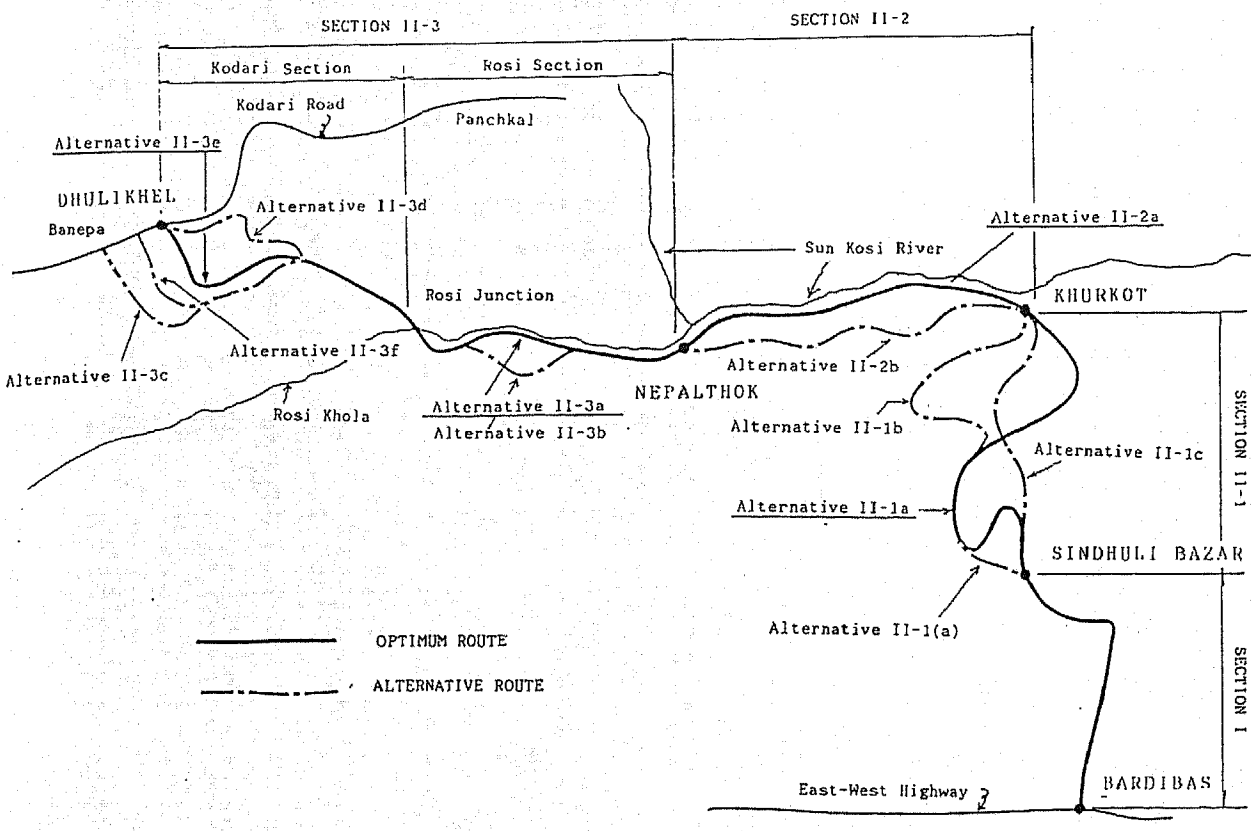

Fig. S.3 Layout of Alternative Routes in Section I and II

Section	Sub-Section	Conceivable Alternative Route	Length (km)	Preliminary Examination
Section I (Bardibas-S.Bazar)	-	None	37	Proposed route passes along the existing road which is under construction by DOR.
Section II-1 (S.Bazar -Khurkot)	-	Alt. II-1a	39	New Route: This route is the most reliable and possible route among three alternatives.
		Alt. II-1b	41	COMTEC Route: The section between Sindhuli Garhi and Khurkot is very difficult due to land slide and topography.
		Alt. II-1c	26	Tunnel Route: This route is the shortest one, however, the construction cost of tunnel (2,000 m) is quite large.
		Alt. II-1(a)	37	Alternative New Route: This route was proposed to shorten Alt. II-1a route by provision of loops between STA5 and STA10.
Section II-2 (Khurkot -Nepalthok)	-	Alt. II-2a	30	Riverside Route: The route passes through left bank of Sun Kosi River. Alignment of road is fair.
		Alt. II-2b	53	Hillside Route: This route was selected taking into account Sun Kosi No.2 Dam Project, shifting the alignment toward hillside.
Section II-3 (Nepalthok -Dhulikhel)	Rosi Section (STA.0-STA.20)	Alt. II-3a	23	Riverside Route: The route passes through left bank of Rosi River. Countermeasures for landslide are required.
		Alt. II-3b	26	Hillside Route: The route was selected to avoid landslides by shifting alignment toward hillside, resulting in bad alignment.
	Kodari Section (STA.20-STA.47)	Alt. II-3c	27	Banepa Route: The route was selected to connect with Banepa. The alignment of road is fair and short by provision of short tunnel (100 m).
		Alt. II-3d	25	Eastern Route of Dhulikhel Hill: This route was selected aiming at shortest route to Dhulikehl. Topography is very steep.
		Alt. II-3e	26	Southern Route of Dhulikhel Hill: This route was selected to connected with Dhulikhel passing on southern slope of D. Hill. The alignment is not fair.
		Alt. II-3f	27	Middle Route to Dhulikhel: This route was selected to connect with the intermediate point of Banepa and Dhulikhel.

Table S.2 Summary of Alternative Routes

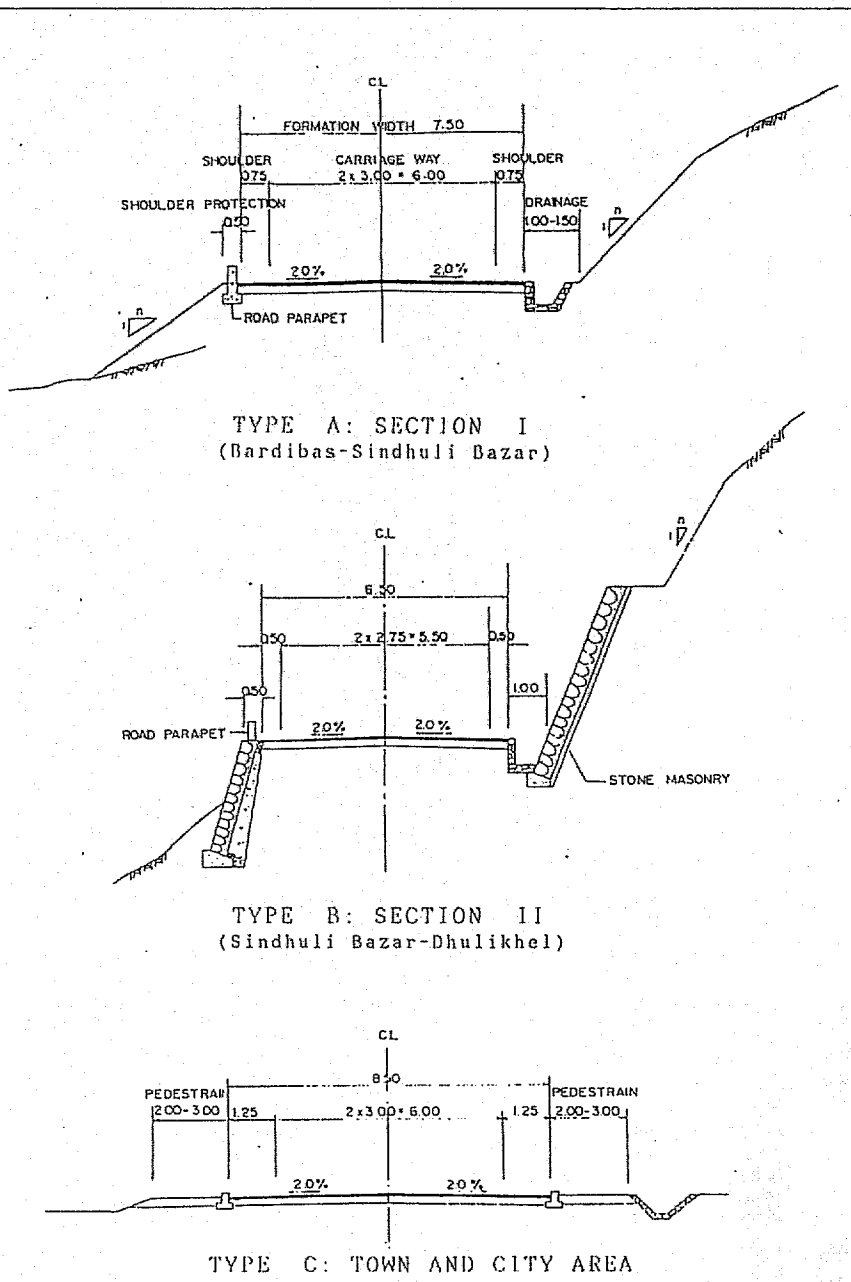

Fig. S.4 Typical Cross Section of Roadway

Table S.3 Estimated Construction Cost

Unit: NRs. 1,000

	Section I	Section II-1	Section II-2	Section II-3	Total
I. Construction Cost					
1. Site clearance and topsoil stripping	1,544	5,567	4,232	6,312	17,655
2. Earthwork	14,698	128,121	64,697	132,783	340,299
3. Pavement work	57,888	89,251	62,338	106,357	315,834
4. Drainage work	48,976	62,766	39,539	75,323	226,604
5. Retaining wall	22,183	182,583	127,614	279,391	611,771
6. Slope protection work	8,801	59,275	82,670	119,006	269,752
7. Rock shed work	-	-	-	21,124	21,124
8. Road furniture	3,409	11,402	18,915	14,604	48,330
9. Bridge work	195,572	154,692	212,852	278,923	842,039
10. Miscellaneous work	52,960	104,049	91,929	155,074	404,012
Total (I)	406,031	797,706	704,786	1,188,897	3,097,420
II. Physical Contingency	60,905	119,656	105,718	178,334	464,613
III. Engineering Services	40,603	79,770	70,479	118,890	309,742
IV. Land Acquisition and Compensation	2,000	3,000	4,000	3,000	12,000
Total (I, II, III, IV)	509,539	1,000,132	884,983	1,489,121	3,883,775
V. Price Escalation					
Case 1	25,477	50,007	44,249	74,456	194,189
Case 2	40,763	88,010	70,799	119,130	310,702
Case 3	61,145	120,016	106,198	178,694	466,053
Case 4	45,859	90,012	79,648	134,021	349,540
Grand Total (I, II, III, IV, V)					
Case 1	535,016	1,050,139	929,232	1,563,577	4,077,964
Case 2	550,302	1,080,142	955,782	1,608,251	4,194,477
Case 3	570,684	1,120,148	991,181	1,667,815	4,349,828
Case 4	555,398	1,090,144	964,631	1,623,142	4,233,315

Exchange Rate US$1.0 = ¥130 = NRs.21.0

Construction Section	Location	Project Length (km)	Total Road Construction Cost(NRsx10^6)	Quantities of Major Work	
Section I	Bardibas - Sindhuli Bazar	37	406	Earthwork	236x10^6 m³
				Bridge	870 m
				Gabion & Retaining Wall	6,400 m
				Pipe & Box	1,345 m
				Slope Protection	97,220 m²
Section II-1	Sindhuli Bazar - Khurkot	39	798	Earthwork	1,416x10^6 m³
				Bridge	760 m
				Gabion & Retaining Wall	46,120 m
				Pipe & Box	4,400 m
				Slope Protection	276,090 m²
Section II-2	Khurkot - Nepalthok	30	705	Earthwork	904x10^6 m³
				Bridge	1,010 m
				Gabion & Retaining Wall	32,170 m
				Pipe & Box	2,780 m
				Slope Protection	249,220 m²
Section II-3	Nepalthok - Dhuhkhel	49	1,189	Earthwork	1,795x10^3 m³
				Bridge	1,240 m
				Gabion & Retaining Wall	45,540 m
				Pipe & Box	4,925 m
				Slope Protection	448,030 m²
	Total	155	3,097	Earthwork	4,351x10^3 m³
				Bridge	3,880 m
				Gabion & Retaining Wall	130,230 m
				Pipe & Box	13,450 m
				Slope Protection	1,070,560 m²

Table S.4 Construction Segments and Quantities

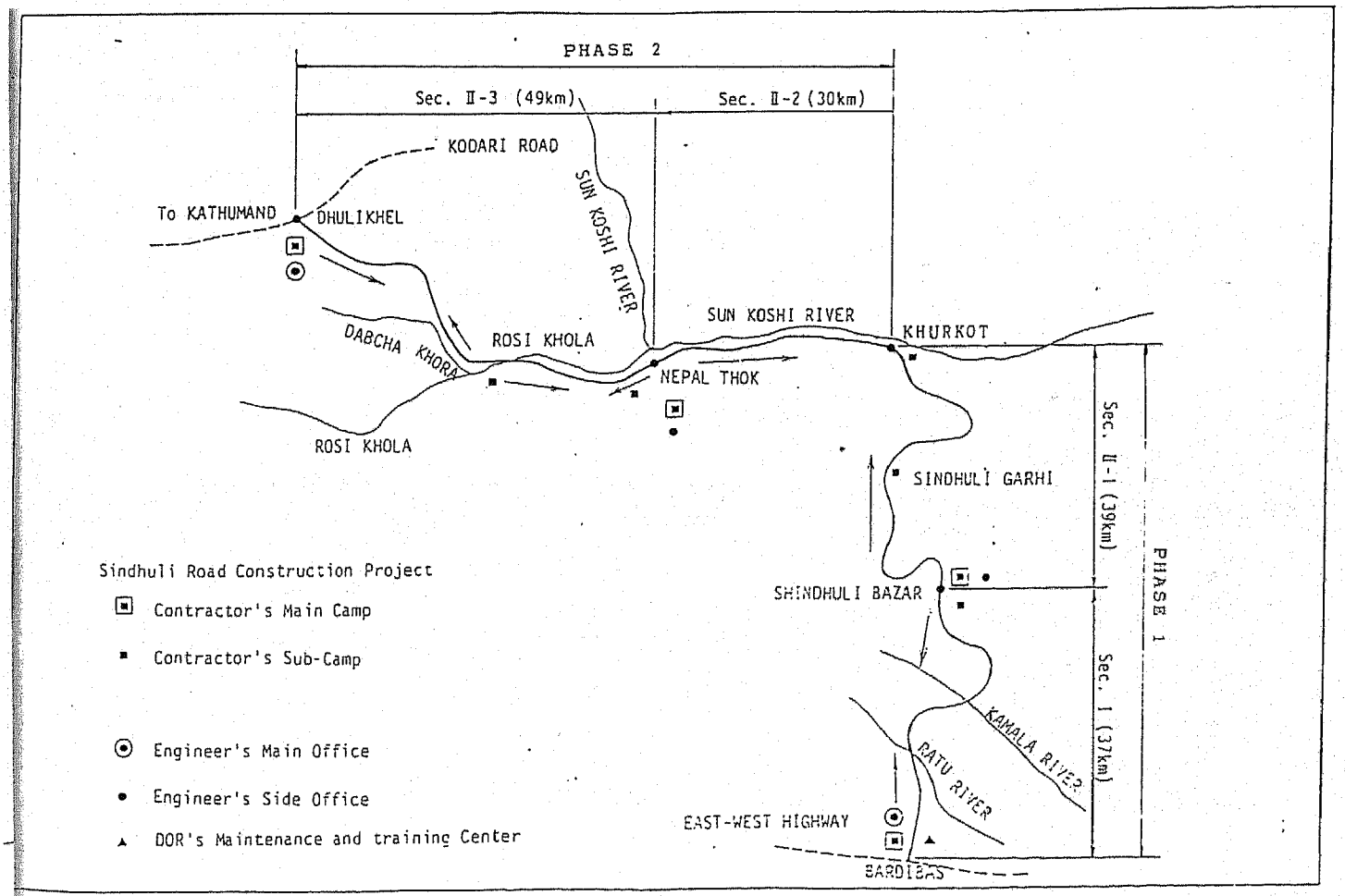

Fig. S.5 Implementation Plan

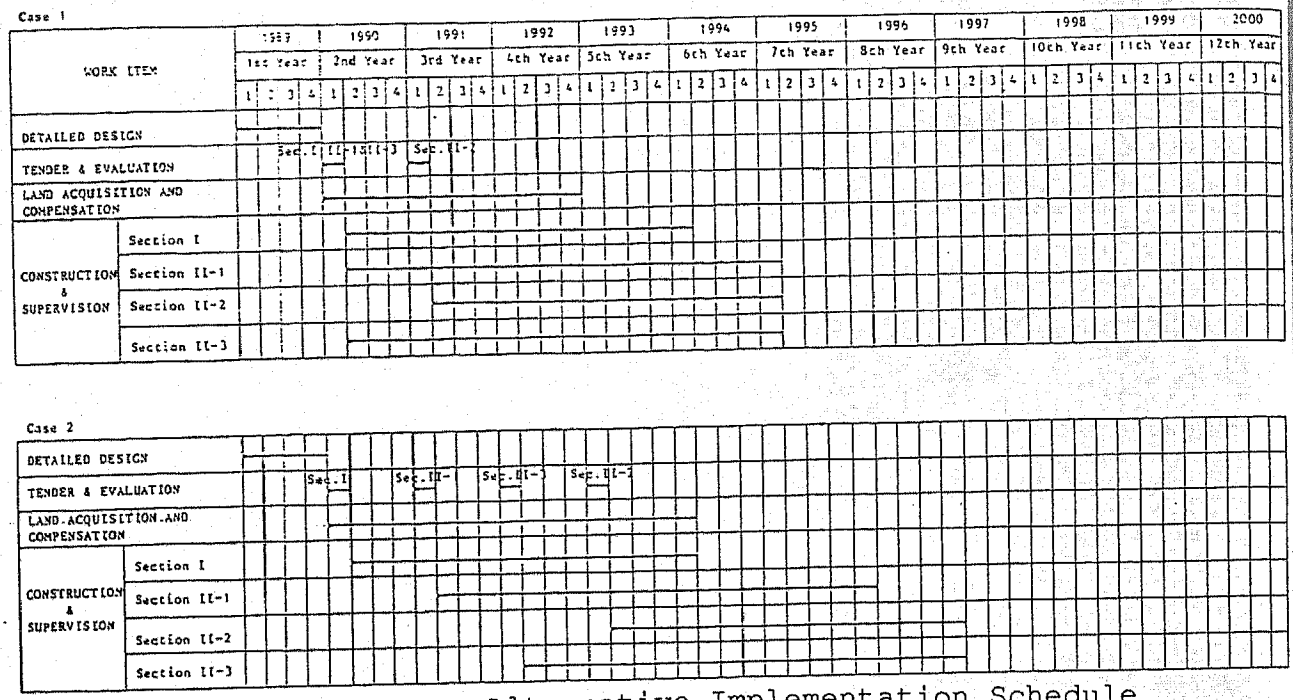

Fig. S.6 (1) Alternative Implementation Schedule (Case1 and Case 2)

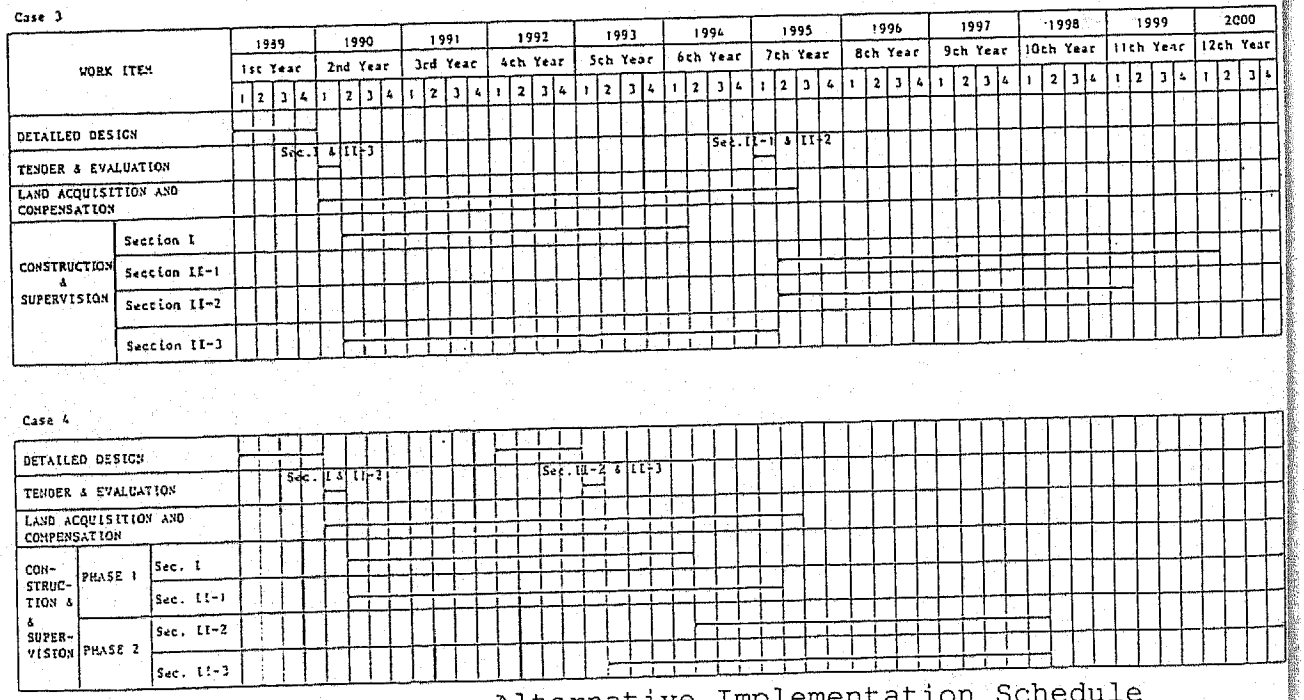

Fig. S.6 (2) Alternative Implementation Schedule (Case3 and Case 4)

Table S.5 Summary of Annual Disbursement Schedule

Unit: 10^6 NRs.

Year	CASE 1			CASE 2			CASE 3			CASE 4			CASE 4 (Phase 1 Only)		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
1st Year	65	1	66	67	1	68	69	1	70	34	1	35	26	1	27
2nd Year	453	87	540	67	12	79	323	57	380	225	43	268	225	43	268
3rd Year	684	123	807	307	56	363	417	71	488	333	61	394	333	61	394
4th Year	747	127	874	549	97	646	487	74	561	314	47	361	281	47	328
5th Year	709	121	830	642	109	751	417	66	483	478	87	565	232	43	275
6th Year	725	101	826	629	115	744	227	38	265	625	105	730	248	41	289
7th Year	123	12	135	719	121	840	321	57	378	559	93	652	65	7	72
8th Year				562	71	633	334	69	403	504	85	589			
9th Year				64	6	70	377	68	445	503	66	569			
10th Year							436	62	498	64	6	70			
11th Year							264	44	305						
12th Year							68	6	74						
Total	3,506	572	4,078	3,606	588	4,194	3,740	610	4,350	3,639	594	4,233	1,410	243	1,653

Table S.6 Disbursement Schedule (Case 4)

Unit: 10^6 NRs.

	Total			1st Year		2nd Year		3rd Year		4th Year		5th Year		6th Year		7th Year	
	F.C.	L.C.	Total	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
1.Construction Cost																	
Section I	355,076	50,955	406,031	-	-	49,455	7,565	111,299	18,421	91,956	12,060	84,527	11,191	17,839	1,718	-	-
Section II-1	665,075	132,631	797,706	-	-	116,400	24,794	133,848	28,584	115,370	23,303	86,280	21,455	164,771	29,602	48,406	4,893
Section II-2	605,465	99,321	704,786	-	-	-	-	-	-	-	-	-	-	91,862	16,005	105,824	25,124
Section II-3	1,008,672	180,225	1,188,897	-	-	-	-	-	-	-	-	181,445	34,910	186,398	34,864	258,303	43,511
Sub-total (1)	2,634,288	463,132	3,097,420	-	-	165,855	32,359	245,147	47,005	207,326	35,363	352,252	67,556	460,870	82,189	412,533	73,528
2.Physical Contingency	395,143	69,470	464,613	-	-	24,878	4,854	36,772	7,051	31,099	5,304	52,838	10,133	69,131	12,328	61,880	11,029
3.Engineering Services	(309,742)	(-)	(309,742)														
Design	61,948	-	61,948	30,974	-	-	-	-	-	30,974	-	-	-	-	-	-	-
Supervision	247,794	-	247,794	-	-	15,857	-	23,372	-	19,415	-	33,585	-	43,445	-	38,885	-
4.Land Acquisition	-	12,000	12,000	-	360	-	2,280	-	2,160	-	2,160	-	2,160	-	2,160	-	720
Total (1 - 4)	3,339,173	544,602	3,883,775	30,974	360	206,590	39,493	305,291	56,216	288,814	42,827	438,675	79,849	573,446	96,677	513,298	85,277
5.Escalation	300,526	49,014	349,540	2,788	32	18,593	3,553	27,476	5,059	25,993	3,854	39,481	7,186	51,610	8,701	46,197	7,675
Grand Total	3,639,699	593,616	4,233,315	33,762	392	225,183	43,046	332,767	61,275	314,807	46,681	478,156	87,035	625,056	105,378	559,495	92,952

Unit: NRs. 1,000

	8 Year		9th Year		10th Year	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
1.Construction Cost						
Section I	-	-	-	-	-	-
Section II-1	-	-	-	-	-	-
Section II-2	156,066	29,591	226,535	26,260	25,178	2,341
Section II-3	215,127	38,079	145,564	26,114	21,035	2,747
Sub-total (1)	371,193	67,670	372,099	52,374	47,013	5,088
2.Physical Contingency	55,679	10,151	55,815	7,856	7,052	763
3.Engineering Services						
Design	-	-	-	-	-	-
Supervision	35,109	-	33,958	-	4,168	-
4.Land Acquisition	-	-	-	-	-	-
Total (1 - 4)	461,981	77,821	461,872	60,230	58,233	5,851
5.Escalation	41,578	7,004	41,568	5,422	5,247	528
Grand Total	503,559	84,825	503,440	65,652	63,475	6,379

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THE FEASIBILITY STUDY

ON

SINDHULI ROAD CONSTRUCTION PROJECT

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ABBREVIATIONS

(1) Domestic Organizations

CBS	Central Bureau of Statistics
CDO	Chief District Officer
DIHM	Department of Irrigation, Hydrology and Meterology
DOR	Department of Roads
DE	Department of Electricit
HMG	His Majesty's Government of Nepal
MWR	Ministry of Water Resources
NEC	Nepal Electricity Corporation
NPC	National Planning Commission

(2) International Organizations

ADB	Asian Development Bank
ESCAP	Economic and Social Commission for Asia and the Pacific
IBRD	International Bank for Reconstruction and Development
JICA	Japan International Cooperation Agency
UNDP	United Nations Development Programme
USAID	United Stated Agency for International Development

(3) Others

AASHTO	American Association of State Highway and Transport Officials
F.I.D.I.C	Federation Internationale des Ingenieurs - Conseils
ADT	Average Daily Traffic
ASL	Above Sea Level
C.A.	Catchment Area
C.D.R.	Central Development Region
DBST	Double Bitumious Surface Treatment
FOB	Free on Board

CIF	Cost, Insurance, Freight
E.D.R.	Eastern Development Region
EL	Elevation Above Sea Level
GDP	Gross Domestic Product
GRP	Gross Regional Product
HBS	Highway Bridge Specification published by JRA
HWL	High Water Level
I.R.C.	Indian Roads Congress
IRR	Internal Rate of Return
JRA	Japan Road Association
LWL	Low Water Level
NRS (2027)	Nepal Road Standards (2027)
OD	Origin and Destination
P.C.	Prestressed Concrete
R.C.	Reinforced Concrete
Sta.	Station
S.W.	Scope of Works
MBT	Main Boundary Thrust (Fault)
MCT	Main Central Thrust
PCU	Passenger Car Unit

(4) Measurement

Length

mm	millimeter
cm	centimeter
m	meter
km	kilometer

Area

cm^2	square centimeter
mm^2	square meter
ha	hectare
km^2	square kilometer
sq.km	square kilometer

Volume

cm^3	cubic centimeter
m^3	cubic meter

Weight

g	gram
kg	kologram
kip	kilopound
M.ton	metric ton

Time

s	second
min	minute
h	hour
d	day
yr	year

Other Measures

%	percent
^oC	degree in centigrade
10^3	thousand
10^6	million
MW	mega watt

Currency

US$	US dollar
Y	Japanese Yen
NRs.	Nepalese Rupees

Current Equivalents

US$1.00 = Yi30 = NRs.21.0 (As of January, 1988)
(or NRs.1.00 = Y6.19)

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

1.1.1 General

The Government of Japan, in compliance with the request of His Majesty's Government of Nepal (hereinafter referred to as "HMG/N"), has agreed to undertake a Feasibility Study on Sindhuli Road Construction Project (hereinafter referred to as "the Study").

Based on this decision, the Government of Japan entrusted the Study to Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programme of the Government of Japan.

In July 1986, JICA despatched a mission headed by Mr. Naotada Isami to Kathmandu for the preliminary survey as well as discussion on the scope of work of the forthcoming feasibility study.

JICA organized an advisory committee (hereinafter referred to as "the Advisory Committee") and the study team (hereinafter referred to as "the Study Team") to undertake the Study.

Following this process, the Study Team, headed by Mr. T. Tamura who was replaced by Mr. M. Koshiba later, mobilized to Kathmandu on November 4, 1986 together with the Advisory Committee for the Study. The Study Team commenced their activities after submission of the Inception Report. Meetings with the Department of Roads, Ministry of Works and Transport, HMG/N (hereinafter referred to as "DOR"), counterpart agency for the Study, were held in order to

confirm the scope of work agreed upon by both the Government of Nepal and the Government of Japan and to discuss the schedule of the Study.

The Study Team carried out their activities with Nepalese counterparts and prepared a Progress Report (I) in March, 1987, a Progress Report (II) in June, 1987, a Interim Report in November, 1987, and a Draft Final Report in March, 1988.

This draft final report describes all the works and findings since the beginning of the Study including the study result of preliminary design and project evaluation.

1.1.2 Necessity of the Study

The Kingdom of Nepal is a land-locked country situated on the south slope of Himalaya Range. It is bordered in south by the Republic of India and in north by the People's Republic of China with the Himalayan ridges.

Kathmandu, the capital of the Kingdom as well as a center of economic and administrative activities, is located in Kathmandu Valley surrounded by mountains on four sides.

At present, there are two main roads connecting Kathmandu with Terai Plain, namely Tribhuban Road and Prithivi Rajmarg (Highway). The former, Tribhuban Road across the Daman Pass (EL = 2,300 m), is however not used as a main transport route because of its narrow and swinging alignment due to extreme mountainous terrain.

The later, Prithivi Rajmarg (Highway), is used as the main transport route connecting Kathmandu with Terai Plain. Most of the eastern traffic coming from Terai Plain to Kathmandu are using this road, passing through Hetauda,

Narayangadh and Mugling. This road however becomes impassable quite often in the rainy season due to landslides and slope failures, resulting in serious shortage of fuel, commodities and consumer goods in the Kathmandu Valley. The necessity for alternative reliable trunk road has been envisaged from the point of security of the capital city of Kathmandu.

Agricultural products produced in Eastern Terai Plain in Central and Eastern Development Regions are transported to Kathmandu by Prithivi Highway and East-West Highway Via Narayangadh and Mugling. This route however is longer way and the transport distance from Janakpur in Central Development Region to Kathmandu is almost 360 km or so. Rapid progressing of agricultural development as well as enhancement of economic activities in the Regions have lead the necessity of direct connection between Eastern Terai and Kathmandu Valley to urgent one.

Rural areas in hill side of Bagmati and Janakpur Zones of Central Development Region have remained isolated due to lack of road facilities for a long time. The strengthening the road network connecting north and south has long been envisaged to have access to the areas outside, either to Kathmandu or to Eastern Terai.

The above are background of the necessity of the construction Project of Sindhuli Road, connecting Bardibas on East-West Highway with Dhulikhel on Kodari Road.

Sindhuli Road has been proposed to provide not only for the short and reliable link between Kathmandu Valley and Eastern Terai Plain but also for the development of the isolated regions nearby the Project Road.

1.1.3 Scope of the Study

The scope of the Study is listed in the Scope of Work which was approved both by DOR and JICA on July 15, 1986 (The document is attached in Appendix 1.2.1). The objective of the Study is to conduct a feasibility study on the construction of Sindhuli Road.

In essence, the Study aims at determination of the optimum schemes of Sindhuli Road through the comparison among conceivable alternatives. The scope of the Study were made clear through the discussion on November 10, 1986, also attached in Apendix 1.2.2.

The Project Road, which has one end at Bardibas on East-West Highway, was proposed by the Study Team to have another end at Banepa on Kodari road in the initial route study, however, it was finally determined by HMG/N to place the end point at Dhulikhel instead of Banepa in accordance with the policy by HMG/N that Sindhuli Road should pass through the point of headquarter of Kabhrepalanchok District. The detail of which are presented in Appendix 1.2.3.

1.2 Project Road

1.2.1 Role of the Project Road

Sindhuli Road is planned to form the major connection between north and south in the Central Development Region, linking Kathmandu, the capital of the Kingdom, with Terai Plain, the most developed agricultural area in Nepal.

Historically, the road network in Nepal has been developed in parallel with Himalayan and Mahabharat Ranges which stretch in east-west direction. This fact resulted in

insufficient road linkings in north-south direction of the nation. Steep topography and poor and unstable geology of the Ranges are main reasons for this lagged construction of road linking north to south.

At present, Kathmandu links to Terai Plain by sole trunk road namely Prithivi Rajmarg, which is not stable and reliable in the rainy season because of the frequent landslides and slope failures. Alternative reliable trunk road is indispensable for more stable transportation of goods and passengers to the capital city.

Sindhuli Road will connect Kathmandu Valley and Terai Plain in shortcut, therefore, the travelling time would be reduced remarkably. Janakpur will be within one days round trip distance from Kathmandu with the construction of the Road, while the present route requires two days for round trip.

From the view point of the road network, the Project Road is planned to provide new linkage connecting Kathmandu Valley and Terai Plain, 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.

1.2.2 Project Outline

Sindhuli Road is planed to connect Bardibas on East-West Highway with Dhulikhel nearby Banepa on Kodari Road. The route passes through such centers of rulal activities on the way as Sindhuli Bazar, Kurkhot and Nepalthok.

The Project Road is broadly divided into two sections, namely, Section I between Bardibas and Sindhuli Bazar with a total length of 37 km, and Section II between Sindhuli Bazar and Dhulikhel having an approximate length of 118 km.

The outline of the Project Road in each section is briefly described as follows:

Section I: Bardibas - Sindhuli Bazar (37 km)

The existing road between Bardibas on East-West Highway and Sindhuli Bazar has been constructed by DOR with the exception of bridges and pavement employing equipments granted by the Japanese Government Aid Program since 1982. The Project, therefore aims at improvement of the existing roadway and construction of bridges and pavement which have been remained untouched so far.

Section II: Sindhuli Bazar - Dhulikhel (118 km)

Section II is entirely new construction of road, since there exists only a mountain trail or small track which links Sindhuli Bazar with Dhulikhel at present.

Section II of the Project Road, starting from Sindhuli Bazar, crosses over Mahabhrat Range at the lowest crossing point nearby Sindhuli Garhi (EL. 1360) and reaches Khurkot. After Khurkot, the Project Road runs along the Sun Kosi river and reaches the confluence of Sun Kosi river and Rosi Khola at Nepalthok. From Nepalthok, the Project Road continues ascending along Rosi Khola and finally reaches Dhulikhel nearby Banepa on Kodari Road.

1.3 Work Schedule

The Study started from November, 1986 and is scheduled to end in June, 1988. An overall work flow is presented in Fig. 1.1 and the major outputs of the Study in each year are summarized below:

The first year (November 1986 - March 1987)

- Road Planning Group

  Field reconnaissance by helicopter, initial route study using a existing topographic map with a scale of 1/50,000, socio-economic study, traffic survey, forecasting of future traffic volume, alternative route study using a topographic map of 1/10,000 and preparation of Progress Report (I).

- Mapping Group

  Preparation of topographic map with a scale of 1/10,000 and aerial photographic survey including ground control survey.

FIGURE 1-1 WORK FLOW DIAGRAM

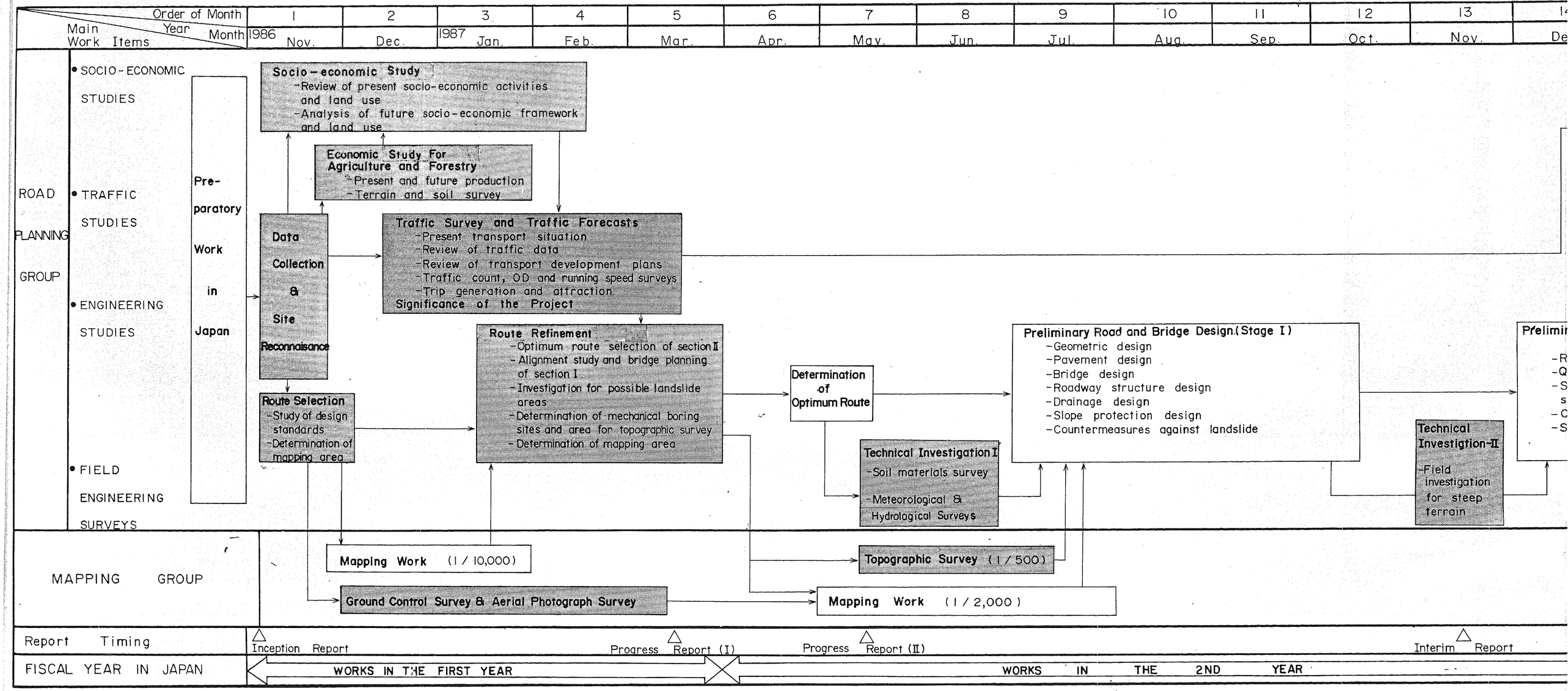
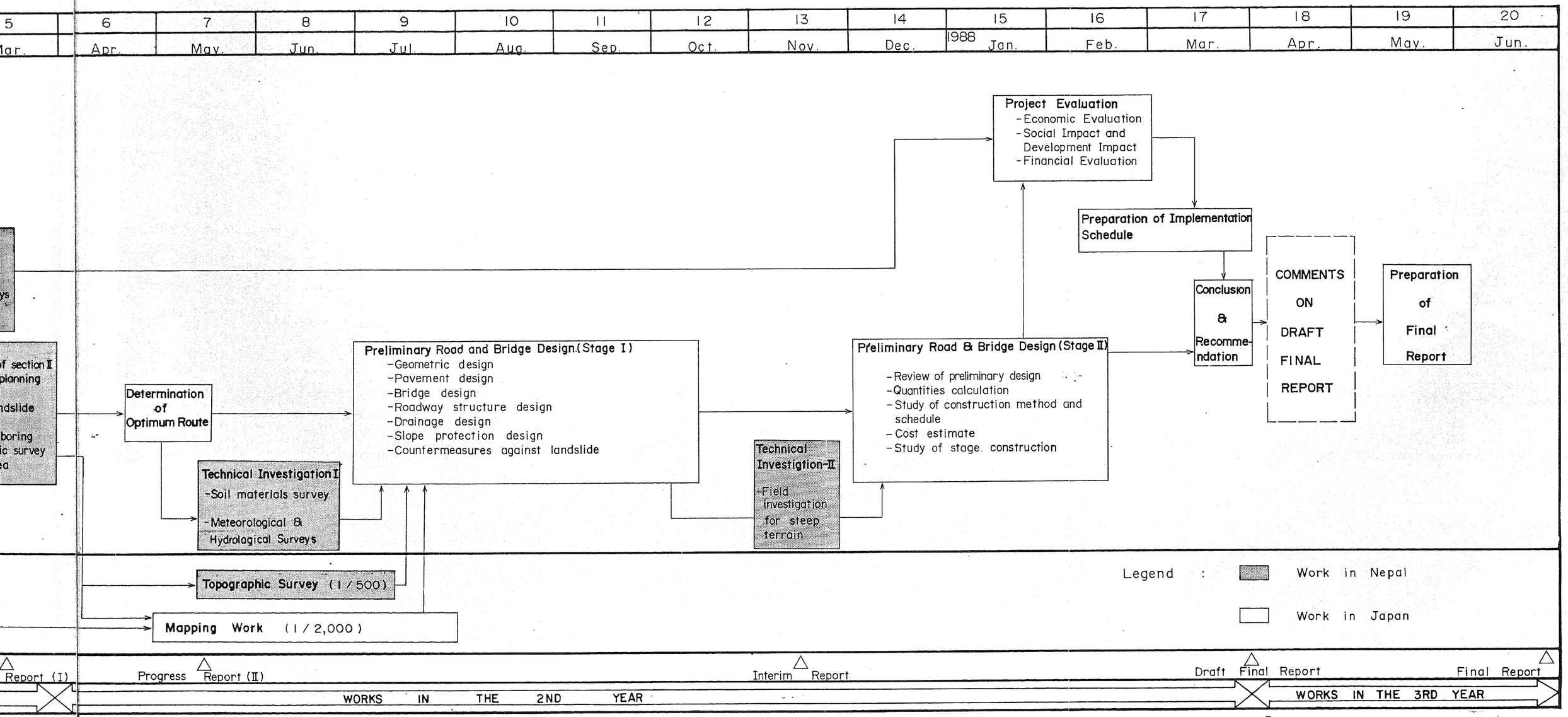
FIGURE 1-1 WORK FLOW DIAGRAM