CHAPTER 6 TRAFFIC DEMAND FORECAST

6.1 General

6.1.1 Outline

For the purpose of formulation of the road development plan and economic evaluation of the Project Road, future traffic demand was forecasted. The process for the forecast is illustrated in Fig. 6.1. Future traffic demand is forecasted for the years of 1995 and 2000.

6.1.2 Definition of Traffic Type

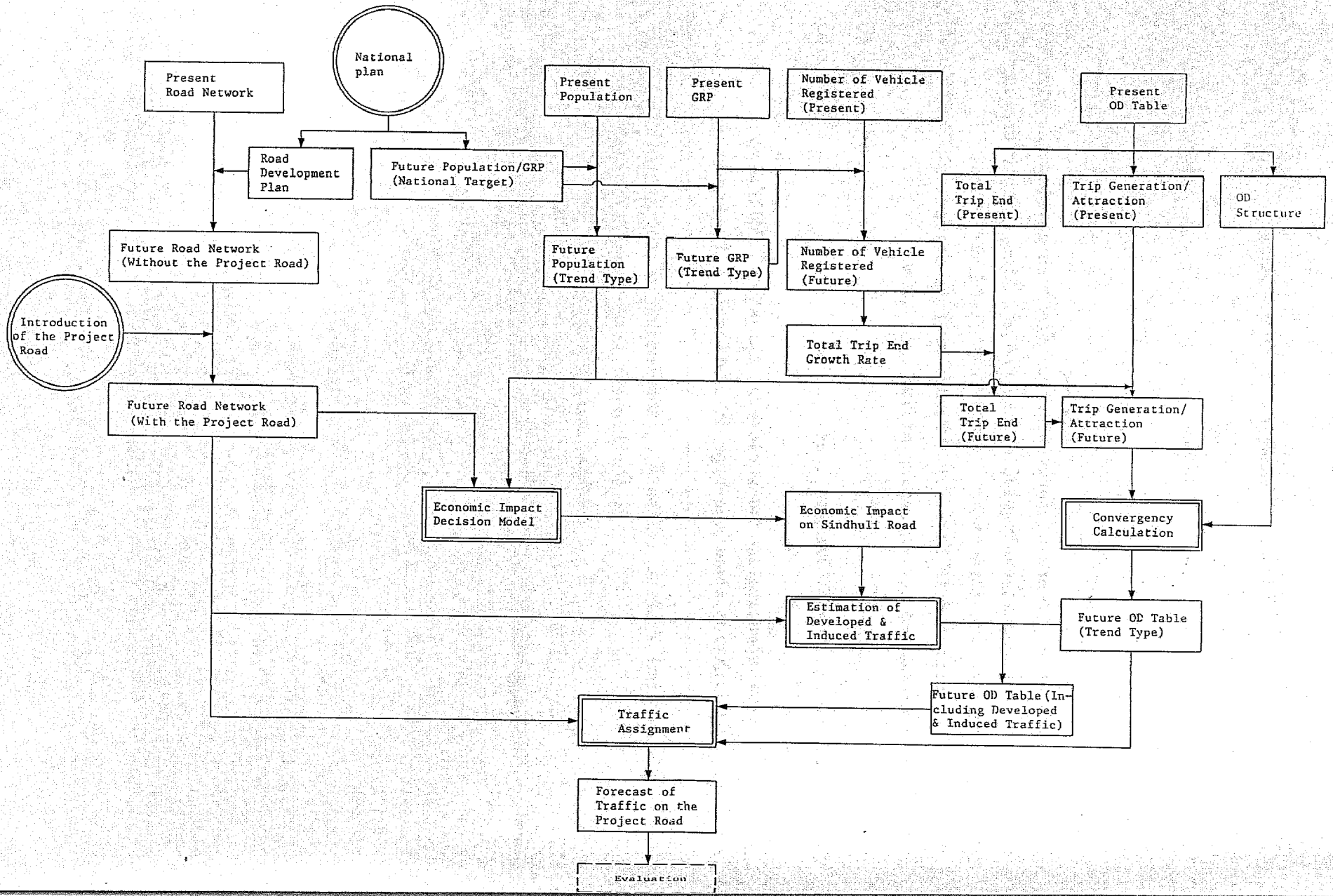
Corresponding to the purpose of the study, following definition about the type of traffic is introduced:

Normal Traffic : Traffic, independent of the introduction of the Project Road, mainly decided by natural increase in population, income and natural level-up of regional economic activities.

Developed & Induced Traffic : Traffic increase as the result of socio-economic level-up due to the innovation in transportation system.

The above classification is to play a quite important role in the evaluation of the Project Road, especially in the estimation of economic benefit from the Project Road.

Fig. 6.1 Procedure for Future Traffic Demand Forecast



6.2 Future Road Network as the Base of Traffic Forecast

Road networks in 1995 and 2000 were established on the basis of road development plan in the Seventh Five Year Plan (1985-90) and through consultation with the DOR.

Most of the road development plans in the study area are based more on the maintenance of existing roads rather than construction of new ones, except for Jiri-Ramechhap road which HMG/N has decided to construct by the year of 1995. Jiri-Ramechhap road is planned to connect with the Project Road near the village of Khurkot and expected to shorten the travel time between Jiri & Ramechhap regions and the Eastern Terai drastically.

From the above, future road network established here is assumed to be composed of following roads;

- The Project Road
- Jiri-Ramechhap road
- Ramechhap-Khurkot access
- Improved existing roads of present

6.3 Future Economic Frame

6.3.1 Basic Concept

For the different handlings of normal traffic and developed & induced traffic in the future traffic, two types of economic frames viz. Trend Type Economic Frame and Impact Type Economic Frame, were introduced as below:

Trend Type Economic Frame; Future economic frame based on the trend of the past and national target envisioned in the Seventh Plan; in which socio-economic impacts which would

be brought about by the Project Road, are not taken into account.

Impact Type Economic Frame; Future economic frame, in which the possible economic impacts by the Project Road are taken into account.

As a matter of fact, the level of future normal traffic is corresponding to the trend type economic frame, while the impact type economic frame comes up with developed & induced traffic attributed to the Project Road.

The relation between the above two economic frames is illustrated in Fig. 6.2.

6.3.2 Trend Type Economic Frame

First of all, future region-wise population and GRP were forecasted based on the trend of the past and national target set force by the Seventh Plan as shown in Table 6.1. Traffic zone-wise population and GRP were obtained by dividing the above regional total in accordance with the size of each zone's tentative future values of population and/or GRP, which were obtained simply by the trend of the past.

6.3.3 Impact Type Economic Frame

(1) General

It is expected that the Project Road would bring about considerable economic impacts on its direct passing areas and surroundings. These impacts are usually incapable of being traced by the trend of the past. In general, these impacts are defined into two parts as below;

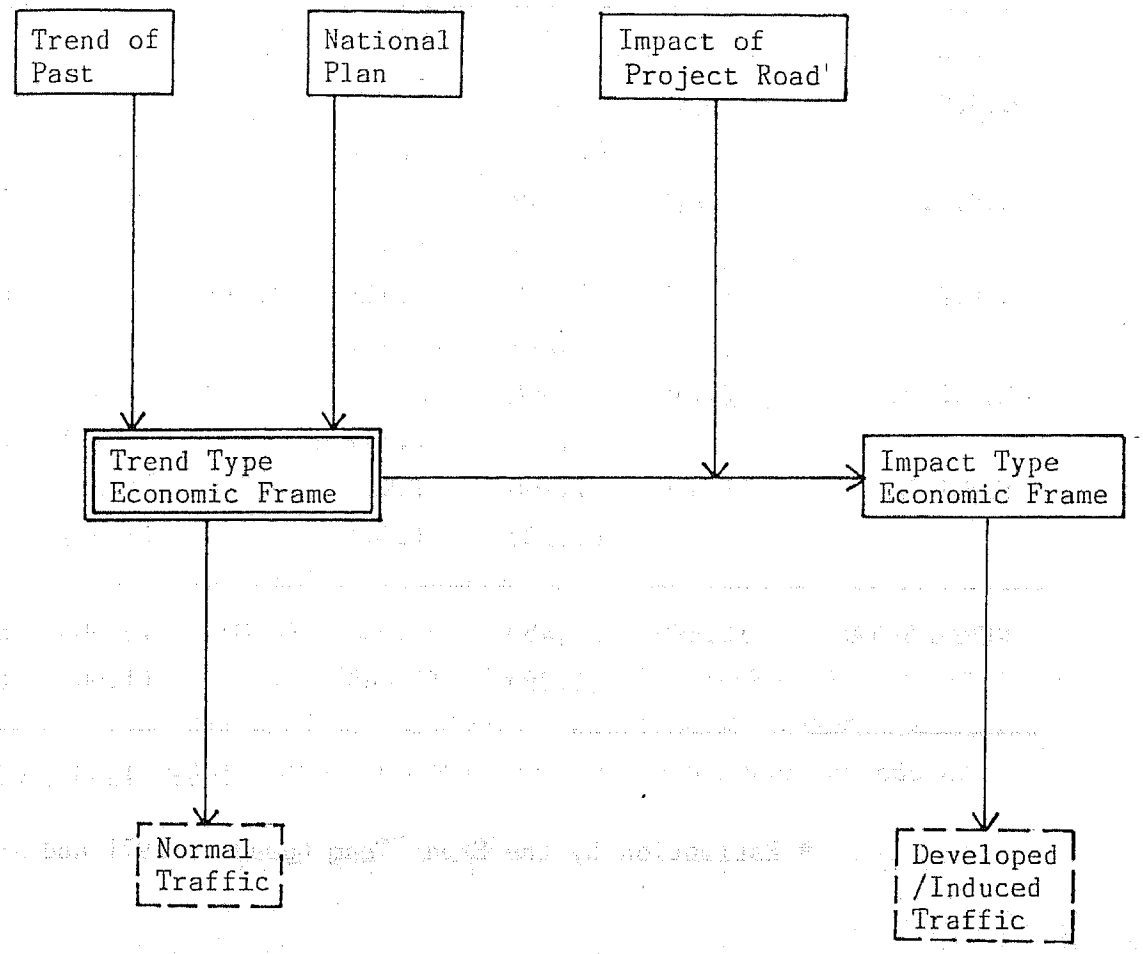


Fig. 6.2 Relation between Trend Type Economic Frame and Impact Type Economic Frame

Table 6.1 Future Population and GRP (Trend Type)

Development Region	Population (In thousand)			GRP (1985 price) (In million NRs.)		
	1985*	1995	2000	1985*	1995	2000
C.D.R.	5,433	6,879	7,631	17,878	28,145	34,725
		(1.27)	(1.40)		(1.57)	(1.94)
E.D.R.	4,211	5,699	6,549	11,068	18,619	23,799
		(1.35)	(1.56)		(1.68)	(2.15)
W.D.R.	3,463	4,413	4,932	7,618	12,069	15,002
		(1.27)	(1.42)		(1.58)	(1.97)
M.W.D.R.	2,149	2,696	2,993	4,699	7,328	9,048
		(1.25)	(1.39)		(1.56)	(1.93)
F.W.D.R.	1,440	1,766	1,933	2,770	4,222	5,140
		(1.23)	(1.34)		(1.52)	(1.86)
NEPAL TOTAL	16,696	21,453	24,038	44,033	70,383	87,714
		(1.28)	(1.44)		(1.60)	(1.99)

( ): 1995 (2000)/1985

* Estimation by the Study Team based on 1971 and 1981 data

(a) Development Effect: Effects upon socio-economic activities which are attributed to structural change of regional economy due to newly constructed road.

(b) Induced Effect : This is an effect on human behaviours which is caused by the changes in inter-regional accessibility.

For the purpose of quantitative expression of these effects, an econometric model was developed here. Details of the model are explained below:

(2) Explanation of the model

Assuming that population and accessibility are two of the factors which determine the level of regional economic activities, following type of model was introduced.

$$Ei = \alpha Pi^{\beta} \cdot Ai^{\gamma}$$

where,

Ei: i zone's GRP (in million NRs.)

Pi: i zone's population (in thousand)

Ai: i zone's accessibility, defined by

$Ai = \frac{1}{\sum_j tij}$, where tij denotes required travel time from zone i to zone j by road (in munute)

α, β, γ : Parameters

The parameters and correlation cofficient of the above model were estimated as below:

α	β	γ	Correlation Coefficient
21.501	0.876	0.217	0.993

Applying future zonal accessibility (Ai) to the above equation under the given level of zone-wise future population (Pi), future zone-wise GRP corresponding to the future road network was obtianed. Tij, used for the above estimation is listed in Appendix 6.4.2.

(3) Amount of Impact Estimated as the Balance of Two Economic Frames

Zone-wise GRP for the years of 1995 and 2000 are shown in Table 6.2 and 6.3. The Project Road is expected to bring about additional 1.3 and 1.6 biillion NRs. to the economy of the Study Area in 1995 and 2000 respectively. Such zones as Ramechhap and Sindhuli, which are located along and nearby the Project Road, are apt to receive more economic impact.

Table 6.2 Zone-wise GRP in 1995 and Amount of Economic Impact by the Project Road

(Unit: million NRs. in 1985 price)

Traffic Zone No.	Name of Traffic Zone	Impact Type (1)	Trend Type (2)	Amount of Impact (1)-(2)
1	Mahottari	1,988	1,923	65
2	Dhanusha	2,587	2,492	95
3	Sindhuli	1,107	1,015	92
4	Ramechhap	834	724	110
5	Dolakha	803	777	26
6	Sarlahi	3,424	3,380	44
7	Kabhrepalanchok	1,780	1,706	74
8	Kathmandu	2,364	2,271	93
9	Bhaktapur	1,060	1,011	49
10	Lalitpur	1,031	990	41
11	Sindhupalchok	1,225	1,170	55
12	Nunakot/Rasuwa	1,311	1,272	39
13	Dhading	1,123	1,101	22
14	Makawanpur	1,585	1,571	14
15	Rauthat/Bara/Parsa	5,195	5,159	36
16	Chitwan	1,596	1,583	13
	C.D.R. Total	29,013	28,145	868
17	Mechi	5,367	5,247	120
18	Koshi	7,340	7,182	158
19	Sagarmatha	6,376	6,190	186
	E.D.R. Total	19,083	18,619	464
	Study Area Total	48,096	46,764	1,332

Table 6.3 Zone-wise GRP in 2000 and Amount of Economic Impact by the Project Road

(Unit: million NRs. in 1985 price)

Traffic Zone No.	Name of Traffic Zone	Impact Type (1)	Trend Type (2)	Amount of Impact (1)-(2)
1	Mahottari	2,378	2,302	76
2	Dhanusha	3,198	3,081	117
3	Sindhuli	1,355	1,242	113
4	Ramechhap	964	837	127
5	Dolakha	964	933	31
6	Sarlahi	4,573	4,514	59
7	Kabhrepalanchok	2,179	2,089	90
8	Kathmandu	2,861	2,748	113
9	Bhaktapur	1,340	1,279	61
10	Lalitpur	1,246	1,197	49
11	Sindhupalchok	1,457	1,392	65
12	Nuwakot/Rasuwa	1,600	1,552	48
13	Dhading	1,295	1,270	25
14	Makawanpur	2,016	1,998	18
15	Rauthat/Bara/Parsa	6,346	6,302	44
16	Chitwan	2,005	1,989	16
	C.D.R. Total	35,777	34,725	1,052
17	Mechi	7,041	6,883	158
18	Koshi	9,396	9,194	202
19	Sagarmatha	7,954	7,722	232
	E.D.R. Total	24,391	23,799	592
	Study Area Total	60,168	58,524	1,644

6.4 Forecast of Future OD Traffic

6.4.1 Procedure

For the different handlings of normal traffic and developed & induced traffic, two types of OD table, viz. trend type OD table and impact type OD table were prepared as explained below:

Trend Type OD Table : Future inter-zonal traffic volume which corresponds to trend type economic frame, independent of impact from the Project Road, consisting solely of "normal traffic".

Impact Type OD Table: Future level of traffic which corresponds to impact type economic frame, including both normal and developed & induced traffic.

From the technical reasons, impact type OD table was obtained through the modification of trend type OD table, which was established based on direct information of trend type economic frame.

6.4.2 Trend Type OD Table

(1) Total Trip-End Growth

(a) Number of vehicle registered

Statistics about car-ownership is very limited in Nepal. Only rough estimates of registered vehicle on national level are available. Accoridng to it, total number of vehicles registered in 1976 and 1981 are

estimated at some 12,000 and 24,000 respectively. This fact implys that during this period the number of vehicles has become double. Annual rate of growth during this period was some 16%, which was far greater than that of GDP in Nepal.*1) It is one of the characteristics in recent Nepal that the growth rate of heavy vehicle is extremely high. The detail are shown in Table 6.4.

Table 6.4 Number of Vehicle Registered in Nepal

	1976	1977	1978	1979	1980	1981	Annual Growth Rate (% (1976-8
Passenger car and jeep	7,765	8,268	9,059	9,613	10,534	11,342	7.9
Truck	3,314	3,615	4,915	6,726	8,353	10,267	25.7
Bus	923	1,084	1,460	1,750	2,16	2,395	21.0
Total	12,002	12,967	15,434	18,089	21,056	24,004	14.9

Source: Department of Roads, 19

(2) Forecast of Total Trip-Ends*2)

Future total trip-ends (right-bottom corner of OD table) was forecasted by the regression model built up on the relationship between the number of vehicle registered and level of GDP. Regression model applied here has following structure;

(Passenger car & Motorcycle)

$V_1 = -11.262 + 558.2G$ $(R = 0.946)$*2)

(Truck)

$V_2 = -28.902 + 951.5G$ $(R = 0.922)$

*1) The growth rate of GDP in this period was about 3.3%.

*2) R denotes correlation coefficient.

(Bus)

$V_3 = -6.921 + 231.1G$ (R = 0.956)

Where,

V_1, V_2, V_3: Number of vehicles
G: GDP

The levels of total trip-ends in 1995 for the trend type economic frame were forecasted by vehicle type as shown in Table 6.5, under the assumed GDP growth rate of 4.5% by the Seventh Plan.

Table 6.5 Future Level of Total Trip-Ends (Trend Type OD Table)

	1995/1987 ratio	Annual Growth Rate (%) (1987-1995*)
Passenger Car & Motorcycle	1.85	8.0
Truck	2.36	11.3
Bus	2.32	11.1

* Same growth rates were being asumed for the forecast of total trip-ends in 2000.

(3) Forecast of Generated & Attracted Traffic

For the purpose of obtaining zone-wise generated & attracted traffic, a method which consists of following steps was applied;

Step 1

First of all, the tentative volumes of each zone's generated and attracted traffic were calculated, applying zone-wise GRP growth rates to the present values of zone-wise generated & attracted traffic.

Step 2

Secondly the tentative values calcualted in the first step were adjusted proportionally so that both the sums of generated and attracted traffic could become equal to the number of total trip-ends determined by the methodology explained in (2) of this section.

(4) Forecast of Trend Type OD Table

Future OD table, corresponding to trend type economic frame, was obtained applying the "present pattern method", by which every component of present OD table was modified through the convergency calculation (Frater Method) so that each row-sum and column-sum of the components could become equal to the values of zone-wise generated and attracted traffic, determined by the methodology explained in (3) of this Section. Trend type OD tables for the years of 1995 and 2000 are listed in appendix 6.4.1.

6.4.3 Impact Type OD Table

In order to estimate volume and OD pattern of developed & induced traffic, another type of OD table, namely impact type OD table, was introduced. The impact type OD table was obtained applying the specially developed conversion factors to each of the components of trend type OD table.

(1) Conversion Factor

Regarding the zone-wise GRP forecasted in Section 6.3 and inter-regional accessibility as two of the explanatory variables for Gravity Model, conversion factors here were defined as below:

$$\varphi_{ij} = \frac{I_{Tij}}{N_{Tij}}$$

$$I_{Tij} = \alpha \frac{(I_{Ei} \cdot I_{Ej})^{\beta}}{(I_{Dij})^{\gamma}}$$

$$N_{Tij} = \alpha \frac{(N_{Ei} \cdot N_{Ej})^{\beta}}{(NDij)^{\gamma}}$$

Where,

φ_{ij} : Conversion Factor

I_{Tij} : Theoretical traffic volume from zone i to j calculated by Gravity Model, under impact type economic frame and travel time on the network "with" the Project Road.

N_{Tij} : Theoretical traffic volume from zone i to j calculated by Gravity Model, under trend type economic frame and travel time on the network "without" the Project Road.

I_{Ei} (I_{Ej}): i (j) zone's size of GRP under impact type economic frame

N_{Ei} (N_{Ej}) : i (j) zone's size of GRP under trend type economic frame

I_{Dij} : Travel distance from zone i to j on the network "with" the Project Road

N_{Dij} : Travel distance from zone i to j on the network "without" the Project Road

α, β, γ : Parameters

The parameters and correlation coefficient in the above Gravity Model were estimated as below:

α	β	γ	R*
0.0097	0.9311	1.1700	0.643

* R denotes correlation coefficient

(2) Forecast of Impact Type OD Table

Impact type OD table was forecasted along the following steps:

Step 1: To estimate future values of ϑij (conversion factor) applying future information about zone-wise GRP and travel time

Step 2: To multiply each component in trend type OD table by corresponding ϑij estimated in Step 1.

Travel time used for the above steps and impact type OD tables obtained here are listed in Appendix 6.4.1 and 6.4.2 respectively.

(3) Estimation of Developed & Induced Traffic

From the above two types of OD table, developed & induced traffic was estimated as the balance of them. Total volume of developed & induced trafic is listed in Table 6.7.

6.4.4 Transferred Traffic to Jaleswor Border Customs

With the introduction of the Project Road, cargoes handled at Jaleswor Border Customs are expected to increase due to the better road accessibility realized, especially for the traffic between India and Kathmandu Valley. It is expected that these increase would be realized in the form of transfer of cargo handlings from Birganj Border Customs, which, at present, is the most dominant border customs for the cargoes between the Kathmandu Valley and India.

For the purpose of forecasting these amounts of transfer, following, "cargo-handling share decision model" was introduced:

$$RB = \alpha \left(\frac{Tjk}{Tbk}\right) \qquad RJ = 1 - RB$$

RB : Birganj's share in the total cargoes transported between the Kathmandu Valley and India, via either Birganj or Jaleswor Customs.

RJ : Jaleswor's share in the total cargoes transported between the Kathmandu Valley and India, via either Birganj or Jaleswor Customs.

Tjk: Travel distance from Jaleswor to Kathmandu (in minute)

Tbk: Travel distance from Birganj to Kathmandu (in minute)

α : Parameter

α is estimated as 0.550 based on the present shares of cargo-handlings for each of the above Border Customs and

present travel-times to Kathmandu from these Border Customs, which are shown in Table 6.6 (1).

Future shares of cargo-handlings for each of the Border Customs are listed in Table 6.6 (2).

Table 6.6 (1) Shares of Cargoes Handled* at Jaleswor and Birganj Border Customs (1986)

Name of Border Customs	Share (%)	Distance to Kathmandu (in minutes)
Jaleswor	23	573
Birganj	77	413
Total	100	-

Source: Facilities at Nepal/Indian Border Customs Point: M.R Shakya, 1980

Table 6.6 (2) Shares of Cargoes handled at Jaleswor and Birganj Border Customs (With the Project Road)

Name of Border Customs	Share (%)	Distance to Kathmandu (in minutes)
Jaleswor	52	311
Birganj	48	358
Total	100	-

Correnspondingtraffic volume was obtained as shown in Table 6.10, applying above shares to the related future traffic volume.

6.5 Traffic Assignment

6.5.1 General

Traffic assignment is a procedure of assigning future OD table to the highway network. Hence this procedure requires, as input, the complete description of future highway network and future OD table. Future traffic volume on various sections of roads in the study area can be forecasted as the result of traffic assignment.

The assignment method applied here is what is called "all-or-nothing method" in which all the vehicles for certain pair of OD were assigned to the shortest route among the possible alternatives of route.

The reason why this method was applied came from following characteristics in highway traffic in the Study Area:

- Traffic volumes on most of the highway are far below the level of capacity.

- The road network in this study is rather simple due to low density of road in this country.

Total flow of traffic assignment is shown in Fig. 6.3.

6.5.2 Preparatory Works

(1) Preparation of Network Data

Future highway network studied in section 2 of this Chapter was transformed into link data which contain all the information about physical conditions of road sections, e.g. length, number of lanes and surface condition. The

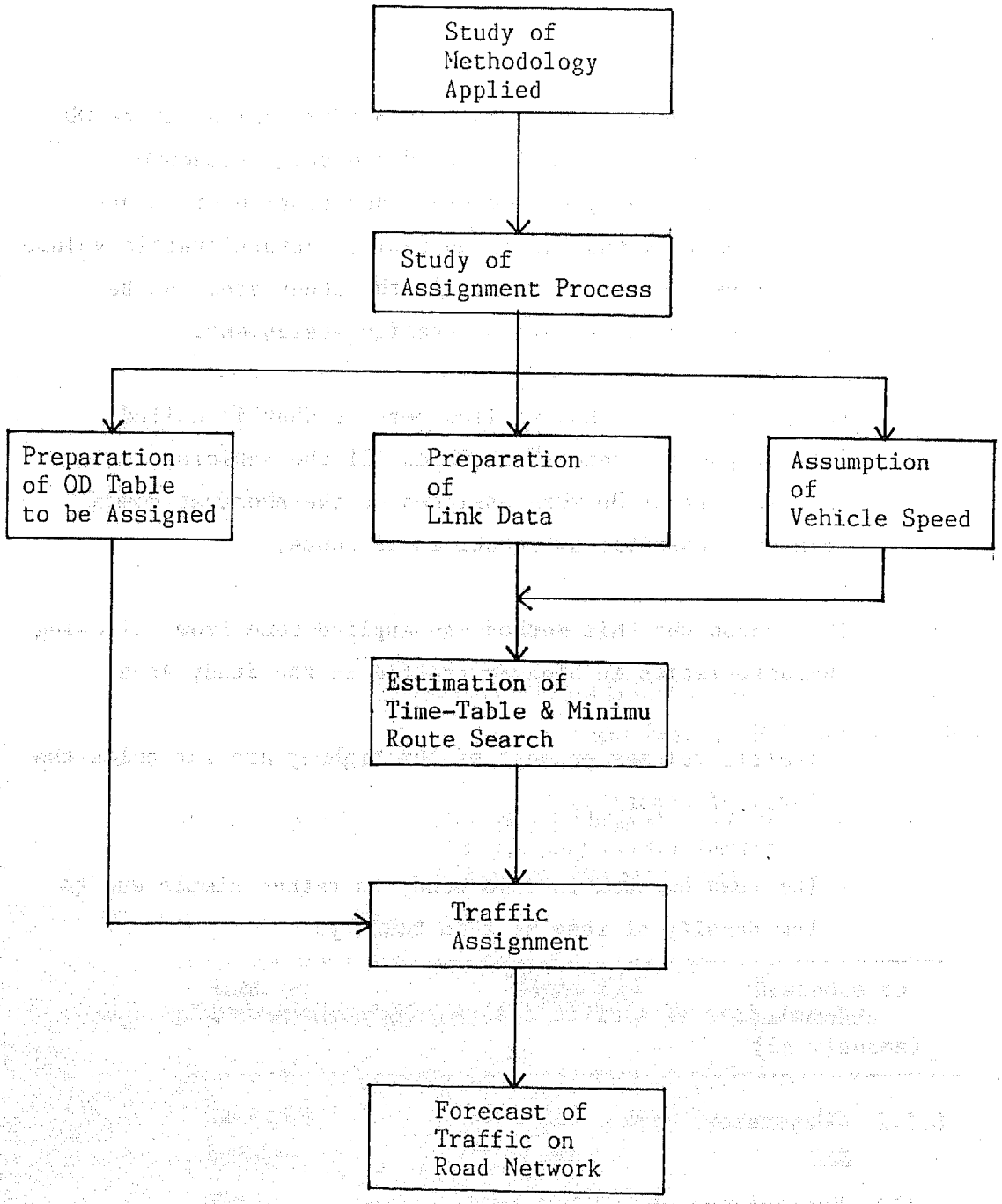


Fig. 6.3 Procedure of Traffic Assignment

total number of links set up in this study is 39 including those links outside the study area. The map of network for assignment established here is shown in Appendix 6.5.1.

(2) Vehicle Speed

Speed levels by vehicle type are sole parameter in the case of assignment of all-or-nothing method. Vehicle speeds by various physical conditions of road established in the Vehicle Running Survey were applied for this purpose (Refer to 5.3).

(3) Assignment Process

For the purpose of obtaining future traffic volume on the Project Road by vehicle type and by traffic type, OD tables by vehicle type (motor-cycle, passenger car, bus and truck) and by traffic type (normal traffic and developed & induced traffic) were assigned on each of the road networks of 1995 and 2000 respectively.

6.6 Result

From the result of forecast following characteristics in future traffic could be pointed out:

(1) Normal traffic

Total trip-ends of normal traffic in 1995 will be about 11900, which is about 2.1 times as large traffic volume as present. Annual traffic growth up to the year 1995 is averagely about 10% as shown in Table 6.7.

(2) Developed & Induced traffic

The number of developed & induced traffic amounts to about 1300 in 1995 as shown in Table 6.7. The shares of these traffic are greater in the direct passing areas of the Project Road and their surroundings.

(3) Vehicle type

The composition of vehicle type in 1995 is shown in Table 6.8. The shares of bus and truck in 1995 will increase to 40% and 37% respectively from the corresponding levels of 39% and 33% at present. On the other hand, the share of passenger car will decrease to 17% in 1995 from 21% of present.

(4) OD pattern

Due to the new generation of developed & induced traffic, traffic interdependence among the regions within the study area would be strengthened. Especially, in such OD pairs as the Kathmandu Valley - Eastern Terai, the Kathmandu Valley - Hilly area in C.D.R. and the Kathmandu Valley - E.D.R., relatively large traffic volume will be seen. The number of traffic of these OD pairs in 1995 are forecasted at 415, 1325

and 314 respectively as shown in Fig. 6.4 and 6.5. These are 2.2, 2.3, and 2.7 times as large as those of 1986 respectively.

(5) Transferred Traffic to Jaleswor Border Customs

The number of traffic between India and the Kathmandu Valley in 1995 is forecasted at 240, in which 124 vehicles, or 52% of the total, have either origin on destination at Jaleswor Border Customs as shown in Table 6.9.

(6) Assigned traffic

The forecasted traffic volumes on section I and II of the Project Road are 830 and 735 in 1995 and 1242 and 1114 in 2000 respectively as shown in Fig. 6.6, 6.7 and 6.8. In terms of PCU the above traffic volumes are equivalent to 2146 and 1924 passenger cars respectively as shown in Fig. 6.9. The share of truck is about 43% for both sections. As long as section I is concerned about 300 vehicles are developed & induced traffic, which accounts for some 40% of the total traffic volume on this section as shown in Table 6.10.

Table 6.7 Future Traffic Volume

(Unit: vehicle/day)

Traffic Type	1986	1995	2000
Normal	5,540	11,876 (0.088)	16,730 (0.082)
Developed and Induced	-	1,305 (-)	1,935 (-)
Total	5,540	13,181 (0.101)	18,663 (0.091)

( ): Average annual growth rate

Table 6.8 Vehicle Composition

(Unit: Percents)

Vehicle Type	1986	1995
Passenger Car	21.3	17.0
Bus	32.9	37.0
Truck	38.9	40.3
Motorcycle	6.9	5.7
Total	100.0	100.0

Table 6.9 Traffic between India and the Kathmandu Valley

(Unit: Vehicle/day)

Places	1995	2000
By Way of Jaleswor	124	177
By Way of Birganj	116	166
Total	240	343

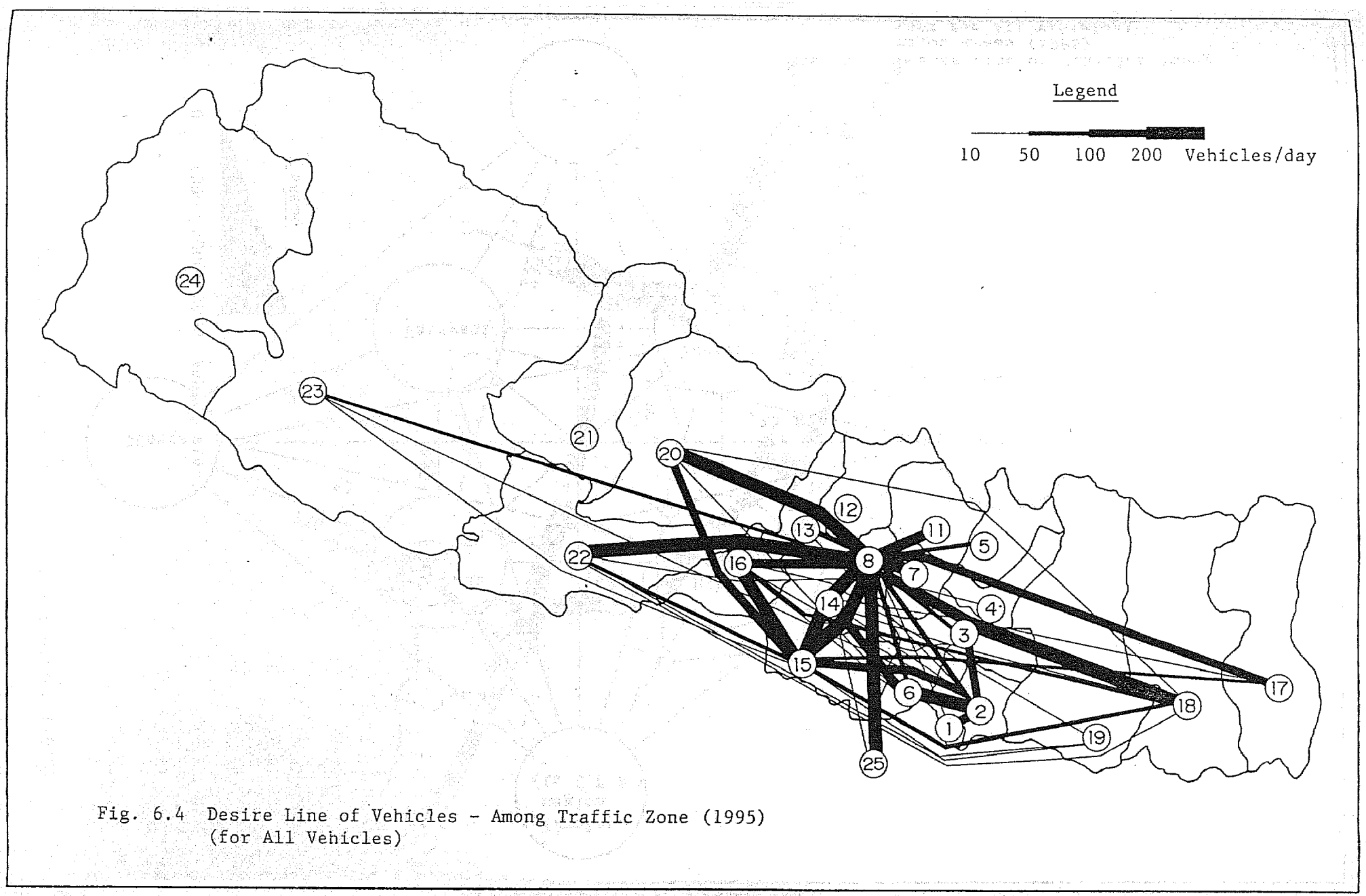
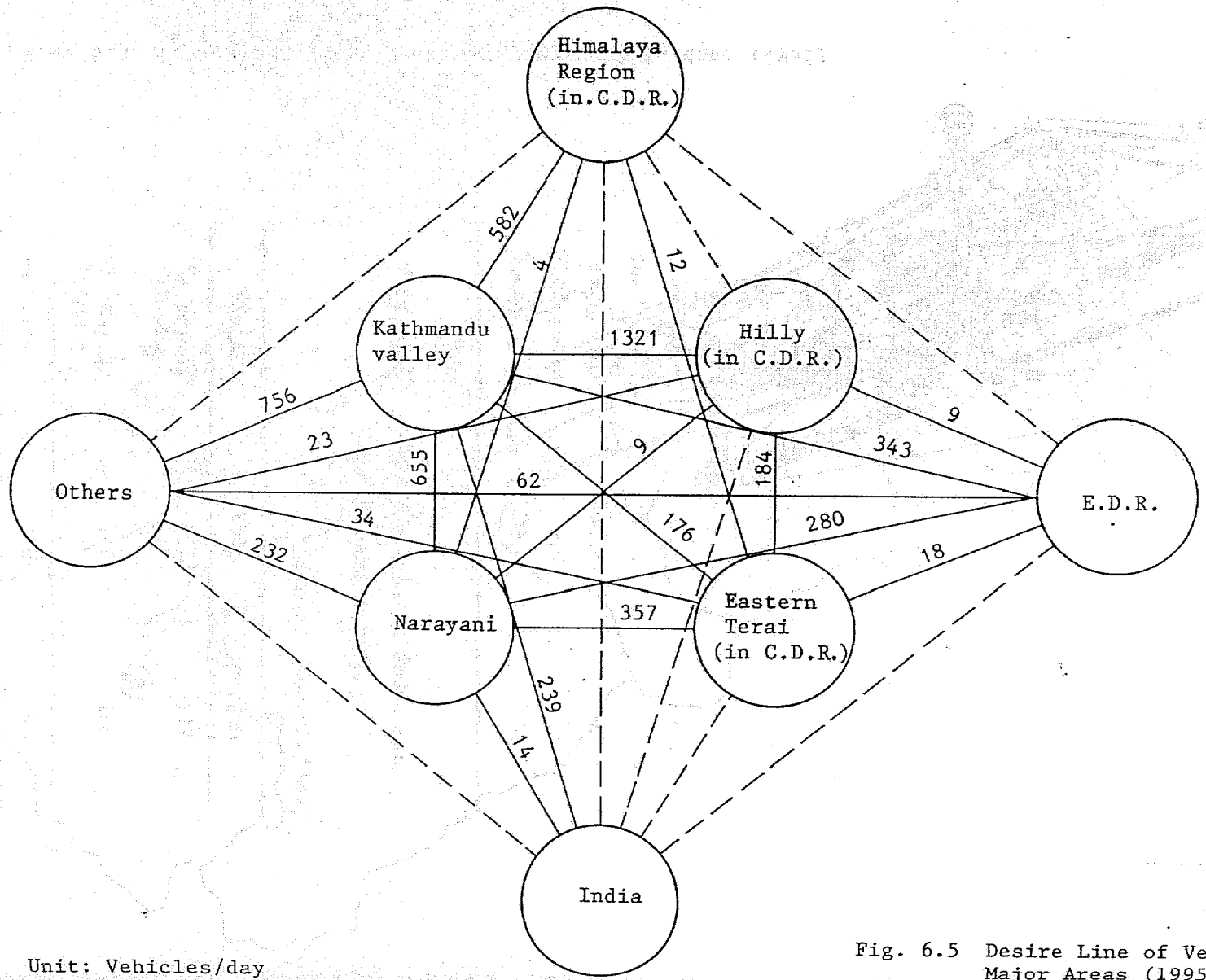


Fig. 6.4 Desire Line of Vehicles - Among Traffic Zone (1995)
(for All Vehicles)



Unit: Vehicles/day

Fig. 6.5 Desire Line of Vehicles Among Major Areas (1995)
(ADT for All Vehicles)

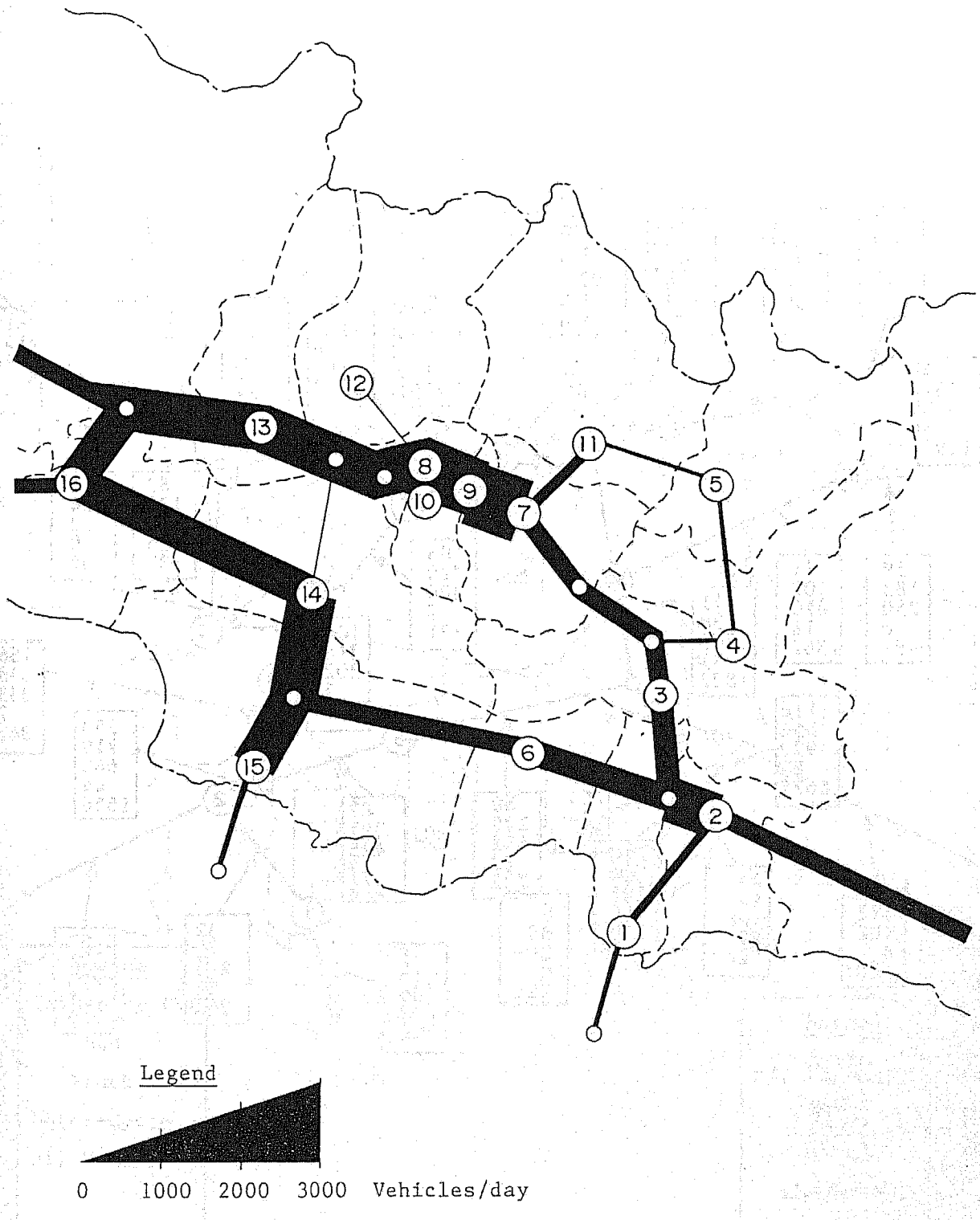


Fig. 6.6 Assigned Traffic of All Vehicles (1995)

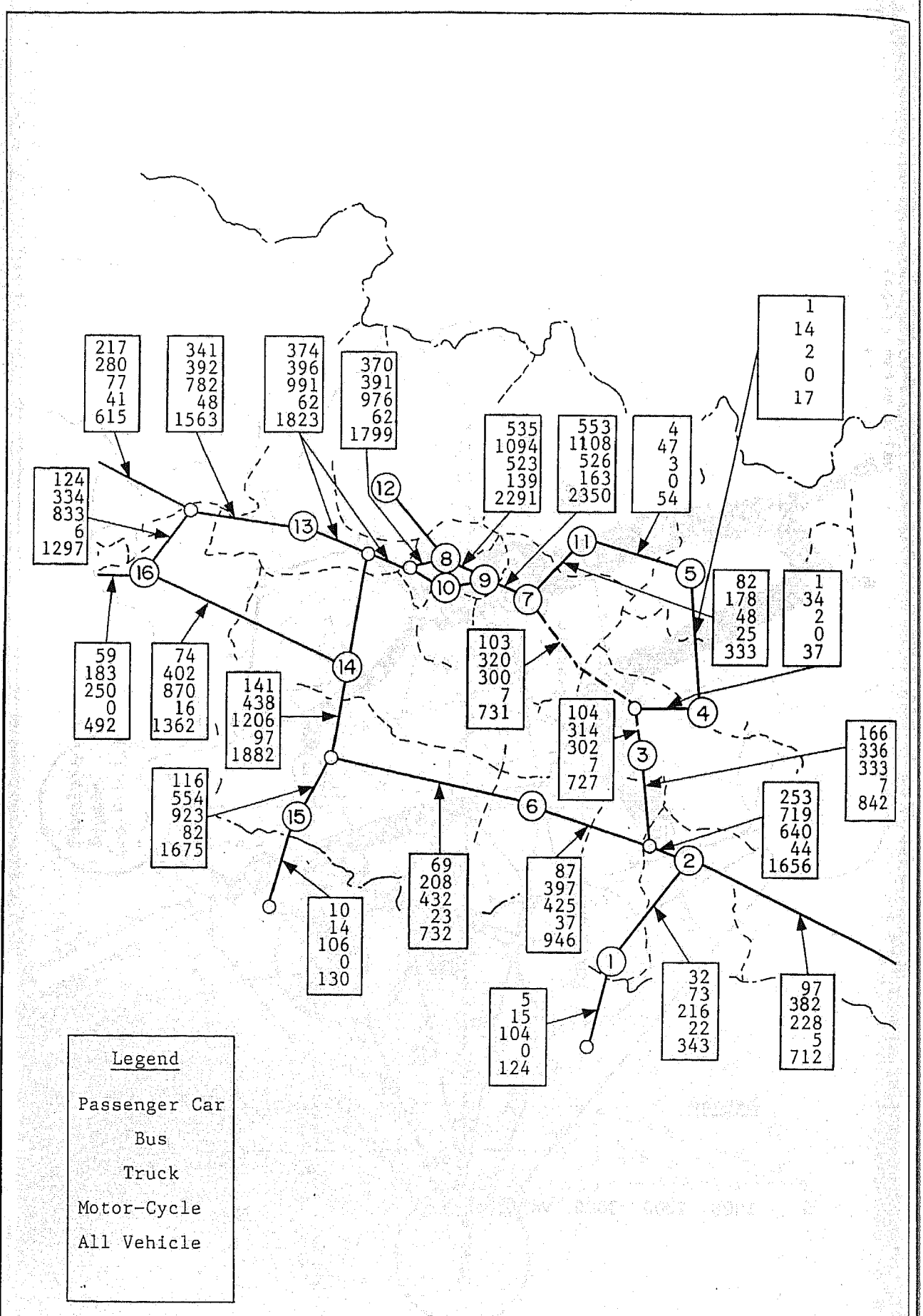


Fig. 6.7 Assigned Traffic (1995)

Unit: Vehicle/day

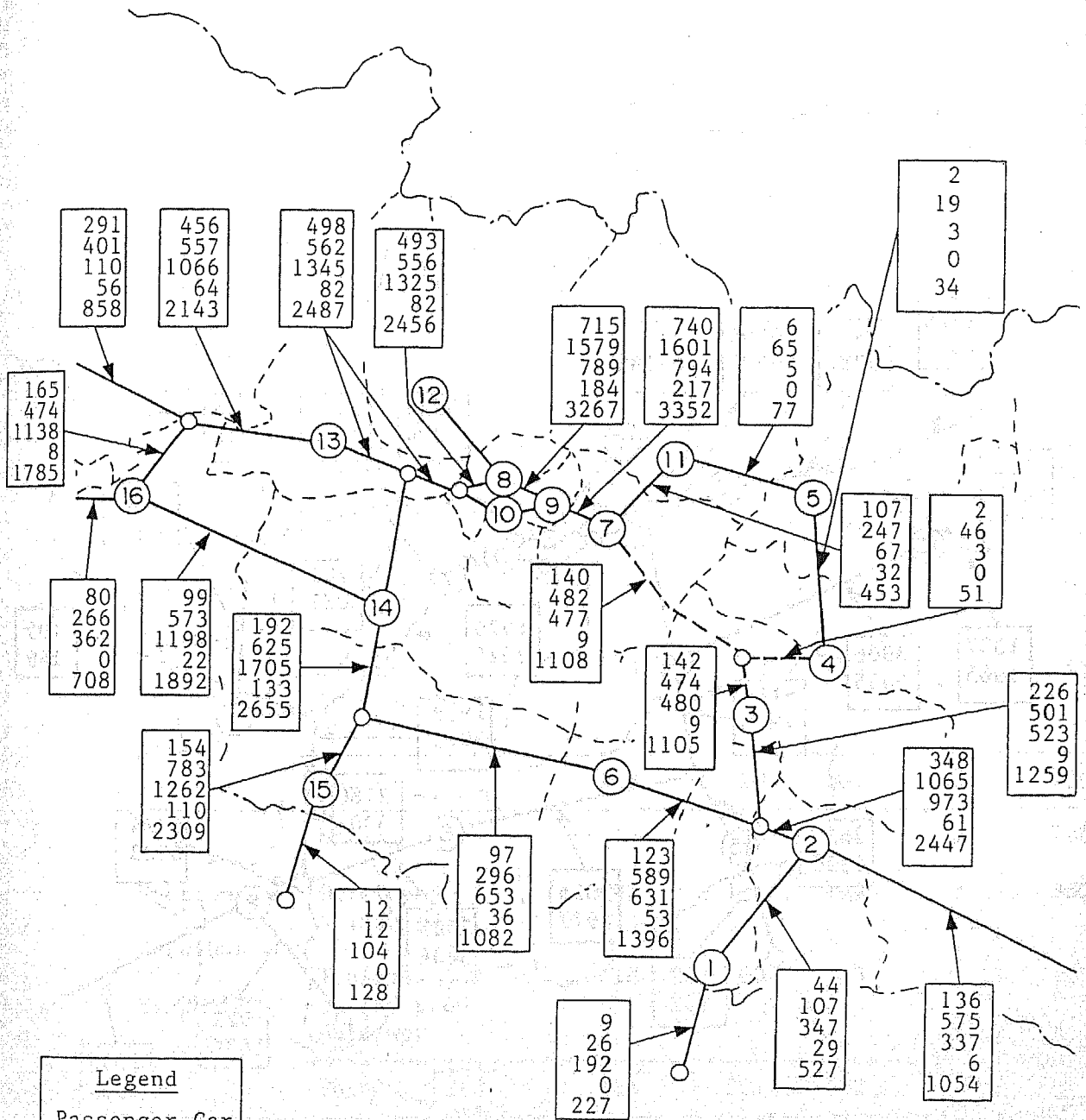


Fig. 6.8 Assigned Traffic (2000)

Unit: Vehicle/day

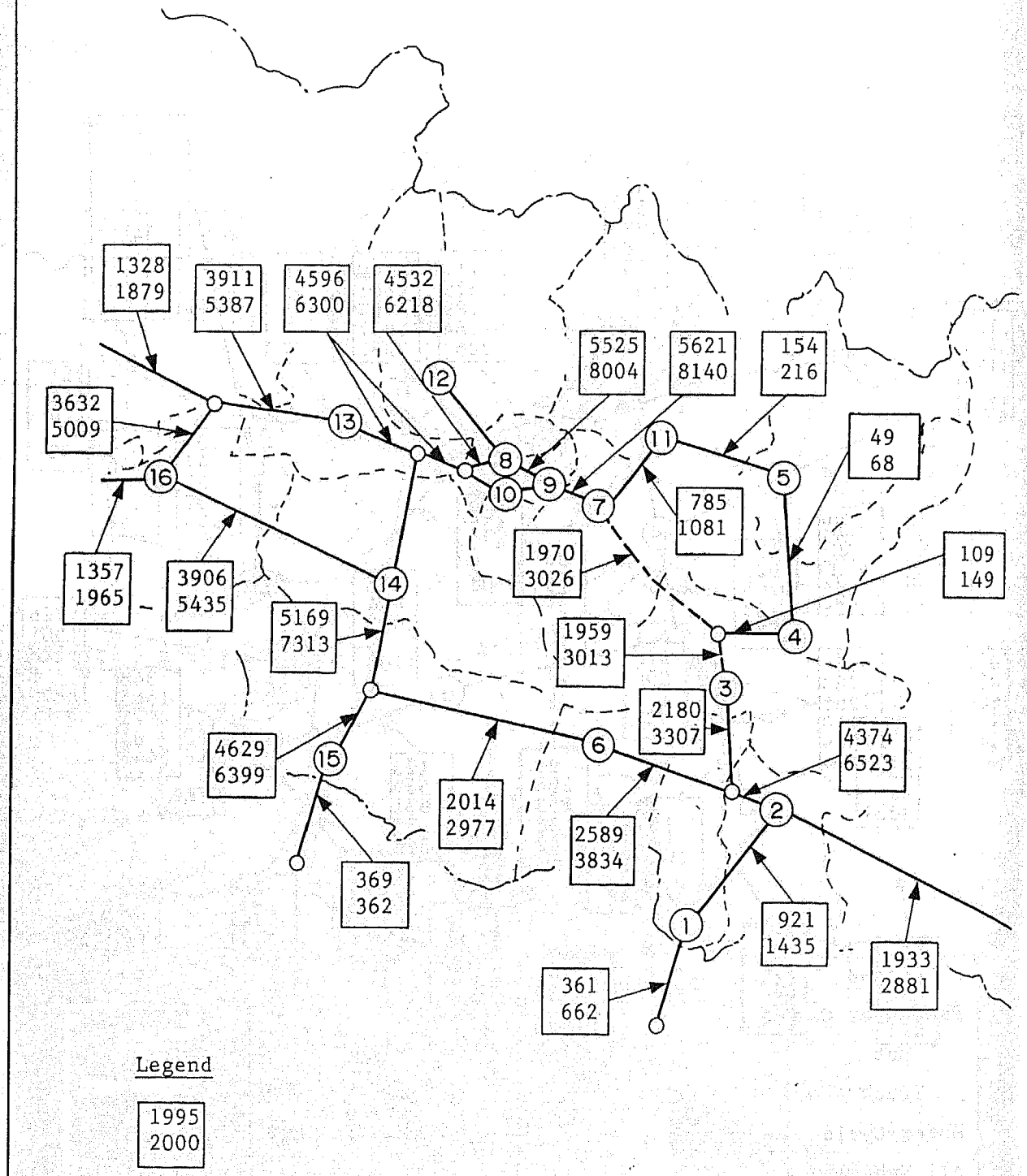


Fig. 6.9 Assigned Traffic 1995, 2000

Unit: PCU/day

Table 6.10 Traffic Volume on the Project Road by Vehicle Type

(Unit: Vehicle/day)

Year Section	Kind of Traffic	Passenger Car	Bus	Truck	Motor Cycle	Total
1995	Normal	85	214	204	4	507
Section I	Developed & Induced	72	94	102	2	270
Bardibas						
Sindhuli	Traffic to and from Jaleswor	9	28	27	1	65
	Total	166	336	333	7	842
1995	Normal	65	208	193	4	470
Section II	Developed & Induced	29	84	80	2	195
Sindhuli						
Dhulikhel	Traffic to and from Jaleswar	9	28	27	1	65
	Total	103	320	300	7	730
2000	Normal	115	320	295	6	736
Section I	Developed & Induced	93	121	164	2	380
Bardibas						
Sindhuli	Traffic to and from Jaleswar	18	60	63	1	142
	Total	226	501	522	9	1258
2000	Normal	87	312	281	6	686
Section II	Developed & Induced	35	110	132	2	279
Sindhuli						
Dhulikhel	Traffic to and from Jaleswar	18	60	63	1	142
	Total	140	482	476	9	1107

CHAPTER 7 DESIGN STANDARD AND ALTERNATIVES

7.1 General

In this Chapter, the basic planning aspects of the engineering field to be applied for Sindhuli Road Project, such as, design standards and alternatives for routes and bridges, are studied.

In order to examine the possible alternatives, field reconnaissance along the project corridor, inventory survey for existing trunk roads, collection and analysis of data were carried out.

Alternative study has been conducted by taking the following procedure.

Initial Route Study

- To study alternative routes using the existing topographic map and aerial photographs, each of a scale of 1/50,000, and select the possible route connecting Bardibas on East/West Highway with Kodari Road.

- To determine the corridor along the possible route on the existing topographic map in a scale 1/50,000 for preparation of the topographic map with a scale of 1/10,000.

Alternative Study on Route and Bridge

- To study alternative routes within the corridor on the map (1/10,000) and select the optimum route of the Project Road.

- To determine the corridor along the optimum route on the above map (1/10,000) for preparation of topographic map with a scale of 1/2,000 which is to be used for the preliminary design of Sindhuli Road Project.

- To establish concepts in bridge planning and study the alternatives on major bridges along the optimum route.

7.2 Design Standard

7.2.1 Classification of the Project Road

As stipulated in Chapter 1, the objective of the Project Road is to connect Bardibas on the Mahendra Rajmarg (East-West Highway) with Dhulikhel on the Araniko Rajmarg (Kodari Road), passing through the intermediate points nearby, Sindhuli Bazar, Sindhuli Garhi, Khurkot and Nepalthok.

The Project Road constitutes a major north-south link connecting Kathmandu Valley with Terai, and forms a part of second east-west highway according to the future road network planned by DOR.

According to the traffic forecast in Chapter 6, the Sindhuli Road serves the greater portion of the longer distance traffic between Kathmandu Valley and Terai or the border near India. The future traffic volume assigned to the project road at 10th year after opening is estimated ranging from 1,100 to 1,500 ADT approximately.

The Project road, therefore, has been defined as the trunk road (Rajmarg or National Highway) with the classification of Class I according to the Nepal Road Standards (2027) as shown in Tables 7.1 and 7.2.

Table 7.1 Classification of Road by Service

1) Trunk Road (Rajmarg or National Highway);

These serve directly the greater portion of the longer distance travel, provide consistantly higher level of service in terms of travel speeds, and bear the inter community mobility (regional interest). These roads shall be main arterial routes passing through the length & breadth of the country as a whole.

2) Feeder Road;

These roads are important to travel of a localized nature than that which trunk roads are intended to serve. These serve the community's wide interest and connect important towns, districts and zonal head quarters to the trunk roads.

3) District Roads;

This class of road consisting of all roads not defined as trunk or feeder and city roads, serves primarily by providing access to abutting land carrying little or no through movement. These roads serves as collector to the feeder roads. These roads should give access to one or more villages to the nearest market or to higher type of roads. Moderate travel speeds are typical on such roads.

4) City Roads and Streets;

These include roads within the urban limits except for the above classes, passing through the city. These provide access to abutting residential, business or industrial properties.

Table 7.2 Classification of Road by Traffic

Classification	Type of Carriageway	Type of Topography	Transport units (T.U.) per day
Class I AA	4 lanes divided 2x2x3.5 metres with central median. Asphaltic concrete or Cement concrete	Level	7,000
		Rolling	5,000
		Mountainous	3,000
Class I A	Two lanes 2x3.5 metres Bituminous premixed wearing course	Level	3,000
		Rolling	2,500
		Mountainous	1,500
Class I	Two lanes 2x3.5 metres surface treatment	Level	1,500
		Rolling	1,000
		Mountainous	300
Class II	Single lane 3.5 metres Surface treatment	Level	300
		Rolling	150
		Mountainous	75
Class III	Single lane 3.5 metres gravel	All topography	less than 75

Roads having transport units greater than 3,000 per hour (30th highest hour ever year's time) will be termed Primary Highways. These are destined to be mostly near metropolitan areas only in the foreseable future.

7.2.2 Geometric Design Standard

Geomoetric Design Standard for Sindhuli Road has been established making reference to Nepal Road Standards (2027) (NRS (2027)) and Japan Road Standards, taking into consideration local conditions. The invntory survey for the existing trunk roads were conducted to examine the scale of Sindhuli Road.

(1) Design speed

Design speeds are determined in accordance with the charactor of the terrain through which the Project Road has to pass.

The adoption of high speeds in hilly or mountainous terrain will result in very high construction costs which are often not justifiable in economic terms, particularly for low traffic roads. Design speeds therefore links closely to traffic volume as well as to the nature of terrain condition.

Based on the above understanding, the design speeds has been determined as follows;

	Terrain Condition	Design Speed (km/hr)
- Section I (Bardibas-Sindhuli Bazar)	Hilly	40 - 50
- Section II (Sindhuli Bazar-Dhulikhel)	Mountainous	30 - 40

The design speed of 20 km/hr shall be applied for the specific placed where the construction works are extremely difficult due to steep terrain, especially hairpin bend section in Section II-1.

(2) Lane Width

Standard lane width of Class I Road is 3.5 meters according to the NRS (2027), however, the following lane widths are recommended for the Project Road considering topographic condition and the existing similar trunk roads, such as Narayangadh - Mugling Road, Dharan - Dhankuta Road, etc.

	Lane width
- Section I (Bardibas - Sindhuli Bazar)	2 x 3.00 m
- Section II (Sindhuli Bazar - Dhulikhel)	2 x 2.75 m
- Town area	2 x 3.00 m

(3) Shoulder width

Considering the topographic conditions along the project corridor, the following shoulder widths are recommended;

	Shoulder Width
- Section I (Bardibas - Sindhuli Bazar)	0.75 m
- Section II (Sindhuli Bazar - Dhulikhel)	0.50 m

For a bridge more than 50 m in length, shoulder width of 0.5 meter is adopted for both Section I and Section II.

(4) Cross Slope of Pavement (Superelevation)

20% of a standard pavement cross slope is recommended based on the Japan Road Standards.

(5) Pedestrian

Pedestrians with a 2.0 to 3.0 meter wide are provided on both sides in a town or village areas wherever found necessary. Sidewalk with 0.75 meter is provided for major bridge on one side.

(6) Clearance

Clearance for roadway is determined in accordance with the NRS (2027) as follows:

- Vertical Clearance : 4.75 m
- Horizontal Clearance: Full roadway width including shoulders

(7) Geometric Alignment

Many of geometric design features, such as, minimum radius of horizontal curve, maximum gradient, superelevation of pavement, widening of carriageway and sight distance are derived from the design speed.

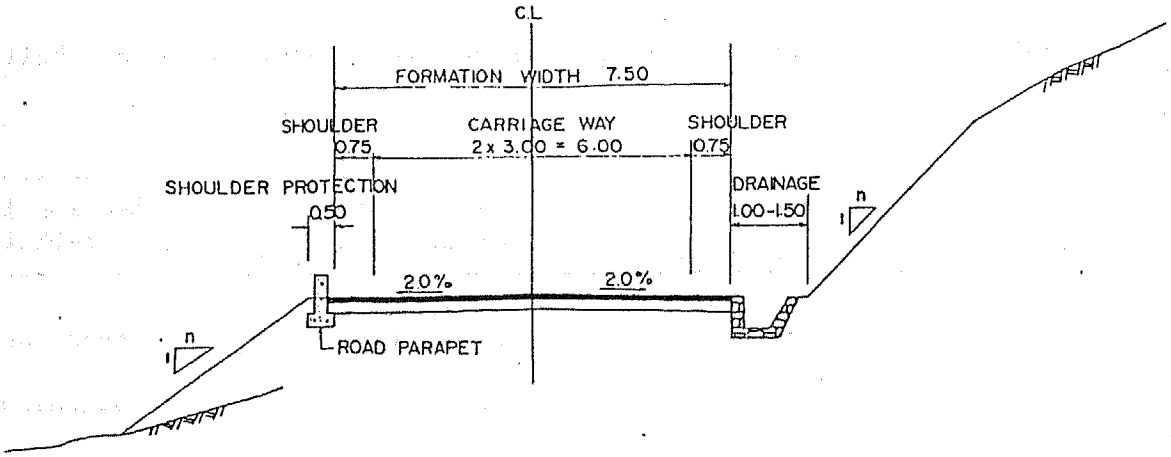
Spiral transition curve (clothoid) is provided on horizontal curve which is shorter than 200 meters radius in principle, however, no transition curve is provided on sharp curve shorter than 40 m radius.

Vertical curves is simple parabolas in accordance with NRS (2027).

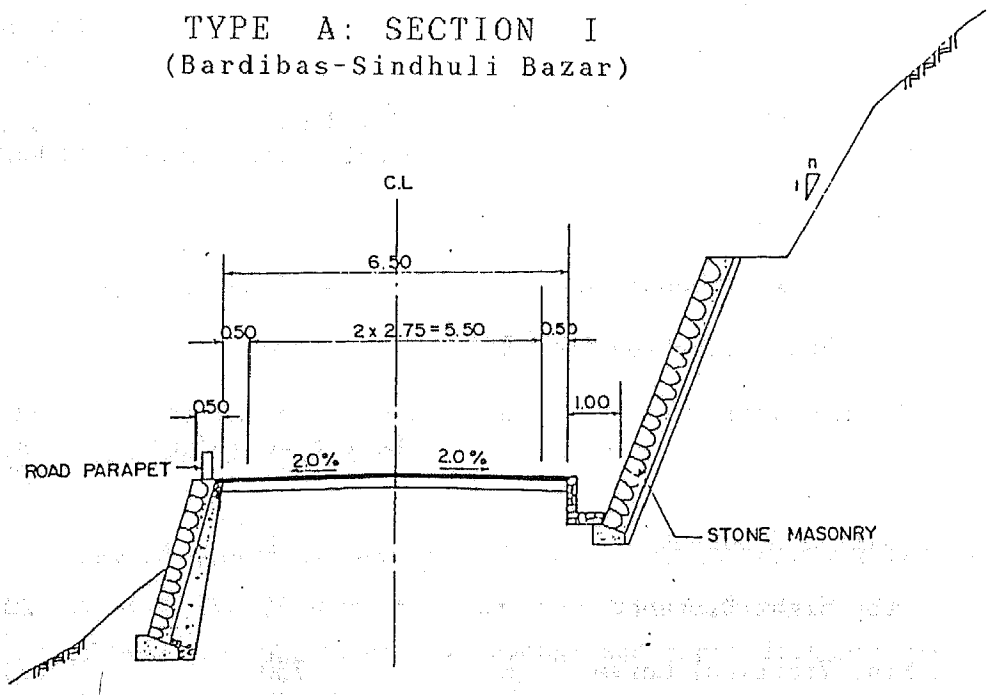
Geometric design criteria and typical cross sections of roadway to be applied for Sindhuli Road are shown in Table 7.3 and Fig. 7.1 respectively.

Table 7.3 Geometric Design Standard to be applied for Sindhuli Road

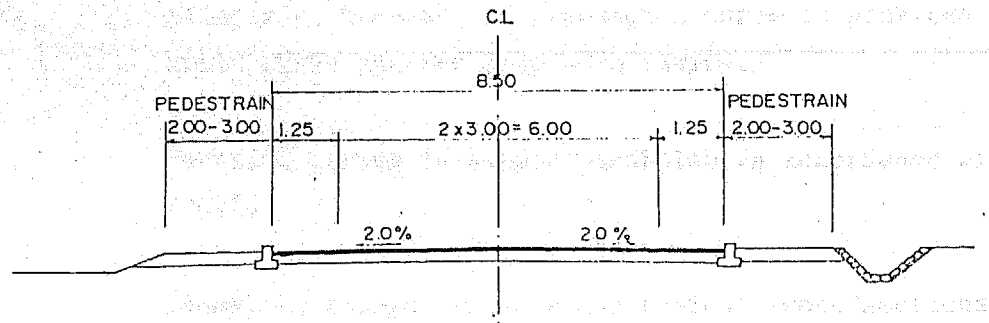
Item	Unit	Section I Bardibas-S.Bazar	Section II S.Bazar-Dhulikhel
. Road Classification	-	Trunk Road	Trunk Road
. Terrain	-	Hilly	Mountainous
. Design Speed	km/hr	50-40	40-30 (20 km/hr for hairpi bend)
. Lane Width	m	2 x 3.00 = 6.00 (Double Carriageway)	2 x 2.75 = 5.50 (Double Carriageway)
. Superelevation	%	2	2
. Crossfall of Shoulder	%	4	4
. Max. Superelevation	%	10	10
. Minimum Radii	m	100 (at 50 km/hr) 60 (at 40 km/hr)	60 (at 40 km/hr) 30 (at 30 km/hr) 15 (at 20 km/hr)
. Maximum Gradient	%	6	9
. Stop Sight Distance	m	55	20 (at 20 km/hr)
. Min. Viertical Curve	m	700	100 (at 20 km/hr)
. Min. Horizontal Curve	m	80	30 (at 20 km/hr)
. Min. Transition Curve	m	40	20
. Vertical Clearance	m	4.75	4.75



TYPE A: SECTION I
(Bardibas-Sindhuli Bazar)



TION II
(S NDHULI BAZAR - BANEPA



TYPE C: TOWN AND CITY AREA

Fig. 7.1 Typical Cross Section of Roadway

7.2.3 Bridges & Structural Design Standard

(1) Applicable Standard

The Design Standard to be applied for bridge is principally NRS (2027) published by Department of Roads of HMG. In case of no design standard covered in NRS (2027), Highway Bridge Specification (HBS) published by Japan Road Association (JRA) shall be applied for the Study. However, local requirements arising from natural phenomenon such as wind, earthquake, rainfall and temperature follow on the Indian Roads Congress (I.R.C.) Bridge Code.

(2) Definition of Structures

Refering to NRS (2027), classification of structures was defined as follows:

Curverts ---------- mainly cross drainage structures, span length or total length less than 5 meters

Minor Bridges ----- total bridge length more than 5 meters but less than 20 meters

Medium Bridges ---- total bridge length more than 20 meters but less than 50 meters

Major Bridges ----- total bridge length more than 50 meters

(3) Loads

Dead load, live load, impact fraction, wind load, earthquake load, thermal effects, stream current force and earth pressure to be applied for the bridge and structural design are specified in Appendix 7.2.1.

(4) Typical Cross Section of Bridge

The typical cross sections of bridges are shown in Fig. 7.2.

7.3 Initial Route Study

7.3.1 General

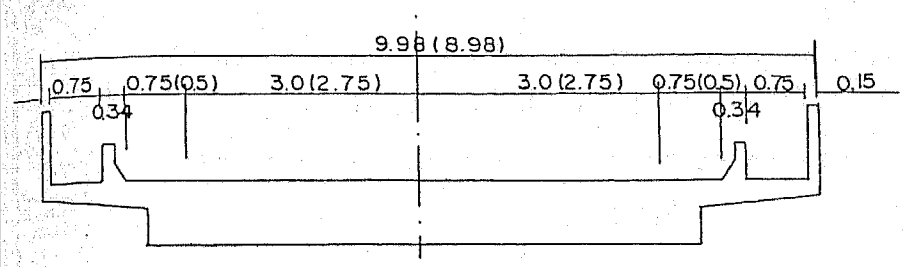
The initial route study was conducted using topographic map and aerial photos, each of a scale of 1/50,000, and information and data obtained through field reconnaissance and inventory survey.

Site reconnaissance was carried out by means of helicopter since there is no jeepable track along the project corridor in Section II between Sindhuli Bazar and Kodari Road, while Section I on foot because of jeepable road available.

The whole route was divided into the following four sections for easy identification as illustrated.

Section I	Bardibas on East/West Highway - Sinduli Bazar
Section II-1	Sindhuli Bazar - Khurkot
Section II-2	Khurkot - Nepalthok
Section II-3	Nepalthok - End point to be determined on Kodari Road

The Project Road, starting from Bardibas on East-West Highway, was determined to be passed through the intermediate point nearby four (4) villages, namely Sindhuli Bazar, Sindhuli Garhi, Khurkot and Nepalthok in accordance with the Minutes of Discussion made on November 11, 1986.



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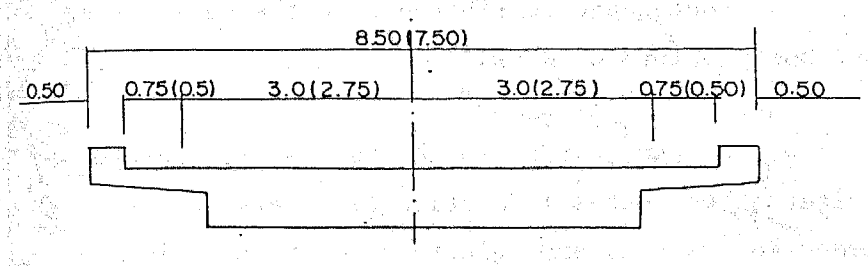

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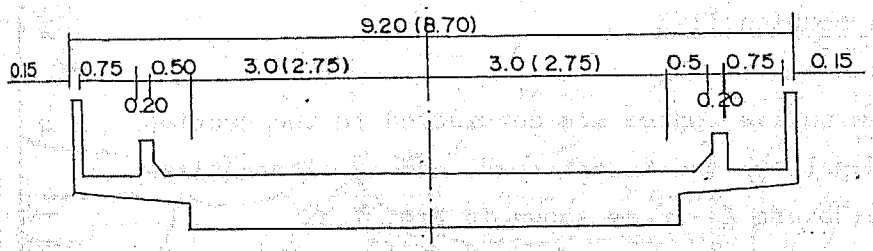
CASE 1 : MEDIAM & MINOR BRIDGE



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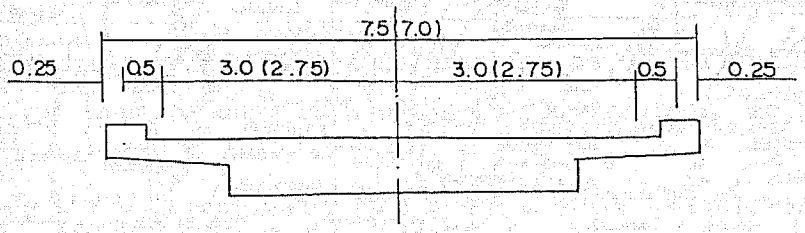

(WITHOUT SIDEWALK)

CASE 2 : MAJOR BRIDGE

Figures in ( ) shows the width as per Type B extremely mountainous terrain.

Fig. 7.2 Typical Cross Section of Bridge

No alternative routes were therefore considered in the Section I, II-1 and II-2 from Bardibas, the beginning point of the Project Road, up to the intermediate village of Nepalthok.

In Section II-3 between Nepalthok and Kodari Road, however, some alternative routes are considered from the engineering and socioeconomic points of view.

The main subject of the initial route study are therefore to study alternative routes in Section II-3 between Nepalthok and Kodari Road and select the most suitable route of the Project Road among various alternative routes.

7.3.2 Study on Alternative Routes in Section II-3

Routes in Section II-3

Three alternative routes are considered in the section between Nepalthok and Kodari road, namely Alternatives II-3A, II-3B and II-3C as shown in Fig. 7.3.

a) Alternative II-3A

Alternative II-3A was selected aiming at the shortest route from Nepalthok to Kodari Road at Panchkal.

This route spans over Rosi Khola at Nepalthok and passes through very steep hillside on the left side of Sun Kosi River up to the confluence of Sun Kosi River and Jhiku Khola. The route bends at the confluence and passes along the narrow gorge of Jhiku Khola and finaly reaches Panchkal on Kodari Road.

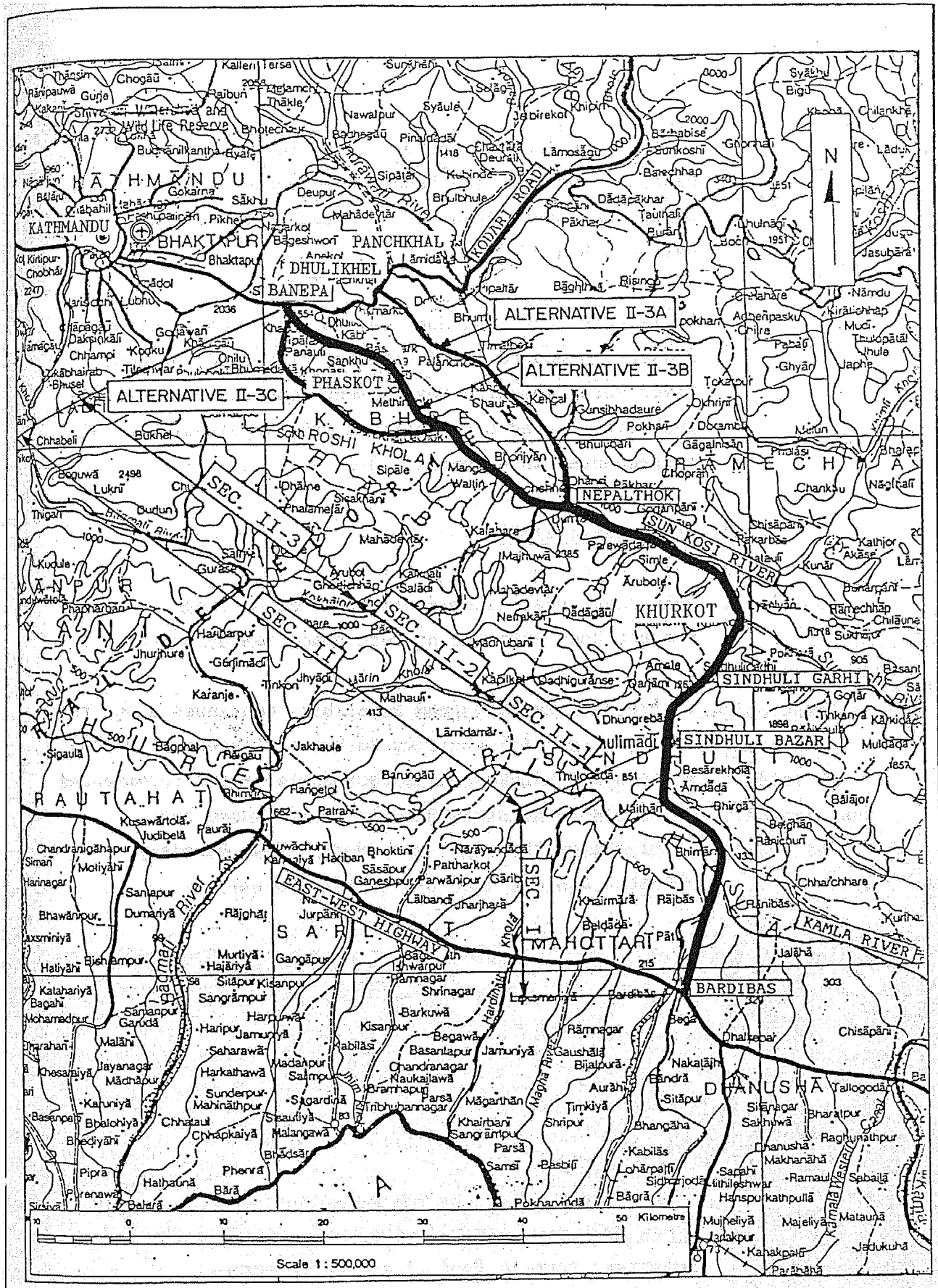

Fig. 7.3 Alternative Routes in Section II-3

Panchkal is located approx. 15 km in the east from Banepa. The existing Kodari Road between Panchkal and Banepa has steep gradient with two or three sharp hair-pin bends.

It is noted that the Sun Kosi No.3 Dam Construction Project, proposed in "The Master Plan Study of Kosi River Water Resource Development" conducted by JICA in 1985, is planned 8 km upstream from Nepalthok. Detail is presented in Appendix 7.3.1.

b) Alternative II-3B

This route was selected aiming at connecting the Project Road with the nearest place nearby Banepa.

The route, starting from Nepalthok, continues along the left bank of Rosi Khola up to the confluence of Dabcha Khola. The right bank of Rosi Khola is not recommended since the large numbers of landslides have been developed on the right bank due to Main Boundary Thrust.

The route crosses Rosi Khola at the point of confluence and runs through a gorge of Dabcha Khola. Proceeding on the cultivated hilly area at the foot of Dabcha, the route passes through Buchakot and Phaskot and finally joints Kodari Road at the place nearby Banepa.

c) Alternative II-3C

This route was selected aiming to pass through the important town of Panauti nearby Banepa.

The route, starting from Nepalthok, follows the same route of Alternative II-3B up to the confluence of

Dabcha Khola. After the confluence, the route continues to ascend on the left bank of Rosi Khola up to Panauti, passing through very steep and narrow gorge of Rosi Khola.

The route bends towards north, running along the existing road and joints Kodari Road at the same point of Alternative II-3B nearby Banepa.

7.3.3 Selection of the Possible Route in Section II-3

Alternative II-3A was the shortest route connecting Nepalthok with Kodari road among three alternatives, however, it is not recommended because of the following disadvantages:

- Sun Kosi No.3 Dam Project, which might be implemented in the near future because of its high priority, would effect on the alignment of the Project Road. Shifting the alignment toward mountain side would be difficult and cause remarkable increase of construction cost due to steep topography and poor geology.

- Topography of gorges along the Sun Kosi Valley and Jhiku Khola are quite severe and difficult.

- Existing Kodari Road between Panchkhal and Banepa approx. 15 km, has to be improved because of its poor alignment and pavement.

- Contribution to the area along the route would be small because of the limited cultivated land and relatively small population.

Alternative II-3C is longer than Alternative II-3B by more than 5 km, and it has to pass through very steep gorge of

Rosi Khola. Alternative II-3C is not advantageous in respect of construction cost, route length and maintenance cost.

Alternative II-3B is advantageous in respect of construction cost and maintenance. Moreover, it will be connected with the place nearest to Banepa, which mostly meets the project requirement specified in Scope of Work. Alternative II-3B is therefore selected as the most advantageous route between Nepalthok and Kodari Road.

7.3.4 Corridor along the Possible Route selected

The corridor of Sindhuli road has been determined along the possible Alternative II-3B selected with 2-6 km wide as shown in Fig. 7.4 (1) through 7.4 (4).

Since no major changes in alignment are considered in Section I, the corridor has been fixed along the existing road with 1-2 km in width.

The corridor nearby end point of the Project Road is extended taking into consideration alternative routes to connecting Dhulikhel.