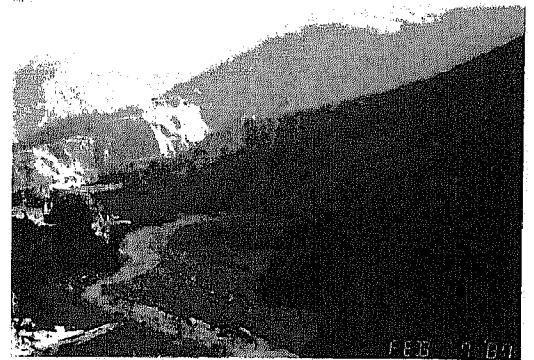


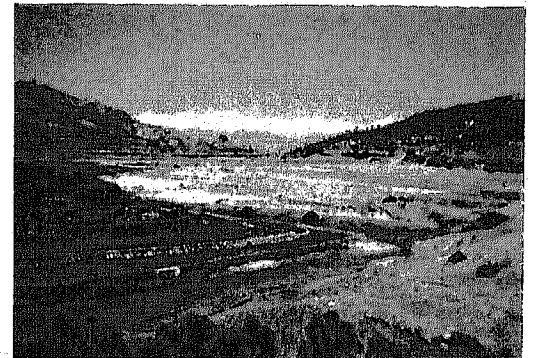
Existing pedestrian suspension bridge across the Rosi Khola at Nepalthok.



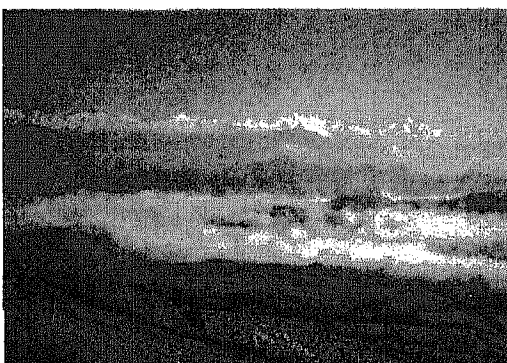
Large landslide developed on the right bank of Rosi Khola. The route passes this area by provision of slope protection.



The Rosi Khola is one of the major tributaries of Sun Kosi. The route runs along the right bank of Rosi Khola.



After passing through the gorge of Dabcha Khola, the route runs through the paddy field developed at Buchakot.



The route, looking at the Himalayan Range, passes on the slope up to Phaskot.



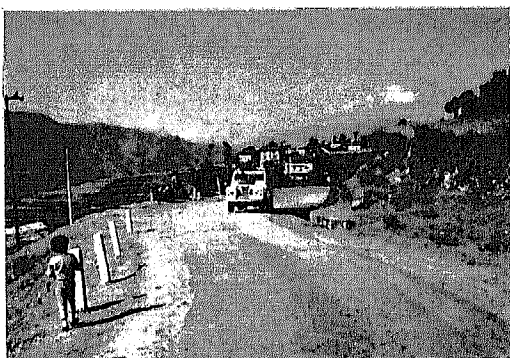
The end point of the Project road is connected with the western end of Dhulikhel town, headquarters of Kabhreparanchok District.



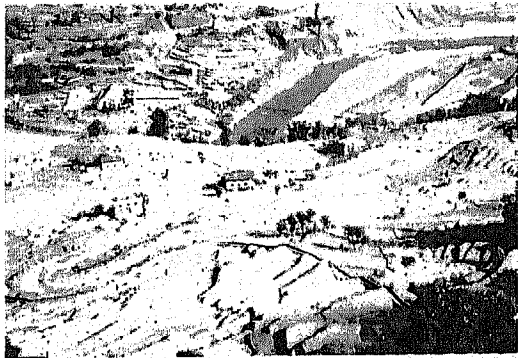
Kodari Road(or Arniko Highway) constructed by China. Improvement of pavement might be required.



Kodari Road become impassable sometimes in the rainy season due to landslides.



Jiri Road constructed with the financial and technical assistance of Swiss.



The road climbs 500m up steep slope with 15 hair-pin bends at the starting point of the Jiri Road.



Dharan-Dhankuta Road constructed by UK. The design standard of Sindhuli Road is more or less same as this road.



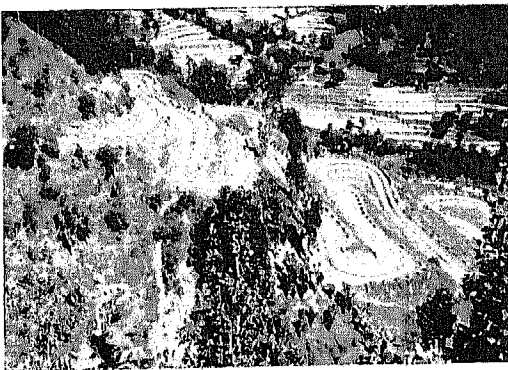
Concrete frame crib wall constructed as the countermeasure for large landslide of cut slope.



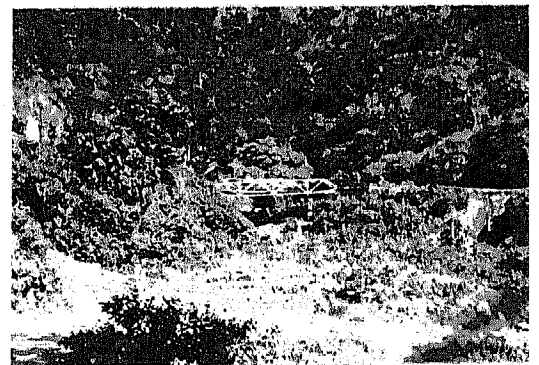
East/West Highway constructed by USSR.



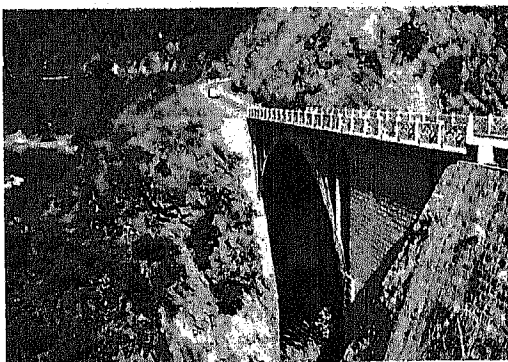
Pavement rehabilitation under construction in East/West Highway.



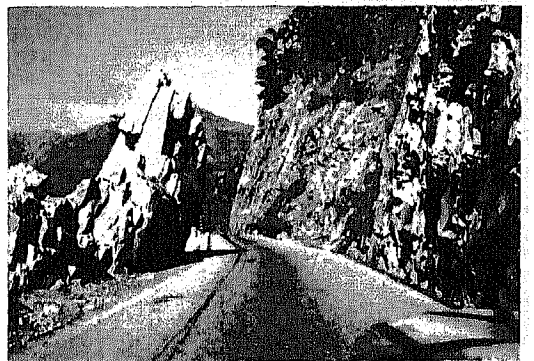
Tribhuvan Road cross over the Daman Pass (EL=2,300m) which is oldest road connecting Terai Plain with Kathmandu Valley.



This road is not used as the main transport route between Terai and Kathmandu because of its narrow and swinging alignment due to steep terrain.



Prithivi Highway, constructed by China, is used as the main route connecting Terai and Kathmandu Valley.



The road, running through steep slope of Narayani river, become impassable sometimes in the rainy season.

The Feasibility Study on Sindhuli Road Construction Project

A. <u>Conclusion and Recommendations</u>	S-1
B. <u>Summary of the Study</u>	
B.1 Introduction	
B.1.1 Background of the Study	S-5
B.1.2 Objective of the Study	S-5
B.1.3 Role of the Project	S-5
B.1.4 Project Outline	S-6
B.2 General Situations of Nepal and the Project Area	
B.2.1 Existing Road Network	S-7
B.2.2 Traffic Situation	S-7
B.2.3 Development Plans	S-7
B.3 Traffic Forecast	
B.3.1 Methodology	S-8
B.3.2 Future Traffic Volume	S-8
B.4 Engineering Surveys and Analysis	S-9
B.5 Preliminary Design of the Project Road	
B.5.1 Alternative Route Study	S-10
B.5.2 The Optimum Route Selected	S-10
B.5.3 Design Standards	S-11
B.6 Construction Cost and Implementation Schedule	
B.6.1 Construction Cost	S-11
B.6.2 Construction Plan and Method	S-12
B.6.3 Implementation Schedule	S-12
B.6.4 Disbursement Schedule	S-15
B.6.5 Maintenance and Training Center	S-15
B.7 Economic Evaluation	
B.7.1 Benefit Estimation	S-17
B.7.2 Economic Evaluation	S-17
B.8 Indirect Effects	
B.8.1 Regional Economy	S-18
B.8.2 Agriculture	S-18
B.8.3 International Trade	S-19
B.8.4 Future Development	S-19

A. CONCLUSION AND RECOMMENDATIONS

A.1 Project Road

The Sindhuli Road Construction Project (the Project Road) aims to construct a 2-lane trunk road which connects Bardibas on East-West Highway in Terai Plain, the most developed agricultural area in Nepal, and Dhulikhel located on Kodari Road near Kathmandu, the capital city of Nepal, in its total length of 155 km.

A.2 Project Feasibility

It is concluded that the Project is technically and economically feasible for constructing 2-lane of paved road in a total length of 155 km, with the highest internal rate of return of 9.88%.

A.3 Project Cost

The total project cost, excluding the contingency of price escalation, is estimated to be NRs. 3,884 million (equivalent to US\$185 million or ¥24,040 million), which is divided into two construction phases as shown below:

- Phase 1 (Section I & Section II-1) : NRs. 1,510 million
(¥9,346 million)
- Phase 2 (Section II-2 & Section II-3): NRs. 2,374 million
(¥14,695 million)

Note: Exchange Rate used for cost estimation is;

US\$ 1.0 = ¥ 130.0 = NRs. 21.0 (As of January, 1988)

A.4 Purpose of the Project

The Project Road is planned to provide new road linkage between Kathmandu Valley and Eastern Terai Plain aiming at;

- (1) functioning as an alternative trunk road connecting Kathmandu Valley and Eastern Terai so as to ensure constant supply of foods and consumers' goods to the people in the capital city,

- (2) ensuring reliable transportation route for international trade between Kathmandu and Indian border, including the traffic to and from Calcutta Port which handles about 95% of Nepalese overseas trade,
- (3) reduction in the travel distance for all the traffic between Kathmandu Valley and Eastern Terai Plain, especially for the traffic transporting agricultural products produced in the Eastern Terai Plain, and
- (4) stimulating and enhancing economic and social activities in the remote hill area of Central and Eastern Development Regions.

A.5 Future Traffic Volume

Traffic volume on the Project Road in the year 2000 is expected to be about 1,200 ADT and 1,100 ADT in Sections I and II respectively, of which about 30% of vehicle are assumed to be the developed and induced traffic owing to the regional development by the Project Road.

A.6 Design Criteria

The preliminary design of the Project Road was conducted employing the following criteria;

- (1) to pay due attention to the slope stabilization since the route passes through extremely steep and unstable mountainous terrain of the Mahabharat Range and Siwalik Hills Range,
- (2) to minimize the maintenance cost of the Project Road taking account of the difficulty in financial arrangement for maintenance, and
- (3) to apply reasonable design standard paying attention to the terrain condition as well as the function of the proposed road expected.

A.7 Implementation Schedule

The implementation schedule has been studied, considering various alternatives; Case 1 (construction period of 5 years), Case 2 (7 years), Case 3 (10 years) and Case 4 (8 years).

Case 4 (construction period of 8 years) is recommended for the implementation of the Project taking into consideration the implementation of Jiri-Ramechap Road which is under construction by DOR as Janakpur Highway connecting Jiri Road and East-West Highway, the small scale of annual investment required for the Project, as well as the study result of economic feasibility with maximum IRR of 9.88%.

Since the construction cost of the Project is considerably large, if there exist any difficulty in financial arrangement, it is recommended to implement Phase 1 between Bardibas and Khurkot (Section I & Section II-1) initially, because of the following reasons:

- (i) Kathmandu Valley will have the alternative route connecting Terai Plain via Jiri Road, in addition to the existing route of Prithivi Highway via Muglin.
- (ii) The Project Road will contribute gratefully to the improvement of the basic human needs in remote hill areas of the Central Development Region.
- (iii) Road network in Central Development Region will be improved by completion of Phase 1 of the Project which will form a part of Janakpur Highway connecting Jiri Road and East-West Highway in Terai.

Phase 2 (Section II-2 & Section II-3) between Khurkot and Dhulikhel should be implemented later stage after financial arrangement is made.

A.8 Maintenance & Training Center

Since a proper and timely maintenance is indispensable for such a mountainous road as the Project, it is recommended, aside from the construction of the Project Road, to establish the Maintenance & Training Center somewhere around Bardibas.

The cost required for the implementation of the Center is estimated to be NRs. 240 million equivalent to US\$ 11 million or ¥ 1,500 million, although these cost is not included in the project cost estimation here.

A.9 Direct Benefit

Direct benefit, which is the sum of the savings in vehicle operating cost and time cost, is estimated at NRs. 202 million per annum in 1995 and NRs. 306 million per annum in 2000.

A.10 Indirect Benefit

In addition to the above direct benefit, the Project Road is expected to bring about great indirect effect on the regional economies surrounding the Road. The amount of indirect benefit is estimated at about NRs. 1,600 million per annum in 2000.

A.11 Improvement of Basic Human Needs

The Project will contribute greatly not only to the economic and social development but also to the improvement of basic human needs for the inhabitants who have long been isolated from other part of the country due to the lack of motorable road in the hill area.

A.12 Expansion of Jaleswor Customs Office

At present most of the long distance traffic between Kathmandu and Calcutta are passing through mainly Birganji Customs Office. After the Project Road is opened to the public, one half of the long distance traffic would be shifted from Birganji to Jaleswor, so that it is recommended to strengthen the existing function of Jaleswor Customs Office.

B. SUMMARY OF THE STUDY

This summary contains the major findings and results of the Study obtained by the JICA Study Team who carried out their works during the period from November, 1986 to March, 1988.

B.1 Introduction

B.1.1 Background of the Study

Recognizing the pressing need of reliable trunk road directly connects Kathmandu Valley with Terai Plain by the construction of Sindhuli Road, His Majesty's Government of Nepal (HMG/N) requested the Government of Japan to provide an assistance for the conduction of a feasibility study on the construction scheme of Sindhuli Road.

In response to this request, the Government of Japan decided to carry out the feasibility study on Sindhuli Road Construction Project (hereinafter referred to as "the Study").

B.1.2 Objective of the Study

The main objective of the Study is to find the most possible route among various conceivable alignments between Bardibas on East-West Highway and the place nearby Dhulikhel on Kodari Road, and to formulate an optimum scheme of the Project Road.

B.1.3 Role of the Project

The Project Road is planned to provide new road linkage connecting Kathmandu Valley and Eastern Terai aiming at;

- (1) functioning as an alternative trunk road connecting Kathmandu Valley and Eastern Terai so as to ensure constant supply of consumers' goods to the people in the capital city,
- (2) ensuring reliable transportation route for international trade between Kathmandu and Indian border, including the traffic to and from Calcutta Port which handles about 95% of Nepalese overseas trade,
- (3) reduction in the travel distance for all the traffic between Kathmandu Valley and Eastern Terai Plain, especially for the traffic transporting agricultural products produced in the Eastern Terai Plain, and
- (4) stimulating and enhancing economic and social activities in the remote hill area of Central and Eastern Development Regions.

B.1.4 Project Outline

Sindhuli Road is planned to connect Bardibas on East West Highway with Dhulikhel on Kodari Road, passing through such villages on the way as Sindhuli Bazar, Khurkot and Nepalthok. The Project Road is estimated to be 155 km long and is divided into two sections as follows;

Section I : Improvement of the existing road and construction of bridges between Bardibas and Sindhuli Bazar (37 km)

Section II: Construction of the new road between Sindhuli Bazar and Dhulikhel (118 km)

B.2 General Situations of Nepal and the Project Area

B.2.1 Existing Road Network

Nepal's provision of roads is said far below the satisfactory standard and there still exist such administrative districts which have no motorable road at all.

Compared to the east-west axis of the nation, road along the north-south direction is not well provided. Most of the nation's roads are substandard with narrow width and many curves in them and not well maintained.

It is recommended to formulate road development plan standing on the scope of total balanceness among the roads in the nation and to place more emphasis on the grade-up of individual roads as well.

B.2.2 Traffic Situation

Nepal's overall traffic level is low. Traffic volume on the East-West Highway ranges between 500 and 800 per day. Maximum traffic with some 1400 is seen in 1987 on the section between Kathmandu and Naubise on the Kathmandu-Pokhara road. The present traffic between the Kathmandu Valley and the Eastern Terai is about 200 per day.

B.2.3 Development Plan

From the beginning of the First Five Year Plan, major focus of development was placed on the Terai and the Kathmandu Valley. This fact spurred the widening of gap in living standard among the different regions in the nation. To correct this skewed development pattern, the concept of "North-South Axis Development Plan" was first proposed in the

4th Five Year Plan (1970-1975). Succeeding to this basic concept, current Seventh Five Year Plan has come up with following national targets for development.

- to increase food
- to increase opportunity for productive employment
- to fulfill the minimum basic need of the people

As for the vicinity of the Project Road, such infrastructure development projects as construction of Jiri-Ramechap Road or Janakpur Highway, Sun Koshi Multipurpose Dam No.2 and No.3 schemes are envisaged in addition to irrigation projects in the Eastern Terai.

B.3 Traffic Forecast

B.3.1 Methodology

For the purpose of different handlings of "normal traffic" and "developed and induced traffic" in economic evaluation, two types of economic frame, e.g. "trend type economic frame" and "impact type economic frame" were introduced. Future traffic was forecasted along the ordinal methodology of "three-stage forecasting step".

B.3.2 Future Traffic Volume

Future traffic volumes around the Project Road are shown in Figs. S.1 and S.2. Traffic volume on the Project Road in the year 2000 is forecasted at about 1,200 ADT and 1,100 ADT in Sections I and II respectively, of which about 30% of vehicle are assumed to be developed & induced traffic due to the regional development effect by the Project Road.

About one half of the long distance traffic between Kathmandu and Calcutta passing through Birganj Customs Office would be shifted to the Project Road after opening to the traffic.

Traffic volume of the Project Road is forecasted as shown below:

Table S.1 Traffic Volume on the Project Road

	(Unit: Vehicle per day)			
	1995		2000	
	Section I	Section II	Section I	Section II
Normal Traffic	507	470	736	686
Developed & Induced Traffic by the Project	270	195	380	279
Traffic to/from India by way of Jaleswor Border Custom	65	65	142	142
Total	842	730	1,258	1,107

B.4 Engineering Surveys and Analysis

Following engineering surveys and analysis were conducted by the Study Team.

- Geological and Soil/Materials Surveys
- Hydrological Survey and Analysis
- Seismic Analysis
- Topographic Survey including Aerial Photographic Survey

Core drillings (9 places, 20 m in depth each) were conducted at the proposed major bridge sites.

B.5 Preliminary Design of the Project Road

B.5.1 Alternative Route Study

Alternative route study has been conducted using the topographic maps with a scale 1/50,000 and 1/10,000 respectively. The outline of alternative routes studied is presented in Fig. S.3 and Table S.2.

B.5.2 The Optimum Route Selected

(1) Section I: Bardibas - Sindhuli Bazar 37 km

No alternative route was considered in this section, since the main subject of the Project in this Section I is to improve the existing road and to construct bridges and pavement.

(2) Section II-1: Sindhuli Bazar - Khurkot 39 km

Alternative II-1a was selected as the optimum route for its advantage in the costs for construction and maintenance.

(3) Section II-2: Khurkot - Nepalthok 30 km

Alternative II-2a was recommended to be the optimum route, since it was confirmed by HMG/N that the alignment design in this section needs no consideration of the Sun Kosi No.2 Dam Scheme which was planned in the "Master Plan Study on the Kosi River Water Resources Development".

(4) Section II-3: Nepalthok - Dhulikhel 49 km

Alternative II-3a and Alternative II-3e were selected as the optimum route of the Project Road in Rosi and Dhulikhel sections respectively. The end point of the Project Road was determined by HMG/N to be connected with Dhulikhel.

B.5.3 Design Standard

Road Classification: Trunk Road of Class I

Design Speed

Section I : 50 km/hr - 40 km/hr

Section II : 40 km/hr - 30 km/hr

Roadway Width

Section I : 7.5 m (6.0 carriageway and 2 x 0.75 shoulder)

Section II : 6.5 m (5.5 carriageway and 2 x 0.50 shoulder)

Road Surface : Asphaltic Concrete

Typical Cross Section: See Fig. S.4

B.6 Construction Cost and Implementation Schedule

B.6.1 Construction Cost

The estimated construction cost is shown in Table S.3, and summarized below:

	Foreign Component (NRs. M.)	Local Component (NRs. M.)	Total Component (NRs. M.)
1. Construction Cost	2,634	463	3,097
2. Physical Contingency	395	69	464
3. Engineering Services	310	-	310
Sub-Total	3,339	533	3,872
4. Land Aquisition	-	12	12
Total	3,339	545	3,884
5. Price Escalation/*	301	49	350
Grand Total	3,640	594	4,234

Exchange Rate: US\$1.0 = ¥130 = NRs.21.0 or NRs.1.0 = ¥6.19
(As of January, 1988)

/* Note: Amount of price escalation is estimated based on the recommended implementation schedule, namely Case 4 (Construction Period 8 years).

B.6.2 Construction Plan and Method

The Project is divided into four (4) construction section as shown in Fig. S.5, taking into consideration magnitude of the project scale as well as the characteristic of terrain conditions.

The quantities of major work in each section is summarized in Table S.4.

The construction period of each section is estimated on the basis of the quantities of critical path work, construction method, workable day, etc. as follows:

Section I	(Bardibas - Sindhuli Bazar 37 km):	4 years
Section II-1	(Sindhuli Bazar - Khurkot 39 km):	5 years
Section II-2	(Khurkot - Nepalthok 30 km):	4 years
Section II-3	(Nepalthok - Dhulikhel 49 km):	5 years

B.6.3 Implementation Schedule

Four (4) alternative implementation schedules have been considered as shown in Fig. S.6, and a brief summary for each case is presented below:

Case 1

Case 1 is an alternative aiming at the shortest implementation of the Project with the construction period of 5 years. It requires large investment in the short term.

Case 2

This alternative is made in order to diversify an annual investment required.

Case 3

Case 3 is the longest implementation schedule among four alternatives with the construction period of 10 years in order to minimize the annual investment.

Case 4

Case 4 is an alternative schedule taking the implementation schedule of Jiri-Ramechap Road into consideration. The Project is scheduled to be constructed for 8 years and implemented in two phases, namely Phase 1 (Sec.I & Sec.II-1) and Phase 2 (Sec.II-2 & Sec.II-3) with each construction period of 5 years.

Recommendation

Case 4 is recommended for the implementation of the Project as shown below, taking into consideration the implementation of Jiri-Ramechap Road which is under construction by DOR as well as the small scale of annual investment required for the Project.

Case 4 (Construction Period; 8 years)

Phase	Section	Year	1	2	3	4	5	6	7	8
Phase 1	Sectio I Section II-1	4								
		5								
Phase 2	Section II-2 Section II-3	4								
		5								

Since the construction cost of the Project is considerably large, if there exist any difficulty in financial arrangement, it is recommended that the Phase 1 between Bardibas and Khurkot be initially implemented because of the following reasons:

- (i) In addition to the existing route of Prithivi Highway via Muglin, Kathmandu Valley will have the alternative route connecting Terai Plain via Jiri Road, by implementation of Phase 1 of the Project as well as Jiri-Ramechap road although it is not all weather conditions road.
- (ii) The Project Road will contribute greatly to the improvement of the basic human needs of the people living in remote hill areas by completion of north-south link in the Central Development Region.
- (iii) The Project Road will form a part of Janakpur Highway connecting Jiri Road and East-West Highway in Terai. Road network in Central Development Region will be improved by completion of Phase 1 of the Project.

Phase 2 between Khurkot and Dhulikhel (Section II-2 & Section II-3) should be implemented later stage after financial arrangement is made.

B.6.4 Disbursement Schedule

The Project cost has been divided into two phases in accordance with the implementation schedule of Case 4 as shown below:

Unit: NRs.M

Item	Phase 1 (Sec.I & Sec.II-1)	Phase 2 (Sec.II-1 & Sec.II-2)	Total
1. Construction Cost	1,204	1,893	3,097
2. Physical Contingency	181	284	465
3. Engineers Services	120	189	309
Sub-total	1,505	2,366	3,871
(Equivalent to:	<u>¥9,316</u>	<u>¥14,645</u>	<u>¥23,961</u>)
4. Land Aquisition	5	7	12
Total	1,510	2,373	3,883
5. Price Escalation	136	214	350
Grand Total	1,646	2,587	4,233
(Equivalent to:	<u>¥10,189</u>	<u>¥16,014</u>	<u>¥26,202</u>)

The summary of cost disbursement schedule is calculated on the basis of the implementation schedules (Case 1, 2, 3 and 4), and presented in Table S.5. Detailed disbursement schedule of Case 4 is shown in Table S.6.

B.6.5 Maintenance and Training Center

Recognizing an importance of maintenance work for Sindhuli Road as well as the necessity for strengthening the capability of DOR's maintenance operation, it is recommended to establish the "Maintenance & Training Center" in the vicinity of the Project Road at Bardibas.

The functions of the Center are expected;

- (1) to build up an efficient maintenance system and to conduct proper maintenance for the Project Road in order to secure not only the road structure but also the safety of the public traffic,
- (2) to provide trained personnel who covers not only the engineer level but also the technician level, to cope with the expanding need for road maintenance, and
- (3) to conduct the construction of feeder roads in its adjoining remote areas, especially the hill area of Ramechap District.

It is recommended to implement the Center in parallel with the construction of the Project Road, since the maintenance work would be started section by section at earlier stage of the road construction.

The cost required for the implementation of the Center is estimated to be NRs. 240 million equivalent to US\$ 11 million or ¥1,500 million. This cost, however, has not been included in the cost of the Project Road, taking into consideration multi functions of the Center.

B.7 Economic Evaluation

The economic analysis in terms of the IRR, B/C, NPV has been carried out on the basis of the implementation schedule and the cost estimate made.

The analysis were conducted based on the alternative implementation schedules, Cases 1, 2, 3 and 4.

The evaluation were made assuming that Jiri-Ramechap Road is implemented by DOR in accordance with the schedule and connected with the Project Road at Khurkot (end point of Section II-1) in 1993.

B.7.1 Benefit Estimation

The annual amount of direct benefit, which is the sum of the saving in vehicle operating cost and time cost, is estimated to be NRs. 202 million annum in 1995 and NRs. 306 million annum in 2000.

B.7.2 Economic Evaluation

Result of economic evaluation is shown in Table S.7. Overall levels of economic indicators are not so high, however, Case 4 shows the highest IRR of 9.88% among four alternatives.

It is concluded that the Project is considered economically feasible and Case 4 of the implementation schedule is the most suitable from the economic point of view.

Table S.7 Result of Economic Evaluation

	IRR (%)	B/C Ratio (Discount Rate 8.0%)	NPV (Discount Rate 8.0%)
Case 1	8.72	1.102	311.1 M.NRs.
Case 2	9.70	1.261	713.2 M.NRs.
Case 3	9.57	1.261	684.9 M.NRs.
Case 4	9.88	1.301	802.2 M.NRs.

(Project life: 25 years)

B.8 Indirect Effects

B.8.1 Regional Economy

The Project Road is expected to stimulate regional economy not only by multiplier effect due to the investment during the construction period, but also by close inter-regional dependency realized by the Project. The annual amount of economic impact brought about by the Project Road is estimated at NRs. 1,332 million and NRs. 1,644 million in 1995 and 2000 respectively.

B.8.2 Agriculture

The Project Road also promotes the agriculture sector in the area as follows:

(1) Expansion of Cash Crop Products

It is expected that the cropping pattern, in the direct passing area of the Project Road and nearby, would change from present substantial crops to cash crops. Such plantation as junar in Sindhuli district will be further promoted.

(2) Enhancement of agricultural products

A case study shows that the Project Road would reduce the price of rice by 380 NRs/ton, which would result in increase in producer's rice price in Terai by 90 NRs/ton and reduction of consumer's price of rice in Kathmandu by 290 NRs/ton. Consequently, the rice supplied from Terai to Kathmandu would be increased by 338 ton annually.

B.8.3 International Trade

- (1) Increased production of cash crops would contribute to the expansion of export. Surplus vegetables and fruits such as junar are possibly transported to India by using the Project Road. In addition to the above, the Project Road would stimulate the creation of new types of exporting industry in a long term.
- (2) A case study suggests, nearly half of the total cargoes transported between the Kathmandu Valley and India will be handled at the Jaleswor Border Customs rather than at Binganj, after completion of the Project Road.

It is therefore recommended that the function of the Jaleswor border custom should be vitalized with the opening of the Project Road, as this border custom has better location for the cargoes between the Kathmandu Valley and India, although this plan entails some negotiation with India.

B.8.4 Future Development

The Project Road would promote an early realization of regional foundation development projects (feeder roads, irrigation and multi-purpose dam projects). In this respect, the Project Road is considered as the first step for the conceivable integrated regional development plan in the Central Hill Region centered around Ramechhap Zone.

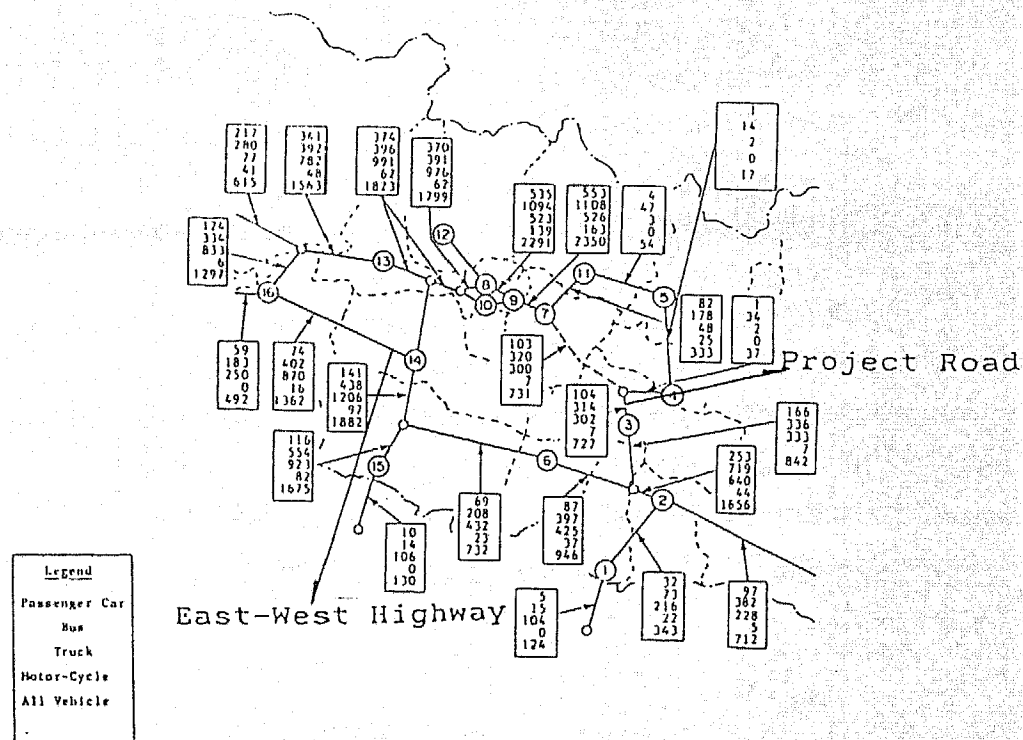


Fig. S.1 Estimated Future Traffic Volume
by Vehicle Type in 1995

Unit: Vehicle/day

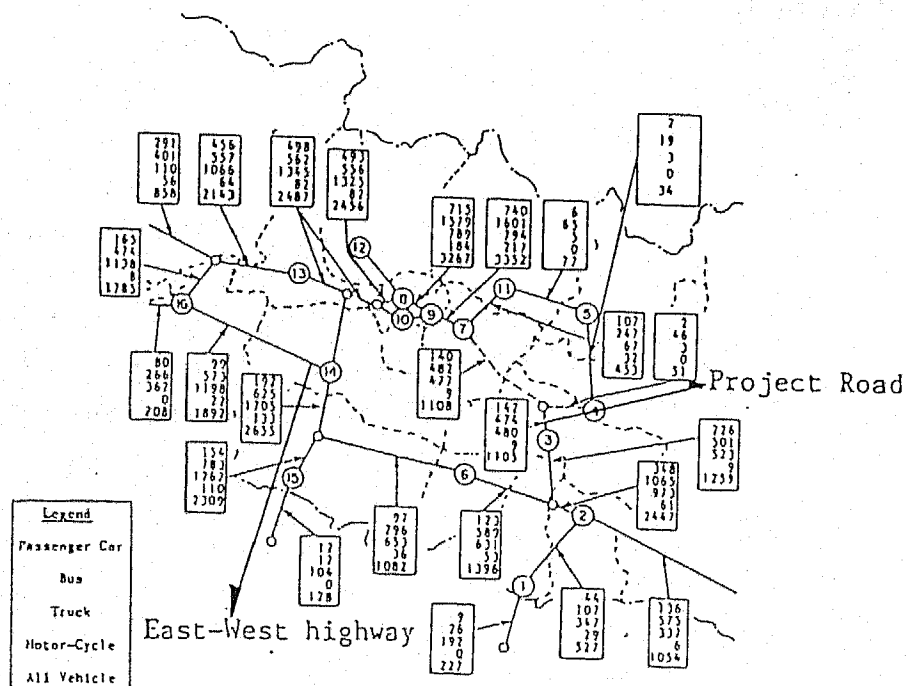


Fig. S.2 Estimated Future Traffic Volume
by Vehicle Type in 2000

Unit: Vehicle/day