 5.12, by using crew cost rates shown in Table 5.1 and vehicle speeds.

Table 5.12 Crew Costs (JD per 1000 km)
(Economic Cost)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars	-	-	-	-
Vans	22.25	11.13	7.42	5.56
Taxis	19.25	9.63	6.42	4.81
Medium Trucks	25.85	12.93	8.62	6.46
Heavy Trucks	32.00	16.00	10.67	8.00

Source : Study Team

5.1.7 Standing Costs

Standing costs include all costs not covered by the previous components of the running costs mentioned above.

According to the previous study [1/], the standing costs are given as a percentage of the total running costs. And this percentage is shown as 10 per cent for passenger cars and 25 per cent for the other vehicles.

These percentages were adopted in this study, standing costs are shown in Table 5.13.

Table 5.13 Standing Costs (JD per 1000 km)
(Economic Cost)

	Travel Speed (km/hr)			
	20	40	60	80
Passenger Cars	3.10	2.45	2.25	2.38
Vans	12.65	8.56	7.34	7.40
Taxis	11.42	7.84	6.80	6.93
Medium Trucks	16.96	12.15	11.46	12.84
Heavy Trucks	31.97	25.71	25.73	29.11

Source: Study Team

Note: 1/ S.W. Abaynayaka
Tables for Estimating Vehicle Operating Costs on Rural Roads in Developing Countries
TRRL, 1976

5.1.8 Summary

In the estimation of traffic demand, the kind of vehicles considered are the cars and trucks mentioned in the previous chapter. Therefore, vehicle operating costs as mentioned above should be classified for these two kinds of vehicles. Vehicle-km were used as a common unit for weighting data on trucks and cars.

The values of these weighted variables are shown in Table 5.14.

The weighted mean of the vehicle operating costs are summarized in Table 5.15.

Table 5.14 Vehicle-km by Each Type of Car

Cars	Vehicle-km per day	Percentage
Passenger cars	122,914	(57.8)
Vans	45,114	(21.2)
Taxis	44,621	(21.0)
Trucks		
Medium Lorry	39,879	(59.6)
Heavy Lorry	27,032	(40.4)

Source : Study Team

Table 5.15 Vehicle Operating Costs (JD per 1000 km)
(Economic Cost)

	Travel Speed (km/hr) 20	40	60	80
Cars				
Fuel	15.44	12.48	12.17	14.35
Oil	0.70	0.56	0.44	0.38
Parts	1.64	1.93	2.24	2.52
Labour	0.18	0.21	0.24	0.27
Tyre	0.22	0.38	0.65	1.03
Depreciation	11.28	8.07	6.27	5.14
Crew	8.76	4.38	2.92	2.19
Standing	6.87	4.88	4.28	4.40
Total	45.09	32.89	29.21	30.28
Trucks				
Fuel	18.30	13.40	12.70	14.15
Oil	1.77	1.37	1.08	0.97
Parts	21.77	24.77	29.60	36.38
Labour	0.92	1.00	1.24	1.50
Tyre	1.69	3.21	5.49	10.14
Depreciation	19.30	12.59	9.34	7.43
Crew	28.33	14.17	9.45	7.08
Standing	23.02	17.63	16.08	19.41
Total	115.1	88.14	84.98	97.06

Source: Study Team
In actual calculation of vehicle operating costs, cost by speed is intercorporated by linear approximation.

Fig. 5.1 Vehicle Operating Costs

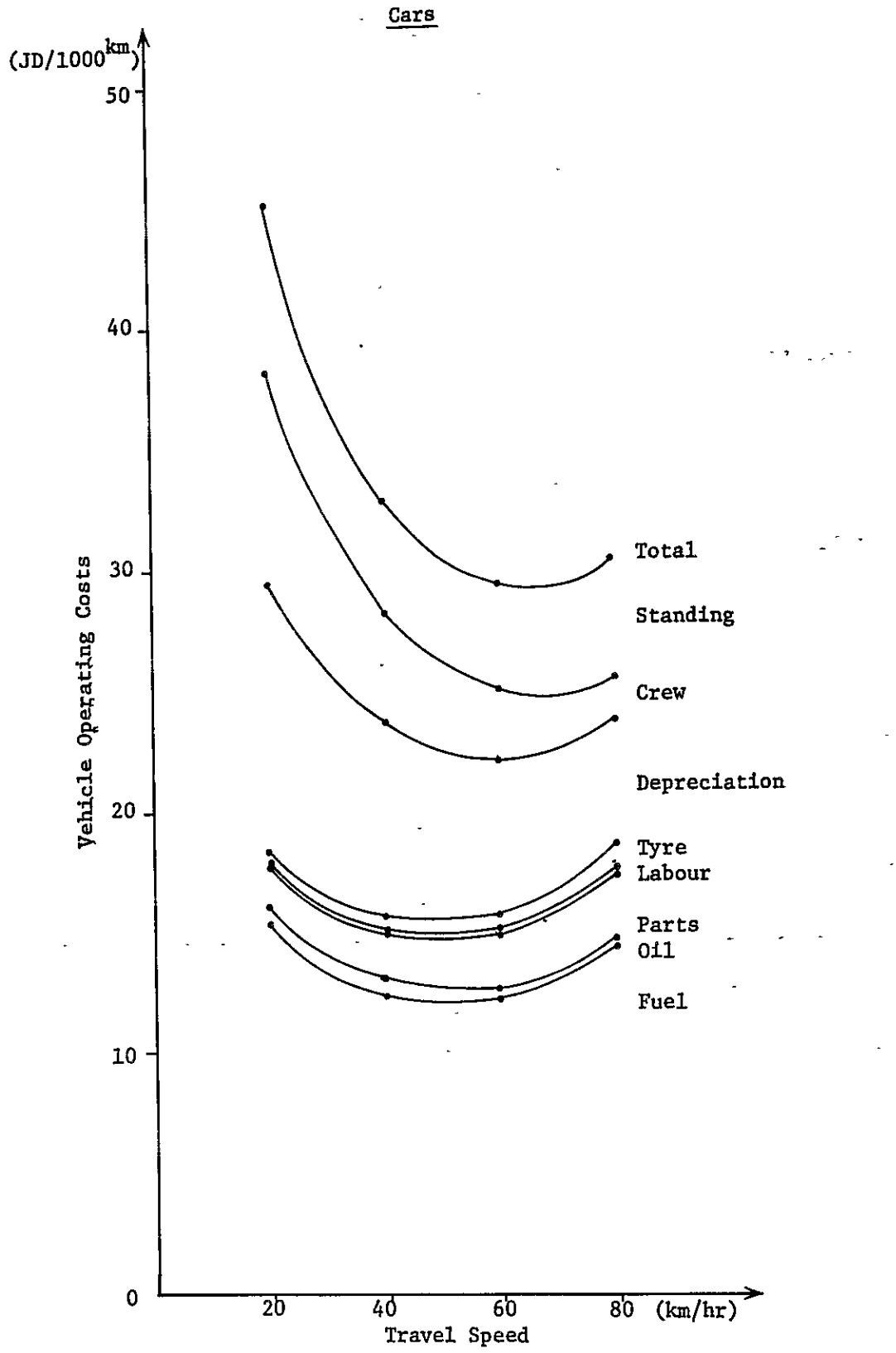
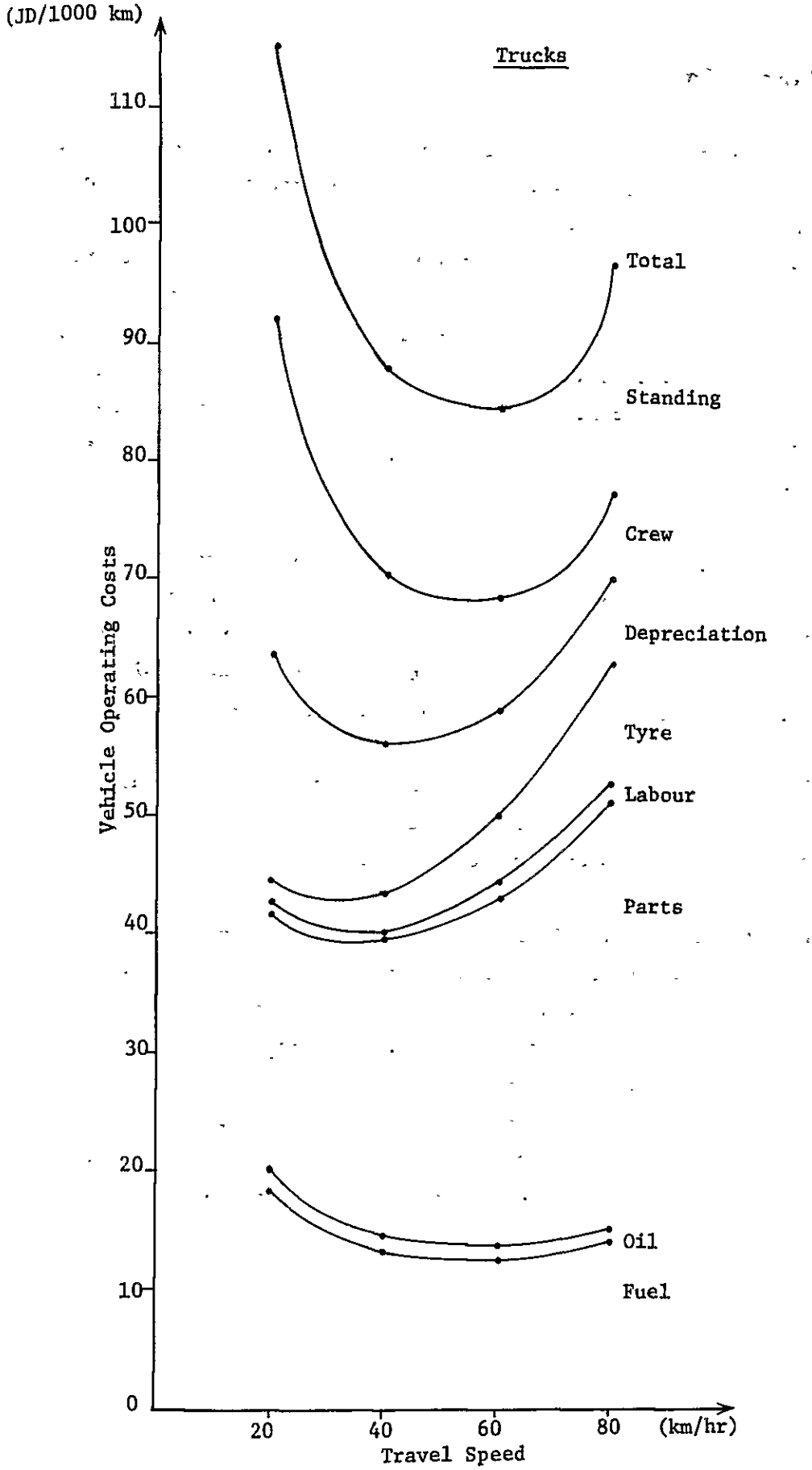


Fig. 5.2 Vehicle Operating Costs



5.2 Value of Time

This category of cost savings means the economic value which can be realized during the saved time. If the travel time is shortened, drivers and passengers may do other things - like work, leisure, etc. So the saved time has economic value. However, value depends on the circumstances. For example, even if the travel time is shortened, someone who is unemployed cannot earn anything during such saved time. In this case, it is accurate to state that the saved time has no value. Also, if the saved time concerns a non-business trip such as a social visit, the saved time may have no economical value.

In the case of a business trip, the saved time is valuable economically, because there are many chances to earn money, since the unemployment/employment ratio is little in Jordan. (For instance, the ratio was 2.13% in the East Bank, but 1.74% in Irbid Governorate in 1974, as shown in Chapter 1).

In this study, assumptions about portion of non-economical activities were made, and the value of time by each kind of vehicle was estimated as mentioned below.

For the purpose of this study and to satisfy the main objective of the work, the value of time for truck drivers and their assistants are included in the vehicle operating costs, as mentioned before. These time savings were computed by the hourly wage rates of these vehicle operators and their assistants. Meanwhile, in the case of occupants of private cars including the driver, and passengers of taxis and trucks, the value of time is estimated in the following paragraphs.

5.2.1 Passenger Cars

(1) Drivers

In this case, the problem is to estimate the car owner's annual income. The price of a private passenger car is very expensive in comparison with the average national income per capita. Therefore, the car owners must earn more than the average income.

According to the previous study (Ministry of Public Works, Feasibility Study for Zarga-Rihab-Irbid Expressway and Rihab-Syrian Border Connector, November 1979), the cost of a new private passenger car in Jordan is JD. 6,180, and the average annual income of car owners is estimated to be JD 4,500. However, recently cheaper cars are imported and it is becoming easier to own a car. Therefore, it appears reasonable to assume that the average annual income of car owners is less than JD. 4,500. In this study, it is assumed to be JD. 3,000, which is equal to about one and a half times the estimated average annual income in Jordan.

Average workers in Jordan work about 280 days a year since there are 52 weekday holidays, 18 national holidays and 14 to 20 extra holidays. They work 6 days a week and about 8 hours a day[1]. This means they work 2240 hours per year.

Therefore, the average wage rate of a driver of a private passenger car is:

$$3000 \div 2240 = 1.339 \text{ JD per hour}$$

Note : 1/ According to The Multi-Purpose Household Survey, 1976. Department of Statistics, weekly hours of work are 46.6 hour on average

Even if the travel time is shortened, the savings is in small amounts for each driver. Therefore motorists do not always value this time savings.

In this study, it is assumed that motorists value their time at 100 percent of the wage rate for travel only for official business purposes and zero percent for other trip purposes.

Since trip purposes are shown as Table 5.16, effective hourly wage rate is as follows:-

1.339 x 0.080 x 1.00 = 0.107 JD per hour.

Table 5.16 Trip Purposes

Type of Trip	Percent of Trips
To work	37.0
On Business	8.0
Return home	35.2
Shopping	7.4
Entertainment	2.7
To school	4.6
Social Visit	3.6
Others	1.5
Total	100.0

Source : Study Team

(2) Passengers

The average gross domestic product (GDP) per capita was JD. 295 in 1979. Assuming the growth rate remained ten percent for two years, GDP per capita in 1981 is estimated to be JD. 358.

The number of non-workers and the worker rate was 3.98:1[1/] in 1980. If this figure is the same in 1981, each wage earner earns about JD. 1,800 per year. Thus, the average wage rate of passengers is:

$$1{,}800 \div 2{,}240 = 0.804 \quad \text{JD. per hour}$$

The car owners interview survey that was carried out by the Study Team shows an average car occupancy of 1.52 persons as reflected in Table 5.17.

Table 5.17 Number of Passengers *

Car	0.52
Van	0.60
Medium Lorry	0.37
Heavy Lorry	0.52

* Note: These figures do not include a driver.

Note : 1/ According to the Ministry of Labour, the number of employed workers in the East Bank was 446,340 in 1980, in the same year the population was 2,225,000. Therefore, the worker ratio is computed as follows:

$$\frac{2{,}225{,}000 - 446{,}340}{446{,}340} = 3.98$$

In the previous study,[1/] approximately 70 percent of the non-drivers were male adults and the remaining 30 percent were women and children.
If the composition ratio of trip purposes is similar to the drivers of private passenger cars, effective hourly wage rate of passengers is:-

$$0.804 \times 0.52 \times 0.7 \times 0.080 \times 1.00 = 0.0234 \text{ JD per hour.}$$

In sum, effective hourly value of private passenger cars is JD 0.130 per hour.

5.2.2 Taxis

The taxi company survey carried out by the Study Team has shown that taxis carry approximately 4.5 passengers on average.

According to the previous study[1/], 80 percent of all taxi passengers were male adults and 75 percent of these were economically active.

It is assumed that the average wage rate of passengers of taxis is equal to the average annual income that is JD. 1,800 per year as estimated above and trip purposes are the same as for the car owners. The resulting total value of the travel time by taxi is:

$$1{,}800 \div 2{,}240 \times 4.5 \times 0.8 \times 0.75 \times 0.080 \times 1.00 = 0.174 \text{ JD per hour.}$$

Note : 1/ Ministry of Public Works
Feasibility Study for Zarga - Rihab - Irbid Expressway and Rihab - Syrian Border Connector
November, 1979

5.2.3 Van

The car-owners interview survey that was carried out by the Study Team has shown that the average van carries approximately 0.6 passengers. Assuming that 70 percent of the passengers are male adults and other conditions are the same as for taxi passengers, the total value of the travel time by van is:-

$$1{,}800 \div 2{,}240 \times 0.6 \times 0.7 \times 0.080 \times 1.00 = 0.027$$

JD per hour.

5.2.4 Average "CARS"

The summary of time savings of cars is shown as Table 5.18.

Table 5.18 Summary of Time Savings for Cars

	Time Savings (JD per hour)	Vehicle-km per day
Private Cars	0.130	122,914 (57.8%)
Taxis	0.174	44,621 (21.0%)
Van	0.027	45,114 (21.2%)
Average	0.117	(100%)

Source : Study Team

In the averaging, the vehicle-km for each type of car as shown in Table 5.18, which is the result of a survey, were adopted. The results of weighted mean is JD 0.117 per hour as the time savings of the average car.

5.2.5 Trucks

Trucks are operated normally by a driver and sometimes an assistant, and they do not carry passengers. Therefore, time savings of truck passengers were ignored.

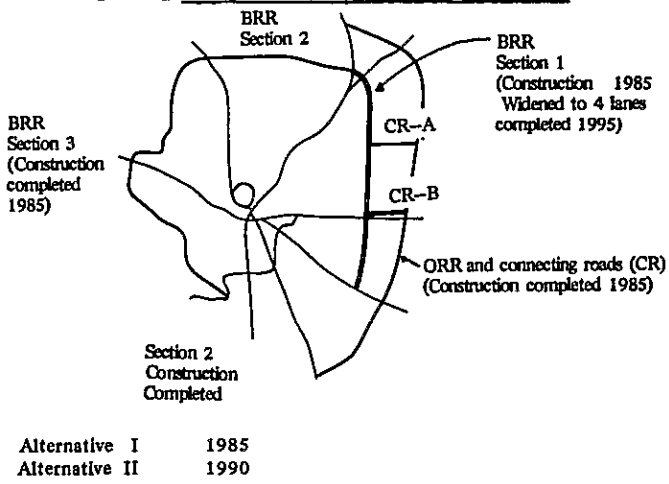
The cost of a driver and an assistant is included in the vehicle operating costs, as mentioned before.

5.3 Project Benefits

When the ring roads are completed ("with project"), vehicles will be able to travel faster, and therefore, vehicle operating costs and travel time will decrease in comparison with the do-nothing situation (ie., "without project"). Project benefits were calculated from the cost savings realized "with project".

Project benefits were calculated for two alternative cases of the ring roads project. Although the details of these two alternatives are mentioned in Chapter 11, the alternatives are briefly summarized in this section. The difference between the two alternatives lies in their construction schedule as shown in following Figure.

Fig. 5.3 Comparison of Alternatives*



* Note : All sections except BRR Section 2 are the same in both Alternatives.

In Alternative II, the northern part (Section 2) of Boundary Ring Road will be constructed by 1990, that is five years delay in comparison with Alternative I. In both alternatives, the total proposed ring roads will be constructed and open to traffic by 1995.

Traffic demand for each alternative in 1985 and 2000 were forecast as mentioned in the previous chapter.

Vehicle operating speed was calculated for each link in the traffic assignment. The vehicle operating costs by link were calculated from the relation between the cost and the speed mentioned in previous section. As the moving time by link was calculated from the speed and the distance of link, the time cost was also calculated.

The total vehicle movement (Vehicle-Km and Vehicle-hr), vehicle operating costs and time cost which were calculated are summarized in Table 5.19 for both alternatives.

Table 5.19 Vehicle Movements and Costs

	1985		2000
Without Project			
Vehicle-Km per day[1/]	1,270,840		2,760,016
Vehicle-hr per day[2/]	37,451		178,380
Operating Costs (JD per day)	64,156		150,787
Time Cost (JD per day)	4,382		20,870
With Project	Alternative I	Alternative II	
Vehicle-Km per day[1)]	1,274,338	1,270,804	2,796,587
Vehicle-hr per day[2)]	33,032	33,293	133,295
Operating Costs (JD per day)	62,692	62,699	146,758
Time Cost (JD per day)	3,865	3,895	15,595
Difference			
Vehicle-Km per day[1)]	-3,498	36	-36,571
Vehicle-hr per day[2)]	4,419	4,158	45,085
Operating Costs Saving (JD per day)	1,464	1,457	4,029
Time Cost Saving (JD per day)	517	487	5,275

Notes: 1/ Cars and Trucks

2/ Only Cars

Source: Study team

If the ring roads are constructed, vehicles which would otherwise pass through the center of the city will travel along the ring roads because vehicles can be driven faster. Therefore, Vehicle-Km in the "with project" case is more than the "without project" case in 1985 (except Alternative II, since the ring road is not fully operational until 1990). On the other hand, vehicle operating costs in the "with project" case are less than the "without project" case because vehicles can be driven faster due to the decrease of congestion in the center of the city. Vehicle operating costs become higher as the speed goes down as mentioned in previous section.

Vehicles can be driven faster in the "with project" case compared to the "without project" case; therefore, time cost is reduced by construction of the ring roads as shown in Table 5.19

Operating costs savings are estimated at about JD 1,500 per day in 1985 and JD. 4,000 per day in 2000. In addition, time savings are estimated at about JD 500 per day in 1985 and JD 5,000 per day in 2000.

If traffic during holidays (70 days) are assumed to be half of that during weekdays, operating costs savings (OCS) per day can be converted to OCS per year as follows:

Annual operating costs savings (OCS)

=(OCS per day)x (70 ÷ 2 + 295)

=(OCS per day)x 330

Time cost savings are obtained in only on working days which are estimated to be 280 days on average.

Therefore time cost savings (TCS) per day can be converted to TCS per year as follows:

(Annual TCS)=(TCS per day)x 280

Traffic demand in 1990 was extrapolated from the growth rate between 1981 and 1985, and traffic demand in 1995 by interpolation of the growth rate between 1985 and 2000.

The growth rates after the year 2000 were assumed to decrease 10 percent every 5 years.

Since the ring roads will be constructed by the end of 1985, project benefits will be obtained starting from 1986. Assuming the project life to be 25 years, the flow project benefits is estimated as shown in Table 5.20.

Total undiscounted project benefits through the project life were estimated at about JD 62 million.

Table 5.20 Project Benefit Flow (Undiscounted)

(1,000 JD in 1981 Price)

Year	Alternative I			Alternative II		
	Operating	Time	Total	Operating	Time	Total
1986	547	176	723	544	167	711
1987	618	212	830	615	202	817
1988	695	253	948	691	242	933
1989	779	300	1,079	775	288	1,063
1990	871	354	1,225	867	341	1,208
1991	923	424	1,347	(Same as Alternative I		
1992	977	504	1,481	after 1990)		
1993	1,035	596	1,631			
1994	1,096	702	1,798			
1995	1,160	824	1,984			
1996	1,382	960	2,342			
1997	1,380	1,069	2,449			
1998	1,370	1,190	2,560			
1999	1,354	1,326	2,680			
2000	1,330	1,477	2,807			
2001	1,300	1,628	2,928			
2002	1,264	1,795	3,059			
2003	1,217	1,979	3,196			
2004	1,161	2,181	3,342			
2005	1,095	2,405	3,500			
2006	1,035	2,626	3,661			
2007	966	2,868	3,834			
2008	888	3,133	4,021			
2009	798	3,423	4,221			
2010	696	3,737	4,433			
Total	25,937	36,142	62,079	25,919	36,087	62,006

Source: Study team.

According to Table 5.20, operating cost savings will decrease from 1997, although time savings will continue to increase. This is due to the difference between operating cost savings and time savings of the vehicles which pass along the ring roads. Since the vehicles which go along the ring roads must be driven a longer distance compared with the "without project" condition, the vehicle-km is bigger and more operating costs are needed. This means that the ring roads have negative operating benefits for the vehicles which use the ring roads.

On the other hand, although the vehicles which don't use the ring roads are driven the same distance in both (With and Without) condition, they are driven faster in the "with project" condition; therefore operating costs are lower than "without project" since operating cost unit decrease as speed increases.

This means that the ring roads have positive operating benefits for the vehicles which don't use the ring roads.

The growth rate of these positive benefits are bigger than negative ones by 1995. However, after 1996, the growth rate of the negative ones becomes bigger than positive benefits; therefore, total operating cost savings decrease from 1996.

Since the vehicles which use the ring roads are driven faster than the "Without project" condition, their Vehicle-hr is smaller. This means that the ring roads have positive time benefits even for the vehicles which use the ring roads.

It is clear that the ring roads also have positive time benefits for the vehicles which don't use the ring roads by reducing congestion. Therefore time savings increase throughout the project.