8.1.3 Investigation of Engineering Alternatives

(1) Batang Rajang River Crossing

There are two ways to cross the river: by bridge or by ferry. An economic evaluation is conducted among 3 bridge alternatives so the most economical bridge plan may be selected and then compared with the ferry alternative. The best bridge plan was finally selected in lieu of the ferry.

1) Comparison between Bridge Alternatives

For the bridge comparison, the bridge engineer of Sarawak J.K.R. joined in the discussions on the following three alternatives:

1. Prestressed Concrete Box Girder Bridge (P.C. Box Girder Bridge)
2. Prestressed Concrete Rahmen Bridge - Type T (P.C.T Rahmen Bridge)
3. Prestressed Concrete Tension Cable Bridge (P.C. Tension Cable Bridge)

The above comparison among the 3 types of bridges has led to the conclusion that the P.C. Box Girder Bridge is the best alternative because of its minimum cost, as shown in Table 8-2.

2) Ferry Boat Alternative

The proposed Batang Rajang Bridge site is characterized by very steep topography on both sides of the river as shown in Fig. 8-1.

The Batang Rajang features remarkable water level variations as shown in Appendix 4-4, and also has a high velocity river current during flood season.

a) Estimated ferry boat operation days

Twin engine ferries normally cruise at a peak speed of 8 sea-miles per hour, and sometimes with 4 engines at a peak speed of 10 sea-miles per hour. Assuming the highest allowable river current velocity for ferry operation is 8 sea-miles per hour, the ferry might be operated 225 days on an annual average, judging from past water level records over more than 10 years time, when the water level of the Bantang Rajang was at 7.9 m or lower.

b) Facilities for ferry boat operation

Since the water level varies remarkably, there are two alternatives for ferry facility: by quay and slip-way.

Table 8-3 shows a comparison of the two alternatives. The quay plan is more

Table 8-2 COMPARISON OF ALTERNATIVE BRIDGE PLANS FOR CROSSING THE BATANG RAJANG

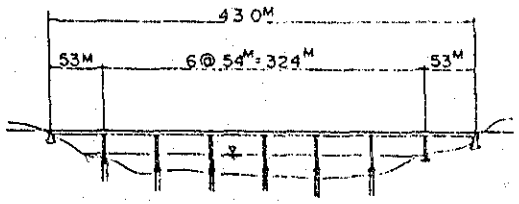
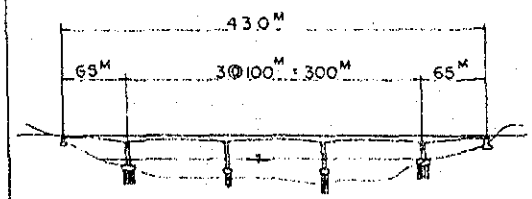
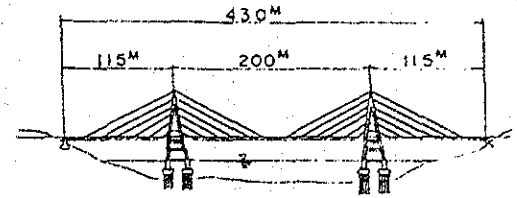
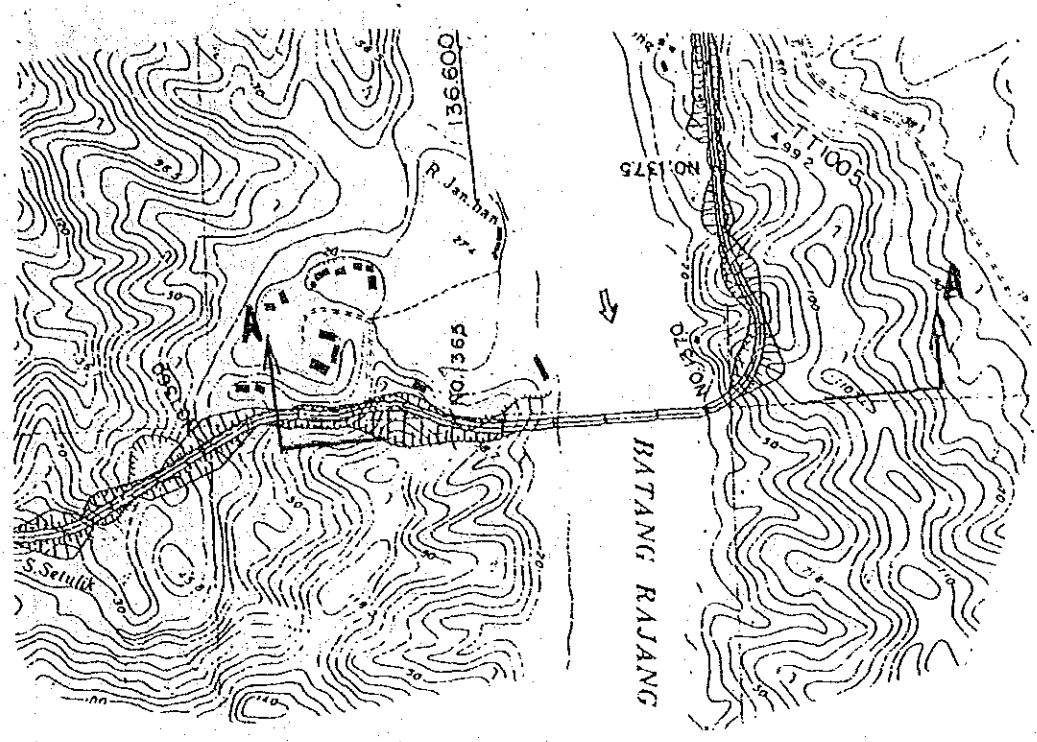
	P.C. Box Girder Bridge	P.C. T Rahmen Bridge	P.C. Tension Cable Bridge
PROFILE			
COST	1. Superstructure M$2,397,000 2. Substructure M$2,682,000 3. Erection M$431,000 Direct Construction Cost M$5,510,000 Indirect Construction Cost M$1,378,000 Project Cost M$6,888,000	1. Superstructure M$4,298,000 2. Substructure M$3,047,000 3. Erection M$1,458,000 Direct Construction Cost M$8,803,000 Indirect Construction Cost M$2,200,000 Project Cost M$11,003,000	1. Superstructure M$2,570,000 2. Substructure M$10,822,000 3. Erection Not estimated Direct Construction Cost M$13,392,000 Indirect Construction Cost M$3,349,000 Project Cost M$16,741,000
MAINTENANCE	Not Necessary	Not Necessary	Not Necessary
SIGHT VIEWING	Fair	Good	Very Good
CONSTRUCTION WORK	Fair	Fair	Difficult for Tower Erection
PRIORITY JUDGMENT	No.1	No.2	No.3

Fig. 8-1 TOPOGRAPHY AROUND THE CROSSING POINT OF THE BATANG RAJANG

PLAN



PROFILE A–A

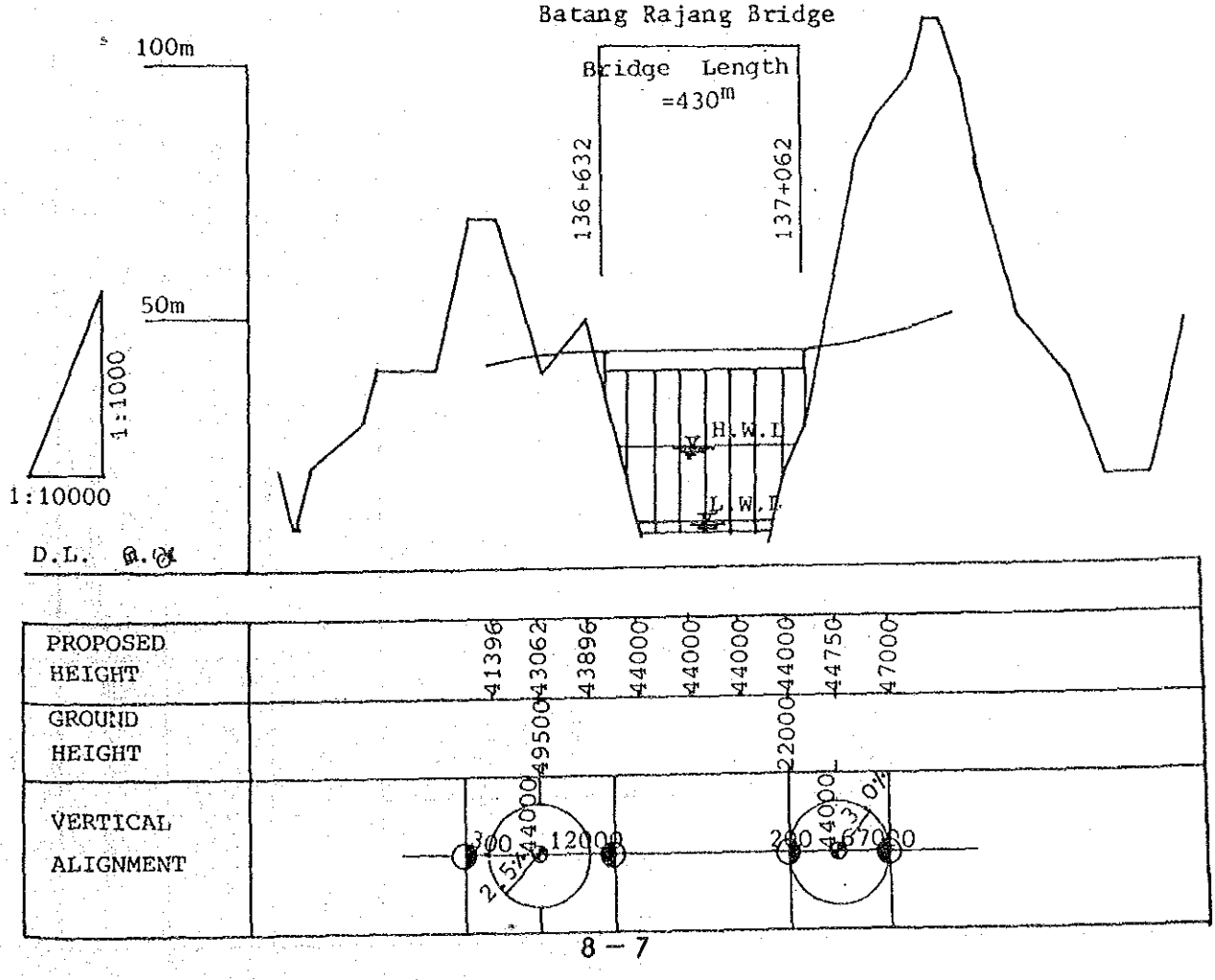
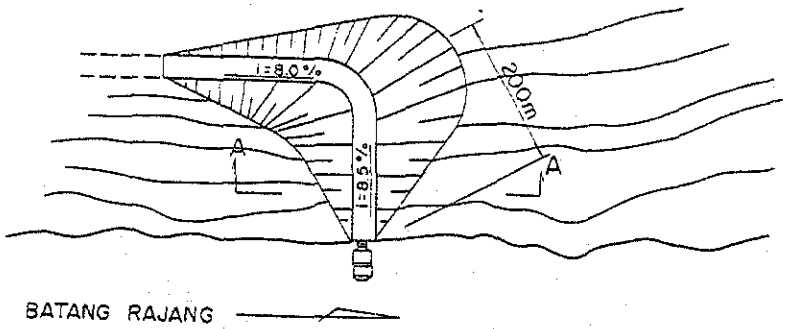
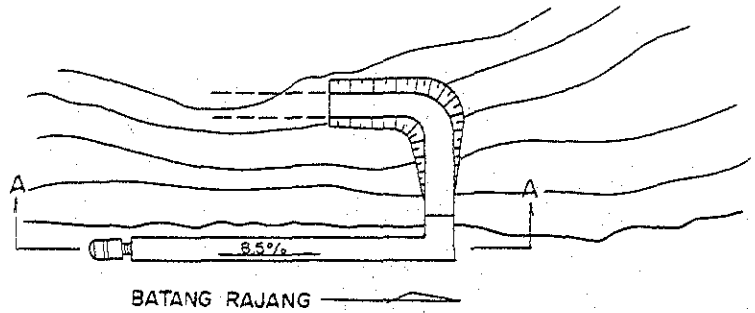
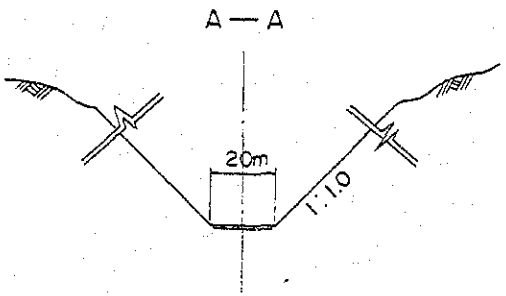
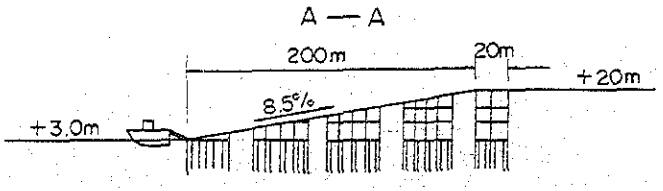


Table 8-3 COMPARISON OF ALTERNATIVE FERRY BOAT PLANS FOR CROSSING THE BATANG RAJANG

Item		No.1 Slipway Plan	No.2 Quay Plan
General Concept	Plan		
	Cross Section		
Estimated Cost		M$9,240,000.-	M$5,883,000.-
Construction Method		Excavation work at steep terrain	Reinforced concrete structure with pile foundation along the Batang Rajang
Terminal Problems		Frequent maintenance work to compensate for soil erosion from the slope caused by heavy rainfall	Troublesome placing concrete for maintenance free structures ranging from 20.00 m to low water level
Technical Judgement		Not suitable	Suitable

advantageous than the slipway plan because of steep topographical conditions.

The design conditions for special quay facilities at both sides are as follows:

a) Ferry facility (quay) height: One end +3.00 m, other end +20.00 m

b) Gradient of quay: 8.5 %

c) Quay length: 200 m

d) Access road to quay: 300 m

3) Determination of Crossing Method of the Batang Rajang

As Table 8-4 indicates, the bridge plan is judged superior to the ferry boat plan from the view points of maintenance and operation cost, although the amount of initial investment is almost the same between the two plans. In addition, the bridge plan offers the great advantage that river can be crossed regardless of the water level variations. On the other hand, ferry service will be cancelled for about one third of each year because of the water level variations. Consequently, the bridge plan (P.C. Box Girder bridge) was adopted for crossing the Batang Rajang.

Table 8-4 COST COMPARISON OF TWO ALTERNATIVES FOR CROSSING THE BATANG RAJANG

Unit: M$

Alternative	Item	Cost		Twenty Years Total
		Construction	Maintenance	
1. Ferry	a. Quay construction cost at both sides	5,883,000	0	5,883,000
	b. Ferry boat construction cost	1,000,000	0	1,000,000
	c. Operation expense (incl. maintenance) M$500,000 x 20 yrs.	0	10,000,000	10,000,000
	d. Engine replacement (estimated) after 10 years usage	0	350,000	350,000
	Total	6,883,000	10,350,000	17,233,000
2. Bridge	P.C. Box Girder Bridge (430 m length)	6,888,000	10,200	6,989,200
	Balance	-5,000	+10,339,800	+10,334,800

8.2 Construction Costs

8.2.1 Construction Schedule

Dividing the Project Road into 8 sections, 5 alternative construction schedules are proposed, as shown in Figs. 8-2, 8-3 and 8-4.

Fig. 8-2 CONSTRUCTION ORDER BY ALTERNATIVE

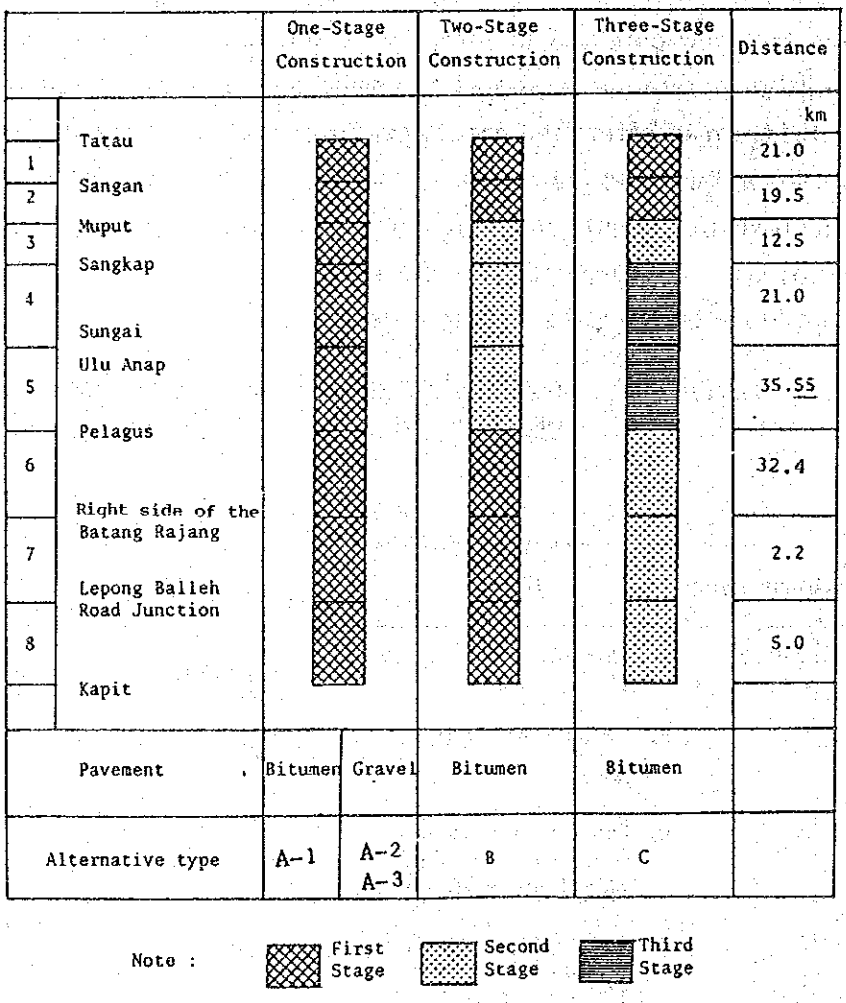


Fig. 8-3 CONSTRUCTION SECTIONS

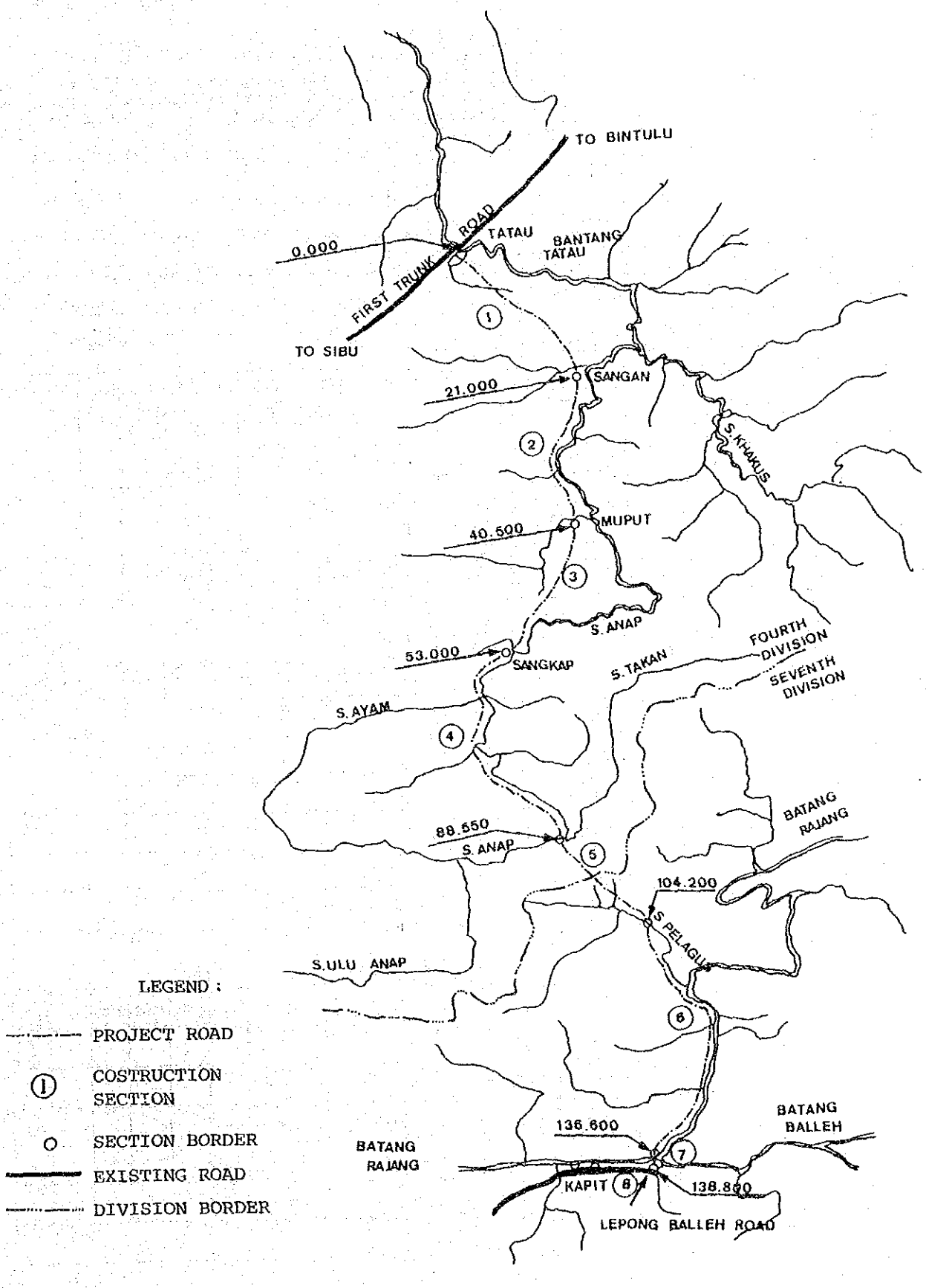
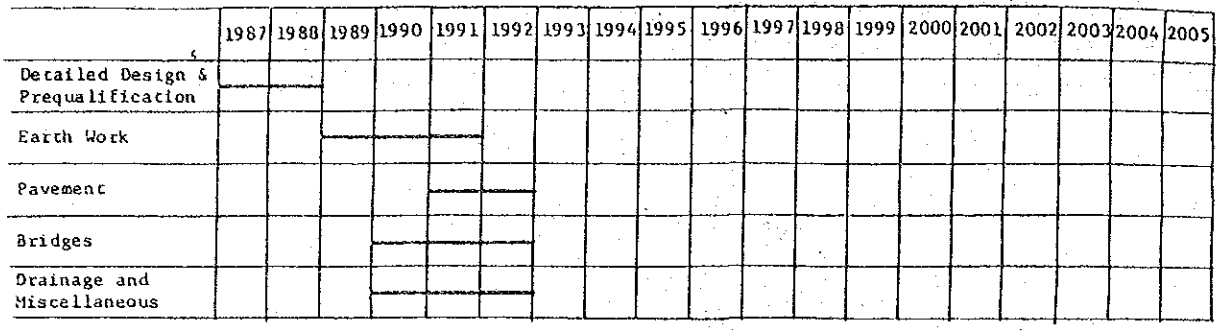
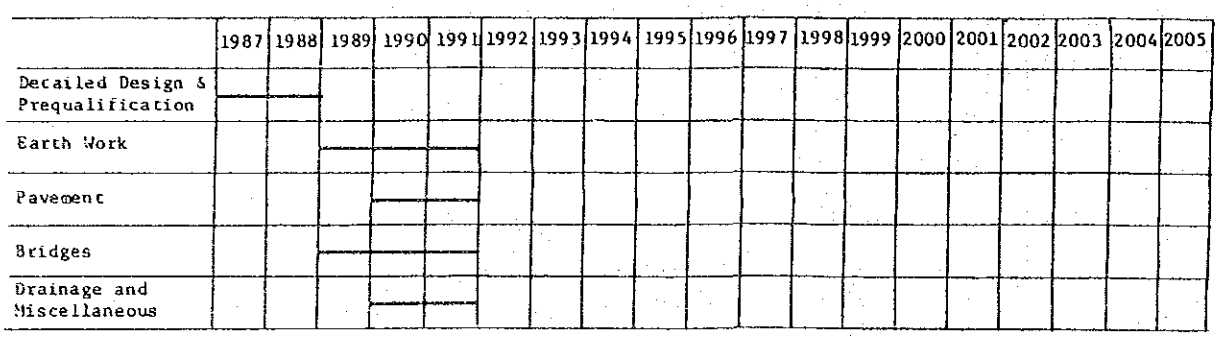


Fig. 8-4 CONSTRUCTION SCHEDULE

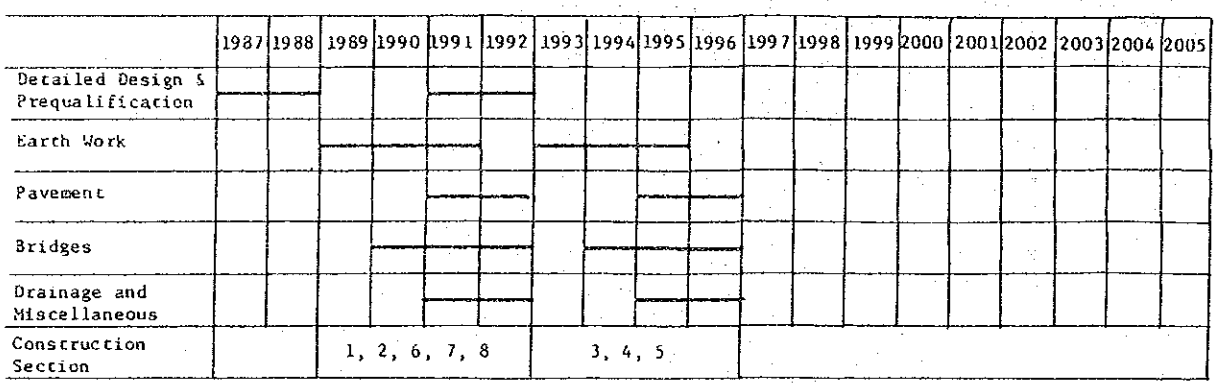
1. One stage construction plan with bituminous surface (A-1) with gravel surface (A-2)



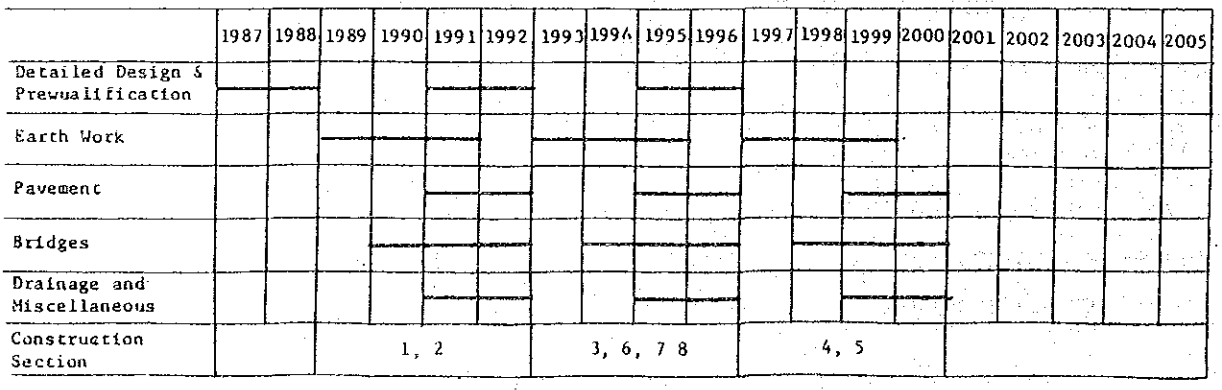
2. One stage construction plan with gravel surface (A-3)



3. Two stage construction plan with bituminous surface (B)



4. Three stage construction plan with bituminous surface (C)



8.2.2 Construction Costs

Unit costs of construction items have been determined for materials, labour and machinery. These costs were calculated at Sarawak's market prices prevailing in October, 1984. These cost factors were obtained from the Sarawak P.W.D. through its local offices and local consultants, as well as from Japanese suppliers.

For the machinery and materials concerned, the unit cost was calculated from the costs of imported machinery and materials, as well as from the costs of domestic machinery and materials, provided that imports were only allowed if the corresponding machinery or materials were not available locally. The domestic and foreign currency components of unit construction costs were calculated according to the following classification:

(1) Classification by Currency Components

The Foreign Currency Component is composed of the following costs:

- Imported machinery (depreciation cost), supplies and raw materials
- Materials imported and processed in Sarawak
- Wages and salaries for foreign residents, and overhead costs and profits for foreign corporations

The domestic currency component is composed of the following costs:

- Domestic machinery and materials, and raw materials originating in Sarawak
- Wages of domestic residents
- Overhead costs and profits for domestic corporations, custom duties and taxes

The following Foreign Exchange Rate of the Malaysian Dollar in October, 1984 was adopted:

M$2.376 = US$1.00 = Yen 240.00

(2) Construction Quantities

The quantities for all construction items estimated for cost purposes in this project were calculated on the basis of the original designs and drawings.

(3) Unit Price Analysis

For the purpose of evaluating construction costs, each payment item was calculated using the basic cost factors determined from the available data.

Unit construction costs are given in Table 8-5. Hourly costs of machinery and facilities expected to be used in construction are given in Table 8-6, and wages for local labour are shown in Table 8-7. Costs of the main materials and supplies expected to be used in the project are shown in Table 8-8.

(4) Construction Costs

The costs for the best route are shown in Table 8-9.
Appendix 6-4 indicates the breakdown of the construction cost.
Appendix 6-5 shows the acquisition costs of construction equipment.
Appendix 6-6 shows the durability and repair coefficient of mechanical equipment.
Appendix 6-7 gives an example of hourly cost analysis.
Appendix 6-8 presents the quantities of materials to be procured and Appendix 6-9 shows the quantity of equipment used for construction.

Table 8-5 (1) UNIT COST OF CONSTRUCTION ITEMS

(Unit: M$)

ITEM	UNIT	FOREIGN	LOCAL	TAX	TOTAL
General Work					
1. Tree Cutting	Piece	21.42	33.82	0.43	55.67
2. Clearing and Grubbing	m^2	0.890	0.646	0.011	1.547
3. Common Excavation (Short Dist.)	m^3	1.691	1.125	0.013	2.829
4. Common Excavation (Medium Dist.)	m^3	2.575	1.426	0.017	4.018
5. Common Excavation (Long Dist.)	m^3	3.269	2.093	0.027	5.389
6. Embankment (Low)	m^3	0.719	0.458	0.006	1.183
7. Embankment (High)	m^3	0.829	0.540	0.007	1.376
Pavement Work					
8. Subgrade Regularization	m^2	0.082	0.061	0	0.143
9. Subbase Course t = 15cm	m^2	3.68	2.06	0.50	6.24
10. Well Graded Aggregate Base Course t = 20cm	m^2	7.25	3.92	1.06	12.23
11. Prime Coat	m^2	1.328	0.182	0.157	1.667
12. Tack Coat	m^2	0.590	0.051	0.068	0.709
13. Bituminous Surface Dressing t = 3cm	m^2	3.061	0.780	0.366	4.207
14. Bituminous Surface Course (Hot mix) t = 5cm	m^2	9.15	3.40	0.97	13.52
Bridge					
15. R.C. Beam Bridge L = 9.1m	U	132,860	157,215	22,190	312,265
16. Prestressed Beam Bridge L = 16.4m	U	136,943	152,596	22,480	312,019
17. P.C.T. Girder Bridge L = 24.4m	U	281,808	201,140	38,979	521,927
18. P.C.T. Girder Bridge L = 27.4m	U	258,568	193,409	35,876	487,853
19. P.C.T. Girder Bridge L = 30.4m	U	195,613	129,889	25,731	351,233
20. P.C.T. Girder Bridge L = 2 x 27.4m	U	423,207	293,345	56,830	773,382
21. P.C.T. Girder Bridge L = 2 x 30.4m	U	367,875	240,215	48,009	656,099
22. P.C.T. Girder Bridge L = 3 x 30.4m	U	540,137	350,533	70,286	960,956

Note: Prices given are for direct costs with no overhead, fringe and profit. Prices were calculated in October 1984.

Table 8-5 (2) UNIT COST OF CONSTRUCTION ITEMS

(Unit: M$)

ITEM	UNIT	FOREIGN	LOCAL	TAX	TOTAL
Drainage					
23. Box Culvert 1.5M x 1.5M	m	448.44	345.06	51.27	844.77
24. Box Culvert 2.0M x 2.0M	m	724.92	537.18	84.14	1,346.24
25. Box Culvert 2.5M x 2.5M	m	956.35	714.32	113.67	1,784.34
26. Box Culvert 3.0M x 3.0M	m	1,291.36	979.15	154.82	2,425.33
27. Box Culvert 2 - 2.5M x 2.5M	m	1,865.38	1,358.17	226.93	3,450.48
28. Box Culvert 2 - 3.0M x 2.5M	m	2,263.21	1,573.17	281.92	4,118.30
29. Box Culvert 2 - 3.0M x 3.0M	m	2,513.30	1,866.52	308.28	4,688.10
30. Corrugated Pipe ϕ1,066mm	m	248.60	38.64	29.50	316.74
31. Corrugated Pipe ϕ1,524mm	m	414.72	59.54	49.27	523.53
Miscellaneous					
32. Side Ditch (Manpower)	m	0	6.336	0	6.336
33. Slope Protection	m^2	1.60	0.40	0	2.00
General (Foundamentals)					
1. Loading of Materials	m^3	0.514	0.365	0	0.879
2. Solid Rock Excavation	m^3	13.30	7.68	1.04	22.02
3. Soft Rock Excavation	m^3	4.632	2.532	0.027	7.191
4. Plain Concrete (σ = 400 kg/cm^2)	m^3	76.76	74.32	14.52	165.60
5. Plain Concrete (σ = 210 kg/cm^2)	m^3	68.98	65.95	12.42	147.35
6. Plain Concrete (σ = 180 kg/cm^2)	m^3	67.07	62.66	11.86	141.59
7. Formwork	m^2	12.96	5.80	1.78	20.54
8. Fabricated Reinforcing Steel	kg	0.594	1.102	0.130	1.826
9. Cement Mortar	m^3	77.43	137.23	15.75	230.41

Legend FOREIGN : Foreign component expressed in Malaysian Dollars

LOCAL : Local component expressed in Malaysian Dollars

Kg: Kilogram, m^2: Square meter, m^3: Cubic meter,

m: Meter, U: Total unit

Table 8-6 HOURLY EQUIPMENT COSTS

(Unit: M$)

EQUIPMENT	FOREIGN	LOCAL	TOTAL
Bulldozer D8L with Ripper	110.26	27.57	137.83
Bulldozer D7G	59.92	14.98	74.90
Motor Scrapper WS-16	116.83	29.21	146.04
Compactor WF-22	74.61	18.65	93.26
Motor Grader GD605A	39.46	9.86	49.32
Tractor Shovel D50S	26.27	6.57	32.84
Wheel Loader 515	30.63	7.66	38.29
Truck Crane NK200	55.61	13.90	69.51
Crawler Crane, Clamshell KH75	60.23	15.06	75.29
Pile Hammer IDH35	29.46	7.36	36.82
Tired Roller TS290 20T	27.54	6.89	34.43
Macadam Roller KD120 10T	17.68	4.42	22.10
Crawler Drill PCR110	21.87	5.47	27.34
Motor Generator EG50	6.25	1.56	7.81
Motor Generator EG200	19.64	4.91	24.55
Air Compressor EC105V	13.62	3.41	17.03
Asphalt Plant TSAP600FAV	122.46	30.62	153.08
Asphalt Finisher MF36W	39.77	9.94	49.71
Asphalt Distributor	11.62	2.91	14.53
Concrete Mixer 0.75 M^3	8.75	2.19	10.94
Chip Spreader	13.28	3.32	16.60
Grout Pump	2.97	0.74	3.71
Dump Truck 15T	41.71	10.43	52.14
Flatbed Truck 7T	11.20	2.80	14.00
Water Tanker 5,000 Lit.	11.97	3.00	14.97
Trailer Truck 25T	22.37	5.59	27.96
Crushing Plant 40 T/H	50.74	12.69	63.43

Note: See Legend under Table 8-1.

Table 8-7 DAILY WAGES

(Unit: M$)

LABOURER	IN SARAWAK		
	WAGES/DAY	TAX	INCOME
Foreman	50	1.50	48.5
Operator	38	-	38
Driver	35	-	35
Carpenter	35	-	35
Mechanic	35	-	35
Iron Worker	35	-	35
Mason	35	-	35
Raker	35	-	35
Skilled Labour	25	-	25
Unskilled Labour	18	-	18
Guardman	40	-	40

Source: From BINTULU P.W.D.

Rate per 9 hours work including allowance.

Table 8-8 COST OF MAIN MATERIALS

(Unit: M$)

DESCRIPTION	UNIT	FOREIGN	LOCAL	TAX	TOTAL
Portland Cement	T	92.00	138.00	(10%)	230.00
Reinforcing Steel SD	Kg	0.48	0.72	(10%)	1.20
Reinforcing Steel SR	Kg	0.36	0.54	(10%)	0.90
Steel Pipe Pile	T	1,110.00	67.00	130.00	1,307.00
P.C. Bar	Kg	3.60	0.21	0.42	4.23
P.C. Cable	Kg	3.10	0.18	0.36	3.64
Bitumen 80-100	T	680.00	120.00	(10%)	800.00
Bitumen cutback RC-70 MC-70	T	935.00	165.00	(10%)	1,100.00
Diesel	Lit.	0.19	0.44	(0.0073)	0.63
Kerosene	Lit.	0.23	0.52	(0.385)	0.75
Motor Oil	Lit.	1.48	3.47	(0.23)	4.95
Grease	Kg	2.10	4.90	(0.20)	7.00
Plank·Lumber	M^3	100.00	150.00	(10%)	250.00
Aggregate	M^3	19.50	15.50	(10%)	35.00
Sand	M^3	14.00	11.00	(10%)	25.00
Corrugated Pipe ϕ1,066mm	T	160.00	8.00	19.00	187.00
Corrugated Pipe ϕ1,524mm	T	280.00	15.00	33.00	328.00
Mineral Filler	T	12.00	18.00	(10%)	30.00
Explosive	Kg	6.00	14.00	(10%)	20.00
Nail	Kg	0.92	1.38	(10%)	2.30
Steel Wire	Kg	0.92	1.38	(10%)	2.30
See/Grass	M^2	0	4.00	0	4.00
Paint	Lit.	0	8.00	(10%)	8.00

Source: BINTULU P.W.D. and Japan supplier

Table 8-9(1) TATAU-KAPIT TRUNK ROAD PROJECT CONSTRUCTION COSTS

(Unit: M$'000)

	FC	LC	TAX	TOTAL
(1) Tree Cutting	1,189	1,878	24	3,091
(2) Clearing and Grubbing	4,941	3,587	61	8,589
(3) Earthwork	76,290	44,559	2,110	122,959
(4) Pavement	25,845	10,805	3,210	39,860
(5) Bridge	10,671	7,020	1,349	19,040
(6) Drainage	5,779	2,467	691	8,937
(7) Miscellaneous	2,569	2,393	0	4,962
(8) Sub-Total (Direct Cost)	127,284	72,709	7,445	207,438
(9) Construction Cost with Overhead and Profit (8)x1.25	159,105	90,886	9,306	259,297
(10) Supervision (9)x0.05	7,955	4,544	465	12,964
(11) Contingency [(9)+(10)]x0.10	16,706	9,543	977	27,226
(12) Total	183,766	104,973	10,748	299,487
(13) Detailed Engineering with Contingency (9)x0.066	10,501	5,998	614	17,113
(14) Compensation	0	1,000	0	1,000
Grand Total	194,267	111,971	11,362	317,600
Cost per KM			(9)	1,868

Table 8-9(2) TATAU-KAPIT TRUNK ROAD PROJECT CONSTRUCTION COSTS BY SECTION

Unit: M$'000

Section	Item	Gravel				Bituminous Surfacing			
		FC	LC	TAX	TOTAL	FC	LC	TAX	TOTAL
Tatau									
	General	927	827	13	1.767	927	827	13	1.767
	Earthwork	7.596	4.460	188	12.244	7.596	4.460	188	12.244
	Pavement	1.730	951	243	2.924	3.888	1.625	481	5.994
	Bridge	1.022	890	149	2.061	1.022	890	149	2.061
1	Drainage	568	195	67	830	568	195	67	830
(0∼21.0 km)	Miscellaneous	366	361	0	747	386	361	0	747
	Sub-Total(Direct Cost)	12.229	7.684	660	20.573	14.387	8.358	898	23.643
	Others	6.435	4.044	346	10.825	7.571	4.399	472	12.442
	Compensation	0	100	0	100	0	100	0	100
	Total Project Amount	18.664	11.828	1.006	31.498	21.958	12.857	1.370	36.185
								Cost per Km	1.407
Sangan									
	General	861	768	12	1.641	861	768	12	1.641
	Earthwork	8.951	5.201	275	14.427	8.951	5.201	275	14.427
	Pavement	1.609	884	226	2.719	3.613	1.511	447	5.571
	Bridge	915	756	131	1.802	915	756	131	1.802
2	Drainage	565	264	68	897	565	264	68	897
(21.0∼40.5km)	Miscellaneous	360	336	0	696	360	336	0	696
	Sub-Total(Direct Cost)	13.261	8.209	712	22.182	15.265	8.836	933	25.034
	Others	6.979	4.319	374	11.672	8.033	4.650	490	13.173
	Compensation	0	100	0	100	0	100	0	100
	Total Project Amount	20.240	12.628	1.086	33.954	23.298	13.586	1.423	38.307
								Cost per Km	1.605
Nuput									
	General	552	492	8	1.052	552	492	8	1.052
	Earthwork	5.725	3.308	194	9.227	5.725	3.308	194	9.227
	Pavement	1.010	555	143	1.708	2.286	594	284	3.524
	Bridge	415	358	61	834	415	358	61	834
3	Drainage	359	186	42	587	359	186	42	587
(40.5∼53.0km)	Miscellaneous	231	216	0	447	231	216	0	447
	Sub-Total(Direct Cost)	8.292	5.115	448	13.855	9.568	5.514	589	15.671
	Others	4.363	2.692	236	7.291	5.035	2.902	310	8.247
	Compensation	0	100	0	100	0	100	0	100
	Total Project Amount	12.655	7.907	684	21.246	14.603	8.516	899	24.018
								Cost per	1.567
Sangkap									
	General	1.570	1.399	22	2.991	1.570	1.399	22	2.991
	Earthwork	29.601	17.257	846	47.704	29.601	17.257	846	47.704
	Pavement	2.873	1.577	407	4.857	6.503	2.713	807	10.023
	Bridge	1.843	1.442	259	3.544	1.843	1.442	259	3.544
4	Drainage	1.867	735	222	2.824	1.867	735	222	2.824
(53.0∼88.550 km)	Miscellaneous	668	615	0	1.283	668	615	0	1.283
	Sub-Total(Direct Cost)	38.422	23.025	1.756	63.203	42.502	24.161	2.156	68.369
	Others	20.220	12.116	924	33.260	22.129	12.714	1.135	35.978
	Compensation	0	300	0	300	0	300	0	300
	Total Project Amount	58.642	35.441	2.680	96.763	64.181	37.175	3.291	104.647
								Cost per Km	2.404
S.Ulu Anap									

Table 8-9(3) TATAU-KAPIT TRUNK ROAD PROJECT
CONSTRUCTION COSTS BY SECTION

Unit: M$'000

Section	Item	Gravel				Bituminous Surfacing			
		FC	LC	TAX	TOTAL	FC	LC	TAX	TOTAL
S. Ulu Anap									
	General	691	616	10	1.317	691	616	10	1.317
	Earthwork	6.347	3.724	158	10.229	6.347	3.724	158	10.229
	Pavement	1.265	694	179	2.138	2.862	1.195	355	4.412
	Bridge	524	508	80	1.112	524	508	80	1.112
5	Drainage	477	244	58	779	477	244	58	779
(88.550 ~ 104.200 km)	Miscellaneous	283	268	0	551	283	268	0	551
	Sub-Total(Direct cost)	9.587	6.054	485	16.126	11.184	6.555	661	18.400
	Others	5.045	3.185	255	8.485	5.886	3.450	347	9.683
	Compensation	0	100	0	100	0	100	0	100
	Total Project Amount	14.632	9.339	740	24.711	17.070	10.105	1.008	28.183
								Cost per Km	1.470
Pelagus									
	General	1.431	1.275	20	2.726	1.431	1.275	20	2.726
	Earthwork	16.478	9.675	408	26.561	16.478	9.675	408	26.561
	Pavement	2.618	1.437	371	4.426	5.926	2.473	736	9.135
	Bridge	1.217	1.167	186	2.570	1.217	1.167	186	2.570
6	Drainage	1.887	834	226	2.947	1.887	837	226	2.947
(104.200 ~ 136.600 km)	Miscellaneous	591	557	0	1.148	591	557	0	1.148
	Sub-Total(Direct cost)	24.222	14.945	1,211	40.378	27.530	15.981	1.576	45.087
	Others	12.746	7.865	638	21.249	14.488	8.410	829	23.727
	Compensation	0	250	0	250	0	250	0	250
	Total Project Amount	36.968	23.060	1.849	61.877	42.018	24.641	2.405	69.064
Right side of the Batang Rajang								Cost per Km	1.739
	General	97	87	1	185	97	87	1	185
	Earthwork	1.593	933	41	2.567	1.593	933	41	2.567
	Pavement	178	97	25	300	403	168	50	621
	Bridge	4.476	1.706	445	6.627	4.476	1.706	445	6.627
7	Drainage	57	9	7	73	57	9	7	73
(136.600 ~ 138.800 km)	Miscellaneous	51	41	0	92	51	41	0	92
	Sub-Total(Direct Cost)	6.452	2.873	519	9.844	6.677	2.944	544	10.165
	Others	3.395	1.512	273	5.180	3.512	1.550	286	5.348
	Compensation	0	50	0	50	0	50	0	50
	Total Project Amount	9.847	4.435	792	15.074	10.189	4.544	830	15.563
								Cost per Km	5.776
Lepong Balleh Road									
	Pavement	257	139	37	433	363	167	50	580
	Bridge	259	193	36	488	259	193	36	488
8	Sub-Total(Direct Cost)	516	332	73	921	622	360	86	1.068
(Repong Balleh Road)	Others	272	175	38	485	327	190	45	562
L = 5.0 km	Total Project Amount	788	507	111	1.406	949	550	131	1.630
	General	6.130	5.465	85	11.680	6.130	5.465	85	11.680
	Earthwork	76.290	44.559	2.110	122.959	76.290	44.559	2.110	122.959
	Pavement	11.540	6.334	1.630	19.504	25.845	10.805	3.210	39.860
	Bridge	10.671	7.020	1.349	19.040	10.671	7.020	1.349	19.040
TOTAL	Drainage	5.779	2.467	691	8.937	5.779	2.467	691	8.937
	Miscellaneous	2.569	2.393	0	4.962	2.569	2.393	0	4.962
	Sub-Total (Direct Cost)	112.979	68.238	5.865	187.082	127.284	72.709	7.445	207.438
	Others	59.456	35.909	3.087	98.452	66.983	38.262	3.917	109.162
	Compensation	0	1.000	0	1.000	0	1.000	0	1.000
	Total Project Cost	172.435	105.147	8.952	286.534	194.267	111.971	11.362	317.600
								Cost per Km	1.868

Note FC : Foreign component LC : Local component

8.2.3 Maintenance and Repair Costs

The Maintenance work necessary to keep the roads in good condition is classified into two types, routine maintenance and periodic maintenance.

Routine Maintenance:

- Patching repair of furrows and potholes
- Clearing of stormwater sewers and culverts, and vegetation control
- Removal of wash-out debris
- Other traffic services

Periodic Maintenance:

- Partial replacement of the surface dressing
- Overlaying of pavement
- Others

Table 8-10 shows the maintenance cost in a year per km. Those details are shown in Appendix 6-10.

Table 8-10 ROAD MAINTENANCE COST M$/km

	Routine Maintenance	Periodic Maintenance
ADT 2,000	6,000	29,450

CHAPTER 9

CONTENTS

CHAPTER 9 ESTIMATION OF FUTURE TRAFFIC DEMAND

9.1 Methodology

9.1.1 Traffic Forecast Method

Traffic is usually classified into the following types according to the traffice demand forecast for the Project Road:

1) Normal traffic
2) Diverted traffice
3) Induced traffic
4) Development traffic

and these traffic types are defined as follow:

1) Normal traffic occurs on the existing road netwerk regardless of the completion of the Project Road. There is no normal traffic at present since no effective road network exists in the Study Area.

2) Diverted traffic occurs upon the completion of the Project Road by diversion from the existing methods of transport. River traffic will divert to road traffic on the Project Road in the Study Area.

3) Induced traffic is newly generated traffic due to improved accessibility and convenience resulting from the completion of the Project Road.

4) Development traffic is generated due to the various develpoment activities resulting from completion of the Project Road.

An outline of the traffic forecast method is summarized in the flow chart in Fig. 9-1.

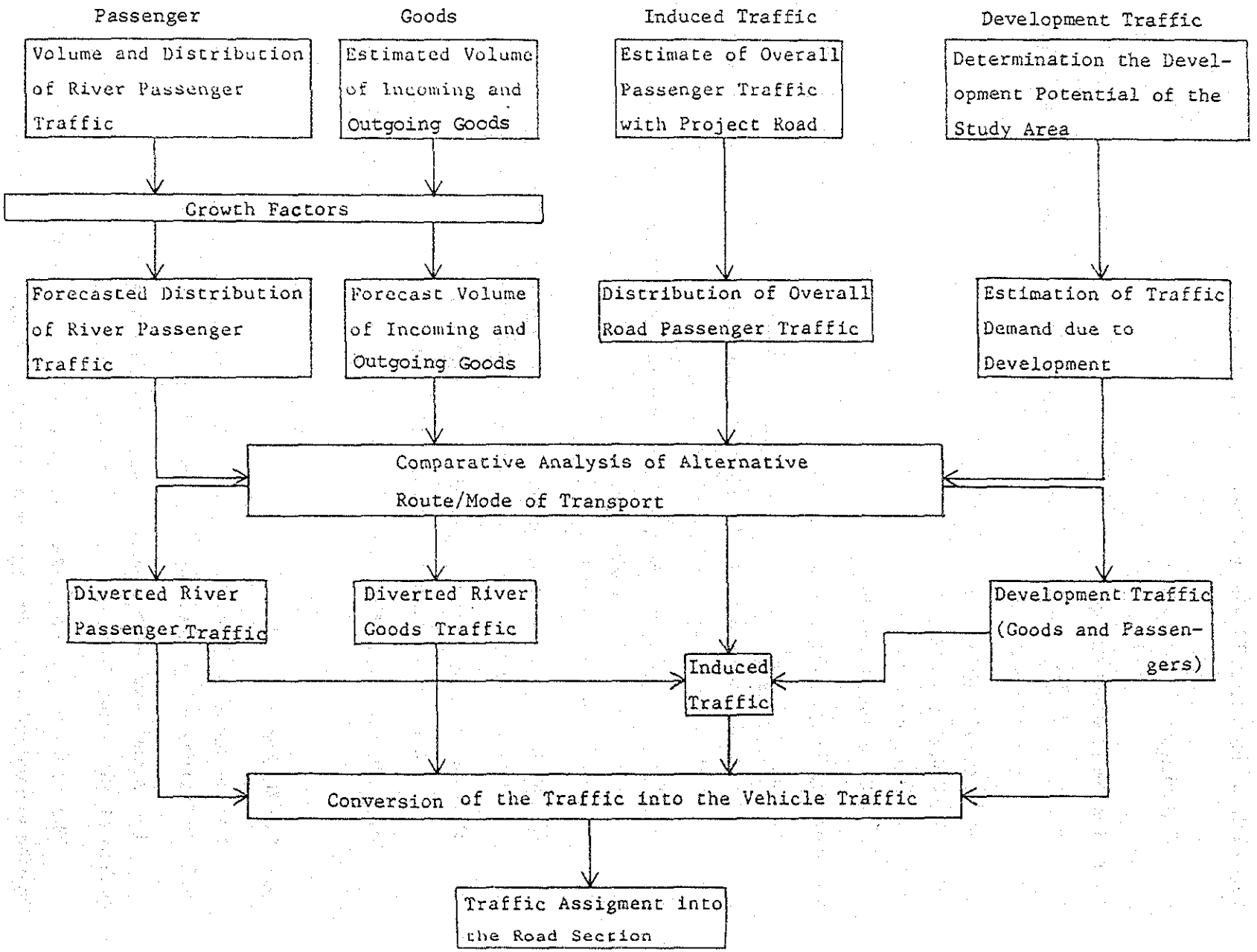
9.1.2 Traffic Zone

For the analysis of traffic, the Study Area and relevant adjacent areas including the Third Division and Belaga have been divided into 14 zones.

The zones have been divided taking into consideration the boundaries of the subdistrict, the Project Road, the rivers and their basins as traffic routes.

The inclusion of Bintulu Zone actually includes parts of the Fourth and Fifth Division located outside the Study Area as a traffic zone, since traffic outside the Study Area is limited and all of it passes through Bintulu town.

Fig. 9-1 OUTLINE OF THE TRAFFIC FORECAST METHOD



The results of zoning are shown in Table 9-1 and graphically shown in Fig. 9-2.

Table 9-1 ZONE FOR TRAFFIC ANALYSIS

Zone No.	Name of Zone	Center of Zone	River Basin/Road
1	Bintulu	Bintulu	Tatau/Bintulu Road
2	Kuala Tatau	Kuala Bazaar	Bg. Tatau
3	Tatau	Tatau Bazaar	Bg. Tatau
4	Kakus	Gabond Trading L/C	Sg. Kakus
5	Anap	Sangan Muput Muput	Sg. Anap Sg. Takan
6	Pelagus Merit	Bg. Rajang	
7	Kapit	Kapit Bazzar	Bg. Rajang
8	Lepong Balleh	Ng. Kebiau	Bg. Balleh Sg. Suut
9	Song	Song	Bg. Rajang
10	Gaat	Ng. Puru	Bg. Balleh
11	Mujong	Ng. Tiau	Sg. Mujong
12	Ulu Balleh	Ng. Entwau	Bg. Balleh
13	Belaga	Belaga Bazzar and Vicinity	Bg. Rajang
14	Third Div.	Sibu	Bg. Rajang

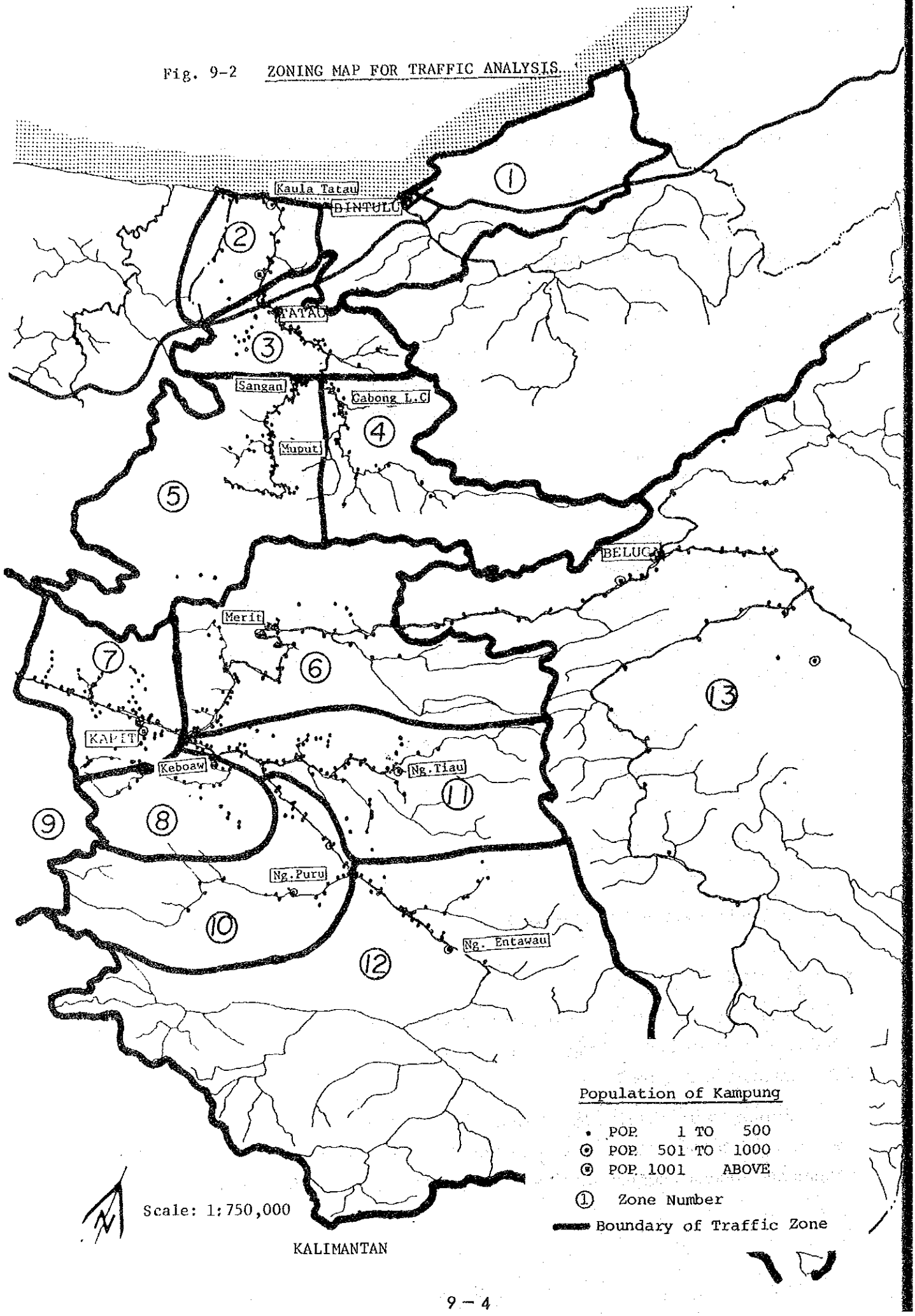
9.2 Traffic Demand in the Study Area

9.2.1 General

The future traffic demand forecast will be made based on the socio-economic forecast date described in Chapter 4 and also on field investigation findings and traffic data explained in Chapter 5.

Future traffic demand in the study of urban transport is normally forecasted based upon home interview surveys to ascertain the relationship between generated traffic volume and home attributes, which are occupation, income level, car ownership etc.

Fig. 9-2 ZONING MAP FOR TRAFFIC ANALYSIS



Future traffic demand in this study, however, is forecasted based upon interview surveys of river traffic characteristics and traffic volume surveys instead of the said method due to the following reasons:

(i) It is practically impossible to conduct home interview surveys because the population is broadly scattered in the interior region.

(ii) A household income survey has not been conducted with the inhabitants who live in the interior region. Even if the survey were conducted by the Study Team, it would not be easy to gather data on household income and expenditures.

(iii) Since there are no roads to connect with other regions in most of the Study Area, it is difficult to forecast the future traffic demand ater the completion of the Project Road based upon present home attributes.

Therefore, future traffic demand is estimated based only upon present traffic data and the zonal population, which are considered to be the most reliable economic indicators. The zonal population has been estimated based upon the future subdistrict population forcasted in Chapter 9 and the Kampong Master List for Malaria control in 1981. The future population of Bintulu Subdistrict has been separately estimated with reference to the Bintulu Master Plan Study. Table 9-2 shows the results of estimated future population by traffic zone.

The present traffic demand level of each traffic zone in terms of number of trip-ends per 1,000 population, is shown in Table 9-3. The annual growth rate of trip-ends per 1,000 population from 1982 to 1984 amounted to 15.0% in the Tatau area and 4.4% in the Kapit area according to the traffic surveys.

The growth rate has been large in the Tatau area since the Trunk Road has been open. The growth of trip-ends per population by zone is shown in Table 9-4.

9.2.2 River passenger traffic demand in the Study Area

(1) Tatau River basins

In the Tatau area the existing river passenger inter zonal traffic demand, in terms of the number of trip-ends per 1,000 population, is much higher in Sungai Kakus than in Sungai Anap as shown in Table 9-3. The main reason for low traffic demand in Sungai Anap is the existence of Sangan which acts as a secondary distribution center in the Sungal Anap basin.

Table 9-2 ESTIMATED POPULATION BY TRAFFIC ZONE

Traffic Zone	1980	1985	1990	1995	2000	2005	2010	Average Annual Growth Rate (%) 80-85	85-90	90-2010	
1. Bintulu	26,791	38,600	56,100	67,900	82,200	99,600	120,600	7.6	7.8	3.9	
2. Kuala Tatau	3,021	3,300	3,700	4,100	4,500	5,000	5,500	2.0	2.0	2.0	
3. Tatau	5,021	5,500	6,100	6,800	7,500	8,200	9,100	2.0	2.0	2.0	
4. Kakus	1,723	1,900	2,100	2,300	2,600	2,800	3,100	2.0	2.0	2.0	
5. Anap	4,302	4,800	5,200	5,800	6,400	7,100	7,800	2.0	2.0	2.0	
6. Pelagus	7,244	8,000	8,800	9,700	10,800	11,900	13,100	2.0	2.0	2.0	
7. Kapit	13,017	15,100	17,500	20,300	23,500	27,300	31,600	3.0	3.0	2.0	
8. Lepong Balleh	3,269	3,600	4,000	4,400	4,900	5,400	5,900	2.0	2.0	2.0	
9. Song	16,887	18,600	20,600	22,700	25,100	27,700	30,600	2.0	2.0	2.0	
10. Gaat	4,838	5,300	5,900	6,500	7,200	7,900	8,800	2.0	2.0	2.0	
11. Mujong	6,816	7,500	8,300	9,200	10,100	11,200	12,300	2.0	2.0	2.0	
12. Ulu Balleh	3,161	3,500	3,900	4,300	4,700	5,200	5,700	2.0	2.0	2.0	
13. Belaga	12,229	13,500	14,900	16,500	18,200	20,100	22,200	2.0	2.0	2.0	
Total:	108,319	129,200	157,100	180,500	207,700	239,400	276,300	3.6	4.0	2.8	Average 1980-2010 3.2

Table 9-3 LEVEL OF INTERZONAL PASSENGER TRAFFIC DEMAND

Traffic Zone	Population 1984	Tripends per day	Tripends/ 1,000 popu./day
1. Bintulu	35,912	-	-
2. Kuala Tatau	3,270	387	118.3
3. Tatau	5,435	1,998	367.6
4. Kakus	1,865	277	148.5
5. Anap	4,657	436	93.6
6. Pelagus	7,841	569	72.6
7. Kapit	14,651	2,922	199.4
8. Lepong Balleh	3,538	758	214.2
9. Song	18,279	(166)	-
10. Gaat	5,237	230	43.9
11. Mujong	7,378	426	57.7
12. Ulu Balleh	3,422	204	59.6
13. Belaga	12,237	66	5.0

Table 9-4 GROWTH OF TRIP-ENDS BY ZONE

Traffic Zone	Population 1982	Population 1984	Annual Growth	Tripends/Day 1982	Tripends/Day 1984	Annual Growth	Tripends/1,000 popu. 1982	Tripends/1,000 popu. 1984	Annual Growth Rate
2. Kuala Tatau	3,143	3,270	2.0%	550	387	-40.3	175.0	118.3	-21.6
3. Tatau	5,224	5,435	2.0	1,216 (990)	1,998 (1,082)	28.2 (4.5)	232.8 (189.5)	367.6 (199.1)	25.7 (2.5)
4. Kakus	1,793	1,865	2.0	261	277	3.0	145.6	148.5	1.0
5. Anap	4,476	4,657	2.0	224	436	39.5	50.0	93.6	36.8
Total in Tatau Area	14,636	15,227	2.0	2,251 (2,025)	3,098 (2,182)	17.3 (3.8)	153.8 (138.4)	203.5 (143.3)	15.0 (1.8)
6. Pelagus	7,537	7,841	2.0	523	569	4.3	69.4	72.6	2.3
7. Kapit	13,810	14,651	3.0	2,513	2,922	7.8	182.0	199.4	4.7
8. Lepong Balleh	3,401	3,538	2.0	651	758	7.9	191.4	214.2	5.8
10. Gaat	5,033	5,237	2.0	205	230	5.9	40.7	43.9	3.9
11. Mujong	7,091	7,378	2.0	391	426	4.4	55.1	57.7	2.3
12. Ulu Balleh	3,289	3,422	2.0	177	204	7.3	53.8	59.6	5.3
13. Belaga	12,723	13,237	2.0	76	66	-7.3	6.0	5.0	-9.5
Total in Kapit Area	52,884	55,304	2.3	4,536	5,175	6.8	85.8	93.6	4.4

Note: ( ): Excluding Vehicle Passenger Trips

The express launch utilization level, providing the only reliable base for estimating future river passenger traffic demand, shows a fairly high growth rate of 50% in the last 2 years. This high growth is largely attributed to the activation of timber production in the Tatau area. The increase in inland inhabitant employment opportunities due to timber production has produced large traffic demand. However, the high growth rate is unlikely to be continued since timber production in this area is estimated to decrease in the future.

(2) Rajang River basins

In the Kapit area, the existing river passenger traffic demand level is still low in the upstream river basin except in Lepong Balleh which is situated close to Kapit town. Since the rapids and shallows are obstacles in the upper parts of the rivers, and Long Houses are scattered in the wide river basin area, it is unlikely that river traffic demand will sharply increase. However, river traffic demand will surely increase along with population increases and commodity market expansion.

The increase of traffic demand between Kapit and Sibu depends upon the growth of Kapit town. Kapit is expected to develop along with timber production and as an administrative center for the development project in Seventh Division.

(3) The growth rate of river traffic

The growth rate shown in Table 9-5 is estimated in this area, based on the growth of trip-ends between 1982 and 1984, and also based on the assumption that passenger traffic will grow in proportion to the increase in income and economic activities in the area. Per capita GDP, which is estimated to grow at a 5% rate in the Fourth Malaysia Plan, has been taken into consideration to determine the passenger traffic growth rate.

Using the above growth rates, future river passenger traffic demand and distribution in the Tatau and Kapit areas have been estimated in Table 9-6 and presented in Fig. 9-3.

9.2.3 Cargo transportation demand

The existing cargo demand in the Study Area basically consists of shipping agricultural products and logs and of the inward delivery demand for consumer goods, construction materials, fertilizer, animal feed, fuel and so forth. The estimates of these cargo transportation demands are summarized in Table 9-7.

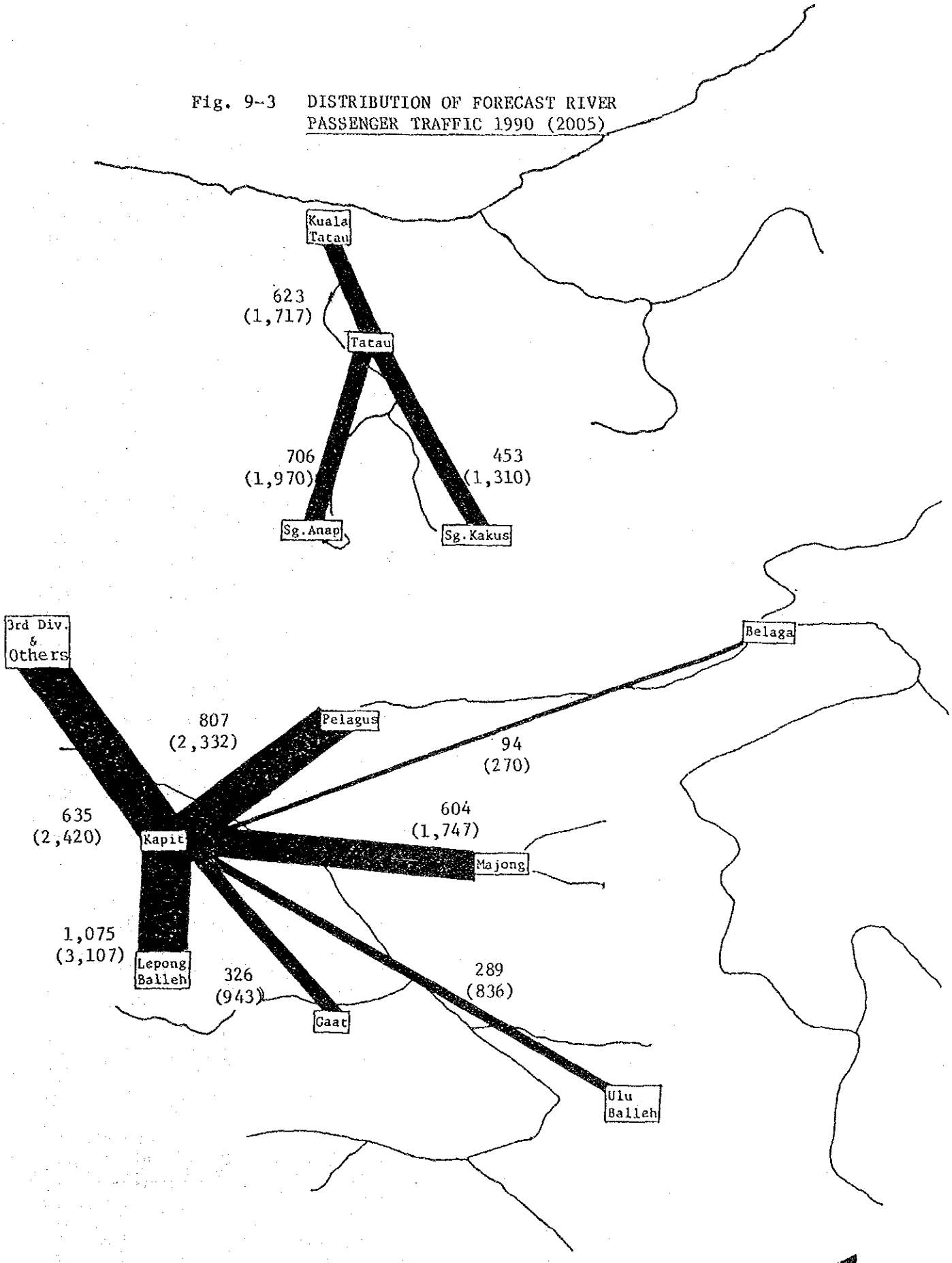
Table 9-5 ASSUMED GROWTH RATE OF RIVER PASSENGER TRAFFIC

		Average Annual Growth Rate (%)				
		1984-1990	1990-1995	1995-2000	2000-2005	2005-2010
Tatau Subdistrict	Long boat Speed boat	8	8	6	6	4
	Express Launch	10	10	8	8	6
Kapit District	Upper Kapit Area	6	6	8	8	6
	Kapit-Sibu (Express Launch)	8	8	10	10	8

Table 9-6 DISTRIBUTION OF FORECASTED RIVER PASSENGER TRAFFIC

	No. of Passengers/day						
	1984	1985	1990	1995	2000	2005	2010
Tatau-Kuala Tatau	387	419	623	929	1,263	1,717	2,128
-Kakus	277	301	453	686	946	1,310	1,652
-Anap	436	473	706	1,056	1,441	1,970	2,452
Tatau Total	1,100	1,193	1,782	2,671	3,650	4.997	6,232
Kapit-Pelagus	569	603	807	1,080	1,587	2,332	3,121
-Belaga	66	70	94	125	184	270	361
-Lepong Balleh	758	803	1,075	1,439	2,114	3,107	4,157
-Mujong	426	452	604	809	1,189	1,747	2,338
-Gaat	230	243	326	437	642	943	1,262
-Ulu Balleh	204	216	289	387	569	836	1,119
Sub-Total	2,253	2,387	3,195	4,277	6,285	9,235	12,358
Sibu-Kapit	400	432	635	933	1,503	2,420	3,556
Kapit-Total	2,653	2,819	3,830	5,210	7,788	11,655	15,914

Fig. 9-3 DISTRIBUTION OF FORECAST RIVER PASSENGER TRAFFIC 1990 (2005)



Figures in parenthesis indicate the passenger traffic volume in 2005.

Table 9-7 SUMMARY OF GOODS TRANSPORT DEMAND

(Unit: 1,000 tons)

	1984	1985	1990	1995	2000	2005	2010
Tatau Sub-district							
Incoming Total	8.8	10.3	12.7	16.0	19.8	24.6	31.0
Rice	0.6	0.6	0.7	0.9	1.0	1.2	1.4
Fuel	3.2	3.4	4.3	5.6	7.1	9.1	11.7
Cement, Iron	1.2	1.3	1.8	2.4	3.2	4.3	5.7
Fertilizer, Feed	-	1.1	1.1	1.2	1.3	1.3	1.5
Other	3.8	3.9	4.8	5.9	7.2	8.7	10.7
Outgoing Total	1,675.0	1,661.7	1,415.8	1,070.0	1,034.1	789.2	
Agricultural Products	1.6	1.7	1.8	2.0	2.1	2.2	2.3
Timber	1,675.0	1,660.0	1,414.0	1,068.0	1,032.0	787.0	
Kapit District							
Incoming Total	23.5	33.2	41.1	50.9	63.4	79.5	99.9
Rice	0.7	0.8	1.8	2.8	4.0	5.3	6.7
Fuel	8.9	9.4	12.3	16.0	20.8	27.2	35.4
Cement, Iron	3.4	3.6	5.0	6.8	9.3	12.7	17.4
Fertilizer, Feed	-	8.5	8.4	8.4	8.3	8.2	8.1
Others	10.5	10.9	13.6	16.9	21.0	26.1	32.3
Outgoing Total	689.3	1,020.3	1,020.4	1,020.4	1,020.5	1,020.5	1,020.5
Agricultural Products	20.3	20.3	20.4	20.4	20.5	20.5	20.5
Timber	669.0	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0

The major outward commodities, namely rubber, pepper and logs, are all shipped outside the Study Area. The present and future estimated quantity of agricultural and forestry products is shown in Chapter 5. This is equal to the commodity volume shipped outside the Study Area. (Appendix 7-1-5) As regards rice, comsumption volume of rice is more than total production in the Study Area as calculated in Appendix 7-1-4. The results indicate rice has been an in-coming commodity.

These outward agricultural commodities are sent by waterway via Tatau and Kapit using longboats from upstream and motor vessels going downstream. As for logs, those that float are rafted and those that sink are transported by barge towed by tugboat.

Inward delivery cargo consists of a large variety of commodities including food, sugar, beverages, cement, steel products, fuel, fertilizer, feed and sundry goods. The transportation demands have been estimated based on the per capita consumption level of these commodities, and they are shown in Appendices 7-1-1, 7-1-2, 7-1-3. As for fertilizer and feed, the commodity volume is estimated based on their per hectare or per head consumption in the future. According to these estiamtions, the total of inward commodities amounted to 32,300 tons in the Study Area in 1984, of which 8,800 tons were in the Tatau area and 23,500 tons were in the Kapit area.

These commodities are transported by 50 to 150 ton motor vessels from major ports up to Tatau or Kapit. Upriver from Tatau and Kapit, daily consumer goods are generally carried by longboats together with passengers.

9.3 Transport Cost Analysis

9.3.1 General

In this section, transport costs in the Study Area are analyzed by comparing scenarios "with" and "without" the Project Road. Transport cost savings, depending on results of this analysis, are one of the direct benefits of road construction and the most important quantifiable indicator of the benefits.

In the Study Area, rivers are the only means of transport. As a results, transport costs are extremely high and travel time is long. Therefore, transport cost savings by road construction will be particularly large and will cause substantial changes in traffic demand and traffic distribution patterns in the Study Area. Especially in the Kapit area, the major trading center is expected to change from Sibu to Bintulu since the Project Road will connect Kapit directly with the Bintulu Development Project Area.

The following appendices explain in detail the data base, assumptions and estimates of transport costs by type of transport, namely vehicles and vesssels:

Estimation of Motor Vehicle Operation Costs	:	Appendix 7-2
Estimation of Vessel Operating Costs	:	Appendix 7-3

9.3.2 Passenger transport costs

(1) Fare

Public transport in the Study Area consists only of express launches and taxicabs, but buses and airline services are in relevant adjacent areas.

Table 9-8 shows a comparison of their unit fares per passenger per kilometer. This indicates the unit costs of buses and express launches are cheapest. But unit costs of express launches vary according to the route.

Table 9-8 COMPARISON OF TRANSPORT FARES (1984)

Mode	Unit Fare (M$/km/Pass)
Bus*1	0.12
Taxi*2	0.60
Express Launch*3	0.08 - 0.13
Air*4	0.40

*1 :	Bintulu - Tatau	M$6.00, distance 51 km
*2 :	Authorized fare	3 - 5 km distance
*3 :	Tatau - Sangan	0.13 M$/km, M$6,00, distance 48 km
	Sibu - Kapit	0.08 - 0.09 M$/km, M$12 - 13, distance 152 km
	Kapit - Belaga	0.11 M$/km, M$18.00, distance 170 km
*4 :	Sibu - Bintulu	M$53.00, distance 165 km

(2) Transport costs

Table 9-9 shows the average operating unit cost of various means of passenger transport including private transport means calculated in economic prices.

Comparing unit fares, the unit fare of a bus is too much higher than unit cost in economic prices.

Among the unit costs, the unit cost of express launches is higher than that of buses in public transport and the unit cost of a long boat is also higher than that of a passenger car in private transport. This proves that river transport costs are higher in the Study Area. In addition, a comparison of travel speeds between modes of transport reveals a greater disadvantage in river transport for passengers.

Table 9-9 COMPARISON OF AVERAGE UNIT TRANSPORT COSTS FOR PASSENGERS (ECONOMIC PRICES)

Mode of Travel		M$ Veh.km	Per Day	Ave. No. of Passengers (Capacity)	Unit Cost/Average Pass/. km	Travel Speed
					(M$)	km/hr
Passenger Car	Gravel	0.6849 (0.5284)	- -	3 (4)	0.228 (0.176)	55
	Paved	0.4727 (0.3633)	- -	3 (4)	0.158 (0.121)	80
Bus	Gravel	1.1768 (1.0310)	- -	25.0 (44)	0.047 (0.041)	40
	Paved	0.8565 (0.7412)	-	25.0 (44)	0.034 (0.030)	47
Express Launch						
Tatau-Gabong L/C		4.5561 (4.2660)	628.74 (588.71)	40 (64)	0.114 (0.107)	35
Kapit-Sibu		4.2255 (4.0167)	1,284.56 (1,221.09)	42 (70)	0.101 (0.096)	35
Long Boat	40 Hp	2.6830 (2.0680)	-	10 (12)	0.268 (0.207)	12
	25 Hp	1.7660 (1.3600)	-	5 (6)	0.353 (0.272)	12
	6 Hp	1.1710 (0.9110)	-	2 (3)	0.586 (0.456)	8

Note: ( ) Without Taxes

(3) Comparative analysis by route (passenger transport)

A comparison of travel time and fare/cost of road and river transport between traffic zones is summarized in Table 9-10 and 9-11.

The travel time is calculated from transport distance divided by average travel speed of transport. Regarding transport costs, a unit fare is used for public transport, while a unit cost in economic prices shown in Table 9-9 is used for private transport. The analysis proves that road transport on the Project Road is

Table 9-10 COMPARISON OF TRAVEL TIME BETWEEN ROAD AND RIVER

(Unit: Hour)

	Tatau	Sg.Kakus	Sg.Anap	Pelagus	Lepong Balleh	Kapit	Belaga
Bintulu	1.28 / 1.28	2.56 / 2.95	2.28 / 4.21	3.85	4.60	4.85	8.42
Tatau		1.28 / 1.67	1.00 / 2.93	2.58	3.33	3.58	———
	Sg.Kakus		0.73 / 2.06	2.76	3.51	3.76	———
		Sg.Anap		1.58	2.33	2.58	———
				Pelagus	0.75 / 2.05	1.00 / 1.11	———
					Lepong Balleh	0.25 / 1.13	———
						Kapit	———
			Sibu	5.44	5.44	4.34	10.01

Upper : with Project Road

Below : without Project Road

Table 9-11 COMPARISON OF TRAVEL COST BETWEEN ROAD AND RIVER

(Unit: M$/passenger)

	Tatau	Sg.Kakus	Sg.Anap	Pelagus	Lepong Balleh	Kapit	Belaga
Bintulu	6.12 / 6.12	11.62 / 12.62	11.92 / 17.96	18.48	22.08	23.28	33.55
Tatau		5.50 / 6.50	4.80 / 11.84	12.36	15.96	17.16	———
	Sg.Kakus		2.86 / 8.46	12.58	16.18	17.38	———
		Sg.Anap		7.56	11.16	12.36	———
				Pelagus	3.60 / 7.89	4.80 / 3.63	———
					Lepong Balleh	1.20 / 2.95	———
						Kapit	———
			Sibu	15.79	15.05	12.16	30.86

Upper : with Project Road

Below : without Project Road

distinctly superior to the existing river transport both in travel time and transport cost. In addition, some traffic zones can be connected only by the Project Road. Therefore, river passenger traffic is expected to be diverted to the Project Road from most of the existing river routes.

9.3.3 Cargo transport cost

(1) Comparison of unit transport cost

Cargo transport costs generally vary by cargo type, distance, loading and unloading costs and other conditions of transport. For the purpose of an inter-modal comparison, hauling costs have been estimated in Table 9-12 assuming standard operating conditions.

Table 9-12 shows that river transport is generally more advantageous than road transport in terms of unit transport cost. However, the unit cost of a long boat, which is a popular transport means upstream of rivers, is far more expensive than the unit coat of road transport.

Since the year-round operation of motor vessels over 150 tons and barges and rafts towed by tug boats is possible only in the main streams of Batang Tatau, Batang Rajang and Batang Balleh, transport costs in the inner area will be very large. The cost of transporting consumer goods and agricultural products by long boat is especially burdensome for many farmers.

(2) Comparison of cargo transport costs on major routes

As cargo traffic volumes and tariff systems in the study areas have not been clarified, operating costs have been compared with interzonal transport costs "With" and "Without" the Project Road. In this comparison, a time value has not been taken into direct consideration.

A comparison of transport costs of representative commodities on major routes is summarized below and in Table 9-13, and further in Appendix 7-4.

1) Bintulu - Sangan (general cargo and logs)

After the completion of the Project Road, the transport cost of general cargo will be about 20% lower by 6-ton truck than by river transport, and moreover, differences in travel time will make truck transport more advantageous.

The transport cost of logs (sinkers) by truck is about 50% higher than by barge towed by tug boats, but the difference may be reduced by saving travel time on the road.

Table 9-12 COMPARISON OF AVERAGE UNIT TRANSPORT COSTS FOR GOODS

(Economical Price)

		Cost (M$)		Average Loading Tonnage	Unit Cost/ ton-km	Average Veh./ Vessel Speed (km/hr.)
		Veh./km	Per Day			
Truck 6 tons	Gravel	0.9123 (0.8281)	-	6.0	0.152 (0.138)	43
	Paved	0.6854 (0.6232)	-	6.0	0.114 (0.104)	55
10 tons	Gravel	1.3673 (1.2098)	-	10.0	0.137 (0.121)	40
	Paved	0.9480 (0.8385)	-	10.0	0.095 (0.084)	50
20 tons (T. Trailer)	Gravel	2.5145 (2.1955)	-	20.0	0.126 (0.110)	40
	Paved	1.7136 (1.4971)	-	20.0	0.086 (0.075)	50
Motor Vessel	50 tons	-	455.40 (417.69)	40.0	0.086 (0.079)	11
	150 tons	-	2,420.74 (2,174.04)	120.0	0.067 (0.060)	12.5
Tug + Barge (480HP)(500 tons)		-	1,454.00 (1,292.93)	400.0	0.030 (0.027)	12
Tug + Log Raft (240HP)(500 tons)		-	783.18 (705.54)	500.0	0.016 (0.014)	10
Long Boat	40 HP	2.6830 (2.0680)	-	1.5	1.789 (1.378)	12
	25 HP	1.7660 (1.3600)	-	0.7	2.523 (1.942)	12
	6 HP	1.7170 (0.9110)	-	0.3	5.723 (3.036)	8

Note: ( ) Without Taxes

Table 9-13 COMPARISON OF CARGO TRANSPORT COSTS BETWEEN ROAD AND RIVER

Section	Type of Commodity	Transport mode	Distance	Transport Cost (M$/Ton)
Bintulu-Sangan	General Cargo	Road	75 km	15.48
		River	108 km	18.73
"	Logs (Sinkers)	Road	75 km	17.44
		River	108 km	9.15
Tatau-Sangan	General Cargo	Road	24 km	7.67
		River	48 km	11.62
Bintulu-Kapit	General Cargo	Road	194 km	35.10
Sibu-Kapit	"	River	152 km	25.85
Bintulu-Bawai	Logs (Sinkers)	Road	184 km	28.41
Tg. Mani-Bawai	Sawn Timber	River	261 km	12.27
Bintulu-Bawai	Logs (Floated)	Road	184 km	28.41
Tg. Mani-Bawai		River	261 km	11.78
Bintulu-Pelagus	Cement/Stone	Road	160 km	26.56
Sibu-Pelagus		River	185 km	17.62
Bintulu-Pelagus	Heavy Equipment for construction	Road	160 km	25.23
		River/ Coastal	557 km	28.79

Note: Cost in 1982

2) Tatau - Sangan (general cargo)

Road transport has an absolute advantage for the transport of general cargo because of the much longer trip if transported by river.

3) Bintulu - Kapit vs. Sibu - Kapit (general cargo)

After the completion of the Project Road, the Bintulu area is likely to become one of the major trading centers for the Kapit area instead of Sibu. Therefore, a comparison of transport costs has been made between Bintulu-Kapit and Kapit-Sibu. The river transport cost of general cargo is about 30% lower than the cost of a 6-ton truck. However, in view of the comparison in travel time (about 6 hours by road, 1 or 2 days by river) truck transport appears to be more advantageous.

4) Bintulu - Bawai vs. Tg. Mani - Bawai (logs)

The major method for shipping out logs will likely be to transfer from Tanjung Mani located downstream of Batang Rajang to Bintulu Port after the completion of the Project Road. A comparison of transport cost has been made between Bintulu-Bawai and Tanjung Mani-Bawai.

The river transport cost of logs (slinkers) has an absolute advantage compared with road transport. However, when logs are processed in the Kapit area, the transport of sawn timber and plywood by truck will be required for the Kapit and Bintulu areas.

5) Bintulu - Pelagus vs. Sibu - Pelagus (cement/stone)

For the transport of cement and crushed stone to use in the Pelagus Hydroelectric Project, the river transport cost from Sibu Port is lower than the truck transport cost from Bintulu Port. The diversion of transport means from river to road will not occur in the case of transport for construction material.

6) Bintulu - Pelagus (heavy equipment)

Bintulu has the only deep water port in Sarawak at present. When heavy equipment for construction of the Pelagus Hydroelectric Project is imported through the Bintulu deep water port, the transport cost of these commodities by a 20-ton truck trailer will be comptetitive with that of water transport. Therefore, if the difference in travel time is taken into account, large truck transport is more advantageous.

9.4 Forecast of diverted traffic

The completion of the Project Road will result in the diversion of river traffic to the road in the affected area. The diverted passenger and cargo traffic from river to road in the Study Area is estimated below.

(1) Diverted passenger traffic

As already seen in 9.3.2, the completion of the Project Road is expected to have a great impact on existing river transport. The advantages of road over river will be established in most areas along the Project Road, in terms of travel time and transport cost.

Table 9-14 shows the modal split of traffic estimated based on an analysis of travel time and transport cost by competitive routes. Existing river traffic for all OD pairs along the Project Road is expected to be diverted to the road. As regards river traffic between Kapit and Pelagus and Lepong Balleh, about 70% of it is assumed to divert to road traffic, since inhabitants living around Kapit town will continue to use river transport. River traffic between Sungai Kakus and Tatau is likely to continue because inhabitants of Sungai Kakus will still be obliged to use the river between Sungai Kakus and Sangan even after the Project Road is constructed. Nevertheless, about 70% of the river traffic between Sungai Kakus and Tatau will be converted to road traffic from Sungan to Tatau to take advantage of time savings.

Table 9-15 shows the future diverted traffic calculated with the forecasted river passengers in Table 9-6 and the above-mentioned proportion of diversion.

According to the current modal split of inter zonal passenger traffic between bus and car, the future modal split has been estimated at 65% for bus and 35% for car. An average number of passengers of 25 per bus and 3 per car has been assumed for conversion of the number of passengers to the volume of motor vehicle traffic.

The forecast of passengers diverted to vehicle traffic is shown in Table 9-16.

(2) Diverted Cargo Traffic

The incoming goods brought in via Tatau which are delivered to the Sungai Anap basin will be entirely shifted to transport by the Project Road after its completion, and the entire volume of outgoing agricultural products of this area will also be diverted to road transport, except logs. Road transport for incoming and outgoing cargo to/from the Sungai Kakus basin is not available directly. However, since Sangan is a secondary delivery center for this area, 70% of the total volume in transport is assumed to be diverted from river to road.

Table 9-14 RIVER PASSENGER TRAFFIC EXPECTED TO DIVERT INTO THE PROJECT ROAD

	Modal Split (%)		1993 Diverted Traffic (No. of Passengers/day
	River	Road	
Kuala Tatau-Tatau	100	-	792
Tatau/Bintulu Sibu			
- Sg. Kakus	30	70	407
- Sg. Anap	-	100	899
Kapit-Lepong Balleh	30	70	897
- Pelagus	30	70	673

Table 9-15 FORECAST OF DIVERTED PASSENGER TRAFFIC

Road Section	No. of Passengers/day				
	1993	1995	2000	2005	2010
Ulu Btg. Mukah/ Bintulu Road - Sangan	1,306	1,536	2,103	2,887	3,608
Sangan - Muput	899	1,056	1,441	1,970	2,452
Muput - Pelagus	-				
Pelagus - Lepong Balleh	673	756	1,111	1,632	2,185
Lepong Balleh-Kapit	1,570	1,763	2,591	3,807	5,095

Table 9-16 FORECAST OF DIVERTED PASSENGER TRAFFIC BY VEHICLE TYPE

(Unit : Vehicle/day)

Road Section	1993			1995			2000			2005			2010		
	Car	Bus	Total	Car	Bus	Total	Car	Bus	Total	Car	Bus	Total	Car	Bus	Total
Ulu Btg. Mukah/ Bintulu Rd. - Sangan	152	34	186	179	40	219	245	55	300	337	75	412	421	94	515
Sangan - Muput	105	23	128	123	27	150	168	37	205	230	51	281	286	64	350
Muput - Pelagus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelagus - Lepong Balleh	79	17	96	88	20	108	130	29	159	190	42	232	255	57	312
Lepong Balleh - Kapit	183	41	224	206	46	252	302	67	369	444	98	542	594	132	726

Table 9-17 DIVERTED RIVER GOODS TRAFFIC

	1993		1995		2000		2005		2010	
	1,000 tons	Veh/day	1,000 tons	Veh/day	1,000 tons	Veh/day	1,000 tons	Veh/day	1,000 tons	Veh/day
Ulu Mukah/Bintulu Rd. - Sangan	6.5	6	7.0	6	8.6	8	10.5	10	13.0	12
Sangan - Muput	5.1	5	5.5	5	6.7	6	8.2	8	10.2	9
Muput - Pelagus	-	-	-	-	-	-	-	-	-	-
Pelagus - Lepong Balleh	8.5	8	8.9	9	10.4	10	12.1	11	14.2	13
Lepong Balleh - Kapit	12.3	11	12.9	12	15.1	14	17.6	16	20.7	19

Conversion rate from tons into veh/day: 3 t/vehicle 365 days/year

The volume of cargo transport to/from Pelagus and Lepong Balleh via Kapit to be diverted to the road has been estimated at 70% of the total, based on the same considerations used for passenger traffic. Table 9-17 shows estimated diverted goods traffic from river to road, basing upon above diversion ratio and future goods demand shown in Table 9-7.

9.5 Forecast of Development Traffic

Development traffic expected from the construction of the Project Road consists of the following:

(i) That which will be generated as a result of agricultural development

(ii) That which will be generated as a result of tourism development

(iii) That which will be generated as a result of the development of the Pelagus Hydroelectric Project

(1) Agricultural development traffic

Development traffic demand for agricultural cargo has been estimated based on the increase of agricultural products in the "with" road case in Chapter 4. it is assumed that all the agricultural development products in the Sungai Anap area and 70% of the same products in the Sungai Kakus area will be carried out to Tatau by truck, and the commodities necessary for agricultural development (fertilizer, animal feed, etc.) will be brought in by return trips of the same trucks. In the Kapit area, the agricultural development area is situated only in Pelagus. All the products are assumed to be carried out to Kapit by truck.

Agricultural development in the Study Area is expected to produce paddy. Although paddy output will be consumed in the Study Area, the rice will have to be carried out to Tatau or to Kapit for processing at rice mills or for delivery.

Provided the development scheme is realized, it is assumed that passenger and goods traffic will be required to support the development. Therefore, it is assumed that the same volume of van/pick up traffic as of trucks will be generated between development areas and Tatau/Kapit.

The forecasted agricultural development traffic is pressented in Table 9-20.

(2) Touurism development traffic

The tourism development traffic has been projected based on the estimated number of visitors in Chapter 4.

The Project Road completion and accompanying tourism development in Pelagus and Kapit will produce sizable traffic demand. But, due to uncertainty in the tourism demand forecast, tourism traffic is estimated based on the minimum demand case for the purposes of this study. The number of visitors estimated to use the Project Road is shown in Table 9-18, and the results of forecasted vehicle traffic are shown in Table 9-20.

(3) Traffic genrated from the Pelagus Hydroelectric Project

The proposed Pelagus Hydroelectric Dam construction will start in the year 2000 and will be completed in 2005. As it is expected that the Project Road will be used for carrying materials for dam construction, the cargo transport demand for this dam construction project has been estimated in Table 9-19. The dam development project is assumed to generate about 100 traffic of 10-ton trucks in a day (in both directions) between the Batang Rajang Bridge and the Pelagus Dam during a 3 year period (2000-2004). The results of this forecasted traffic are also in Table 9-20 apart from the other development traffic. The traffic generated from the Hydroelectric Project has not been included in the total of development traffic because it is expected to occur only in the short term.

9.6 Estimate of Overall Passenger Traffic "with" Project Road

9.6.1 General

In this part an entirely different method from the one described before will be used to forecast passenger traffic to be generated upon completion of the Project Road. The method is applied only for passenger movement since this could be determined fairly accurately during the field traffic survey, and since population data is the only relatively reliable regional economic indicator.

9.6.2 Demand forecast

(1) Method of estimation

The field survey of river traffic has yielded the data of passenger traffic volume and average transport costs per trip-end for each traffic zone. Travel cost is usually considered to be the comprehensive factor controlling traffic demand in the transport market mechanism.

Table 9-18 ESTIMATED NO. OF VISITORS USING THE PROJECT ROAD

From/To	1995	2000	2005	2010
Bintulu - Kapit	8,000	9,000	11,500	14,900
Kapit - Bintulu	7,800	8,900	11,400	14,500

Table 9-19 ESTIMATED COMMODITY VOLUME FOR THE HYDRO-ELECTRIC PROJECT

Cement	575,600 tons
Steel	41,470 tons
Total	557,070 tons
No. of Vehicle	100/day
10^t Truck Carry	5^t/day x 365

Table 9-20 ESTIMATED DEVELOPMENT TRAFFIC

Road Section	Type of Development	Average Daily Traffic				Type of Vehicle
		1995	2000	2005	2010	
Ulu Mukah/ Bintulu Rd. - Sangan	Agriculture	7	10	12	14	- 6 ton Truck for Transporting Products
		7	10	12	14	- for Passenger Traffic (van/ Pick-up)
	Tourism	8+2	9+2	11+3	14+3	- Tourism Traffic (Car+Mini-bus)
		10	11	14	17	- Related Traffic (Van/Pick-up)
Sangan - Muput	Agriculture	4	5	6	7	- 6 ton Truck for Transporting Products
		4	5	6	7	- for Passenger Traffic (Van/Pick-up)
	Tourism	8+2	9+2	11+3	14+3	- Tourism Traffic (Car+Mini-bus)
		10	11	14	17	- Related Traffic (Van/Pick-up)
Muput - Pelagus	Tourism	8+2	9+2	11+3	14+3	- Tourism Traffic (Car+Mini-bus)
		10	11	14	17	- Related Traffic (Van/Pick-up)
Pelagus - Lepong Balleh	Agriculture	1	20	21	22	- 6 ton Truck for Transporting Products
		1	20	21	22	- Related Traffic (van/Pick-up)
	Tourism	8+2	9+2	11+3	14+3	- Tourism Traffic (Car+Mini-bus)
		10	11	14	17	- Related Traffic (Van/Pick-up)
Lepong - Kapit	Agriculture	1	20	21	22	- 6 ton Truck for Transporting Products
		1	20	21	22	- for Passenger Traffic (Van/Pick-up)
	Tourism	8+2	9+2	11+3	14+3	- Tourism Traffic (Car+Mini-bus)
		10	11	14	17	- Related Traffic (Van/Pick-up)

Therefore, there is considered to be some relationship between transport cost and traffic volume.*

The field survey of river traffic has revealed that the following euqation describes the relationship between the average travel cost per each trip-end and the generation/concentration traffic volume per population of a traffic zone (relevant values used for developing the equation are shwon in Table 9-21):

$$Ti = \alpha \frac{1}{C_i^{\beta}}$$

where, Ti = trip-end per 1,000 population of Zone-i
Ci = average transport cost per trip-end of Zone-i
α = 1,272.4761
β = 1.17386
R = 0.9142 (correlation coefficient)

This equation has been translated into the curve in Fig. 9-4, which shows that as transportation cost decreases, the volume of traffic increases.

The average transporrt cost per trip-end of Zone-i is calculated using the following equation:

$$Ci = \sum_{j=1}^{n} Cij \cdot Vij / \sum_{j=1}^{n} Vij$$

where, Ci = average transport cost per trip-end of Zone- i
Cij = transport cost between Zone- i and Zone -j
Vij = Traffic volume between Zone-i and Zone-j

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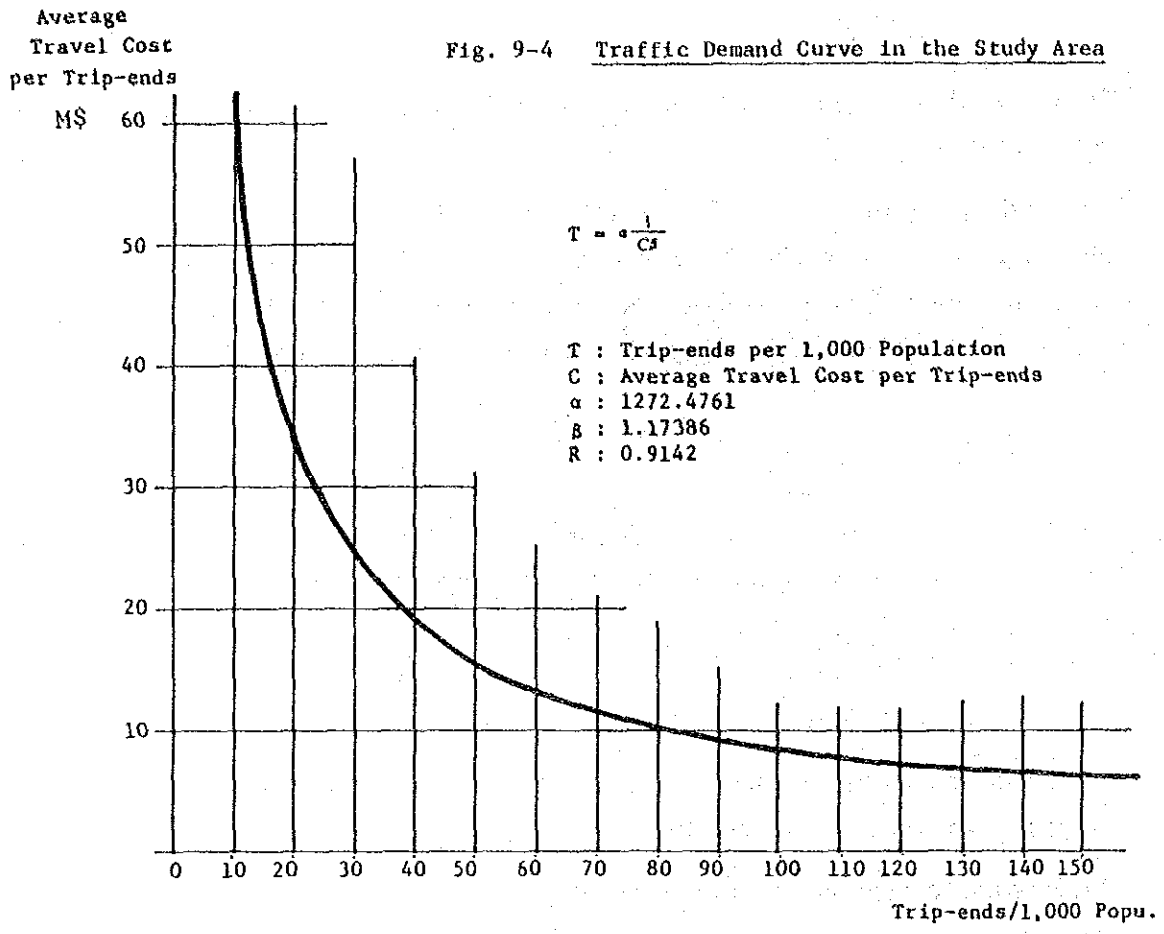
*) The method used is an application of simple price theory.
In traffic engineering, Mr. Gerald Kraft used this method to forecast inter-city traffic volume in his "Demand for Intercity Passenger Travel in the Washington-Boston Corridor (1963)". His methodology is usually referred to as the Kraft Model.
The Kraft Model is considered suitable for forecasting traffic patterns in this project, accounting for many more traffic purposes other than commuting traffic.

Fig. 9-4 Traffic Demand Curve in the Study Area



(2) Passenger traffic demand forecast

Table 9-21 presents the relationship between trip-end and average transport cost for each traffic zone without the Project Road in 1982 and with the Project Road in 1993. The "with" situation also includes the growth in traffic from 1982 to 1993.

The analysis is as follows:

(i) In the "without" case, the number of trip-ends per 1,000 people in 1982 presents the present river passenger traffic demand level (refer to Table 9-4). The theoretical value of average transport cost is calculated based upon the equation in Fig. 9-4. The actual value is estimated based upon unit fare/cost in Table 9-11. The difference between the two values in the Anap Zone results from that actual value that has been estimated based upon the cost of express service.

(ii) In the "with" situation, the average transport costs in some traffic zones are reduced using the Project Road.
The estimated trip-end per 1,000 people is calculated from the equation as the traffic demand level after the completion of the Project Road in 1982.

(iii) As some parts of the area in the traffic zone are believed to be practically free from the impact of the Project Road, an adjustment has been made for 70% of the estimated trip-end.

(iv) Traffic demand after completion of the Project Road has been obtained simply by multiplying the estimated trip-end per 1,000 population by the zonal population adding in the growth factor of traffic from 1982 to 1993. Annual growth rates of 6.4% in the Tatau area and 4.0% in the Kapit area are adopted to estimate traffic in the years 1993.

This equation, which relies on the sample OD survey taken in Tatau and Kapit in 1982, reflects relatively long distance trips between the rural zones and the major centers in the Study Area: Bintulu, Tatau and Kapit. Therefore, the results are believed to correspond to future vehicle patterns in the Project Area even if it is based on the river passenger traffic data.

For the equation, the future zonal populations have already been shown, in Table 9-2 and the time distance between zones was determined in Table 9-10.

Based on the obtained distribution pattern, the adjusting calculations have been done using the previouly predicted trip-end for each zone using the Flator Method. A future passenger traffic volume between zones for the "with" the Project Road case has been obtained as presented in Table 9-22.

Table 9-21 ESTIMATED PASSENGER TRAFFIC DEMAND (WITH ROAD SITUATION IN 1993)

	Without the Project Road				With the Project Road			
		Average Travel Cost(M$/Trip-end)		Ave.	Est.		Adjusted Trip-ends/ 1,000 popu.	
Traffic Zone	1982 Trip-ends/ 1,000 popu.	Theoretical Value	Estimated Actual Value	Travel Cost (M$/ Trip-end	Trip-ends/ 1,000 popu.	Adjustment Factor	Non Growth	With Growth Factor
Kakus	145.6	6.34	6.50	6.34	145.6	-	145.6	264.1
Anap	50.0	15.76	11.84	4.70	206.9	x0.70*	144.8	286.5
Pelagus	69.4	11.92	11.54	4.63	210.5	x0.70*	147.4	226.9
Lepong Belleh	191.4	5.02	4.80	2.61	412.6	x0.70*	288.8	444.6

Note *: It was assumed 30% of the area will be little affected by the Project Road.

9.6.3 Overall passenger traffic

(1) Passenger traffic distribution model

The following gravity type model was used to estimate passenger movement between relevant traffic zones and the major centers, based on field survey findings:

$$Tij = K \frac{(Pi \cdot Pj)^{\alpha}}{Dij^{\beta}}$$

where, Tij = distribution traffic volume between Zones i and j
Pi = population of Zone i
Pj = population of Zone j
Dij = time distance between Zones i and j
K = 15.789576
α = 0.191039
β = 0.564525
R = 0.8592 (correlation coefficient)

(2) Vehicular traffic by road section

Future vehicle traffic volume on the Project Road by section, shown in Table 9-23, has been obtained by distributing the value of Table 9-22, using the same method used to calculate diverted traffic. A passenger split of 65% bus (average passengers, 25) and 35% car (average passengers, 3) was used.

(3) Relationship between traffic forecast and car ownership

Future traffic volume is not forecasted based upon car ownership as stated above. For the sake of caution, approximate unit passenger car ownership is estimated based upon the traffic forecast in 1993.

The number of passenger car trips is calculated from the total number of generated trips: 12,300 trips/day (including trips between Tatau and Bintulu) as follows:

12,300 person trips/day x 0.35 (using rate of passenger car)
÷ 3 persons (average number of passengers) = 1,400 vehicle trips/day

If it is assumed that one trip/day is generated for each passenger car, the number of passenger cars in the Study Area is estimated at 1,400 and the rate of car ownership is about 50 persons per vehicle.

Table 9-24 shows the present status of passenger car ownership in Sarawak by Division, compared with that in the Study Area.

Table 9-22 ESTIMATED DISTRIBUTION OF PASSENGER TRAFFIC IN THE STUDY AREA IN 1993

(Unit : Passenger/day)

	Tatau	Kakus	Anap	Pelagus	Lepong Balleh	Kapit	Total	Estimated Tripends 1/
Bintulu	-	44	148	580	266	80	(1,118)	-
	Tatau	506	1,340	-	-	-	(1,846)	2,923
		Kakus	-	-	-	43	593	581
			Anap	-	-	141	1,629	1,604
				Pelagus	-	1,464	2,044	2,132
					Lepong Balleh	1,520	1,786	1,867
						Kapit	3,683 (3,248)	3,523

Note: 1/ These trip-ends were estimated based on the trip-ends/1,000 population from Table 9-21.

Table 9-23 ESTIMATED FUTURE PASSENGER TRAFFIC ON THE PROJECT ROAD - 1993 (WITH SITUATION)

(Unit : Vehicle/day)

Road Section	1993			2000			2010		
	Car	Bus	Total	Car	Bus	Total	Car	Bus	Total
Ulu Mukah/ Bintulu Rd. - Sangan	327	73	400	495	110	605	753	168	921
Sangan - Muput	287	64	351	435	97	532	665	148	813
Muput - Pelagus	130	29	159	199	44	243	315	70	385
Pelagus - Lepong Balleh	181	40	221	277	62	339	430	99	529
Lepong Balleh - Kapit	275	61	336	417	93	510	638	142	780

Table 9-24 PASSENGER CAR OWNERSHIP

	Area	Population	Passenger Car	Population/ Passenger Car
Present	First Division	453,000 (1980)	44,054 (1983)	10
	Fourth Division	199,000 (1980)	20,014 (1983)	10
	Seventh Division	63,000 (1980)	110 (1983)	573
	Study Area	52,500 (1980)	** 200 (1983)	263
Future	Study Area	65,500 (1990)	*1,400 (1993)	47

Note: * 35 percent of person trips use passenger cars (three passengers)
** Based upon an estimate by the Study Team.

9.7 Forecast of Induced Traffic

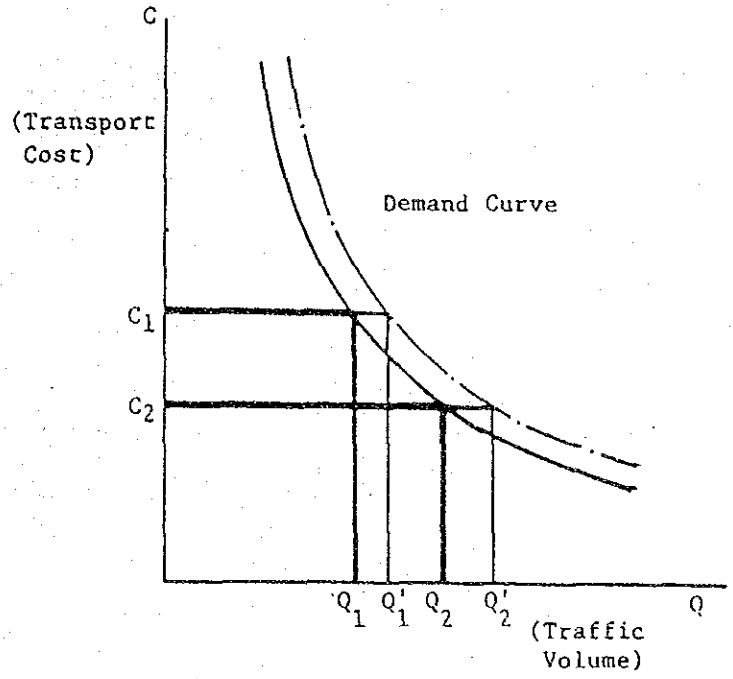
(1) Definition of induced traffic

Induced traffic can be defined as the traffic newly generated due to the reduction of transport costs, even if generating potentials are constant. As is shown in Fig. 9-5, cost reduction from C_1 to C_2 results in an increase of traffic Q_1 to Q_2. Thus $Q_2 - Q_1$ represents the induced traffic volume.

Development traffic can be defined in the figure as the traffic generated due to the shift in the demand curve because traffic generating potntials will increase due to development. Thus $Q_1' - Q_1$ represents the development traffic volume.

As the traffic volume forecasted in Section 9.6 is the total passenger traffic or Q'_2, induced traffic can be calculated by deducting Q_1 (or normal and diverted traffic volume) and $Q_1' - Q_1$ (= $Q_2' - Q_2$ or development traffic from Q_2').

Fig. 9-5 Demand Curve for Traffic



(2) Estimate of induced traffic

Induced passenger traffic volume by the Project Road section, therefore, was calculated by deducting the sectional passenger traffic volume of diverted and development traffic from that of the total.

The traffic has so far been only passenger traffic. Truck traffic has been estimated assuming a 60 % ratio of bus and car traffic to total traffic and a 1:5 ratio between van/pick-up and medium truck. Table 9-25 shows the results of the estimates.

9.8 Summary of Forecast Traffic

Table 9-26 summarizes forecasted traffic voulume on the Project Road sections for the years 1993, 2000, 2005 and 2010. Most of the sections have a volume of 400 to 600. However, the Muput-Pelagus section which is the longest road section at 64 km, has the lowest volume among all the Project Road sections. Fig. 9-6 presents the forecasted traffic volume on the Project Road sections in 1993 and 2010,

Table 9-27 shows the forecasted volume on the Project Road section by traffic type, and Table 9-28 shows the forecasted volume by vehicle type.

Table 9-25 FORECAST OF INDUCED TRAFFIC BY PROJECT ROAD SECTIONS

(Unit: Vehicle/day)

Road Section	1993					1995					2000				
	Car/ Taxi	Bus	Van/ P.up	Truck	Total	Car/ Taxi	Bus	Van/ P.up	Truck	Total	Car/ Taxi	Bus	Van/ P.up	Truck	Total
Ulu Mukah/ Bintulu Rd.- Sangan	173	38	24	118	353	181	40	25	123	369	241	53	33	163	490
Sangan - Muput	180	40	25	123	368	192	43	26	131	392	258	58	35	176	527
Muput - Pelagus	128	28	17	87	260	138	31	19	94	282	190	42	26	129	387
Pelagus - Lepong Balleh	100	22	14	68	204	109	24	15	74	222	138	31	19	94	282
Lepong Balleh - Kapit	90	19	12	61	182	95	21	13	64	193	106	24	15	73	218

Road Section	2005					2010				
	Car/ Taxi	Bus	Van/ P.up	Truck	Total	Car/ Taxi	Bus	Van/ P.up	Truck	Total
Ulu Mukah/ Bintulu Rd.- Sangan	265	59	36	180	540	318	71	43	216	648
Sangan - Muput	326	66	44	218	654	365	81	50	248	744
Muput - Pelagus	241	53	33	163	490	301	67	41	204	613
Pelagus - Lepong Balleh	146	32	20	99	297	161	39	22	111	333
Lepong Balleh - Kapit	62	14	9	43	128	30	7	4	21	62

Table 9-26 SUMMARY OF FORECASTED TRAFFIC VOLUME ON THE PROJECT ROAD SECTION (ADT)

Road Section	1993	1995	2000	2005	2010	Average Annual Growth Rate (%)		
						1995-2000	2000-2005	2005-2010
Ulu Mukah/ Bintulu Rd. - Sangan	556	628	840	1,014	1,237	6.0	3.8	4.1
Sangan - Muput	510	575	770	983	1,151	6.1	4.7	3.4
Muput - Pelagus	267	302	409	518	647	6.3	4.8	4.5
Pelagus - Lepong Balleh	315	361	513	610	736	7.3	3.5	3.8
Lepong Balleh - Kapit	424	479	663	756	885	6.7	2.7	3.2

Fig. 9-6 SUMMARY OF FORECASTED TRAFFIC BY VEHICLE TYPE ON THE PROJECT ROAD SECTION IN 1993

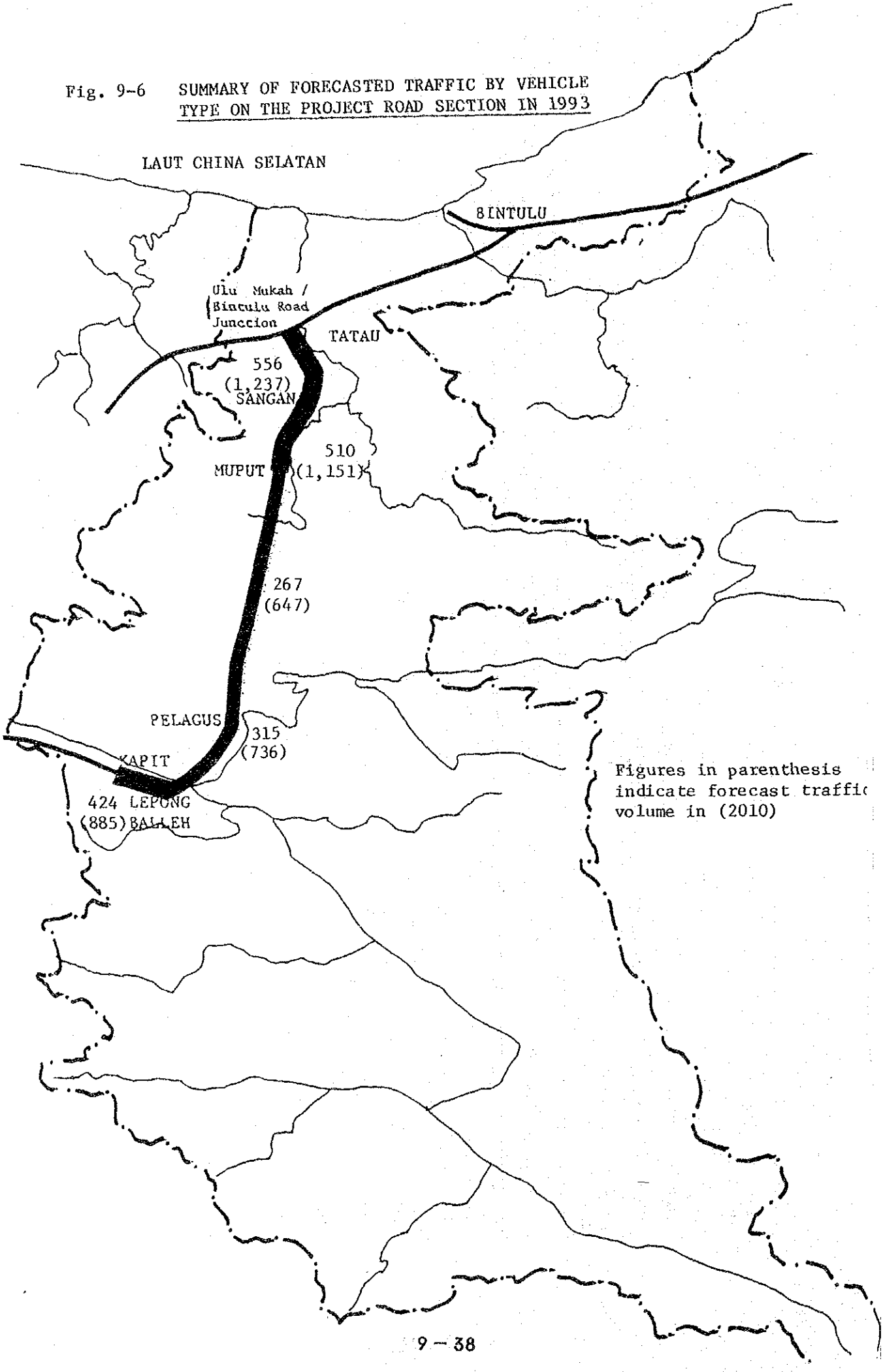


Table 9-27 SUMMARY OF FORECASTED TRAFFIC VOLUME BY TRAFFIC TYPE

(Unit : Vehicle/day)

Road Section	1993				1995				2000			
	Diverted	Development	Induced	Total	Diverted	Development	Induced	Total	Diverted	Development	Induced	Total
Ulu Mukah/ Bintulu Rd. - Sangan	192	11	353	556	225	34	369	628	308	42	490	838
Sangan - Muput	133	9	368	510	155	28	392	575	211	32	529	770
Muput - Pelagus	-	7	260	267	-	20	282	302	-	22	387	409
Pelagus - Lepong Balleh	104	7	204	315	117	22	222	361	169	62	282	513
Lepong Balleh - Kapit	235	7	182	424	264	22	193	479	383	62	218	663

Road Section	2005				2010			
	Diverted	Development	Induced	Total	Diverted	Development	Induced	Total
Ulu Mukah/ Bintulu Rd. - Sangan	422	52	540	1,014	527	62	648	1,237
Sangan - Muput	289	40	654	983	359	48	744	1,151
Muput - Pelagus	-	28	490	518	-	34	613	647
Pelagus - Lepong Balleh	243	70	297	610	325	78	333	736
Lepong Balleh - Kapit	558	70	128	756	745	78	62	885

Table 9-28 SUMMARY OF FORECASTED TRAFFIC BY VEHICLE TYPE ON THE PROJECT ROAD SECTION

(Unit: Vehicle/day)

Road Section	1993					1995					2000				
	Car/ Taxi	Bus	Van/ P.up	Truck	Total	Car/ Taxi	Bus	Van/ P.up	Truck	Total	Car/ Taxi	Bus	Van/ P.up	Truck	Total
Ulu Mukah/ Bintulu Rd. - Sangan	327	73	30	126	556	368	82	42	136	628	495	110	54	181	840
Sangan - Muput	287	64	30	129	510	323	72	40	140	575	435	97	51	187	770
Muput - Pelagus	130	29	21	87	267	146	33	29	94	302	199	44	37	129	409
Pelagus - Lepong Balleh	181	40	18	76	315	205	46	26	84	361	277	62	50	124	513
Lepong Balleh - Kapit	275	61	16	72	424	309	69	24	77	479	417	93	46	107	663

Road Section	2005					2010				
	Car/ Taxi	Bus	Van/ P.up	Truck	Total	Car/ Taxi	Bus	Van/ P.up	Truck	Total
Ulu Mukah/ Bintulu Rd. - Sangan	613	137	62	202	1,014	753	168	74	242	1,237
Sangan - Muput	567	120	64	232	983	665	148	74	264	1,151
Muput - Pelagus	252	56	47	163	518	315	70	58	204	647
Pelagus - Lepong Balleh	347	77	55	131	610	430	99	61	146	736
Leong Balleh - Kapit	517	115	44	80	756	638	142	43	62	885

CHAPTER 10

CONTENTS

CHAPTER 10 PROJECT COSTS AND BENEFITS

10.1 Benefits

10.1.1 Elements of Benefit

The benefits for the road construction/improvement project are distinguished as the following:

(i) Savings in Vehicle Operating Costs
(ii) Time Savings Benefits
(iii) Benefits from Generated Traffic
(iv) Benefits from Accident Savings
(v) Other Intangible Benefits as:
- Increased accessibility to the hospital and school
- Increased opportunities for agricultural and industrial development
- Improvement of administrative efficiency, etc.

(1) Savings in Vehicle Operating Costs

The savings in vehicle operating costs are usually evaluated as benefits to normal traffic. The benefits generate from the difference between vehicle operating cost on the existing road, and operating costs on the road after improvement. On the Project Road, normal traffic has not been projected because there are few existing road sections between Kapit and Lepong Balleh which have just recently been completed.

However, after the completion of the Project Road, this kind of benefit will be generated from the savings between vessel operating costs on the river and vehicle operating costs on the road. Therefore, the savings in transport operating costs have been projected for the diverted traffic from river transport into road transport in the Study Area.

(2) Time Saving Benefits

Time savings benefits are important for the transport project. The evaluation of time savings is extremely difficult between the different modes of transport, such as river transport and road transport. In addition, it is difficult to estimate the time savings value in money terms. Therefore, the Study Team has not considered time savings benefits to avoid an uncertain estimation.

(3) Benefits from Generated Traffic

Aside from diverted traffic, some additional traffic may be expected due to agricultural and tourism development in the Project Area. The Study Team estimated the benefit to this type of traffic as benefit to development traffic.

Another type of traffic is expected to be newly generated due to a large amount of transport cost reduction. The Study Team has evaluated this as benefits to induced traffic.

In general, the benefit to generated traffic is evaluated at half the benefit to normal or diverted traffic. In this project, however, the transport cost reduction between river and road will be substantial in addition to large induced traffic volume. The Study Team has therefore evaluated the benefit to induced traffic at one-fourth rather than one-half the benefit to diverted traffic.

(4) Benefit from Accident Savings

It is noted that some river transport routes have dangerous rapids. Therefore, road construction will reduce accidents. However, the Study Team has no data for accident savings at present. Therefore, benefits from accident savings have not been considered.

(5) Other Intangible Benefits

As for the other miscellaneous benefits resulting from project implementation, the Study Team has no means to compute benefits in terms of money. But these intangible benefits should be considered in making the final decision for or against project implementation.

10.1.2 Pricing

Shadow pricing for foreign exchange has not been considered because there is almost no difference between the official foreign exchange rate and the prevailling rate. Nor should the opportunity cost of labor be considered, due to the general shortage of labor in Sarawak, including unskilled labor.

Therefore, price adjustments for the economic evaluation are limited to customs tax, sales tax and other internal taxes which are included in market prices.

10.1.3 Benefits to Diverted Traffic

Benefits to diverted traffic are expected as savings in transport operating costs evaluated as the difference between existing river transport and future road transport for the same origin and destination of traffic. Tables 10-1 and 10-2 show the average savings in transport cost per passenger/ton-kilometer for river and road transport by relating zone pairs to the Project Road. Data on transport operating costs has been prepared in Tables 9-9 and 9-12 in Chapter 9. This cost data indicates economic prices in 1984 present value, excluding taxes. Vehicle operating costs on the road have been adjusted by gradients (see Appendix 8-1, 8-2, 8-3 and 8-4).

The benefit to diverted traffic is computed from the cost saving per passenger/ton kilometer by multiplying by the diverted traffic volume. Tables 10-2 and 10-3 show the total benefit to diverted traffic both for passengers, and goods (Appendices 8-5 and 8-6 show the benefits to passenger and goods diverted traffic, respectively).

The benefits to diverted traffic are substantial relative to the small traffic volume, especially in the Tatau-Anap zone pair. This is because the cost of existing river transport is remarkably high due to the long distance and the use of private transport means, such as the longboat.

10.1.4 Benefits to Development Traffic

Benefit to development traffic have been summarized in Table 10-5. The unit value of the benefit to tourism passenger traffic between Bintulu (Tatau) and Kapit has been estimated based on the assumed reduction in transport cost per passenger-kilometer by river and road transport. The benefit to tourism passenger traffic was calculated from this unit value and the passenger traffic which is shown in Table 9-18.

The unit value of the benefit to agricultural cargo traffic has been assumed based on the amount of reduction in transport cost per ton for each zone pair of diverted traffic. (see Table 10-4)

The benefit to agricultural cargo traffic was estimated from the cargo volume of agricultural production. (see Table 4-7 and Appendix 8-7)

The unit benefit of van/pick-up which pertains to agricultrual development was considered only for passengers based on the cost savings to diverted traffic. The benefit was computed by multiplying by passenger traffic volume as shown in Appendix 8-8. These computations are shown in Table 10-5. Appendix 8-9 gives the benefit to development Traffic. All the unit values of development traffic were assumed to be half of the values of the reduction cost to diverted traffic.

Table 10-1 SAVINGS IN PASSENGER TRANSPORT COSTS BETWEEN RIVER AND ROAD TRANSPORT

Zone Pair	Distance (km)		Transport Cost(M$/Pass) [3]		Reduction of Costs
	River [1]	Road [2]	River	Road	
Tatau-Kakus	50	22+22(River)	14.10	2.13(G) + 6.20 1.47(P)	5.77(G) 6.43(P)
-Anap	48+(16)	40	13.54+7.30	3.88(G) 2.68(P)	16.96(G) 18.16(P)
Kapit-Pelagus	33	40	9.31	3.72(G) 2.60(P)	5.59(G) 6.71(P)
-Lepong Balleh	25	10	7.05	0.93(G) 0.65(P)	6.12(G) 6.40(P)

Notes: 1) : ( ) indicates longboat transport only
2) : Including feeder road
3) : Transport unit cost (M$/Passenger km)

River

Express Launch 0.107 x 50%

Longboat 0.456 x 50%

Road

Car : 0.187(G) x 35% Bus : 0.048(G) x 65%
(Tatau) 0.128(P) (Tatau) 0.034(P)

Car : 0.181(G) x 35% Bus : 0.045 x 65%
(Kapit) 0.124(P) (Kapit) 0.033

(G) : Gravel Road

(P) : Paved Road

Table 10-2 SAVINGS IN CARGO TRANSPORT COSTS

Zone Pair	Distance(Km)		Transportation Cost(S/ton) 2)		Reduction of Costs
	River	Road	River	Road	
Tatau-Kakus	30	22+22(River)	23.45	3.52(G)+10.32 2.64(P)	9.61(G) 10.49(P)
-Anap	64	40	30.02	6.40(G) 4.80(P)	23.62(G) 25.22(P)
Kapit-Pelagus	33	40	15.48	6.80(G) 4.56(P)	8.68(G) 10.92(P)
-Lepong Balleh	25	10	11.73	1.52(G) 1.14(P)	10.21(G) 10.59(P)

Note: 1) Including Feeder Roads

2) Unit Cost (MS/ton Km) River Cargo Vessel (50t) 0.079 x 70%
Long Boat (40Hp) 1.378 x 30%
Road 6t Truck Gravel 0.160 (Tatau) 0.152 (Kapit)
Paves 0.120 (Tatau) 0.114 (Kapit)

Table 10-3 BENEFITS TO DIVERTED TRAFFIC (TOTAL)

(Gravel) Unit: M$'000/year

Zone Pair	1993	1995	2000	2005	2010
Tatau-Kakus	870	1,025	1,412	1,953	2,462
-Anap	5,685	6,667	9,078	12,389	15,420
Kapit-Pelagus	1,447	1,620	2,357	3,435	4,581
-Lepong Balleh	2,043	2,290	3,354	4,915	6,566
Total	10,045	11,602	16,201	22,692	29,029

(Paved) Unit: M$'000/year

Zone Pair	1993	1995	2000	2005	2010
Tatau-Kakus	970	1,142	1,574	2,176	2,742
-Anap	6,088	7,139	9,721	13,265	16,510
Kapit-Pelagus	1,741	1,949	2,835	4,129	5,506
-Lepong Balleh	2,135	2,394	3,507	5,139	6,867
Total	10,934	12,624	17,637	24,709	31,625

Table 10-4 THE UNIT VALUE OF BENEFITS TO DEVELOPMENT TRAFFIC

(Unit : M$)

Type of Traffic	Unit Cost		Adjust-ment Factor	Unit Value of Benefit
Tourism Passenger Traffic	River Road Distance		x 1/2	13.23(G)
	(0.282 - 0.097(G)) x 143 Km =	26.46(G)		15.37(P)
	(0.282 - 0.067(P)) x 143 Km =	30.74(P)		
Agriculture Cargo Traffic	Tatau - Kakus	9.61(G)	x 1/2	4.81(G)
		10.49(P)		5.25(P)
	- Anap	23.62(G)		11.81(G)
		25.22(P)		12.61(P)
	- Pelagus	8.68(G)		4.34(G)
		10.92(P)		5.46(P)
	- Balleh	-		-
Agriculture Passenger (Van/Pick-up)	Tatau - Kakus	5.77(G)	x 1/2	2.89(G)
		6.43(P)		3.22(P)
	- Anap	16.96(G)		8.48(G)
		18.16(P)		9.08(P)
	- Pelagus	5.59(G)		2.80(G)
		5.71(P)		3.36(P)

Notes:

(1) River

Express 0.107 x 50%
Longboat 0.456 x 50%
} 0.282 M$/Passenger Km

Road

Car 0.187(G) x 35%
0.128(P) x 35%
} 0.097(G)

Bus 0.048(G) x 65%
0.034(P) x 65%
} 0.067(P)

(2) (G): Gravel Road
(P): Paved Road

Table 10-5 SUMMARY OF BENEFITS TO DEVELOPMENT TRAFFIC

(Gravel)

Unit: M$'000/year

Type of Traffic	1995	2000	2005	2010
Tourism Passenger Traffic	209	237	303	388
Agriculture Products	111	211	235	264
Van/Pick-up Passenger Traffic	49	123	139	154
Total	369	571	677	806

(Paved)

Unit: M$'000/year

Type of Traffic	1995	2000	2005	2010
Tourism Passenger Traffic	243	275	352	452
Agriculture Products	120	237	265	296
Van/Pick-up Passenger Traffic	55	142	158	176
Total	418	654	775	924

10.1.5 Benefits to Induced Traffic

After the completion of the Project Road, induced traffic will be generated in all traffic zone pairs within the Study Area. Because almost no means of transport exists in some of the traffic zone pairs, it is nearly impossible to estimate transport cost reduction for these pairs.

Therefore, the following method has been adopted for estimating the benefit to induced traffic:

For passenger traffic, average transport distance per trip-end has been estimated for each traffic zone from Table 9-23. The amount of transpost cost reduction per trip-end in both the "with" and the "without" situations in Anap, Pleagus and Lepong Balleh zones are calculated from Table 9-22.

The savings in transport cost per kilometer per trip-end has been calculated from the data, as shown in Table 10-6.

Table 10-6 SAVINGS IN TRANSPORT COST PER TRIPEND

(M$)

Traffic Zone	Average Transport Distance per Trip-ends	Average Transport Cost Reduction per Trip-end	Saving per Kilometer per Trip-end
Anap	51.47 Km	7.14	0.139
Pelagus	69,95 Km	6.91	0.099
Lepong Balleh	35.91 Km	2.19	0.061

The Anap zone will have the largest savings from the Project Road, where express launch services are limited.

Unit benefit to passenger traffic has been estimated based on the value at Pelagus, which is close to the average among the three zones.

The savings by vehicle type were calculated as shown in Table 10-7. Benefit to induced traffic was assumed to be a quarter of the savings in transport cost.

Table 10-7 SAVING BY VEHICLE TYPE

(M$)

	Unit Savings Cost for Passengers	Average No of Passengers	Unit Value of Benefit
Car	0.099	3	x 1/4 = 0.074/Vehicle Km
Bus	0.099	25	x 1/4 = 0.619/Vechicle Km

Due to the lack of available data for the estimation of benefits to goods traffic, the benefit to induced goods traffic was estimated by applying the savings cost used for diverted traffic.

The unit value of benefit to induced traffic is indicated in Table 10-8.

Table 10-8 SAVINGS COSTS BY VEHICLE TYPE

(M$)

Type of Vehicle	Unit Savings Cost M$/ton	Average Loading Volume			Unit Value of Benefit/Vehicle Km
Truck	0.469	3 t	x 1/4		0.352
Van/Pick-up	0.099	1 man	x 1/4	0.025	0.083
	0.469	0.5 t	x 1/4	0.058	

By multiplying these unit benefit values by the length of road section and traffic volume, the benefit to induced traffic has been obtained for truck and van/pick-up for each road section as presented in Table 10-9.

Table 10-9 BENEFITS TO INDUCED TRAFFIC

(Unit : M$'000)

Road Section	Distance	1995					2000				
		Car	Bus	Van/ Pick-up	Truck	Total	Car	Bus	Van/ Pick-up	Truck	Total
1. Ulm Mukah/ Bintulu Rd. - Sangan	21.0 km	103	190	16	332	641	137	251	21	440	849
2. Sangan - Muput	19.5 km	101	189	15	328	633	135	256	21	441	853
3. Muput - Pelagus	63.7 km	237	446	37	769	1,489	327	604	50	1,056	2,037
4. Pelagus - Lepong Balleh	32.8 km	96	178	15	312	601	122	230	19	396	767
5. Lepong Balleh - Kapit	6.8 km	17	32	3	56	108	19	37	3	64	123
Total	143.8 km	554	1,035	86	1,797	3,472	740	1,378	114	2,397	4,629

Road Section	2005					2010				
	Car	Bus	Van/ Pick-up	Truck	Total	Car	Bus	Van/ Pick-up	Truck	Total
1. Ulm Mukah/ Bintulu Rd. - Sangan	150	279	23	486	938	180	337	27	583	1,127
2. Sangan - Muput	171	290	26	546	1,033	192	357	30	621	1,200
3. Muput - Pelagus	415	763	64	1,334	2,576	518	964	79	1,670	3,231
4. Pelagus - Lepong Balleh	129	237	20	417	806	143	289	22	468	922
5. Lepong Balleh - Kapit	11	22	2	38	73	5	11	1	18	35
Total	876	1,591	135	2,821	5,423	1,038	1,958	159	3,360	6,515

10.1.6 Summary of Benefits for Alternative Road Construction Plans

The estimation of the benefits described hereto have pertained to the benefits arising from a one-stage construction plan of asphalt-paved or gravel road. However, the alternative plans will result in different benefit values and a different timing for benefit generation. Table 10-10 shows the benefit stream in each alternative case. These benefit values have been computed using basically the same method used for the one-stage construction case.

As for the benefit to induced traffic, it has been assumed that only one-third of the benefit will be realized in the initial year of the road's completion, and that the benefit will gradually increase to 100% of the potential benefit within the subsequent three years.

The differences of estimation under each alternative plan are as follows:

(1) Cases A-1, A-2 and A-3

The estimations of benefits in Cases A-1, A-2, and A-3 are the one stage construction cases and follow the methods discussed in detail already. The difference between A-1 and A-2 results from different cost savings on the road surface structure - asphalt-paved and gravel.

Case A-3 is the same as Case A-2 except for the timing of the construction. In Case A-3, the Project Road will be open in 1992, while in Case A-2 the Road will be open to traffic in 1993.

(2) Case B

Under this case, the Project Road plan will follow a two-stage construction. The road section between Sungai Muput and Pelagus will not commence service until 1997. Therefore, only 40% of induced traffic relating to the completed section will be generated until 1996. A large part (about 75%) of induced traffic and tourism development traffic will not come during the four years from 1993 to 1996.

(3) Case C

Under this case, the road will be constructed in three-stages. Until 1997, only the Tatau-Sungai Muput road section will commence its service. The generation of benefits from diverted traffic will not occur in the Kapit-Pelagus road section until 1997. The benefits to induced and development traffic will come to only a small amount (about 15% of induced and 40% of development) during the 4 years from 1993 to 1996. The other part of the benefits will be generated on a five year delay behind case B, and all benefits will occur in 2001.

Table 10-10(1) BENEFIT STREAM FOR ALTERNATIVE PLANS

(Unit : M$'000)

Year	Case A-1				Case A-2				Case A-3			
	Diverted	Develop-ment	In-duced	Total	Diverted	Develop-ment	In-duced	Total	Diverted	Develop-ment	In-duced	Total
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	9347	0	868	10215
1993	10934	0	1157	12091	10045	0	1157	11202	10045	0	1157	11202
1994	11749	0	2315	14064	10795	0	2315	13110	10795	0	2315	13110
1995	12624	418	3472	16514	11602	369	3472	15443	11602	369	3472	15443
1996	13497	457	3678	17632	12403	403	3678	16484	12403	403	3678	16484
1997	14431	500	3895	18826	13260	439	3895	17594	13260	439	3895	17594
1998	15429	547	4126	20102	14175	480	4126	18781	14175	480	4126	18781
1998	16496	598	4370	21464	15154	523	4370	20047	15154	523	4370	20047
2000	17637	654	4629	22920	16201	571	4629	21401	16201	571	4629	21401
2001	18867	677	4778	24322	17330	591	4778	22699	17330	591	4778	22699
2002	20184	700	4932	25816	18538	611	4932	24081	18538	611	4932	24081
2003	21592	724	5090	27406	19831	632	5090	25553	19831	632	5090	25553
2004	23098	749	5254	29101	21213	654	5254	27121	21213	654	5254	27121
2005	24709	775	5423	30907	22692	677	5423	28792	22692	677	5423	28792
2006	25959	803	5626	32388	23838	701	5626	30165	23838	701	5626	30165
2007	27273	831	5836	33940	25041	726	5836	31603	25041	726	5836	31603
2008	28652	861	6054	35567	26306	752	6054	33112	26306	752	6054	33112
2009	30102	892	6280	37274	27634	778	6280	34692	27634	778	6280	34692
2010	31625	924	6515	39064	29029	806	6515	36350	29029	806	6515	36350
2011	33225	957	6758	40940	30495	835	6758	38088	30495	835	6758	38088
2012	34906	991	7011	42908	32043	864	7011	39918	32043	864	7011	39918
Total:	432989	13058	97199	543246	397625	11412	97199	506236	406972	11412	98067	516451

Table 10-10(2) BENEFIT STREAM FOR ALTERNATIVE PLANS (Cont'd)

Year	Case B				Case C			
	Diverted	Development	Induced	Total	Diverted	Development	Induced	Total
1987	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0
1993	10934	0	264	11198	7058	0	170	7228
1994	11749	0	529	12278	7645	0	340	7985
1995	12624	175	793	13592	8281	167	510	8958
1996	13497	204	837	14538	8970	177	540	9687
1997	14431	493	2012	16936	14431	238	685	15354
1998	15429	542	3190	19161	15429	278	834	16641
1999	16496	595	4370	21461	16496	324	983	17803
2000	17637	654	4629	22920	17637	379	1037	19053
2001	18867	677	4778	24322	18867	677	2389	21933
2002	20184	700	4932	25816	20184	700	3742	24626
2003	21592	724	5090	27406	21592	724	5090	27406
2004	23098	749	5254	29101	23098	749	5254	29101
2005	24709	775	5423	30907	24709	775	5423	30907
2006	25959	803	5626	32388	25959	803	5626	32388
2007	27273	831	5836	33940	27273	831	5836	33840
2008	28652	861	6054	35567	28652	861	6054	35557
2009	30102	892	6280	37274	30102	882	6280	37274
2010	31625	924	6515	39064	31625	924	6515	39064
2011	33225	957	6758	40940	33225	957	6758	40940
2012	34906	991	7011	42908	34906	991	7011	42908
Total:	432989	12547	86181	531717	416139	11447	71077	498663

10.2 Summary of Project Cost

Costs of various alternative road construction plans are summarized in economic values in Table 10-11. The costs presented in the table include design, construction, maintenance, administration and compensation costs covering rural roads. The durable years of the road have been assumed as 20 and the residual value has been accounted for in the last year of the calculation period for adjusting the difference of construction timing. Although the cost figures are actually including taxes, the Study Team used these figures as economic values because the proportion of taxes is small.

Table 10-11 SUMMARY OF PROJECT COSTS

(Unit : M$'000)

	Year	Case A-1	Case A-2	Case B	Case C
1	1987	5713	5144	3387	1346
2	1988	12400	11290	5776	2870
3	1989	65231	74654	30241	14610
4	1990	80395	97723	36480	16390
5	1991	97969	97723	54669	26308
6	1992	35979	1227	28379	13768
7	1993	833	1227	35442	20852
8	1994	833	1227	37967	25695
9	1995	833	1227	50271	38333
10	1996	833	1227	16881	20829
11	1997	833	1227	833	30539
12	1998	4087	1227	2594	33633
13	1999	833	1227	532	42573
14	2000	833	1227	532	13913
15	2001	833	1227	532	671
16	2002	833	1227	2026	1775
17	2003	4087	1227	278	482
18	2004	833	1227	2340	1594
19	2005	833	1227	278	1702
20	2006	833	1227	278	278
21	2007	833	1227	278	278
22	2008	20191	1227	11051	6088
23	2009	278	1227	9418	7035
24	2010	278	1227	278	7624
25	2011	278	1227	278	278
26	2012	-24667	-11657	-38625	-73614
Total		313048	299417	292417	255580

10.3 Economic Evaluation

In this Item the results of the project evaluation are discussed by Cost /Benefit analysis. The results are discussed mainly in terms of the Internal Rate of Return (I.R.R.) because I.R.R. is an easy parameter to grasp in the evaluation of alternative plans.

10.3.1 Alternative Road Construction Plans

In this study, the following alternative road construction plans have been formulated.

(1) Road surface type

Two cases are assumed:

(a) asphalt pavement (b) gravel surfaced road

(2) Construction Stage

Three cases are considered

(a) Full construction in one stage

(b) Construction in two stages

(c) Construction in three stages

Details of alternative cases are summarized in Table 10-12.

Table 10-12 ALTERNATIVE CONSTRUCTION PLANS FOR PROJECT ROAD

Construction Stage		Initial Type of Road Surface	Case
One Stage	Whole section will be open for traffic in 1993	Asphalt Paved	A-1
		Gravel	A-2
	Whole section will be open in 1992	Gravel	A-3
Two Stage	1st Stage (1993) Ulu. Mukah/Bintulu Road to Sg. Muput Kapit to Pelagus 2nd Stage (1997) Sg. Muput to Pelagus	Asphalt Paved	B
Three Stage	1st Stage (1993) Ulu. Mukah/Bintulu Road to Sg. Muput 2nd Stage (1997) Kapit to Pelgus Sg. Muput to R. Sangkap 3rd Stage (2001) R. Sangkap to Pelagus	Asphalt Paved	C

10.3.2 The Social Discount Rate

The social discount rate is equal to the opportunity cost of capital. The opportunity cost of capital is equivalent to the accounting rate of interest. If Malaysia borrows foreign money in the international market at a competitive rate of interest, the marginal cost of such borrowing is unlikely to exceed 10-12 %. Therfore, the upper limit of the discount rate will be lower than 10-12.

The Study Team has adopted a cut-off discount rate of10% adhering to the advice of the Malaysian Government.

Table 10-13 presents the costs and benefits, discounted at 10% per annum to arrive at present values. Appendix 8-10 indicates those values at discount rates of 8% and 12% for reference.

Table 10-13 PRESENT VALUE OF COST/BENEFIT FOR ALTERNATIVE PLANS (DISCOUNT RATE OF 10%)

(M$ 000)

Alternative Case	Benefit				Cost	B/C Ratio	NPV (B-C)
	Diverted	Development	Induced	Total			
A-1	94,659	2,717	21,701	119,076	226,880	0.53	-107,803
A-2	86,994	2,377	21,701	111,023	223,331	0.50	-112,308
A-3	92,748	2,377	22,240	117,365	223,331	0.53	-105,996
B	94,659	2,419	16,772	113,921	188,082	0.61	-74,161
C	86,419	2,119	11,993	100,530	144,693	0.70	-44,163

Note : B/C - Benefit Cost Ratio
NPV- Net Present Value

Under a discount rate of 10%, all alternative plans are not feasible from an economic standpoint.

10.3.3 Best Estimate

As shown in Table 10-14, the best estimate internal rate of return among the alternative project plans between 1987 and 2012 was computed as 5.89% when the road construction is done in three stages. For this road project, stage construction is considered to have the advantage because a large amount of benefit is generated at the initial stage.

The difference is not large between asphalt-paved and gravel in one-stage construction. Case A-3 is more economical than Case A-2 because in Case A-3, benefits will be generated from 1992, one year earlier than Case A-2 benefits.

In all alternative cases, the internal rates of return are not high enough to reach 10% which is the opportunity cost of capital.

Table 10-14 INTERNAL RATE OF RETURN FOR ALTERNATIVE PLANS

Alternative Case	I.R.R. (%)
A-1	4.20
A-2	3.90
A-3	4.15
B	4.95
C	5.89

10.3.4 Sensitivity Analysis

A sensitivity analysis was conducted for the two cases of stage construction, Case B and Case C.

For Case B, with construction cost fluctuation of +10% and +20%, the rate of return dropped from 4.95 to 4.09 and to 3.33 percent, respectively. With construction cost reductions of 10% and 20%, the Internal rate of return increases from 4.95 to 5.93 and to 7.08.

On the other hand, with a ±30% fluctuation in benefits to induced traffic (the most uncertain element of benefit), the rate of return changes from 4.51 to 5.37, as shown in Table 10-15.

Table 10-15 SENSITIVITY ANALYSIS FOR CASE B

(Internal Rate of Return %)

Benefit \ Cost	-20%	-10%	Original Cost	+10%	+20%
-30%	6.62	5.48	4.51	3.66	2.91
Normal	7.08	5.93	4.95	4.09	3.33
+30%	7.53	6.37	5.37	4.50	3.73

Table 10-16 represents changes in the rate of return with the fluctuation of cost and benefits to induced traffic.

In both cases, the rate of return changes more sensitively with the fluctuation of costs than with the fluctuation of benefits to induced traffic.

Table 10-16 SENSITIVITY ANALYSIS FOR CASE C

(Internal Rate of Return %)

Cost / Benefit to Induced Traffic	-20%	-10%	Original Cost	+10%	+20%
-30%	7.89	6.59	5.48	4.53	3.70
Normal	8.33	7.01	5.89	4.93	4.08
+30%	8.74	7.41	6.28	5.31	4.46

10.3.5 Priority of Alternative Plans

All of the construction alternatives are infeasible if only judged from the viewpoint of an economic evaluation. If the Project be implemented by "Case C", namely a three-stage construction plan, this would be the most economical alternative since it shows much better values for I.R.R, B/C and NPV.

CHAPTER 11

CONTENTS

CHAPTER 11 CONCLUSIONS AND RECOMMENDATIONS

11.1 Comprehensive Evaluation

The following shows the results of an economic evaluation, taking into account the benefis with high reliability.

- Internal Rate of Return (IRR): 5.89
- Benefit/Cost Ratio (B/C Discount Rate at 10%) : 0.70
- Net Present Value (NPV) : -44,163 million M$

Purely from an economical viewpoint, the above values are too low to justify the feasibility of the Tatau-Kapit Trunk Road. However, the economic feasibility of the Trunk Road Project improves by taking the following benefits into consideration, aside from the benefits involved in the economic evaluation.

a) Contribution to Pelagus Hydro-electric Dam Construction Project

If the Project Road is not realized, SESCO will build a transportation road for construction materials at its own expense for the dam, which is scheduled to be completed in 2005.

Therefore, the Project Road will save construction costs of the transport road and will also help to transport construction materials. Since these benefits involve large indefinite factors (delay of contstruction schedule, etc.), they have been excluded in the economic evaluation. If they are considered, the IRR value will be 7.92, and the B/C will be 0.85 in Case C. However, value of benefit is still lower than that of cost. (refer to Appendix 9-1)

b) Contribution to Coal Mining Development

Coal deposits spread along the project road near the border of the Fourth Division and the Seventh Division, on which the feasibility study has been carried out. The Project Road will be used as a part of the coal transportation road.

The benefits are excluded in the economic evaluation as the development program is not formulated yet.

c) Tourism Promotion

Minimum tourism development is involved in the economic evaluation. The Project Road will provide ready access to the Seventh Division and thereby contribute to the development of tourism along the Project Road much more than expected.

d) Contribution to the Development of the Lumber Industry

The lumber indstry has been developed actively in the Project Area, particularly upstream from Sangkap along the Sungai Anap. However, lumbering will be restricted to preserve forest resources in about ten years. Nevertheless, logging will continue at a constant volume. Sapling plantation, etc. using appropriate means will be devised for preservation of the harvested forest. Traffic will use the Project Road, and therefore, the Project Road will benefit the lumber industry.

e) Promotion of Employment Opportunities

The construction of the Project Road will promote agricultural development, coal mine development, etc., leading to the promotion of new employment opportunities.

f) Contribution to the Sarawak State Government for the Efficient Regional Administration of Isolated Areas

It is very difficult for the Sarawak Government, under the current conditions of a river-dependent economy, to promote any efficient regional administration development.

For example, no traffic routes connect Kapit, which is the administration center of the Seventh Division, with other Divisions, except for the water way through the Batang Rajang.

In addition, during high water levels, it often becomes difficult to maintain river traffic. Under the circumstances, the construction of the Second Trunk Road connecting to the First Trunk Road will assume a good degree of importance as the most reliable traffic route.

g) Other Benefits

Other benefits include increased accessibility to the hospital, and the schools, and industial development opportunities.

11.2 Conclusion and Recommendations

(1) Conclusion

a) The Project Road seems to offer little in the way of economic feasibility. However, taking into consideration a number of benefits disregarded in

the economic evaluation, namely, the contribution to the hydroelectric dam at Pelagus, coal mining, and forestry development, regional administration development, etc., it may be said that the earliest possible construction of the Project Road is preferable.

(2) Recommendations

1) The Sarawak State Government should make efforts to improve road benefits by promoting the agricultural development projects and tourism development projects along the Project Road.

2) Project Road should be constructed on the basis of a three-stage construction plan, viz.:

1st Stage: Tatau/Mutput Area in the Fourth Division where traffic volume is large
2nd Stage: Kapit Pelagus area in the Seventh Division
3rd Stage: Remaining sections

3) The Project Road should preferably be fully paved by the time it is open to public traffic.

4) It took four years to complete the feasibility study of the Project Road because of the two-years required for aerial photography. During the period, project circumstances have changed slightly. The Study Team was informed of the new hydroelectric dam construction project close to Sangkap along the Sungai Anap in Februay 1985.

It is, however, very difficult to involve, in the Final Report, the results of the alternative alignment study, caused by the new dam project, taking into account the study flow and little information on the dam project. Therefore, aside from the Formal Final Report, a Study Report is to be submitted regarding the preliminary alternative alignment resulting from the new dam construction project.

It is strongly recommended that the alternative alignment caused by the new dam project be studied when the Project Road is realized.

APPENDIX

List of Appendices

Appendix 1-1 GROSS DOMESTIC PRODUCT IN MALAYSIA, 1976-1984

	1976	1977	1978	1979	1980	1981	1982	1983 *1	1984 *2	Average Annual Growth Rate
Gross Domestic Product at 1970 Constant Prices (M$ million)	19.373	20.875	22.264	24.324	26.228	28.092	29.553	31.206	33.065	6.9%
Population (000)	12,237	12,574	12,903	13,275	13,745	14,075	14,413	14,744	15,068	2.6%
Per Capita GDP at 1970 Constant Prices (M$)	1.583	1.660	1.725	1.832	1.908	1.996	2.050	2.117	2.194	4.2%
Growth Rate of GDP (%)	11.6	7.8	6.7	9.3	7.8	7.1	5.2	5.6	6.0	-
Growth Rate of Per Capita GDP (%)	-	4.9	3.9	6.2	4.1	4.6	2.7	3.3	3.6	-

Note: *1 Estimate
*2 Forecast

Source: Economic Report 1983/84. Ministry of Finance, Malaysia.

Appendix 1-2 GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN - SARAWAK 1972-1981

in 1970 Constant Prices

Unit: M$ million, %

	1972		1973		1974		1975		1976		1977		1978		1979		1980		1981	
1. Agriculture and Livestock	148	15.3	153	14.5	163	14.6	163	14.5	181	13.5	172	12.4	185	13.0	197	12.6	192	11.5	182	10.2
2. Forestry and Logging	91	9.4	94	8.9	81	7.2	72	6.4	124	9.3	138	9.9	169	11.9	212	13.6	236	14.1	245	13.7
3. Fishing	20	2.1	45	4.3	59	5.3	74	6.6	83	6.2	94	6.8	88	6.2	93	6.0	77	4.6	69	3.8
4. Mining and Quarring	190	19.6	186	17.6	165	14.8	181	16.1	234	17.5	225	16.2	189	13.3	205	13.1	193	11.6	198	11.0
5. Manufacturing	77	7.9	97	9.2	100	8.9	93	8.3	101	7.6	106	7.6	111	7.8	120	7.7	140	8.4	148	8.3
6. Electricity and Water	15	1.5	17	1.6	20	1.8	23	2.0	26	1.9	26	1.9	30	2.1	34	2.2	37	2.2	43	2.4
7. Construction	55	5.7	66	6.2	88	7.9	68	6.1	78	5.8	82	5.9	84	5.9	89	5.7	114	6.8	150	8.4
8. Wholesale and Retail Trade	101	10.4	103	9.7	110	9.8	111	9.9	122	9.1	128	9.2	136	9.6	152	9.7	164	9.8	178	9.9
9. Restaurants and Hotels	11	1.1	11	1.0	12	1.1	13	1.2	14	1.0	15	1.1	16	1.1	17	1.1	19	1.1	20	1.1
10. Transport and Communication	39	4.0	39	3.7	44	3.9	47	4.2	61	4.6	65	4.7	72	5.1	75	4.8	86	5.2	104	5.8
11. Finance, Insurance, Real Estate and Business Services	17	1.8	22	2.1	21	1.9	24	2.1	28	2.1	31	2.2	35	2.5	39	2.5	40	2.4	52	2.9
12. Owner Occupied Dwellings	49	5.1	49	4.6	51	4.6	51	4.5	52	3.9	53	3.8	55	3.9	56	3.6	59	3.5	61	3.4
13. Community, Social and Personal Services	12	1.2	13	1.2	15	1.3	16	1.4	20	1.5	22	1.6	23	1.6	23	1.5	23	1.4	24	1.3
14. Less: Imputed Bank Services Charges	8	-0.8	11	-1.0	11	-1.0	12	-1.1	12	-0,9	13	-0.9	15	-1.1	18	-1.2	20	-1.2	24	-1.3
15. Sub-Total: Domestic Product of Industries	817	84.2	884	83.6	918	82.1	924	82.4	1,112	83.2	1,144	82.5	1,178	83.0	1,294	83.0	1,360	81.5	1,450	80.9

Appendix 1-2 GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN - SARAWAK 1972-1981 (Cont'd)
in 1970 Constant Prices

Unit: M$ million, %

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
16. Domestic Product of Government Services	106 10.9	112 10.6	127 11.4	137 12.2	158 11.8	178 12.8	185 13.0	200 12.8	209 12.5	245 13.7
17. Producers of Private Non-Profit Services to Households	1 0.1	1 0.1	1 0.1	1 0.1	1 0.1	1 0.1	1 0.1	1 0.1	1 0.1	1 0.1
18. Domestic Services of Households	3 0.3	3 0.3	3 0.3	3 0.3	3 0.2	3 0.2	3 0.2	3 0.2	3 0.2	3 0.2
19. Domestic Product excluding Import Duties	927 95.6	1,000 94.5	1,049 93.8	1,065 94.9	1,274 95.3	1,326 95.6	1,367 96.3	1,498 96.1	1,573 94.3	1,699 94.8
20. Import Duties	43 4.4	58 5.5	69 6.2	57 5.1	63 4.7	61 4.4	53 3.7	61 3.9	95 5.7	94 5.2
21. Gross Domestic Product in Purchaser's Value	970 100	1,058 100	1,118 100	1,122 100	1,337 100	1,387 100	1,420 100	1,559 100	1,668 100	1,793 100

Source: Annual Statistics Bulletin Sawarak, 1980 & 1982

Appendix 1-3 IMPORTS BY COMMODITY

Unit: M$ million, %

		1970		1975		1978		1980		1981		1982	
		$	%	$	%	$	%	$	%	$	%	$	%
1.	Food	102.5	15.5	182.6	21.5	242.4	21.0	328.6	14.3	409.4	13.6	426.1	12.8
2.	Beverages & Tobacco	27.3	4.1	38.5	4.5	74.9	6.5	116.4	5.1	124.8	4.2	140.3	4.2
3.	Crude Materials (Inedible)	9.0	1.4	22.4	2.6	28.3	2.5	39.8	1.7	36.9	1.3	31.7	1.0
4.	Mineral Fuels, Lubricants	293.0	44.4	142.4	16.7	53.3	4.6	142.9	6.2	177.3	5.9	196.8	5.9
5.	Animal & Vegetable Oils & Fats	0.7	0.1	2.4	0.3	3.0	0.3	9.7	0.4	11.0	0.4	10.9	0.3
6.	Chemicals	32.8	5.0	68.5	8.0	97.3	8.4	155.6	6.8	182.8	6.1	205.8	6.2
7.	Manufactured Goods	68.9	10.4	141.8	16.7	172.4	15.0	453.1	19.7	610.2	20.3	734.5	22.1
8.	Machinery & Transportation Equipment	86.7	13.1	177.1	20.8	391.1	34.0	906.1	39.4	1,231.5	41.0	1,335.7	40.2
9.	Miscellaneous Manufactured Articles	28.2	4.3	50.0	5.9	69.1	6.0	118.8	5.2	143.4	4.8	201.3	6.1
10.	Miscellaneous Transactions & Commodities	11.3	1.7	25.2	3.0	19.8	1.7	27.8	1.2	73.9	2.5	36.7	1.1
	TOTAL:	660.4	100.0	850.9	100.0	1,151.6	100.0	2,298.8	100.0	3,001.1	100.0	3,319.8	100.0

Source: Annual Statistics Bulletin Sarawak 1980

Appendix 1-4 EXPORTS BY COMMODITY

Unit: M$ million, %

Item	1970		1975		1978		1980		1981		1982	
	$	%	$	%	$	%	$	%	$	%	$	%
1. Food	62.1	9.2	114.5	8.2	165.5	8.7	144.0	3.6	131.0	2.9	119.8	2.4
2. Beverages & Tobacco	0.5	0.2	0.5	0.0	0.8	0.0	2.0	0.0	2.7	0.1	3.3	0.1
3. Crude Materials (Inedible)	241.1	35.9	165.1	11.9	483.3	25.3	1,053.2	26.1	982.7	21.8	1,442.7	29.1
4. Mineral Fuels, Lubricants	327.0	48.7	1,025.3	73.9	1,068.2	56.0	2,515.4	62.2	3,018.6	66.8	3,055.2	61.6
5. Animal & Vegetable Oils & Fats	3.5	0.5	8.1	0.6	31.3	1.6	38.8	1.0	26.8	0.6	26.6	0.5
6. Chemicals	0.3	0.1	0.7	0.1	2.0	0.1	3.0	0.1	3.0	0.1	4.4	0.1
7. Manufactured Goods	25.0	3.7	35.8	2.6	96.7	5.1	110.8	2.7	98.4	2.2	105.8	2.1
8. Machinery & Transportation Equipment	5.0	0.7	17.7	1.3	45.6	2.4	143.1	3.5	184.4	4.1	156.2	3.2
9. Miscellaneous Manufactured Articles	2.3	0.3	4.5	0.3	8.4	0.4	13.7	0.4	13.7	0.3	16.6	0.3
10. Miscellaneous Transactions & Commodities	4.6	0.7	15.2	1.1	6.8	0.4	17.4	0.4	56.1	1.2	26.0	0.5
TOTAL:	671.4	100.0	1,387.4	100.0	1,908.6	100.0	4,041.4	100.0	4,517.3	100.0	4,956.6	100.0

Source: Annual Statistics Bulletin Sarawak 1980

Appendix 1-5 POPULATION DISTRIBUTION BY COMMUNITY

Unit: Person

Period \ Community	TOTAL	Ibans	Bidayuhs	Melanaus	Other Indigenous	Malays	Chinese	Others
Census 1947	546,385	190,326	42,195	35,560	29,867	97,469	145,158	5,810
Census 1960	744,529	237,741	57,619	44,661	37,931	129,300	229,154	8,123
Census 1970	976,269	303,461	83,612	53,379	50,696	181,426	293,949	9,746
30th June, 1970	972,582	303,045	83,146	53,234	50,541	180,452	292,455	9,709
31st December, 1970	985,452	305,061	84,704	53,785	51,148	183,648	297,282	9,824
30th June, 1971	998,199	307,351	86,061	54,315	51,818	186,638	302,069	9,947
31st December, 1971	1,010,965	309,628	87,428	54,845	52,489	189,635	306,870	10,070
30th June, 1972	1,024,470	312,027	88,916	55,495	53,173	192,994	311,694	10,171
31st December, 1972	1,038,037	314,520	90,411	56,140	53,817	196,356	316,515	10,278
30th June, 1973	1,051,997	317,115	91,993	56,834	54,514	199,801	321,337	10,403
31st December, 1973	1,066,067	319,796	93,582	57,552	55,179	203,252	326,175	10,531
30th June, 1974	1,079,694	322,407	95,019	58,292	55,947	206,564	330,817	10,648
31st December, 1974	1,093,405	325,082	96,460	59,038	56,721	209,860	335,474	10,770
30th June, 1975	1,107,323	327,757	98,001	59,937	57,406	213,268	340,072	10,882
31st December, 1975	1,121,146	330,606	99,424	60,471	58,197	216,530	344,913	11,005
30th June, 1976	1,134,938	333,348	100,840	61,128	58,962	219,950	349,578	11,132
31st December, 1976	1,148,991	336,076	102,232	61,764	59,704	223,118	354,842	11,255
30th June, 1977	1,162,998	338,761	103,800	62,547	60,473	226,768	359,257	11,392
31st December, 1977	1,177,236	341,728	105,356	63,276	61,179	230,206	363,972	11,519
30th June, 1978	1,191,429	344,721	106,744	64,085	61,954	233,777	368,482	11,666
31st December, 1978	1,205,973	347,843	108,068	64,886	62,645	237,340	373,398	11,793
30th June, 1979	1,220,673	350,836	109,460	65,776	63,354	241,125	378,211	11,911
31st December, 1979	1,236,428	354,158	110,966	66,630	64,122	244,990	383,504	12,058

Source: Annual Statistics Bulletin Sarawak 1980