CHAPTER 8 CONSTRUCTION AND MAINTENANCE/OPERATION COSTS

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8.1 General

The Study Team established a unit price for each construction item using basic cost elements such as labour, materials, equipment, overhead, profit etc. The unit prices were computed in accordance with the following criteria.

(1) The estimates were prepared on the assumption that all construction works will be contracted to a general contractor by international tender.

(2) The unit prices were computed under the economic conditions prevailing in July, 1983.

(3) The costs were estimated for all alternatives and were classified into foreign currency (indicated in K.Shs) and local currency (indicated in K.Shs) portions.

Foreign currency and local currency components of each unit price were computed from the following classification of basic cost elements.

The foreign currency component consists of the costs of:

- Imported equipment, materials and supplies;
- A portion of domestic materials and supplies
- Wages of expatriate personnel; and
- Overhead and profit of foreign firms.

The local currency component includes the cost of:

- A portion of domestic materials and supplies
- Wages of local personnel;
- Overhead and profit of local firms; and
- Taxes.

(4) The unit price of each work item is obtained by adding the labour cost, equipment cost, material cost, etc. for the item, and the result is checked against recent actual figures for construction work in Kenya.

(5) Major materials costs include the following items:–
Fuel, reinforcing bars, prestressing bars, structural steel, fine aggregate, coarse aggregate, cement, asphalt and steel pipe piles.

(6) The Kenyan tax on equipment and materials is computed. Import duty is free based on a current agreement for an other similar project.

(7) Land acquisition and compensation were based on unit cost data obtained from Mombasa Municipality.

(8) Physical contingency was estimated to be 10% of the total of construction cost, engineering fee, and land acquisition and compensation cost.

(9) The final engineering, supervision fees and administration cost etc. were assumed to be 10% of the total of construction cost, and the breakdowns are as follows:

- Final Engineering: 5%
- Supervision, Administration: 5%

The rates of exchange used to convert the Kenyan Shilling to Japanese Yen and US Dollar are K.Shs 13.06 = US$1.00 = Yen 241.

8.2 Unit Prices

8.2.1 Unit Costs of Materials

The unit cost data of material was collected. The costs of imported materials are based on the CIF Mombasa price whereas those of local materials are based on the market prices in Mombasa. The unit costs of the major material items are as shown in Table 8.2.1 and 8.2.2.

Table 8.2.1 UNIT COSTS OF DOMESTIC MATERIALS

(Unit: K.Shs)

Major Material	Description	Unit	Unit Cost
Fuel Gasoline		Lit	7.5
Diesel		Lit	5.5
Engine Oil		Lit	21.5
Sand		CU.M	58
Crushed Stone	Crusher dust	CU.M	31
	1/4"	CU.M	93
	1/2" ∿ 2"	CU.M	97
	Boulder 6" x 9"	CU.M	70
Cement	Standard	Ton	1,143
	Portland	Ton	1,213
	Sulphate resisting	Ton	1,285.3
Timber	Cypress	CU.M	1,550
	Cedar	CU.M	1,720
	Hardwood	CU.M	6,360
Paint	Road marking paint	Lit	80
	Paint for metal	Lit	60
Asphalt	60-80, straight	Ton	2,866
	Emulsion	Lit	4.1
Concrete Block	5" x 10" x 36"	No.	30
Concrete Pipe	ϕ400	L.M	210
	ϕ600	L.M	400
	ϕ1,000	L.M	780

Table 8.2.2 UNIT COSTS OF FOREIGN MATERIALS (1)

(Unit: K.Shs)

Material	Description	Unit	Unit Cost
Steel Deformed Bar	JIS G3112 SD30	Ton	4,150
Steel Plate	JIS G3101 SS41	Ton	6,300
	JIS G3106 SM50Y	Ton	7,400
	JIS G3106 SM58	Ton	9,500
High Strength Bolt (HTB)	JIS B1186 F10T	Ton	13,500
Bearing Shoe	Tefron	Ton	38,000
	Roller	Ton	105,600
	B.P	Ton	8,800
	Rubber	L.M	19,500
Expansion Joint	Demag	L.M	184,900
	Rubber	L.M	16,500
P.C Stranded Cable	JIS G3536 SWPR	Ton	18,700
P.C Rod Bar	JIS G3109 SBPR 95/120	Ton	17,600
Guard Rail	Steel (Post ctc 4.0m)	L.M	268
Hand Rail	Steel (For Embankment)	L.M	2,400
	(For Bridges)	L.M	3,000
Street Lighting	Steel Taper Pole (H=12m) (For Embankment)	No.	11,000
	Ditto (For Bridges)	No.	13,000
Traffic Sign	Type A (1,000x2,000)	No.	4,500
	Type B (ϕ600)	No.	650
Chatter Bar	L=300 (ctc 1,000)	No.	400
Back-hoe	0.3 m^3	No.	641,700
Tire-dozer	2.3 m^3 (530B)	No.	164,800
Dozer-shovel	D50S	No.	498,400
Reverse Circulation Drill	S-320	No.	1,794,100
Clamshell Bucket	2 ton (CH-1,000)	No.	4,105,400
Three-wing Bit	ϕ2.0 m ∿ ϕ3.0 m	No.	65,400
	ϕ2.0 m ∿ ϕ2.4 m	No.	64,200
Vibro Pile Hammer	60 Km	No.	520,800
Hoist	KME, PM-500	No.	778,700
Climbing Shutter		L.S	2,429,900
Crawler Crane	300 ton	No.	19,250,000

Table 8.2.2 UNIT COSTS OF FOREIGN MATERIALS (2)

(Unit: K.Shs)

Material	Description	Unit	Unit Cost
Crawler Crane	80 ton	No.	5,918,200
Truck Crane	127 ton	No.	8,890,000
	50 ton	No.	5,556,900
	35 ton	No.	2,610,200
Climbing Tower-Crane	192 t-m H=190 m	No.	5,382,400
	100 t-m H=80 m	No.	2,261,400
Climbing Crane (Universally operatable)	Cap. 20 ton	No.	2,490,000
Tower Jib Crane	Cap. 40 ton	No.	2,803,000
Portal Crane	Cap. 100 ton	No.	2,055,800
Flat-Bed Trailer Truck	Cap. 40 ton	No.	1,246,000
	Cap. 20 ton	No.	748,000
Truck	Cap. 10 ∿ 11 ton	No.	424,900
Dump truck	Cap. 10 ∿ 11 ton	No.	477,200
Reefer truck	Cap. 4 ton	No.	623,000
Cargo truck	Cap. 4 ton	No.	343,000
Micro Bus	26 persons	No.	353,000
Wagon		No.	137,000
Sedan		No.	112,000
Jeep		No.	342,000
Fork-Lift Truck	Cap. 4 ton	No.	273,200
	Cap. 3 ton	No.	240,000
Trolley	Cap. 40 ton	No.	93,400
Rail	30 kg/m	Ton	6,850
Deck-Barge	Cap. 500 ton	No.	1,856,400
Tug-Boat	180 PS	No.	2,261,400
Winch	35 KW		105,000
	50 H.P		374,000
	30 H.P		218,000
Concrete Plant	3.0m^3x2 No. (360 m^3/hr)	No.	4,678,500
Crusher	50 ∿ 115 ton/hr	No.	485,900
Aggregate Screen	30 m^3/hr	No.	623,000
Grout Mixer		No.	21,800

Table 8.2.2 UNIT COSTS OF FOREIGN MATERIALS (3)

(Unit: K.Shs)

Material	Description	Unit	Unit Cost
Grout Pump		No.	48,300
Vibrator	ϕ60, 1.2 Kw	No.	8,400
Concrete Bucket	1.5 m^3	No.	39,800
Generator	300 KVA	No.	735,100
	125 KVA	No.	521,000
	100 KVA	No.	238,000
	40 KVA	No.	200,000
Cubicle	50 ∿ 100 KVA	No.	169,400
Engine Compressor	50 H.P	No.	284,400
Cantilever Carriage	600 t-m	No.	3,344,500
	400 t-m	No.	2,455,300
	300 t-m	No.	2,010,600
	200 t-m	No.	1,566,000
Launching Girder	L = 100 m, Cap. 100 ton	No.	2,018,400
Electric Arc Welder	500A	No.	18,200
	300A	No.	12,500
Engine Welder	150A	No.	49,800
Impact Wrench		No.	8,940
Torque Wrench		No.	6,230
Nut Rummer		No.	21,800
Calibrator		No.	28,000
Freyssinet Jack	12ϕ 7 m/m E	No.	87,800
Dywidag Jack	Cap. 70 ton	No.	46,500
	Cap. 50 ton	No.	39,600
Oil Jack	Cap. 500 ton	No.	224,000
	Cap. 200 ton	No.	62,300
	Cap. 100 ton (Stroke 1,500 mm)	No.	93,400
	Cap. 50 ton	No.	18,700
Tension Jack (Cable)	Cap. 500 ton	No.	487,500
Pump for Tension Jack		No.	438,800
Electric-Motor Pump for Jack	0.75	No.	39,500

Table 8.2.2 UNIT COSTS OF FOREIGN MATERIALS (4)

(Unit: K.Shs)

Material	Description	Unit	Unit Cost
Electric-Motor Pump Unit		L.S	209,000
Hand-Pump Unit		No.	40,500
Bar Bender		No.	49,100
Lever Block	Cap. 3 ∿ 5 ton	No.	520
Dynamometer	Cap. 100 ton	No.	44,800
Cable Stranded Reel Set		L.S	872,000
Staging System		L.S	9,970,000
Stiffening Materials		L.S	868,000
Road Mat		L.S	1,760
Travelling Staging	(Under Main Girders)	L.S	623,000
Scaffolding Pipe	L = 6.0 m	No.	120
	L = 3.0 m	No.	60
Scaffolding Board		No.	180
Surveying Instrument		L.S	324,000

8.2.2 Unit Cost of Labour

The unit labour cost is based on the actual cost prevailing in Mombasa and Nairobi. The costs are classified into three categories as follows:

Class-I	
Foreman, Heavy Equipment Operator	12.5 Shs/hr (100 Shs/8 hr)
Class-II	
Carpenter, Steel worker, Mason, Truck driver	8.5 Shs/hr (68 Shs/8 hr)
Class-III	
Common labour	5.68 Shs/hr (45.5 Shs/8 hr)

8.2.3 Equipment Costs

An assessment of hourly equipment costs was made for the plant that would probably be used in the construction of the Project. These equipment rates are shown in Table 8.2.3.

That is, the estimated hourly direct costs are calculated based on the estimated CIF unit prices at Mombasa Port and the operating costs (fuel, lubricant and other expenses) are based on the market prices in Mombasa.

8.3 Unit Cost for Work Items

The unit cost for work items is calculated from the material cost, labour cost, equipment cost, etc. taking into consideration the local conditions in Mombasa, and the unit costs are listed in Table 8.3.1, 8.3.2 and Appendix D.

8.4 Quantity of Work Items

The quantities by work item are calculated for the approach road (embankment section) and bridge sections (main bridge and approach bridge) based on the preliminary design described in Chapter 7.

The construction quantities are also estimated by alternative navigation clearances and structural type of main bridge (prestressed concrete and steel).

Table 8.4.1 is presented for approach road, Table 8.4.2 for P.C main bridge (H=55M) and Appendix E.

Table 8.2.3 EQUIPMENT DIRECT COST PER HOUR

Equipment	P.S/Weight (Ton)	Purchase Price	Economical Life /Hours(days) used per Year		Depreciation Rate and cost		Fuel/Oil Consumption per Hour (day)	Local Portion	Foreign Portion
		K.Shs.	Year	Hours/days	$x10^{-6}$	K.Shs	K.Shs	K.Shs	K.Shs
Bulldozer 15 t	141/14.6	920,000	6	1,100	352	324	115	62	377
Bulldozer 21 t	211/22.1	1,406,000	6	1,100	352	495	145	78	562
Bulldozer with ripper 21 t	160/5.2	239,000	6	1,100	359	675	169	91	753
Convertible Excavator 0.7 m^3	130/22.1	1,195,000	5	1,300	308	368	75	40	403
Dump Truck 6 t	160/5.2	239,000	4	1,500	367	88	42	23	107
Flat Bed Truck 6 t	170/4.6	211,000	4	1,500	367	78	36	19	95
Flat Bed Truck with 2t crane	85/2.7	154,600	4	1,300	365	57	30	16	71
Semi-Trailar Truck 32t	320/20.5	901,000	5	1,200	342	308	181	98	391
Concrete Mixer Truck 3.2 m^3	195/7.5	326,700	5	1,000	360	118	50	27	141
Concrete Pump Truck 45 m^3	145/73	833,300	4	1,300	419	349	43	23	369
Water Tank Truck 3,500 lit	160/11	313,000	5	1,200	333	104	86	45	145
Motor Grader 3.7 m	126/12	753,900	6	1,000	353	266	71	30	307
Tandem Roller 8~10t	58/8	400,000	7	800	391	156	37	20	173
Macadam Roller 8~10t	58/8	391/000	7	900	348	136	37	20	153
Macadam Roller 12t	89/10.1	364,900	7	900	348	127	37	20	144
Tyre Roller 8~20t	85/8	472,800	7	900	348	165	31	17	179
Vibration Roller	49/6.7	491,300	6	750	471	231	37	20	248
Mechanical Broom	160/5.6	741,000	5	1,000	360	267	86	45	308
Rammer 60~100 Kg	4/0.078	15,590	3	140 day	4,167 day	65 day	5 day	3 day	67 day
Stone Crushing Plant Cone Crusher ø1,500	150/42	3,245,600	9	5,000	185	600	173	93	680
Concrete Plant 3 m^3 x 2 No.,360m^3/hr	74 kw/230	5,427,800	8	6,500	154.6	839	113	61	891
Rod Vibrator 60~75 mm	1.2 kw/0.044	9,600	3	120 day	3,889	37	1	1	37
Asphalt Plant 50 t/hr	159 kw/40	4,312,500	6	1,000	362	1,561	137	74	1,624
Asphalt Distributor 1,500 lit	84/3.5	245,000	6	600	533	131	176	95	212
Asphalt Finisher 3~6m	78 kw/14	1,322,500	6	750	471	623	122	66	679
Asphalt Kettle 6,000ℓ	12.0	60,700	4	100 day	3,350 day	203	10	5	208
Electric Generator 150 kw	150kw/1.45	355,000	11	170 day	1,016	361	133	72	422
Portable Belt Conveyer 7 m	3/0.23	1,710	1.5	125 day	8,667	15	5	3	17
Air Compresor 2 m^3/min	28/0.67	82,500	6	140 day	2,500	206	39	21	224
Line Marker	/0.12	38,350	4	840	417	16	5	3	18

Table 8.3.1 UNIT COST FOR WORK ITEMS (APPROACH ROAD)

(Unit: K.Shs)

Work Item	Description	Unit	Unit Cost		
			L.C	F.C	Total
Clearing & Grubbing (A)	Common field	HA	2,180	8,220	10,400
(B)	Demolish of house	No.	4	14	18
Removal of Old Pavement		SQ.M	7	29	36
Removal of Street Lighting Post		No.	510	1,110	1,620
Embankment with Borrow Material	Class-S2	CU.M	17	52	69
Excavation & Disposal	L=5km	CU.M	15	51	66
Top Soil for Slope Protection	t=0.2 m	L.M.	74	298	372
Earth Drain	0.5 x 0.5 m	L.M.	37	148	185
R.C Pipe Culvert	D=400	L.M.	510	75	585
Catch Basin W/cover	600x600x600	EACH	1,870	430	2,300
Concrete Curb	5"x10"x36"	L.M	53	5	58
Concrete Curb & Gutter	W=500	L.M.	81	19	100
Subgrade Preparation		SQ.M	20	5	25
Sub-base Course	t=175	CU.M	189	51	240
Base Course	t=150	CU.M	290	185	475
Asphalt Surface Course	t=50	TON	350	330	680
	t=80	TON	560	530	1,090
	Foot path t=30	TON	210	200	410
Bituminous Prime Coat		SQ.M	3.5	4.5	8.0
Chatter Bar	L=300	No.	12	15	27
Retaining Wall	H=2m	L.M.	21,700	960	22,660
Stone Masonry		SQ.M	520	230	750
Strip Sodding		SQ.M	8	2	10
Guard Rail		L.M.	58	342	400
Road Sign Type A	ϕ600	No.	120	970	1,080
B	2,000x1,000	No.	190	4,670	4,860
Road Marking	w=150	SQ.M	134	33	167
Road Lighting: (A)Earth	H=12m	No.	1,800	14,200	16,000
(B)Bridge	H=12m	No.	1,900	28,600	30,500
Hand rail	H=1,500	L.M.	10	4,050	4,060
Traffic Signal		No.	500	88,900	89,400

Table 8.3.2 UNIT COST FOR WORK ITEMS

(1) P.C MAIN BRIDGE H=55M, PHASE-I

Work Item		Sub-Item	Class	Unit	Unit Cost (K.Shs.)		
					L.C	F.C	Total
Superstructure	Main Girder	Concrete	$\delta ck=350kg/cm^2$	CU.M	930	750	1,680
		Form	Steel	SQ.M	68	232	300
		Reinforcement	SD30	Ton	2,387	11,833	14,220
		P.C. Rod	SBPR 95/120	Ton	7,386	57,114	64,500
		P.C. Cable	SWPR	Ton	12,883	97,117	110,000
	Stayed Cable	P.C. Cable	SWPR	Ton	16,150	122,550	138,700
	Erection & Equipment	-	-	L.S.	3,368,000	20,351,000	23,719,000
Tower	Tower	Concrete	$\delta ck=350kg/cm^2$	CU.M.	930	750	1,680
		Form	Steel	SQ.M.	80	270	350
		Reinforcement	SD30	Ton	2,387	11,833	14,220
	Erection & Equipment	-	-	L.S.	1,050,000	6,150,000	7,200,000
Substructure & Footing	Body & Footin Footing	Concrete	$\delta ck=300kg/cm^2$	CU.M.	960	690	1,650
			$\delta ck=240kg/cm^2$	CU.M.	900	650	1,550
		Form	Steel	SQ.M.	80	270	350
		Reinforcement	SD30	Ton	2,387	11,833	14,220
	Pile Foundation	Cast-in-place Pile	R.C.D ϕ3.0m	L.M.	13,800	53,900	67,700
	Shoe	Tefron	800x800x150	No.	14,000	56,000	70,000
		Roller		Ton	12,377	95,923	108,300
	Expansion Joint	Demag		L.M.	37,900	151,700	189,600
	Temporary & Other Work			L.S.	17,007,000	96,373,000	113,380,000

(2) APPROACH BRIDGE H=55M, PHASE-I

	Work Item	Sub-Item	Class	Unit	Unit Cost (K.Shs.)		
					L.C	F.C	Total
Superstructure	R.C. Hollow	Concrete	$\delta ck=240kg/cm^2$	CU.M.	900	650	1,550
		Form	Steel	SQ.M.	80	270	350
		Reinforcement	SD30	Ton	2,387	11,833	14,220
	Post Tension T-Girder	Concrete	$\delta ck=350kg/cm^2$	CU.M.	930	750	1,680
		Form	Steel	SQ.M.	75	245	320
		Reinforcement	SD30	Ton	2,387	11,833	14,220
		PC Cable	SWPR	Ton	12,883	97,117	110,000
	P.C Rigid Frame	Concrete	$\delta ck=350kg/cm^2$	CU.M.	930	750	1,680
		Form	Steel	SQ.M.	68	232	300
		Reinforcement	SD30	Ton	2,387	11,833	14,220
		P.C Rod	SBPR 95/120	Ton	7,386	57,114	64,500
	Erection & Equipment			L.S.	4,040,000	22,899,000	26,939,000
Substructure	Body & Footing	Concrete	$\delta ck=240kg/cm^2$	CU.M.	900	650	1,550
		Form	Steel	SQ.M.	80	270	350
		Reinforcement	SD30	Ton	2,387	11,833	14,220
	Pile Foundation	Cast-in-place pile	R.C.D $\phi 3.0$	L.M.	13,800	53,900	67,700
			$\phi 2.5$	L.M.	11,800	46,200	58,000
			$\phi 2.0$	L.M.	9,860	38,540	48,400
	Shoe	BP		Ton	3,250	13,001	16,251
		Rubber	R75	No.	1,480	5,920	7,400
			R65	No.	1,400	5,600	7,000
			R55	No.	1,280	5,120	6,400
			R45	No.	1,160	4,640	5,800
	Expansion Joint	Rubber		L.M.	2,840	11,360	14,200
	Temporary & Other Work			L.S.	10,808,000	61,246,000	72,054,000

(3) APPROACH BRIDGE H=55 M, PHASE-II

	Work Item	Sub-Item	Class	Unit	Unit Cost (K.Shs.)		
					L.C	F.C	Total
Superstructure	R.C. Hollow	Concrete	$\delta ck=240kg/cm^2$	CU.M.	900	650	1,550
		Form	Steel	SQ.M.	80	270	350
		Reinforcement	SD30	Ton	2,387	11,833	14,220
	Post Tension T-Girder	Concrete	$\delta ck=350kg/cm^2$	CU.M.	930	750	1,680
		Form	Steel	SQ.M.	75	245	320
		Reinforcement	SD30	Ton	2,387	11,833	14,220
		P.C Cable	SWPR	Ton	12,883	97,117	110,000
	P.C Rigid Frame	Concrete	$\delta ck=350kg/cm^2$	CU.M.	930	750	1,680
		Form	Steel	SQ.M.	68	232	300
		Reinforcement	SD30	Ton	2,387	11,833	14,220
		P.C Rod	SBPR 95/120	Ton	7,386	57,114	64,500
	Erection & Equipment			L.S.	3,922,000	22,228,000	26,150,000
Substructure	Body & Footing	Concrete	$\delta ck=240kg/cm^2$	CU.M.	900	650	1,550
		Form	Steel	SQ.M.	80	270	350
		Reinforcement	SD30	Ton	2,387	11,833	14,220
	Pile Foundation	Cast-in-place pile	R.C.D ϕ3.0	L.M.	13,800	53,900	67,700
			ϕ2.5	L.M.	11,800	46,200	58,000
			ϕ2.0	L.M.	9,860	38,540	48,400
	Shoe	BP		Ton	3,250	13,001	16,251
		Rubber	R75	No.	1,480	5,920	7,400
			R65	No.	1,400	5,600	7,000
			R55	No.	1,280	5,120	6,400
			R45	No.	1,160	4,640	5,800
	Expansion Joint	Rubber		L.M.	2,840	11,360	14,200
	Temporary & Other work			L.S.	17,917	101,533	119,450

Table 8.4.1 QUANTITIES FOR ROAD CONSTRUCTION

Work Item	Unit	Quantities					
		H=73.2 m		H=55 m		H=45 m	
		Phase-I	Phase-II	Phase-I	Phase-II	Phase-I	Phase-II
Clearing & Grubbing (A)	HA	6.6	2.0	8.1	1.4	8.8	1.1
(B)	No.	10	40	11	15	11	9
Removal of Old Pavement	SQ.M	114	644	1,362	375	1,362	488
Removal of Street Lighting Post	EACH	62	6	44	4	44	4
Embankment with Borrow Material	CU.M.	37,671	25,037	25,898	19,126	28,557	18,673
Excavation & Disposal	CU.M.	-	3,740	2,925	3,712	2,925	2,896
Top Soil for Slope Protection	CU.M.	1,372	1,187	1,531	1,347	1,562	1,377
Earth Drain	L.M.	5,080	300	5,310	300	5,750	300
R.C. Pipe Culvert	L.M.	341	424	389	294	417	311
Catch Basin W/Cover	No.	54	78	92	108	99	110
Concrete Curb	L.M.	4,420	9,980	4,251	9,120	3,956	9,705
Concrete Curb & Gutter	L.M.	2,660	3,870	4,761	5,317	4,981	5,442
Subgrade Preparation	SQ.M.	39,750	39,200	52,160	34,980	52,160	31,800
Sub-base Course	CU.M.	6,148	6,228	8,298	5,565	8,298	5,060
Base Course	CU.M.	5,220	5,160	6,863	4,611	6,863	4,190
Asphalt Surface Course t = 50	TON	6,447 (4,872)	7,233 (7,233)	6,607 (5,795)	5,566 (4,802)	6,533 (5,723)	5,049 (4,285)
t = 80	TON	(3,131)	-	(1,603)	(1,527)	(1,603)	(1,527)
t = 30	TON	1,342 (1,113)	1,371 (1,371)	1,040 (925)	980 (866)	1,010 (895)	895 (780)
Bituminous Prime Coat	SQ.M.	56,057	62,895	57,449	48,400	56,812	43,905
Chatter Bar	No.	1,777	-	-	-	-	-
Retaining Wall	L.M.	-	440	240	520	180	500
Stone Masonry	SQ.M.	180	60	60	60	60	60
Strip Sodding	SQ.M.	6,861	5,933	7,654	6,736	7,812	6,884
Guard Rail	L.M.	1,000	540	1,490	750	1,490	750
Road Sign (A)	No.	4	-	2	-	2	-
(B)	No.	4	4	4	4	4	4
Road Marking	SQ.M.	2,022	2,353	1,549	1,477	1,549	1,388
Road Lighting (A)	No.	70	152	124	64	124	61
(B)	No.	71	91	57	83	57	78
Hand rail	L.M.	3,640	4,650	1,985	2,845	1,690	2,400
Traffic Signal	No.	7	3	7	3	7	3

Note: Figures in the blacket are the quantities for the main bridge in case of steel.

Table 8.4.2 QUANTITIES FOR BRIDGE CONSTRUCTION

(1) P.C. MAIN BRIDGE, H = 55, PHASE I & II

	Item	Sub-Item	Class	Unit	Quantities
Superstructure	Main Girder	Concrete	$\delta ck=350$ kg/cm^2	CU.M.	11,286
		Form	Steel	SQ.M.	39,743
		Reinforcement	SD30	Ton	1,354
		P.C Rod	SBPR 95/120	Ton	225
		P.C Cable	SWPR	Ton	151
	Stayed Cable	P.C Cable	SWPR	Ton	966
	Erection & Equipment		-	L.S.	1
Tower	Tower	Concrete	$\delta ck=350$ kg/cm^2	CU.M.	5,558
		Form	Steel	SQ.M.	6,380
		Reinforcement	SD30	Ton	389
	Erection & Equipment		-	L.S.	1
Substructure & Footing	Body & Footing	Concrete	$\delta ck=300$ kg/cm^2	CU.M.	10,104
			$\delta ck=240$ kg/cm^2	CU.M.	5,552
		Form	Steel	SQ.M.	13,994
		Reinforcement	SD30	Ton	1,607
	Pile Foundation	Cast-in-place Pile	R.C.D ϕ3.0 m	L.M.	1,920
	Shoe	Tefron	800x800x150	No.	8
		Roller	12 Nos.	Ton	23.2
	Expansion joint		Demag	L.M.	22
Temporary & Other Work				L.S	1

(2) APPROACH BRIDGE, H=55M, PHASE I & II

	Item	Sub-Item	Class	Unit	Quantities	
					Phase-I	Phase-II
Superstructure	R.C Hollow	Concrecte	$\delta ck=240 kg/cm^2$	CU.M.	3,031	5,063
		Form	Steel	SQ.M.	6,864	11,467
		Reinforcement	SD30	Ton	561	937
	Post Tension T-Girder	Concrete	$\delta ck=350 kg/cm^2$	CU.M	3,648	4,690
		Form	Steel	SQ.M.	21,158	26,673
		Reinforcement	SD30	Ton	421	563
		P.C Cable	SWPR	Ton	183	246
	P.C Rigid Frame	Concrete	$\delta ck=350 kg/cm^2$	CU.M.	4,511	6,032
		Form	Steel	SQ.M	15,268	20,661
		Reinforcement	SD30	Ton	539	720
		P.C Rod	SBPR 95/120	Ton	324	423
	Erection & Equipment			L.S	1	1
Substructure	Body & Footing	Concrete	$\delta ck=240 kg/cm^2$	CU.M	11,544	20,798
		Form	Steel	SQ.M.	13,597	24,273
		Reinforcement	SD30	Ton	1,159	1,571
	Pile Foundation	Cast-in-place pile	R.C.D $\phi 3.0$	L.M.	0	0
			" $\phi 2.5$	L.M.	280	210
			" $\phi 2.6$	L.M.	420	840
	Shoe	BP		Ton	15.6	9.6
		rubber	R75t	No.	0	60
			R65t	No.	192	300
			R55t	No.	0	24
			R45t	No.	192	480
	Expansion joint	Rubber		L.M.	396	748
Temporary & Other Work				L.S	1	1

8.5 Land Aquisition and Compensation Costs

The data of land acquisition and compensation costs are obtained from the Municipal Council of Mombasa, which are shown below:

1) Land Price (Unit: Shs/M²)

Location	Residential	Commercial
(1) Mombasa Island		
Kizingo Area		
1st Beach Row	200 – 250	–
2nd Beach Row	175 – 220	Ave. 250
3rd Beach Row	150 – 200	–
Ganjoni Area	Ave. 125	Ave. 250
(2) South Mainland		
Inland Area incl. the area of A-14	25 – 45	

2) Compensation Cost (Unit: Shs/M²)

	Island	South Mainland
(1) Swahili House with electricity but no water service	–	1,400 Shs/M²
(2) Same above with Makuti roof	–	1,000
(3) Permanent House with electricity and water services,		
Single Storey	2,000 Shs/M²	1,800
Double Storey	2,250	2,100
Multi Storey	2,350	2,200

8.6 Preliminary Construction Cost Estimates

8.6.1 *General*

The construction cost estimate were made for each alternative based on the quantities and on the unit prices presented in 8.4 of Chapter 8. The costs are split into foreign and local currency components.

In this sub-section the following costs are estimated.

- Expansion cost for existing ferry terminal
- Tunnel cost (case for T_2, Immersed Tube Tunnel)
- Bridge cost by navigation clearance (H = 73.2, 55, 45 M)
- Tollgate cost

The former two costs are estimated in Appendix G and I.

8.6.2 Project Cost

1) Project Cost

The project costs by navigation clearance, type (P.C and Steel) and Phasing (I & II) are presented in Tables 8.6.1 and 8.6.2, and summarized in Table 8.6.3.

Table 8.6.3 TOTAL PROJECT COST

(Unit: 1,000 K.Shs)

	Phase I	Phase II	Total
P.C. Case			
H = 73.2 M	1,810,671	1,372,298	3,182,969
H = 55	1,076,958	1,248,819	2,325,777
H = 45	925,513	1,056,972	1,982,485
Steel Case			
H = 73.2 M	1,844,710	1,372,298	3,217,008
H = 55	1,231,133	1,402,933	2,634,066
H = 45	1,088,065	1,219,462	2,307,527

Table 8.6.1 PROJECT COST (P.C. MAIN BRIDGE)

(Unit: 1,000 K.Shs)

Navigation Clearance / Phase / Portion / Item	73.2M				55M				45M			
	Phase-I		Phase-II		Phase-I		Phase-II		Phase-I		Phase-II	
	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.
(1) Bridge	288,700	1,163,800	212,373	849,490	168,949	675,796	195,038	780,151	144,377	577,508	166,251	665,005
(2) Approach Road	8,707	26,396	18,763	31,123	15,109	20,567	19,091	21,356	13,866	19,508	18,167	18,971
(3) Construction Cost (1)+(2)	297,407	1,190,196	231,136	880,613	184,058	696,363	214,129	801,507	158,243	597,016	184,418	683,976
(4) Engineering Fee (3)x10%	29,741	119,020	23,114	88,061	18,406	69,636	21,413	80,151	15,824	59,702	18,442	68,398
(5) Land Aquisition & Compensation	9,700	-	24,620	-	10,590	-	18,090	-	10,590	-	5,650	-
(6) Sub-Total (3)+(4)+(5)	336,848	1,309,216	278,870	968,674	213,054	765,999	253,632	881,658	184,657	656,718	208,510	752,374
(7) Contingency (6)x10%	33,685	130,922	27,887	96,867	21,305	76,600	25,363	88,166	18,466	65,672	20,851	75,237
(8) Sub-Total of Currency Portion	370,533	1,440,138	306,757	1,065,541	234,359	842,599	278,995	969,824	203,123	722,390	229,361	827,611
Phase (6)+(7)	1,810,671		1,372,298		1,076,958		1,248,819		925,513		1,056,972	
Total Project Cost	3,182,969				2,325,777				1,982,485			

Table 8.6.2 PROJECT COST (STEEL MAIN BRIDGE)

(Unit: 1,000 K.Shs)

Item \ Navigation Clearance / Phase / Portion	73.2M				55M				45M			
	Phase-I		Phase-II		Phase-I		Phase-II		Phase-I		Phase-II	
	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.
(1) Bridge	295,677	1,182,707	212,373	849,490	194,202	776,812	220,292	881,166	171,016	684,061	192,889	771,559
(2) Approach Road	9,861	27,490	18,763	31,123	15,698	21,126	19,655	21,890	14,456	20,067	18,731	19,505
(3) Construction Cost (1)+(2)	305,538	1,210,197	231,136	880,613	209,900	797,938	239,947	903,056	185,472	704,128	211,620	791,064
(4) Engineering Fee (3)x10%	30,554	121,020	23,114	88,061	20,990	79,794	23,995	90,306	18,547	70,413	21,162	79,106
(5) Land Acquisition & Compensation	9,700	-	24,620	-	10,590	-	18,090	-	10,590	-	5,650	-
(6) Sub-Total (3)+(4)+(5)	345,792	1,331,217	278,870	968,674	241,480	877,732	282,032	993,362	214,609	774,541	238,432	870,170
(7) Contingency (6)x10%	34,579	133,122	27,887	96,867	24,148	87,773	28,203	99,336	21,461	77,454	23,843	87,017
(8) Sub-Total of Currency Portion	380,371	1,464,339	306,757	1,065,541	265,628	965,505	310,235	1,092,698	236,070	851,995	262,275	957,187
Phase (6)+(7)	1,844,710		1,372,298		1,231,133		1,402,933		1,088,065		1,219,462	
Total Project Cost	3,217,008				2,634,066				2,307,527			

The bridge costs including P.C and steel main bridges are compared in Appendix F. These are summarized in Table 8.6.4.

The total construction costs of steel including approach bridge and Phase-I & II construction costs are more expensive than that of P.C bridge, 1.4% at 73.2 m, 14% at 55 m and 17% at 45 m.

Table 8.6.4 BRIDGE CONSTRUCTION COST COMPARISON (P.C and Steel)

(Unit: 1,000 K. Shs.)

Navi. Clearance	P.C Case			Steel Case		
	Main Bridge	Approach Bridge	Total	Main Bridge	Approach Bridge	Total
73.2^{M}	861,376	1,643,987	2,505,363	896,260	1,643,987	2,540,247
55	1,133,802	686,132	1,819,934	1,386,340	686,132	2,072,472
45	1,102,708	450,433	1,553,141	1,369,092	450,433	1,819,525

Note: The figures above are the total of currency portion and phasing of the Project.

Furthermore, steel Main bridge costs by navigation clearance are also higher than that of P.C Main bridge, 4% at 73.2 m, 22% at 55 m and 24% at 45 m as shown in Table 8.6.5.

Table 8.6.5 MAIN BRIDGE COST BY BRIDGE TYPE (PHASE-I COST)

(Unit: Million K.Shs.)

Type & Clearance / Major Work	P.C Bridge			Steel Bridge		
	73.2^{M}	55^{M}	45^{M}	73.2^{M}	55^{M}	45^{M}
Superstructure	345	246.2	244.6	405.4	324.9	324.9
Tower	36.6	24.3	23.8	100.6	89.0	89.0
Substructure	328.3	183.0	172.6	211.0	140.6	133.7
Temporary & Other Works	151.4	113.4	110.3	179.3	138.6	136.9
Total	861.3	566.9	551.3	896.3	693.2	684.5

Note: The total construction cost for 55 and 45 m must be doubled by adding the cost in Phase-II.

2) Tollgate

Tollgates are planned and described in 7.3.4 in Chapter 7. In the case of toll levy for the project road, additional cost must be estimated for determination of toll rate by vehicle type.

In Phase-I construction additional pavement will not be required. The cost is mainly estimated for three gates construction. In Phase-II additional pavement of 900 m^2, two tollgates and removal and construction of curb & Gutter, etc. are required. These costs are estimated by phase as shown in Table 8.6.6.

Table 8.6.6 TOLLGATE CONSTRUCTION COST

(Unit: 1,000 K.Shs)

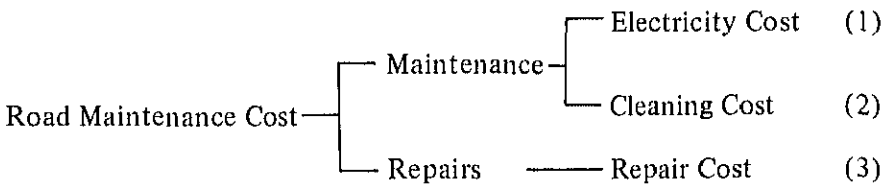
Phase	LC	FC	Total
Phase - I	210	210	420
Phase - II	325	264	589

8.7 Maintenance and Operation Costs

8.7.1 Maintenance Costs

Maintenance has been defined as "the preserving and keeping of each type of roadway, roadside, structure, and facility as nearly as possible in its original condition as constructed or as subsequently improved, and the operation of road facilities and services to provide satisfactory and safe transportation".

The maintenance cost of the project road is estimated for the following items.



(1) Electricity Cost

This includes the cost of electricity for lighting, traffic signal, inspection elevator in towers (steel main bridge), etc. These costs were estimated based on the required electricity of each facility.

(2) Cleaning Cost

This includes the cost of cleaning the road surface, drainage facilities, guard rails, traffic sign boards, slope and median strip, etc. This was estimated refering to available Japanese data.

(3) Repair Cost

This includes the cost of road surface repairs, overlays, painting of bridges and guard rails etc., inspection of structures, expansion joint repairs and inspection and repair of electric and traffic control facilities.

Overlaying is assumed every five years. Painting of handrails, etc. is assumed as once in every 20 year. The painting of steel main bridge is designed as a permanent painting and theoretically no re-painting is required. Observing the existing steel bridge applied by permanent painting, repainting is carried out within 20 years, such as San Fransisco Bay Bridge. Therefore it is assumed that repainting is executed every 20 years after opening and then every 5 years considering the site working conditions.

According to the conditions, maintenance costs by bridge type are estimated in Table 8.7.1.

Table 8.7.1 MAINTENANCE COST

(Unit: 1,000 K.Shs./year)

Cost \ Clearance	73.2 M	55 M	45 M
1) Electricity Cost	1,490.6	1,636.2	1,536.2
2) Cleaning Cost	1,670.0	1,832.5	1,720.5
3) Repair Cost	8,563.0 (11,223.0)	6,533.0 (9,743.0)	6,014.0 (9,224.0)
Total	11,723.6 (14,383.6)	10,001.7 (13,211.7)	9,270.7 (12,480.7)

Note: The figures in brackets snow the cost for steel main bridge case.

8.7.2 Operation Costs

The staff required for operation of tollgates are described in Chapter 7. It should be noted that the site staff for the maintenance work calculated in the previous paragraph is not included in the operation costs.

One supervisor and collectors arranged in each tollgate work in a three shift system of 8 hour/day. Annual operation cost including electricity and some facility rapair costs is estimated disregarding alternative navigation clearance as shown in Table 8.7.2.

Table 8.7.2 OPERATION COST FOR TOLLGATE

	(Unit: K.Shs/Year)
Phase I	265,680
Phase II	356,400

CHAPTER 9 IMPLEMENTATION PLAN

CHAPTER 9 IMPLEMENTATION PLAN

9.1 General

The Ministry of Transport and Communications (MOTC) will be Government Agency responsible for the execution of the project. The Government will engage the contractor by international bidding. For the implementation of the project, stage construction (Phase-I and II) is adopted.

9.2 Implementation Schedule

9.2.1 Stage Construction

The construction of the project road requires a very large investment due to the high navigation clearance. In general for a large scale project, it is desireable to construct in stages following the pattern of the traffic demand.

Two construction cases were considered. Construction in one phase and construction in two phases were examined for the navigation clearance of 55 m. As a result, construction in two phases is to be prefered as described in Chapter 10.

The scale of project cost will also be controlled by the size of the general financial package approved by international financing agencies.

Stage construction is applied to this project and should be considered for the number of traffic lanes. Fig. 9.2.1 and 9.2.2 show the construction stage of the project.

1) Phase-I Construction

In Phase-I all alternatives (by navigation clearance) access to Lunga Lunga Road on the Likoni side, whilst on Mombasa Island all access to Nyerere Ave., except the alternative with navigation clearance of 73.2 m, which accesses to the intersection of Nyerere Ave. and Mbaraki Road.

2) Phase-II Construction

For all cases of navigation clearance a four-lane extension to Mbaraki Road on the island is the major part of Phase II work. In the case of 55 m and 45 m clearances an additional two lanes including the bridge section will be constructed. For the case of 73.2 m clearances only the additional two lanes of approach roads will be constructed.

The extensions to the South in Likoni area and the extension to the future trunk road (for the future section excluding this project) should be established in compliance with the Mombasa Transportation Plan and this Study (Chapter 6).

The intersection of Nyerere Ave. and Dedan Kimathi Ave. for both 55 and 45 m clearances will remain an at-grade intersection.

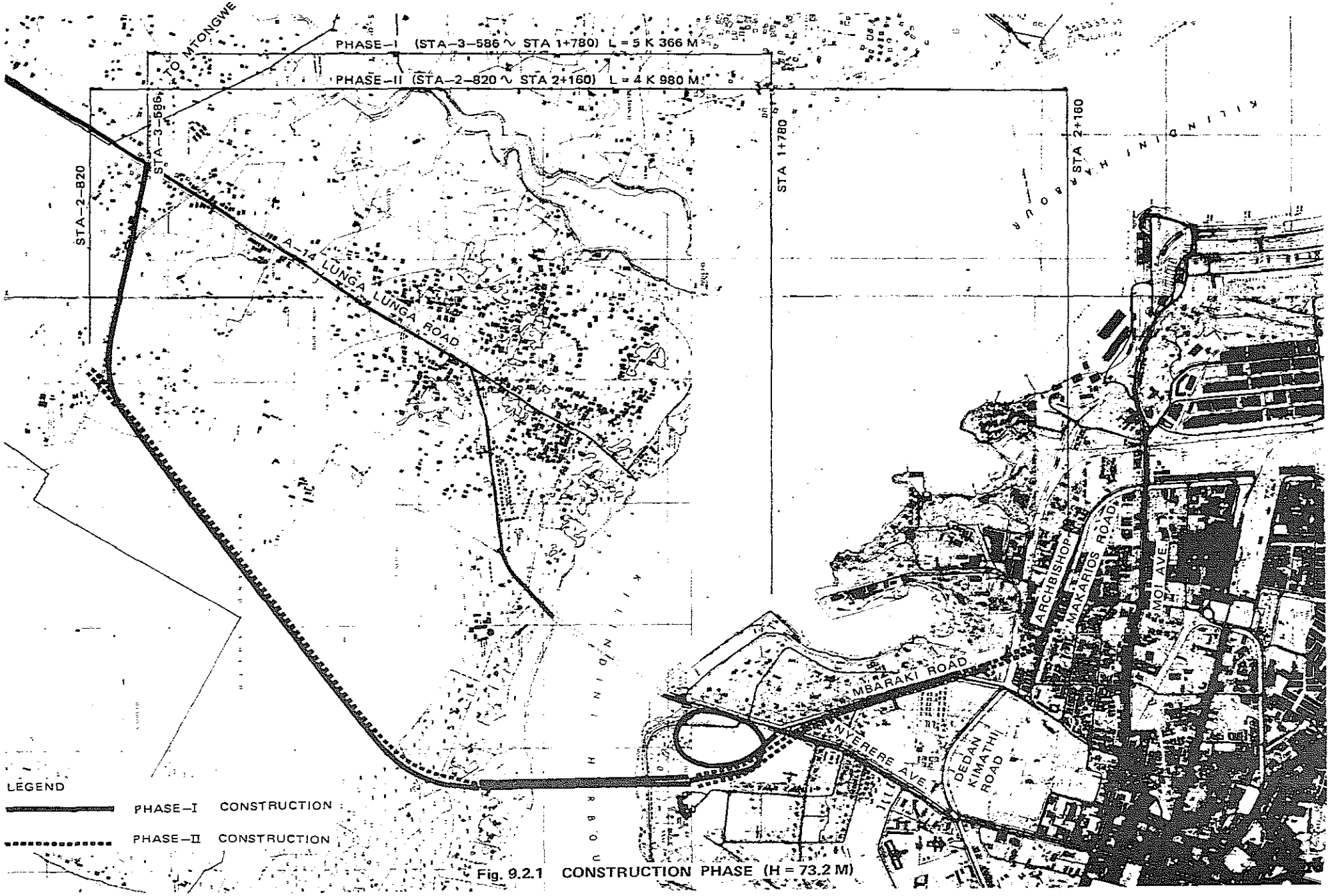


Fig. 9.2.1 CONSTRUCTION PHASE (H = 73.2 M)

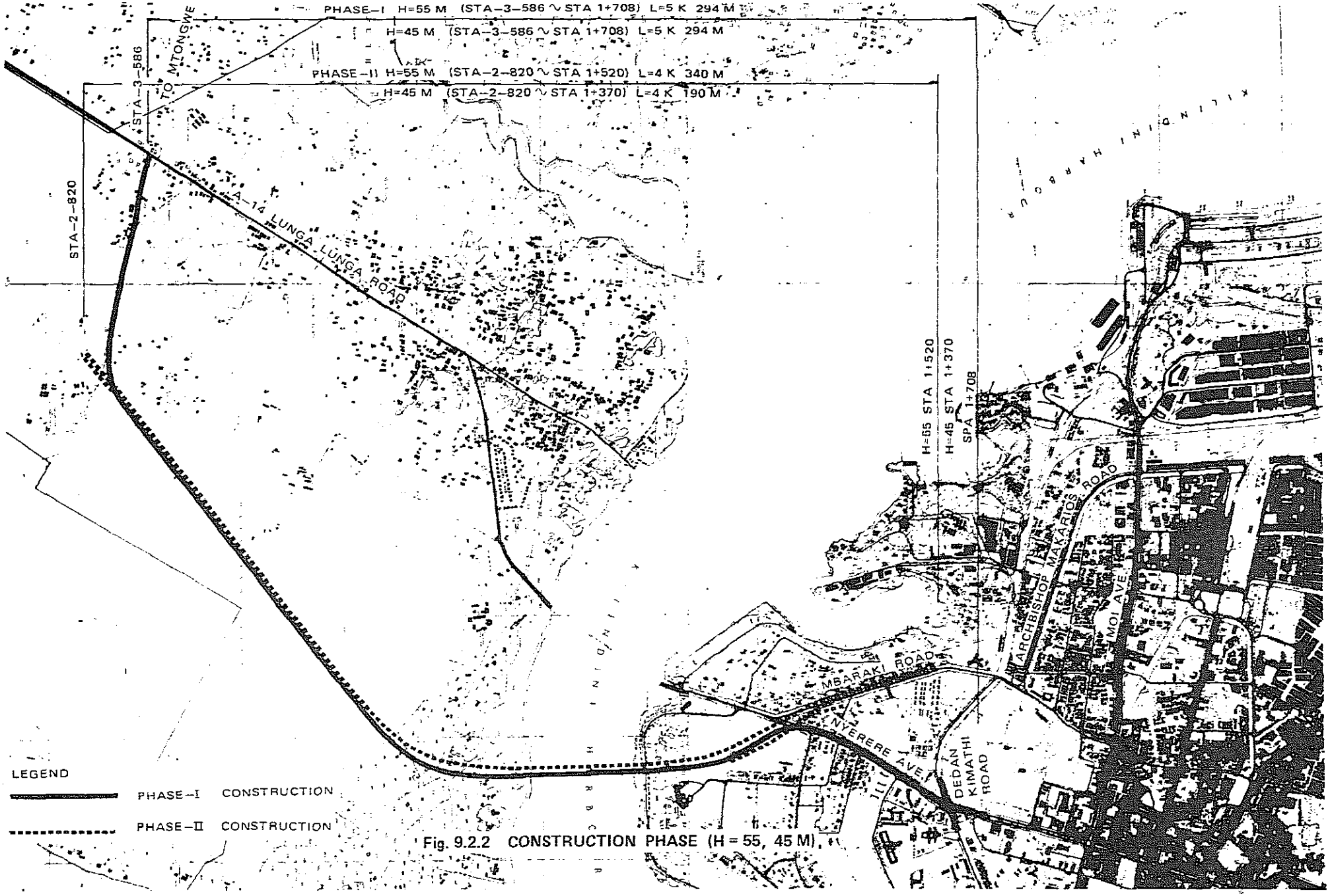


Fig. 9.2.2 CONSTRUCTION PHASE (H = 55, 45 M)

9.2.2 Implementation Plan

Prior to the construction it will be necessary to carry out such pre-construction preparatory work as wind tunnel test, topographic survey, soils investigation, detailed design, land acquisition, and financial procurement. The minimum period required for such preparatory procedures is estimated to be 4 years for all alternative clearances.

The detailed design including additional wind tunnel testing will take about 2.5 years. During the land acquisition period, final negotiations on financial procurement are completed and the contract for construction can be approved and awarded. It is assumed this process will take about one year.

Bridge construction is the major protion of this project. The construction period for each alternative was analyzed considering annual working days and average construction speed of each work item. The construction periods for a P.C/steel main bridge case are shown in Fig. 9.2.3 and 9.2.4 based on the bridge construction periods analyzed in Appendix H. The construction period for a steel bridge is one year shorter than the P.C bridge as summarized in Table 9.2.1.

Table 9.2.1 CONSTRUCTION PERIOD

Navigation clearance	P.C Bridge		Steel Bridge	
	Phase-I	Phase-II	Phase-I	Phase-II
73.2M	5	4	4	4
55	4	4	3	3
45	4	4	3	3

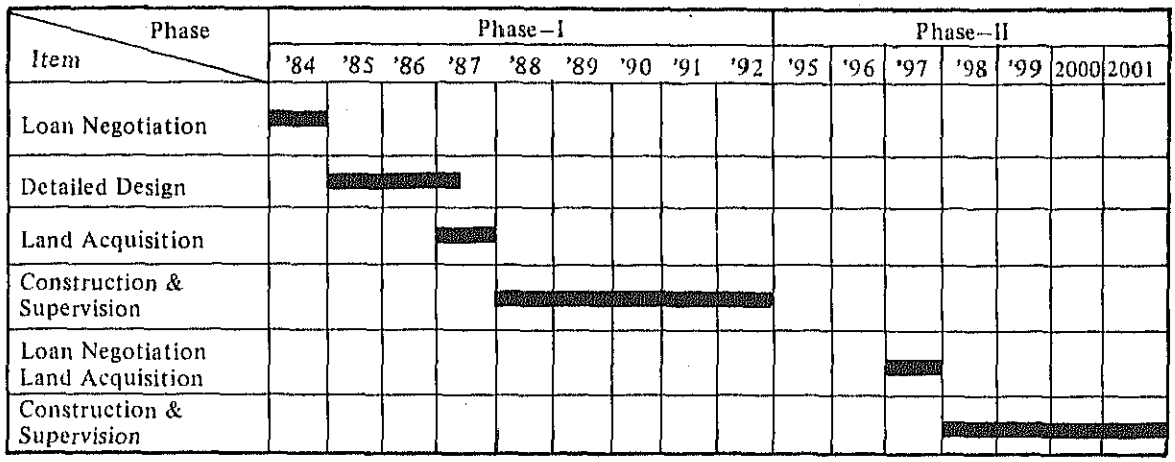
The opening year of the project road by alternative case are shown in Table 9.2.2. The opening of Phase-II will take place in 2002 according to the traffic demand analyzed in Chapter 5.

Table 9.2.2 OPENING YEAR OF PROJECT ROAD

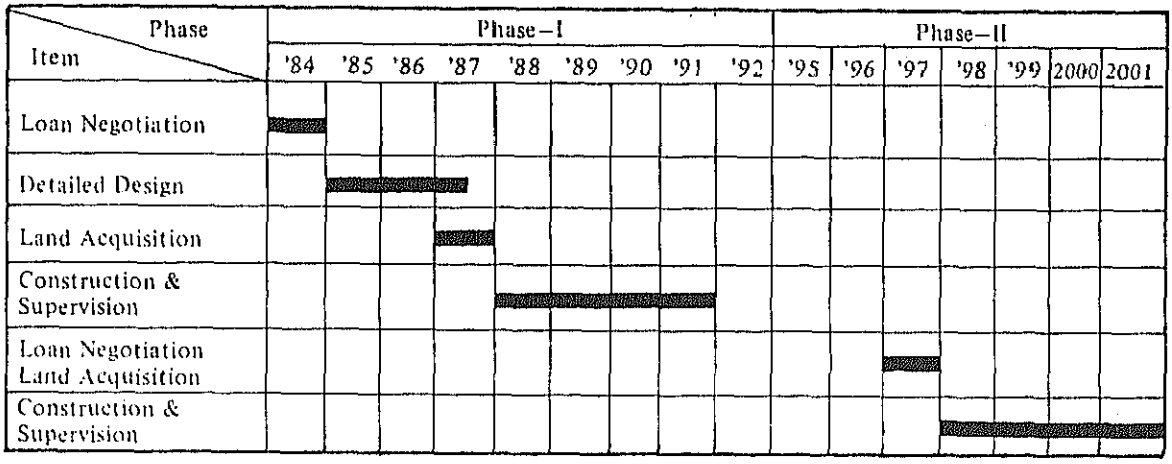
Navigation clearance	P;C Case		Steel Case	
	Phase-I	Phase-II	Phase-I	Phase-II
73.2M	1993	2002	1992	2002
55	1992	2002	1991	2002
45	1992	2002	1991	2002

Fig. 9.2.3 IMPLEMENTATION SCHEDULE (P.C MAIN BRIDGE CASE)

Navigation Clearance: 73.2^{M}



Navigation Clearance: 55^{M}



Navigation Clearance: 45^{M}

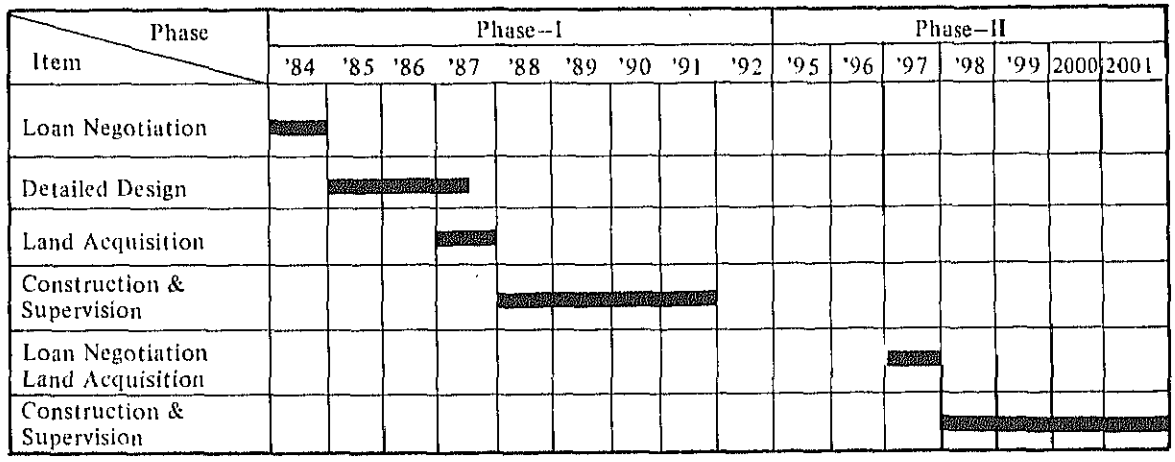


Fig. 9.2.4 IMPLEMENTATION SCHEDULE (STEEL MAIN BRIDGE CASE)

Navigation Clearance: 73.2M

Item \ Phase	Phase–I									Phase–II						
	'84	'85	'86	'87	'88	'89	'90	'91	'92	'95	'96	'97	'98	'99	2000	2001
Loan Negotiation																
Detailed Design																
Land Acquisition																
Construction & Supervision																
Loan Negotiation Land Acquisition																
Construction & Supervision																

Navigation Clearance: 55M

Item \ Phase	Phase–I									Phase–II						
	'84	'85	'86	'87	'88	'89	'90	'91	'92	'95	'96	'97	'98	'99	2000	2001
Loan Negotiation																
Detailed Design																
Land Acquisition																
Construction & Supervision																
Loan Negotiation Land Acquisition																
Construction & Supervision																

Navigation Clearance: 45M

Item \ Phase	Phase–I									Phase–II						
	'84	'85	'86	'87	'88	'89	'90	'91	'92	'95	'96	'97	'98	'99	2000	2001
Loan Negotiation																
Detailed Design																
Land Acquisition																
Construction & Supervision																
Loan Negotiation Land Acquisition																
Construction & Supervision																

CHAPTER 10

ECONOMIC EVALUATION AND FINANCIAL STUDY

CHAPTER 10 ECONOMIC EVALUATION AND FINANCIAL STUDY

10.1 General

The economic evaluation is to determine whether this project will contribute to the over-all economy of Kenya based on a comparison of costs and benefits. Although costs represent commitments and consumption of resources (including labour) for the implementation of the project, transfer payments such as tax are not included in the economic cost, since these elements are more institutional than economic attributes. The effects of transfer payments have already been taken into consideration for the financial evaluation using the financial cost of the project which is presented in the sub-section 10.11. Fig. 10.1.1 shows the work flow chart for economic evaluation.

10.1.1 Alternatives

A total of 11 alternatives (P.C and steel main bridge, immersed tube tunnel) including phasing were evaluated as shown in Table 10.1.1.

Table 10.1.1 ALTERNATIVES FOR ECONOMIC EVALUATION

Alternative / Phasing		Bridge Clearance			Tunnel
		73.2M	55M	45M	
Single Construction	PC	0	0	0	0
	Steel	-	-	-	
Staged Construction	PC	0	0	0	0
	Steel	0	0	0	

Note : Mark "0" means the alternative evaluated in the study.

Financial studies, financing and toll bridge accounting, were also carried out for the bridge alternative of 55 m clearance as described in Sub-section 10.11.

10.1.2 Contents of Benefit

It is not possible to express all benefits from projects in monetary terms since there are usually no market prices for such benefits.

In this project the following five benefits can be quantities and be calculated.

(1) User's benefit (Vehicle operating cost and Time cost savings)
(2) Ferry cost saved by the project
(3) Flow effects of the investment
(4) Residual value of the investment
(5) Benefit from regional development

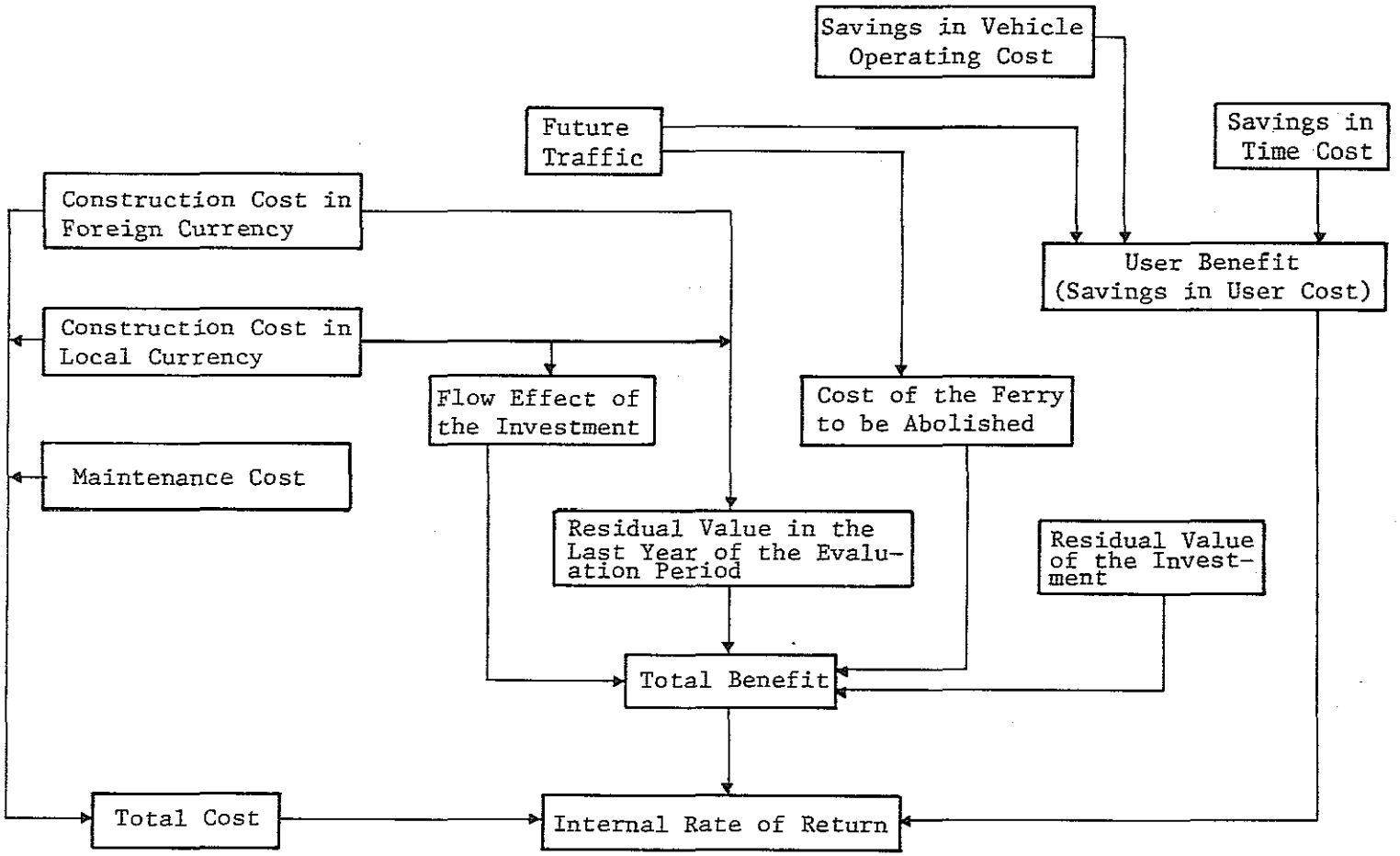


Fig. 10.1.1 WORK FLOW CHART OF ECONOMIC EVALUATION

The last benefit listed above can be quantified but is a material for the sensitivity analysis due to the reliability on quantification.

There are also some immeasurable benefits derived from the project such as increased comfort, convenience and reliability, lower vehicle maintenance costs, fewer accidents and less damage to goods, scenic spots as nice view of the bridge, etc.

10.2 *Conversion Factors*

The project cost was estimated in terms of financial cost. For the economic evaluation the cost should be converted to the economic cost excluding transfer elements.

The conversion factors to be used in this project are shown in Table 10.2.1, which the factor for foreign components of the cost was estimated to be about 0.8 in the cost estimation.

Table 10.2.1 CONVERSION FACTORS

Standard Conversion Factor (SCF)		0.92
Conversion Factor for Consumer Goods (CFC)		0.935
Conversion Factor for Domestic Procurement	Unskilled Labor Cost	0.935
	Local Materials	0.834
	Local Fuel Cost	0.167
	Local Other Cost	0.644
	Land Acquisition	0.920
	Compensation	0.920
	Local Engineering Fee	0.935
	Local Part of Contingency	0.676

Note: Detailed calculation of the above factors to be described in Appendix J.

10.3 Project Costs

The total project cost is composed of construction cost, land acquisition and compensation cost, final engineering and supervision services and physical contingency. Each component is subdivided into the local and foreign currency portions, and tax element for the respective portions were subtracted.

A summary of these portions is presented in Table 10.3.1 through 10.3.3 for the cases of 55 m bridge and others in Appendix J. The transfer portions for 11 alternatives are shown in Table 10.3.4.

Table 10.3.1 PROJECT COST

1. Navigation Clearance = 55 Meters
2. PC Bridge
3. Stage Construction

(Unit : 1,000 Shs.)

Value	Year	Bridge		Approach Road		Engineering & Supervision		Land Acquisition	Contingency		Total Project Cost	
		Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion		Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion
Financial Value	1985	0	0	0	0	6636	31601	0	664	3160	7300	34761
	1986	0	0	0	0	6636	31601	0	664	3160	7300	34761
	1987	0	0	0	0	6636	31601	10590	1723	4219	18949	46410
	1988	58456	292282	7555	17838	2489	11850	0	6850	32197	75349	354167
	1989	56091	280455	0	0	2489	11850	0	5858	29231	64438	321536
	1990	34972	174862	0	0	2489	11850	0	3746	18671	41207	205384
	1991	19429	97146	7555	17838	2489	11850	0	2947	12683	32420	139517
	1997	0	0	0	0	0	0	18090	1809	1809	19899	19899
	1998	55391	276954	9546	20224	2489	11850	0	6742	30903	74167	339930
	1999	70409	352043	0	0	2489	11850	0	7290	36389	80187	400283
	2000	48369	241847	0	0	2489	11850	0	5086	25370	55944	279067
	2001	20869	104345	9546	20224	2489	11850	0	3290	13642	36194	150061
	Total	363987	1819934	34200	76123	39819	189606	28680	46669	211434	513354	2325777
Economic Value	385	0	0	0	0	5004	24975	0	500	2498	5504	27473
	1986	0	0	0	0	5004	24975	0	500	2498	5504	27473
	1987	0	0	0	0	5004	24975	7985	1299	3296	14288	36256
	1988	44076	231136	5696	13923	1876	9366	0	5165	25443	56814	279868
	1989	42293	221784	0	0	1876	9366	0	4417	23115	48586	254265
	1990	26369	138281	0	0	1876	9366	0	2825	14765	31070	162412
	1991	14650	76823	5696	13923	1876	9366	0	2222	10011	24444	110123
	1997	0	0	0	0	0	0	13640	1364	1364	15004	15004
	1998	41765	219015	7197	15740	1876	9366	0	5084	24412	55922	268533
	1999	53088	278396	0	0	1876	9366	0	5496	28776	60461	316538
	2000	36471	191253	0	0	1876	9366	0	3835	20062	42182	220680
	2001	15735	82516	7197	15740	1876	9366	0	2481	10762	27290	118384
	Total	274446	1439204	25787	59325	30023	149853	21625	35188	167001	387069	1837007

Table 10.3.2 PROJECT COST

1. Navigation Clearance = 55 Meters
2. PC Bridge
3. Non-stage Construction

(Unit : 1,000 Shs.)

Value	Year	Bridge		Approach Road		Engineering & Supervision		Land Acquisition	Contingency		Total Project Cost	
		Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion		Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion
Financial Value	1985	0	0	0	0	5516	26001	0	552	2600	6068	28601
	1986	0	0	0	0	5516	26001	0	552	2600	6068	28601
	1987	0	0	0	0	5516	26001	28680	3420	5468	37616	60149
	1988	68557	342784	17100	38062	3310	15600	0	8897	39645	97863	436090
	1989	122571	612856	0	0	3310	15600	0	12588	62846	138469	691302
	1990	67073	335364	0	0	3310	15600	0	7038	35096	77421	386061
	1991	26710	133552	0	0	3310	15600	0	3002	14915	33022	164068
	1992	11871	59356	17100	38062	3310	15600	0	3228	11302	35509	124320
	Total	296782	1483912	34200	76123	33098	156003	28680	39276	174472	432037	1919190
Economic Value	1985	0	0	0	0	4155	20526	0	416	2053	4571	22579
	1986	0	0	0	0	4155	20526	0	416	2053	4571	22579
	1987	0	0	0	0	4155	20526	21625	2578	4215	28358	46366
	1988	51692	271073	12893	29663	2493	12316	0	6708	31305	73786	344357
	1989	92419	484646	0	0	2493	12316	0	9491	49696	104403	546658
	1990	50573	265206	0	0	2493	12316	0	5307	27752	58373	305274
	1991	20140	105613	0	0	2493	12316	0	2263	11793	24896	129722
	1992	8951	46939	12893	29663	2493	12316	0	2434	8892	26771	97809
	Total	223774	1173478	25787	59325	24931	123157	21625	29612	137758	325728	1515343

Table 10.3.3 PROJECT COST

1. Navigation Clearance = 55 Meters
2. Steel Bridge
3. Stage Construction

(Unit : 1,000 Shs.)

Value	Year	Bridge		Approach Road		Engineering & Supervision		Land Acquisition	Contingency		Total Project Cost	
		Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion		Local Currency Portion	Local Currency Portion + Foreign Currency Portion	Local Currency Portion	Local Currency Portion + Foreign Currency Portion
Financial Value	1985	0	0	0	0	7497	35847	0	750	3585	8247	39432
	1986	0	0	0	0	7497	35847	0	750	3585	8247	39432
	1987	0	0	0	0	7497	35847	10590	1809	4644	19896	51081
	1988	75350	376753	7849	18412	3749	17924	0	8695	41309	95643	454398
	1989	80341	401708	0	0	3749	17924	0	8409	41963	92499	461595
	1990	38510	192552	7849	18412	3749	17924	0	5011	22889	55119	251776
	1998	0	0	0	0	0	0	18090	1809	1809	19899	19899
	1999	74943	374716	9828	20773	3749	17924	0	8852	41341	97372	454753
	2000	93888	469441	0	0	3749	17924	0	9764	48737	107401	536102
	2001	51460	257301	9828	20773	3749	17924	0	6504	29600	71540	325596
	Total	414494	2072472	35353	78369	44985	215084	28680	52351	239460	575863	2634066
Economic Value	1985	0	0	0	0	5653	28333	0	565	2833	6218	31166
	1986	0	0	0	0	5653	28333	0	565	2833	6218	31166
	1987	0	0	0	0	5653	28333	7985	1364	3632	15002	39950
	1988	56814	297937	5918	14369	2827	14166	0	6556	32647	72115	359119
	1989	60577	317671	0	0	2827	14166	0	6340	33184	69744	365021
	1990	29037	152270	5918	14369	2827	14166	0	3778	18081	41560	198886
	1998	0	0	0	0	0	0	13640	1364	1364	15004	15004
	1999	56507	296325	7410	16166	2827	14166	0	6674	32666	73418	359324
	2000	70792	371234	0	0	2827	14166	0	7362	38540	80980	423941
	2001	38801	203473	7410	16166	2827	14166	0	4904	23381	53941	257186
	Total	312529	1638911	26656	61069	33918	169998	21625	39473	189160	434201	2080763

Table 10.3.4 AMOUNT OF TRANSFER PORTION

(Unit: 1,000 K.Shs.)

Phasing \ Alternative		Bridge Clearance			Tunnel
		73.2M	55M	45M	
Single Construction	P.C	667,749	403,847	333,657	921,383
	Steel	-	-	-	
Staged Construction	P.C	667,749	488,770	416,391	1,130,976
	Steel	675,009	553,303	484,430	

10.4 Maintenance Costs

The maintenance costs estimated in Chapter 8 was also converted in terms of economic cost and is shown in Table 10.4.1.

Table 10.4.1 MAINTENANCE COSTS

(Unit: 1,000 Shs. 1983 Price)

Alternative \ Phase / Value			Phase-I		Phase-II	
			Financial	Economic	Financial	Economic
Bridge Clearance	73.2M	P.C	3,452	3,176	8,272	7,610
		Steel	4,782	4,399	9,602	8,834
	55M	P.C	3,205	2,949	6,797	6,253
		Steel	4,275	3,933	8,937	8,222
	45M	P.C	3,085	2,838	6,186	5,691
		Steel	4,154	3,822	8,326	7,660
Tunnel			10,500	9,660	16,000	14,720

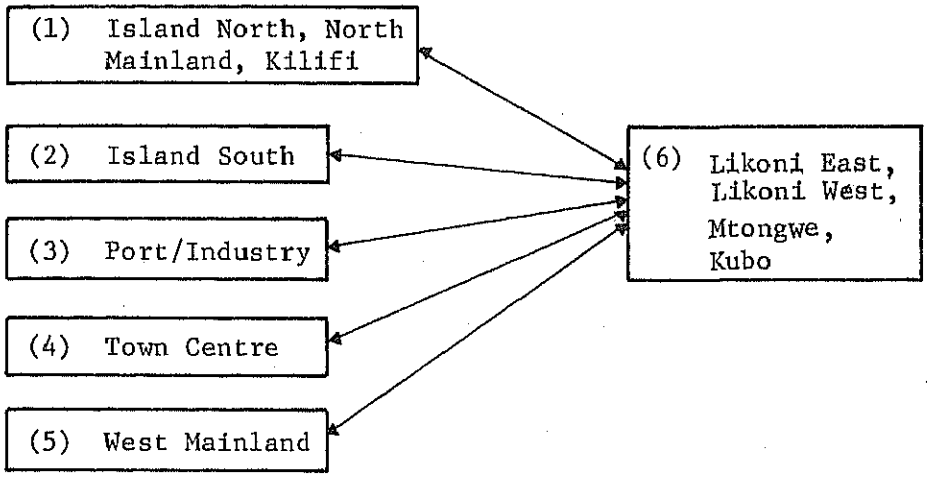
Note: The conversion factor of 0.92 (SCF) to be used.

10.5 User's Benefit

10.5.1 Premises for User's Benefit Analysis

1) Zoning

A total of 29 zones were considered in forecasting traffic demand in Chapter 5. For the convenience of benefit calculation the following 6 zones and 5 zonal pairs were selected, since only the channel crossing traffic is the objective for estimation of user's benefit.



2) Forecast Traffic

In the traffic survey conducted in April 1983, the heavy trucks with more than three axles were included in the medium truck (more than 1.5 ton tare weight) but were only very few. If the crossing facility will be constructed, then heavy trucks will increase.

During the study the border of Tanzania was reopened and in 1976 a total of 60 trailers (25 ton) were counted daily at the border.

Interviews were carried out in KENATOKO, suppliers of construction material, etc. These companies have the intention to purchase heavy trucks instead of using existing medium trucks upon the opening of the crossing.

It is difficult to forecast what percentages will be converted to heavy trucks, but it is assumed that about 45% of medium trucks will be converted to heavy trucks to give a truck composition similar to that using the Makupa Causeway.

The final traffic demand for user's benefit calculation by the target year was estimated based on the traffic demand forecast in Chapter 5 as shwon in Table 10.5.1.

3) Link Network

The link network and its conditions to be used for the calculation of user's benefit are presented in Appendix J.

4) Route Search

The route search study is made based on the shortest distance principle. Table 10.5.2 shows the distances by zone-pair, comparing the distance via existing ferry route and the one via proposed crossing route. All the routes via the proposed structures are greater in distance.

Table 10.5.1 ESTIMATED TRAFFIC (AADT)

Traffic	Zonal Pair	1993 Car & Light	1993 Small Bus	1993 Big Bus	1993 Medium Truck	1993 Big Truck	1993 Total	2002 Car & Light	2002 Small Bus	2002 Big Bus	2002 Medium Truck	2002 Big Truck	2002 Total	2010 Car & Light	2010 Small Bus	2010 Big Bus	2010 Medium Truck	2010 Big Truck	2010 Total
Normal Traffic	1 - 6	680	154	278	74	43	1230	937	214	378	103	60	1692	1196	275	488	130	76	2165
	2 - 6	100	23	40	10	6	178	136	30	56	14	9	246	186	40	75	20	12	333
	3 - 6	838	194	340	91	54	1517	1180	270	480	129	76	2135	1591	364	649	175	102	2881
	4 - 6	1171	268	476	127	75	2116	1642	373	668	179	104	2966	2201	500	894	241	141	3977
	5 - 6	458	106	185	49	29	826	640	147	259	69	40	1155	854	193	348	92	54	1541
	Total	3246	744	1318	352	206	5867	4535	1034	1842	494	289	8194	6028	1372	2454	658	385	10897
Induced Traffic	1 - 6	222	38	83	34	5	381	344	48	131	45	13	582	510	66	190	63	22	852
	2 - 6	17	3	7	4	1	32	37	6	14	6	2	64	58	8	21	7	3	98
	3 - 6	208	38	80	27	9	355	357	47	132	44	17	597	560	69	207	65	28	929
	4 - 6	239	35	90	32	9	405	424	55	155	51	21	706	670	82	247	75	34	1108
	5 - 6	105	13	39	14	4	175	179	22	66	22	8	297	281	35	103	33	14	465
	Total	791	119	300	111	28	1348	1340	178	499	168	62	2246	2079	260	768	244	101	3452
Developed Traffic	1 - 6	0	0	0	0	0	0	397	55	151	51	16	669	869	113	324	108	39	1454
	2 - 6	0	0	0	0	0	0	43	6	16	6	2	73	99	13	37	12	4	165
	3 - 6	0	0	0	0	0	0	417	55	154	51	19	696	954	119	352	110	48	1583
	4 - 6	0	0	0	0	0	0	495	64	182	58	25	824	1140	140	420	128	58	1886
	5 - 6	0	0	0	0	0	0	209	26	78	26	9	347	476	60	176	55	23	792
	Total	0	0	0	0	0	0	1560	206	580	192	70	2609	3538	446	1310	413	172	5879
Total	1 - 6	902	192	360	108	48	1611	1677	318	660	199	99	2943	2575	455	1002	301	137	4470
	2 - 6	117	26	47	14	7	210	217	42	86	26	13	383	343	61	133	39	19	596
	3 - 6	1046	223	420	119	63	1872	1953	372	766	225	112	3428	3105	553	1208	350	177	5393
	4 - 6	1409	303	566	159	84	2521	2560	491	1006	288	150	4496	4012	721	1561	444	233	6971
	5 - 6	562	118	224	63	33	1001	1028	194	403	117	57	1799	1611	288	627	180	92	2798
	Total	4037	862	1618	463	234	7215	7436	1417	2921	854	421	13049	11645	2078	4532	1315	658	20228

Table 10.5.2 SAVINGS IN DISTANCE

(Unit: Kilometers)

Zonal Pair			①-⑥	②-⑥	③-⑥	④-⑥	⑤-⑥
Distance via Existing Ferry			7.6	5.1	7.0	5.0	8.3
Distance via Proposed Crossing	H = 73.2M	Phase I	10.2	7.7	9.6	7.6	10.9
		Phase II	8.8	7.7	8.2	7.6	9.5
	H = 55M	Phase I	9.0	8.0	8.9	6.4	9.9
		Phase II	9.0	8.0	8.6	6.4	9.9
	H = 45M	Phase I	9.0	8.0	8.9	6.4	9.9
		Phase II	9.0	8.0	8.5	6.4	9.8
	Tunnel		7.4	8.5	6.7	6.9	8.0
Saving in Distance	H = 73.2M	Phase I	-2.6	-2.6	-2.6	-2.6	-2.6
		Phase II	-1.2	-2.6	-1.2	-2.6	-1.2
	H = 55M	Phase I	-1.4	-2.9	-1.9	-1.4	-1.6
		Phase II	-1.4	-2.9	-1.6	-1.4	-1.6
	H = 45M	Phase I	-1.4	-2.9	-1.9	-1.4	-1.6
		Phase II	-1.4	-2.9	-1.5	-1.4	-1.5
	Tunnel		0.2	-3.4	0.3	-1.9	0.3

10.5.2 Vehicle Operating Cost

The major cost items of the vehicle operating cost is estimated in Appendix J and tabulated by type of vehicle in Table 10.5.3.

The cost values of 4.7 shs/km and 12.6 shs/km for medium truck and big truck, respectively do not include their respective interests (0.442 shs/km and 2.070 shs/km), but these interests are included in their respective time cost.

The calculated vehicle operating costs and their savings are shown in Table 10.5.4, which are obtained by multiplying the values in Table 10.5.2 by the above respective unit prices. The savigns are all in minus figures because the distance via proposed structure route is greater as shown in Table 10.5.2.

Table 10.5.3 VEHICLE OPERATING COST (1983 price, Economic Value)

(Unit: Shs/vehicle/km)

	Vehicle	Car	Light Truck	Small Bus	Big Bus	Medium Truck	Big Truck
Variable Cost	Fuel	0.686	0.979	0.979	1.603	1.640	3.055
	Oil	0.024	0.037	0.037	0.078	0.067	0.084
	Repair	0.191	0.381	0.381	0.852	0.577	1.050
	Sub Total	1.149*		1.397	2.533	2.284	4.189
Fixed Cost	Depreciation	0.411	0.958	0.958	4.559	0.695	3.489
	Interest	0.258	0.271	0.271	0.966	(0.442)	(2.070)
	Crew	-	-	0.594	0.701	0.818	1.164
	General Ad.	-	-	-	0.758	0.584	1.168
	Insurance	0.215	0.225	0.225	0.802	0.368	2.588
	Sub Total	1.169*		2.048	7.786	2.907	10.479
Grand Total		2.318*		3.445	10.319	4.749	12.598

Note: * indicates the average value of car and light truck.

10.5.3 Time Cost Saving

1) Time and Time Saving

The trip time by zonal pair and their time saving are calculated for alternatives and is shown in Table 10.5.5. In the table the term of "Trip Time Without Project" expresses the trip time using the existing ferry. The total trip time including queuing time and crossing time and unloading time is estimated in Table 10.5.6.

Table 10.5.6 ESTIMATED TOTAL CROSSING TIME

Vehicle Type	Crossing Time
Car and light vehicle	20 minutes/unit
Small bus	20
Big bus	20
Medium truck	40
Big truck	40

The estimation is simulated upon traffic volume by time band (Table 10.5.7), average operating schedule (Table 3.2.2) and survey data (crossing time, loading and unloading time in Table 3.2.5).

The total crossing time is claculated for the estimated left over vehicles as shown in Table 10.5.8.

Table 10.5.4 VEHICLE OPERATING COST AND THEIR SAVINGS

(Unit: Shs/vehicle, Economic cost, 1983 price)

		Zonal Pair	Phase-I Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck	Phase-II Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck
Without Project		①∿③	18.2	25.8	78.3	35.7	95.8	Same as Phase I				
		②∿⑥	12.2	17.3	52.5	24.0	64.3					
		③∿⑥	16.8	23.8	72.1	32.9	88.2					
		④∿⑥	12.0	17.0	51.5	23.5	63.0					
		⑤∿⑥	19.9	28.2	85.5	39.0	104.6					
With Project	H = 73.2M	①∿⑥	24.5	34.7	105.1	47.9	128.5	21.1	29.9	90.6	41.4	110.9
		②∿⑥	18.5	26.2	79.3	36.2	97.0	18.5	26.2	79.3	36.2	97.0
		③∿⑥	23.0	32.6	98.9	45.1	121.0	19.7	27.9	84.5	38.5	103.3
		④∿⑥	18.2	25.8	78.3	35.7	95.8	18.2	25.8	78.3	35.7	95.8
		⑤∿⑥	26.2	37.1	112.3	51.2	137.3	22.8	32.3	97.8	44.7	119.7
	H = 55M	①∿⑥	21.6	30.6	92.7	42.3	113.4	21.6	30.6	92.7	42.3	113.4
		②∿⑥	19.2	27.2	82.4	37.6	100.8	19.2	27.2	82.4	37.6	100.8
		③∿⑥	21.4	30.3	91.7	41.8	112.1	20.6	29.2	88.6	40.4	108.4
		④∿⑥	15.4	21.8	65.9	30.1	80.6	15.4	21.8	65.9	30.1	80.6
		⑤∿⑥	23.8	33.7	102.0	46.5	124.7	23.8	33.7	102.0	46.5	124.7
	H = 45M	①∿⑥	Same as H = 55M					21.6	30.6	92.7	42.3	113.4
		②∿⑥						19.2	27.2	82.4	37.6	100.8
		③∿⑥						20.4	28.9	87.5	40.6	107.1
		④∿⑥						15.4	21.8	65.9	30.1	80.6
		⑤∿⑥						23.5	33.3	100.9	46.1	123.6
	Tunnel	①∿⑥						17.8	25.2	76.2	34.8	93.2
		②∿⑥						20.4	28.9	87.6	39.9	107.1
		③∿⑥						16.1	22.8	69.0	31.5	84.4
		④∿⑤						16.6	23.5	71.1	32.4	86.9
		⑤∿⑥						19.2	27.2	82.4	37.6	100.8
Saving in * V.O.C (H = 55M)		①∿⑥	-3.4	-4.8	-14.4	-6.6	-17.6	-3.4	-4.8	-14.4	-6.6	-17.6
		②∿⑥	-7.0	-9.9	-29.9	-13.6	-36.5	-7.0	-9.9	-29.9	-13.6	-36.5
		③∿⑥	-4.6	-6.5	-19.6	-8.9	-23.9	-3.8	-5.4	-16.5	-7.5	-20.2
		④∿⑥	-3.4	-4.8	-14.4	-6.6	-17.6	-3.4	-4.8	-14.4	-6.6	-17.6
		⑤∿⑥	-3.8	-5.4	-16.5	-7.5	-20.2	-3.8	-5.4	-16.5	-7.5	-20.2

Note: * The other case of 73.2, 45 m and tunnel were also calculated.

Table 10.5.5 TIME AND TIME SAVINGS

(Unit: Minutes/Vehicle)

		Zonal Pair	Phase-I Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck	Phase-II Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck
Trip Time Without Project		①∿⑥	33.10			55.60	57.93	Same as Phase I				
		②∿⑥	28.10			50.60	51.93					
		③∿⑥	31.90			54.40	56.49					
		④∿⑥	27.90			50.40	51.69					
		⑤∿⑥	34.50			57.00	59.61					
Trip Time With Project	H = 73.2M	①∿⑥	14.70				18.40	11.60				14.72
		②∿⑥	9.70				12.40	9.70				12.40
		③∿⑥	13.50				16.96	10.40				13.28
		④∿⑥	9.50				12.16	9.20				11.84
		⑤∿⑥	16.10				20.08	13.00				16.40
	H = 55M	①∿⑥	12.68				16.06	12.68				16.06
		②∿⑥	10.68				13.66	10.68				13.66
		③∿⑥	12.48				15.82	11.80				14.88
		④∿⑥	7.48				9.82	7.48				9.82
		⑤∿⑥	14.48				18.22	14.48				18.22
	H = 45M	①∿⑥	12.77				16.06	12.77				16.06
		②∿⑥	10.77				13.66	10.77				13.66
		③∿⑥	12.57				15.82	11.70				14.75
		④∿⑥	7.57				9.82	7.57				9.82
		⑤∿⑥	14.57				18.22	14.30				17.87
	Tunnel	①∿⑥						9.70				12.32
		②∿⑥						11.90				14.96
		③∿⑥						8.30				10.64
		④∿⑥						8.70				11.12
		⑤∿⑥						10.90				13.76
Saving in Trip Time (H = 55M)		①∿⑥	20.42			42.92	41.88	20.42			42.92	41.88
		②∿⑥	17.42			39.92	38.28	17.42			39.92	38.28
		③∿⑥	19.42			41.92	40.68	20.10			42.60	41.61
		④∿⑥	20.42			42.92	41.88	20.42			42.92	41.88
		⑤∿⑥	42.52			42.52	41.40	20.02			42.52	41.40

Table 10.5.7 TRAFFIC VOLUME THROUGH LIKONI FERRY BY TIME BAND AND VEHICLE TYPE

From Mbaraki to Likoni					Time Band	From Likoni to Mbaraki				
Car, Light, Matatu	Truck	Bus	Heavy Truck	Total		Car, Light, Matatu	Truck	Bus	Heavy Truck	Total
7	0	0	0	7	0-1	18	0	0	0	18
6	0	0	0	6	1-2	7	0	0	0	7
8	0	0	0	8	2-3	2	0	0	0	2
5	0	0	0	5	3-4	3	0	0	0	3
8	0	1	0	9	4-5	10	0	1	0	11
7	0	7	0	14	5-6	16	2	2	0	20
15	7	2	0	24	6-7	32	6	0	0	38
26	19	0	0	45	7-8	78	16	2	0	96
72	28	5	0	105	8-9	83	13	2	0	98
54	18	0	0	72	9-10	126	20	0	0	146
39	10	0	0	49	10-11	117	16	2	0	135
105	28	1	0	134	11-12	89	18	2	0	109
113	14	4	0	131	12-13	48	17	0	0	65
42	20	10	0	72	13-14	62	24	0	0	86
48	15	0	0	63	14-15	25	4	0	0	29
57	16	0	0	73	15-16	68	21	1	0	90
95	14	1	2	112	16-17	75	13	0	0	88
101	9	2	0	112	17-18	51	18	1	0	70
57	2	0	0	59	18-19	51	6	1	1	59
39	0	0	0	39	19-20	45	0	5	0	50
42	2	2	0	46	20-21	38	0	6	0	44
28	0	0	0	28	21-22	21	0	1	0	22
21	0	0	0	21	22-23	19	0	0	0	19
21	0	0	0	21	23-24	12	0	0	0	12
1016	202	35	2	1255	Total	1096	194	26	1	1317

Table 10.5.8 SIMULATED QUEUING VEHICLES FROM LIKONI AND MBARAKI

No. of Ferry Trip	Vehicles Actually Carried by the Ferry	Vehicles Waiting for the Ferry	Vehicles Left Over	Vehicles Incoming after the preceding Ferry has started	No. of Ferry Trip	Vehicles Actually Carried by the Ferry	Vehicles Waiting for the Ferry	Vehicles Left Over	Vehicles Incoming after the preceding Ferry has started	No. of Ferry Trip	Vehicles Actually Carried by the Ferry	Vehicles Waiting for the Ferry	Vehicles Left Over	Vehicles Incoming after the preceding Ferry has started
1	9	9	0	9	31	31	61	30	29	61	25	33	7	19
2	13	13	0	13	32	21	59	38	29	62	18	26	8	19
3	5	5	0	5	33	31	67	36	29	63	26	27	1	19
4	3	3	0	3	34	20	64	44	28	64	19	19	0	18
5	4	4	0	4	35	29	71	42	27	65	13	13	0	13
6	6	6	0	6	36	20	71	51	29	66	13	13	0	13
7	8	8	0	8	37	29	80	51	29	67	13	13	0	13
8	10	10	0	10	38	26	80	54	29	68	13	13	0	13
9	6	6	0	6	39	18	68	50	14	69	11	11	0	11
10	8	8	0	8	40	26	64	38	14	70	11	11	0	11
11	8	8	0	8	41	18	52	34	14	71	11	11	0	11
12	8	8	0	8	42	26	48	22	14	72	11	11	0	11
13	8	8	0	8	43	26	37	11	15	73	11	11	0	11
14	10	10	0	10	44	18	30	12	19	74	23	23	0	23
15	20	21	1	20	45	26	31	5	19	75	23	23	0	23
16	22	21	0	22	46	18	24	6	19	76	8	8	0	8
17	20	21	1	20	47	25	25	0	19	77	8	8	0	8
18	22	21	0	22	48	17	17	0	17	78	7	7	0	7
19	21	21	0	21	49	7	7	0	7	79	10	10	0	10
20	21	21	0	21	50	8	8	0	8	80	9	9	0	9
21	21	21	0	21	51	8	8	0	8	81	7	7	0	7
22	21	21	0	21	52	10	10	0	10	82	6	6	0	6
23	21	21	0	21	53	19	20	1	20					
24	23	23	0	23	54	21	21	0	20					
25	21	32	11	32	55	19	20	1	20					
26	31	43	12	32	56	21	21	0	20					
27	21	44	23	32	57	30	33	3	33					
28	31	55	24	32	58	30	34	4	31					
29	31	55	24	31	59	30	35	5	31					
30	21	53	32	29	60	18	32	14	27					

2) Time Cost Saving

The time value is estimated in Appendix J and tabulated in Table 10.5.9. Time cost saving is obtained by multiplying Table 10.5.5 (Time and time Saving) and Table 10.5.9 (Time Value) and is presented in Table 10.5.10.

Table 10.5.9 TIME VALUE

(Unit: Shs/hour; Economic Value, 1983 Price)

Type of Veh. / Year	Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck
1983 Before Adjustment	83	71	166	40	150
After Adjustment	53	42	106	40	150
1990	63.0	49.9	126.0	40	150
2000	80.6	63.9	161.3	40	150
2010	103.3	81.8	206.5	40	150

Note: The annual growth rate of time value is assumed 2.5% except trucks. The 2.5% rate is referred to the rate of the national income per capita in the period 1970.

10.5.4 User Benefit

The total user benefit is finally obtained by multiplying estimated traffic (Table 10.5.1) and User cost saving and benefit (Table 10.5.11) and is presented in Table 10.5.12 for the bridge case of 55 m. The other cases are also computed.

The benefit of induced traffic is usually taken as 50% of the benefit of the normal traffic as shown in Fig. 10.5.1.

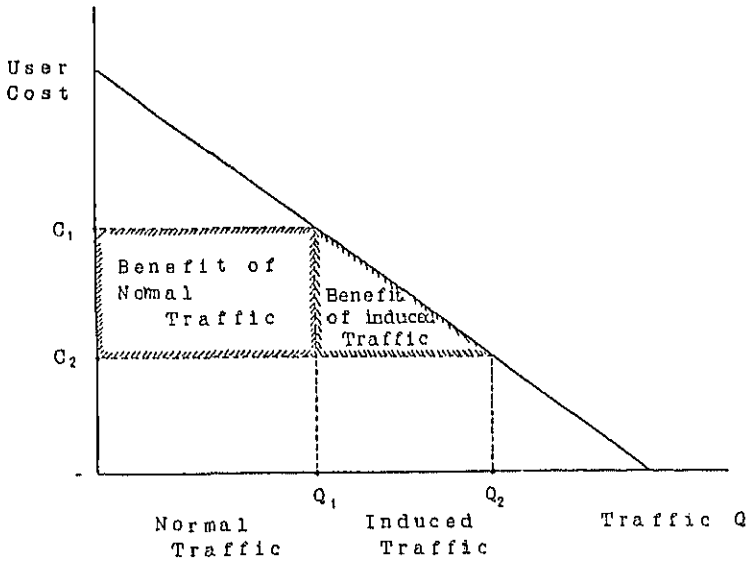


Fig. 10.5.1 CONCEPTION OF BENEFITS FROM NORMAL AND INDUCED TRAFFIC

Table 10.5.10 TIME COST AND ITS SAVINGS FOR 55M CLEARANCE

(Unit ; shs/vehicle, economic cost, 1983 price)

	Year	1992					2002					2010				
	Vehicle Type / Zonal Pair	Car and Light	Small Bus	Big Bus	Medium Truck	Big Truck	Car and Light	Small Bus	Big Bus	Medium Truck	Big Truck	Car and Light	Small Bus	Big Bus	Medium Truck	Big Truck
Time Cost without Project	1 - 6	37	29	73	37	145	47	37	93	37	145	57	45	114	37	145
	2 - 6	31	25	62	34	130	40	31	79	34	130	48	38	97	34	130
	3 - 6	35	28	70	36	141	45	36	90	36	141	55	43	110	36	141
	4 - 6	31	24	62	34	129	39	31	79	34	129	48	38	96	34	129
	5 - 6	38	30	76	38	149	49	39	97	38	149	59	47	119	38	149
Time Cost with Project	1 - 6	14	11	28	8	40	18	14	36	8	40	22	17	44	8	40
	2 - 6	12	9	24	7	34	15	12	30	7	34	18	15	37	7	34
	3 - 6	14	11	28	8	40	17	13	33	8	37	20	16	41	8	37
	4 - 6	8	7	17	5	25	11	8	21	5	25	13	10	26	5	25
	5 - 6	16	13	32	10	46	20	16	41	10	46	25	20	50	10	46
Saving in Time Cost	1 - 6	23	18	45	29	105	29	23	58	29	105	35	28	70	29	105
	2 - 6	19	15	38	27	96	25	19	49	27	96	30	24	60	27	96
	3 - 6	21	17	43	28	102	28	22	57	28	104	35	27	69	28	104
	4 - 6	23	18	45	29	105	29	23	58	29	105	35	28	70	29	105
	5 - 6	22	18	44	28	103	28	22	57	28	103	34	27	69	28	103

Table 10.5.11 USERS' COST AND BENEFIT FOR 55M CLEARANCE

(Unit : Shs/Vehicle, economic cost, 1983 price)

	Year / Vehicle Type / Zonal Pair	1992					2002					2010				
		Car and Light	Small Bus	Big Bus	Medium Truck	Big Truck	Car and Light	Small Bus	Big Bus	Medium Truck	Big Truck	Car and Light	Small Bus	Big Bus	Medium Truck	Big Truck
User Cost without Project	1 - 6	55	55	151	73	241	65	63	172	73	241	75	71	192	73	241
	2 - 6	43	42	115	58	194	52	49	132	58	194	61	56	149	58	194
	3 - 6	52	52	142	69	229	62	59	162	69	229	72	67	182	69	229
	4 - 6	43	41	113	57	192	51	48	130	57	192	60	55	148	57	192
	5 - 6	58	58	162	77	254	69	67	183	77	254	79	75	204	77	254
User Cost with Project	1 - 6	36	42	121	51	154	40	45	129	51	154	43	48	136	51	154
	2 - 6	31	37	106	45	135	34	39	113	45	135	38	42	119	45	135
	3 - 6	35	41	119	50	152	37	42	122	48	146	41	45	129	48	146
	4 - 6	24	28	82	35	105	26	30	87	35	105	28	32	92	35	105
	5 - 6	40	46	134	56	170	44	50	143	56	170	49	53	152	56	170
User Benefit (Savings in User Cost)	1 - 6	19	13	31	22	87	25	18	43	22	87	32	23	56	22	87
	2 - 6	12	5	9	13	59	18	10	19	13	59	23	14	30	13	59
	3 - 6	17	11	23	19	78	25	17	40	21	84	31	22	53	21	84
	4 - 6	19	13	31	22	87	25	18	43	22	87	32	23	56	22	87
	5 - 6	18	12	28	21	83	24	17	40	21	83	31	22	52	21	83

Table 10.5.12 TOTAL AMOUNT OF USERS' BENEFIT : H = 55 Meters (Stage Construction)

(Unit : 1,000 Ksh, economic value, 1983 prices)

	Year	1992						2002						2010					
	Vehicle Type / Zonal Pair	Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck	Total	Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck	Total	Car & Light	Small Bus	Big Bus	Medium Truck	Big Truck	Total
Normal Traffic	1 - 6	4557	706	2986	573	1322	10153	8711	1414	5974	827	1906	18833	13871	2317	9948	1046	2415	29596
	2 - 6	430	44	119	46	121	760	878	107	394	68	190	1637	1562	203	823	95	259	2942
	3 - 6	4850	714	2770	608	1459	10501	10569	1678	7061	986	2314	22609	17853	2918	12481	1334	3123	37708
	4 - 6	7861	1228	5099	983	2281	17452	15267	2462	10552	1436	3311	33029	25527	4213	18224	1938	4480	54382
	5 - 6	2924	446	1797	357	833	6358	5711	908	3790	523	1229	12161	9540	1540	6658	699	1643	20080
	Total	20731	3139	12771	2567	6016	45224	41137	6569	27772	3841	8951	88269	68354	11190	48134	5112	11919	144709
Developed Traffic	1 - 6	0	0	0	0	0	0	3698	365	2377	410	505	7345	10079	954	6612	870	1232	19746
	2 - 6	0	0	0	0	0	0	280	21	115	27	35	478	831	67	403	58	88	1448
	3 - 6	0	0	0	0	0	0	3734	342	2259	392	593	7319	10702	957	6767	840	1468	20733
	4 - 6	0	0	0	0	0	0	4602	422	2873	468	784	9149	13226	1177	8567	1025	1847	25843
	5 - 6	0	0	0	0	0	0	1861	160	1137	195	267	3620	5321	480	3376	419	714	10310
	Total	0	0	0	0	0	0	14164	1310	8750	1492	2185	27912	40159	3635	25725	3211	5348	78079
Induced Traffic	1 - 6	736	89	436	131	62	1454	1597	160	1034	182	214	3187	2957	279	1934	254	357	5781
	2 - 6	34	3	10	8	4	60	119	10	50	13	24	216	244	21	118	17	33	432
	3 - 6	598	54	322	89	122	1184	1598	147	970	168	259	3143	3142	278	1991	249	422	6081
	4 - 6	773	79	472	121	123	1569	1970	181	1227	205	340	3923	3886	344	2515	304	535	7584
	5 - 6	325	26	186	52	56	645	800	67	485	84	118	1553	1567	138	985	124	217	3032
	Total	2467	251	1425	402	367	4911	6084	564	3766	652	956	12022	11796	1060	7544	948	1563	22911
Total	1 - 6	5303	795	3421	704	1383	11607	13996	1939	9385	1419	2626	29365	26907	3550	18494	2169	4003	55124
	2 - 6	464	46	130	55	125	820	1277	138	559	108	249	2331	2638	291	1344	170	380	4822
	3 - 6	5548	768	3091	697	1580	11685	15901	2167	10291	1546	3167	33072	31697	4153	21239	2422	5012	64522
	4 - 6	8634	1308	5571	1104	2405	19021	21839	3064	14652	2109	4436	46100	42639	5734	29307	3267	6862	87809
	5 - 6	3249	472	1983	409	889	7003	8371	1135	5412	802	1614	17334	16429	2158	11019	1242	2573	33421
	Total	23198	3390	14196	2969	6383	50135	61385	8443	40298	5984	12091	128202	120309	15886	81402	9270	18831	245698

10.6 Ferry Cost Saved by the Project

If the project crossing will be realized, the existing ferry can be removed. The ferry operation cost, the construction cost for future additional berth and new ferry boats are therefore considered the benefit of the project.

10.6.1 Ferry Plan (Without Project Case)

The existing ferry facility must be expanded according to the traffic demand as estimated in Chapter 5.

The ferry development plan containing one ferry (Safina Class) and one additional berth provided once in 10 years was found that the service level can be maintained as now as shown in Table 10.6.1.

10.6.2 Ferry Costs

The construction cost for additional berth is estimated in Chapter 8. The ferry boat cost was obtained from KBS. Those two costs are converted to the economic cost using conversion factor (SCF = 0.92).

The ferry operation cost is estimated by the following equation.

Table 10.6.1 FERRY SERVICE LEVEL

Year	Name of Ferry	No. of Ferry	No. of Trips per Day (2 way)	Capacity per day (PCU)	ADT in PCU	ADT/ Capacity
1983	Sofina	1	75	3450	-	-
	Movita	1	72	2304	-	-
	St. Michael	1	17	374	-	-
	Total	3	164	6128	3804	0.62
1990	Sofina	2	150	6900	-	-
	Movita	1	72	2304	-	-
	St. Michael	1	17	374	-	-
	Total	4		9578	4939	0.52
2000	Sofina	3	225	10350	-	-
	Movita	1	72	2304	-	-
	St. Michael	1	17	374	-	-
	Total	5		13028	7171	0.55
2010	Sofina	4	300	13800	-	-
	Movita	1	72	2304	-	-
	St. Michael	1	17	374	-	-
	Total	6		16478	10410	0.63

$$TOC_t = K_1 + K_2 \cdot ADT_t$$

where: TOC_t = operational cost in year t
ADT_t = ADT in year t (traffic without project)
K_1, K_2 = parameters (K_1 = 937, K_2 = 1.73 verified with determinant factor, R^2 = 0.87)

The parameters, K_1 and K_2 in the above equation are obtained through the regression analysis from the data on the actual operational cost.

The total ferry cost is tabulated in Table 10.6.2.

10.7 Benefit from Regional Development

The project, if it is realized, will produce the regional development in the process as follow:

Construction of Project → Reduction in Transportation Cost → Reduction in Production Cost → Increase in Demand → Increase in Production

From this process, developed traffic will be generated on one hand, and on the other hand there will arise added value from the expanded production.

This increase in added value is the most favorable aim by the project execution. However it is difficult to estimate what portion of the added value is produced by the project.

In this project some portion of the value was estimated using a model as described in Appendix J. Due to the unreliability of the estimation the benefit is excluded in the project benefit and is the material for the sensitivity analysis.

The benefit is estimated as the assumed portion of the added value produced by the project as shown in Table 10.7.1.

Table 10.7.1 NET INCREASE IN ADDED VALUE DUE TO REGIONAL DEVELOPMENT

(Unit: 1,000 Shs, 1983 Price)

Alternatives \ year		2002	2010
Bridge	H = 73.2M	34443	71564
	H = 55M	34835	72312
	H = 45M	34850	72324
Tunnel		34695	71367

10.8 Flow Effect

The effect from the public investment is generally considered of both stock effect and flow effect. The former is the effect arising from the social capital stock generated by the project, and its representative is the users' benefits.

Table 10.6.2 FERRY COST SAVED BY THE PROJECT

Year	ADT (PCU, without Project)	Cost of Ferry (economic cost, 1,000 shs)			
		Operational Cost	Construction Cost of New Ferry	Construction Cost of Additional Berths	Total
1990	4,939	9,481	13,500	6,992	29,973
1991	5,120	9,795	0	0	9,795
1992	5,321	10,142	0	0	10,142
1993	5,523	10,490	0	0	10,490
1994	5,733	10,855	0	0	10,855
1995	5,951	11,232	0	0	11,232
1996	6,177	11,623	0	0	11,623
1997	6,412	12,030	0	0	12,030
1998	6,656	12,452	0	0	12,452
1999	6,909	12,890	0	0	12,890
2000	7,171	13,343	13,500	6,992	33,835
2001	7,444	13,815	0	0	13,815
2002	7,727	14,305	0	0	14,305
2003	8,020	14,812	0	0	14,812
2004	8,325	15,339	0	0	15,339
2005	8,641	15,886	0	0	15,886
2006	8,970	16,455	0	0	16,455
2007	9,311	17,045	0	0	17,045
2008	9,664	17,656	0	0	17,656
2009	10,032	18,292	0	0	18,292
2010	10,410	18,951	13,500	6,992	39,443
2011	10,810	19,643	0	0	19,643
2012	11,210	20,335	0	0	20,335
2013	11,610	21,027	0	0	21,027
2014	12,010	21,719	0	0	21,719
2015	12,410	22,411	0	0	22,411
2016	12,810	23,103	0	0	23,103

The flow effect is the multiplier effect arising from the investment accompanied by the project construction and affecting only during the construction period.

The multiplier effect arises only for the domestic procurement as described in Appendix J and the results are tabulated in Table 10.8.1.

Table 10.8.1 BENEFIT OF FLOW EFFECT

(Unit: 1,000 Shs, 1983 Price)

Year	Bridge Clearance						Tunnel
	H = 73.2 M		H = 55 M		H = 45 M		
	P.C	Steel	P.C	Steel	P.C	Steel	
1985	6,503	6,603	4,899	5,534	4,216	4,885	16,265
86	6,503	6,603	4,899	5,534	4,216	4,885	37,303
87	13,663	13,763	12,716	13,352	12,033	12,703	33,969
88	35,003	56,097	50,564	64,182	44,000	55,080	59,477
89	72,920	77,426	43,242	62,072	33,127	56,826	59,477
90	68,018	68,761	27,653	36,988	25,027	32,331	59,477
91	39,888	33,158	21,755		20,980		79,425
92	14,545						79,425
97	18,174	18,174	13,353	13,353	4,171		58,634
98	44,052	44,313	49,771	65,342	48,416	4,171	58,952
99	76,788	77,113	53,810	72,072	39,011	60,201	58,952
2000	43,397	43,674	37,542	48,008	29,561	62,927	78,359
2001	15,050	15,421	24,288		25,467	40,410	78,041

10.9 Residual Value

The assumption is made that the proposed bridge could be used for 60 years at the end of which its residual value is zero, while the study period of 30 years is considered in this study. The residual value of the bridge at the end of 30 years is computed on the straight line method.

10.10 Comparison of Cost and Benefit

10.10.1 Economic Internal Rate of Return

Currently the general market interest rate in Kenya is around 16%. This rate includes inflation hedge. The substantial interest rate of approximate 10% is considered excluding the inflation hedge. The project can therefore be feasible for the national economy in Kenya, if the economic internal rate of return is counted at more than 10%.

The premises for the calculation of internal rate of return are as follows:

- Project life span to be 30 years from the starting point of construction (1988) and 16 years after operating for full length of the project road.

– Residual value to be considered at the end of the project life

– The benefit from regional development excluded from the project benefits (For reference the case including this benefit is shown in Appendix J).

As a result the economic internal rate of return summarized in Table 10.10.1 and is shown in Table 10.10.2 and 10.10.3, and Appendix J.

Table 10.10.1 ECONOMIC INTERNAL RATE OF RETURN

(Economic IRR)

Alternative / Staging	Bridge			Tunnel
	H = 45 M	H = 55 M	H=73.2M	
Non-stage Construction	0.1025	0.0887	0.0585	0.0536
Staged Construction	0.1190	0.1055	0.0690	0.0561

Note : IRR of bridge alternatives are estimeted for P.C main bridges.

From Table 10.10.1 the alternatives, P.C main bridge with 45 and 55 m navigation clearance, are the most favorable with more than 10% IRR.

10.10.2 Sensitivity Analysis

As for the sensitivity analysis, generally the economic cost, benefit and project life span are the major objectives to test the effects of future unknown factors and to examine the certainty of economic feasibility of the project.

For the case of 55 m clearance (P.C main bridge) these elements are set up against the initial conditions and tested in their combinations as follows:

– 10% increase of the construction cost

– 10% decrease of the total benefit

– Longer life span of 25 years after the commencement of the project road operation for its full width

These results are presented in Table 10.10.4. The value of IRR revealed quite reasonable with around 10% except Case B, which is a rare case which occurred simultaneously.

As a result, among the selected alternatives, the case of navigation clearance 55 m and P.C main bridge disclosed the most favarable result considering the actual harbour operation.

Table 10.10.2 CASH FLOW (Unit: 1,000 Ksh, economic value, 1983 price)

1. Navigation Clearance = 55 Meters (PC Bridge)
2. Stage Construction
3. Excluding item (3)
4. Discount Rate (1) = I R R = 0.1055
5. Residual Value (2) is considered as benefit in the last year only.

Year	Investment	Maintenance Cost	Total Cost	User Benefit	Saved Ferry Cost	Net Increase in Added Value due to Regional Development (3)	Flow Effect	Residual Value (2)	Total Benefit	Cash Flow	Discounted and Accumulated Cash Flow (1)
1985	27473	0	27473	0	0	0	4899	27473	4899	-22574	-22574
1986	27473	0	27473	0	0	0	4899	54488	4899	-22574	-42994
1987	36256	0	36256	0	0	0	12716	89829	12716	-23540	-62256
1988	279868	0	279868	0	0	0	50564	368176	50564	-229304	-231977
1989	254265	0	254265	0	0	0	43242	616257	43242	-211023	-373261
1990	162412	0	162412	0	0	0	27653	768246	27653	-134759	-454875
1991	110123	0	110123	0	0	0	21755	865240	21755	-88367	-503286
1992	0	2949	2949	50135	29973	0	0	850275	80108	77159	-465049
1993	0	2949	2949	57646	10490	0	0	835311	68136	65187	-435829
1994	0	2949	2949	65156	10855	0	0	820346	76011	73062	-406203
1995	0	2949	2949	72667	11232	0	0	805382	83899	80950	-376512
1996	0	2949	2949	80177	11623	0	0	790417	91800	88851	-347032
1997	15004	2949	17952	87688	12023	0	13353	790457	113064	95111	-318488
1998	268533	2949	271481	95198	12452	0	49771	1043775	157421	-114060	-349453
1999	316538	2949	319486	102709	12890	0	53810	1340622	169409	-150078	-386307
2000	220680	2949	223629	110219	33835	0	37542	1536337	181596	-42033	-395644
2001	118384	2949	121332	117730	13815	0	24288	1626077	155833	34500	-388712
2002	0	6253	6253	128202	14305	0	0	1595460	142507	136254	-363946
2003	0	6253	6253	142889	14812	0	0	1564843	157701	151448	-339046
2004	0	6253	6253	157576	15339	0	0	1534226	172915	166662	-314259
2005	0	6253	6253	172263	15886	0	0	1503610	188149	181896	-289788
2006	0	6253	6253	186950	16455	0	0	1472993	203405	197152	-265796
2007	0	6253	6253	201637	17045	0	0	1442376	218682	212429	-242412
2008	0	6253	6253	216324	17656	0	0	1411759	233980	227727	-219736
2009	0	6253	6253	231011	18292	0	0	1381143	249303	243050	-197844
2010	0	6253	6253	245698	39443	0	0	1350526	285141	278888	-175122
2011	0	6253	6253	260385	19643	0	0	1319909	280028	273775	-154944
2012	0	6253	6253	275072	20335	0	0	1289292	295407	289154	-135667
2013	0	6253	6253	289759	21027	0	0	1258675	310786	304533	-117302
2014	0	6253	6253	304446	21719	0	0	1228059	326165	319912	-99851
2015	0	6253	6253	319133	22411	0	0	1197442	341544	335291	-83306
2016	0	6253	6253	333820	23103	0	0	1166825	356923	350670	-67654
2017	0	6253	6253	348507	23103	0	0	1136208	371610	365357	-52902
2018	0	6253	6253	363194	23103	0	0	1105591	1491888	1485635	1357

B/C= 1.001568 IRR= .1055

Table 10.10.3 CASH FLOW (Unit: 1,000 Ksh, economic value, 1983 price)

1. Navigation Clearance = 55 Meters (PC Bridge)
2. Non-stage Construction
3. Excluding item (3)
4. Discount Rate (1) = I R R = 0.0887
5. Residual Value (2) is considered as benefit in the last year only.

Year	Investment	Maintenance Cost	Total Cost	User Benefit	Saved Ferry Cost	Net Increase in Added Value due to Regional Development (3)	Flow Effect	Residual Value (2)	Total Benefit	Cash Flow	Discounted and Accumulated Cash Flow (1)
1985	22579	0	22579	0	0	0	4068	22579	4068	-18511	-18511
1986	22579	0	22579	0	0	0	4068	44781	4068	-18511	-35514
1987	46366	0	46366	0	0	0	25239	90395	25239	-21127	-53339
1988	344357	0	344357	0	0	0	65670	433226	65670	-278687	-269308
1989	546658	0	546658	0	0	0	92919	972620	92919	-453740	-592287
1990	305274	0	305274	0	0	0	51952	1261518	51952	-253322	-757914
1991	129722	0	129722	0	0	0	22157	1369776	22157	-107564	-822512
1992	97809	0	97809	0	0	0	23826	1443959	23826	-73983	-863322
1993	0	6253	6253	55319	29973	0	0	1418703	85292	79039	-823275
1994	0	6253	6253	63417	10855	0	0	1393448	74272	68019	-791619
1995	0	6253	6253	71515	11232	0	0	1368192	82747	76494	-758919
1996	0	6253	6253	79613	11623	0	0	1342936	91236	84983	-725550
1997	0	6253	6253	87711	12023	0	0	1317681	99734	93481	-691835
1998	0	6253	6253	95810	12452	0	0	1292425	108262	102008	-658042
1999	0	6253	6253	103908	12890	0	0	1267169	116798	110544	-624405
2000	0	6253	6253	112006	33835	0	0	1241913	145841	139588	-585390
2001	0	6253	6253	120104	13815	0	0	1216658	133919	127666	-552615
2002	0	6253	6253	128202	14305	0	0	1191402	142507	136254	-520486
2003	0	6253	6253	142889	14812	0	0	1166146	157701	151448	-487683
2004	0	6253	6253	157576	15339	0	0	1140891	172915	166662	-454525
2005	0	6253	6253	172263	15886	0	0	1115635	188149	181896	-421285
2006	0	6253	6253	186950	16455	0	0	1090379	203405	197152	-388193
2007	0	6253	6253	201637	17045	0	0	1065123	218682	212429	-355442
2008	0	6253	6253	216324	17656	0	0	1039868	233980	227727	-323192
2009	0	6253	6253	231011	18292	0	0	1014612	249303	243050	-291577
2010	0	6253	6253	245698	39443	0	0	989356	285141	278888	-258255
2011	0	6253	6253	260385	19643	0	0	964101	280028	273775	-228210
2012	0	6253	6253	275072	20335	0	0	938845	295407	289154	-199062
2013	0	6253	6253	289759	21027	0	0	913589	310786	304533	-170865
2014	0	6253	6253	304446	21719	0	0	888333	326165	319912	-143657
2015	0	6253	6253	319133	22411	0	0	863078	341544	335291	-117465
2016	0	6253	6253	333820	23103	0	0	837822	356923	350670	-92303
2017	0	6253	6253	348507	23103	0	0	812566	371610	365357	-68223
2018	0	6253	6253	363194	23103	0	0	787311	1173608	1167355	2446

B/C= 1.002215 IRR= 8.870001E-02

Table 10.10.4 SENSITIVITY ANALYSIS (EIRR)

Case	Cost +10%	Benefit −10%	Evaluation Period + 9 Years	EIRR
A	O	–	–	0.098
B	O	O	–	0.088
C	–	–	O	0.112
D	O	–	O	0.104

Note: "O" means the case conducted for sensitivity analysis.

10.11 Financial Study

10.11.1 Financing

About 80% of the project cost (foreign currency component) must be procured from foreign financing agencies Using conditions; uniform annual interest rate of 4%, total redemption period of 30 years including a grace period of 10 years from the start of detailed design of the project and annual even redemption amount (redemption + interest), the maximum annual amortization amounts to 133.4 million shilling around 2013 as shown in Table 10.11.1.

10.11.2 Toll Bridge Accounting

The standard tollway covers the construction cost as well, but the toll road covering the maintenance and operating cost prevails in Kenya.

The major subject in this kind of toll levy system is to determine the toll fare under the favorable financial operation.

As for the reference the following premises are established for the case of 55 m clearance (P.C main bridge).

(1) Toll rates by vehicle type are based on considering the scale of user benefit and damage to the road as follows:

Car & Light	:	1 Shs.
Small Buses	:	1
Big Buses	:	3
Medium Trucks	:	2
Big Trucks	:	3

(2) A 10% discount rate is applied for the calculation of financial B/C ratio as well as accumulated surplus (dificit) and depreciation allowance.

(3) Project life span is assumed to be 30 years from 1991.

Table 10.11.1 ANNUAL AMORTIZATION FOR FOREIGN CURRENCY LOAN

(Unit: 1,000 Shs. 1983 Price, Financial Value)

YEAR	LOAN RESIDUAL	TOTAL LOAN RE-DEMPTION	LOAN INTEREST	TOTAL AMORTIZA-TION
1985	27461	0	0	0
1986	54922	0	1098	1098
1987	82383	0	2197	2197
1988	361201	0	3295	3295
1989	618299	0	14448	14448
1990	782476	0	24732	24732
1991	889573	0	31299	31299
1992	889573	0	35583	35583
1993	889573	0	35583	35583
1994	889573	0	35583	35583
1995	888651	922	35583	36505
1996	886770	1881	35546	37427
1997	883891	2879	35471	38349
1998	1137297	12357	35356	47713
1999	1435908	21485	45492	66977
2000	1631173	27858	57436	85294
2001	1712471	32569	65247	97816
2002	1678600	33871	68499	102370
2003	1643373	35226	67144	102370
2004	1606738	36635	65735	102370
2005	1568637	38101	64270	102370
2006	1529012	39625	62745	102370
2007	1487802	41210	61160	102370
2008	1436019	51783	59512	111295
2009	1371415	64604	57441	122045
2010	1296735	74681	54857	129537
2011	1215243	81492	51869	133361
2012	1130491	84752	48610	133361
2013	1042350	88142	45220	133361
2014	950683	91667	41694	133361
2015	857369	93313	38027	131341
2016	762344	95025	34295	129320
2017	665539	96806	30494	127299
2018	585377	80162	26622	106783
2019	520927	64451	23415	87866
2020	465979	54948	20837	75785
2021	416713	49266	18639	67905
2022	365476	51236	16669	67905
2023	312191	53286	14619	67905
2024	256773	55417	12488	67905
2025	199139	57634	10271	67905
2026	139200	59939	7966	67905
2027	76863	62337	5568	67905
2028	31589	45275	3075	48350
2029	8056	23533	1264	24796
2030	0	8056	322	8379
2031	0	0	0	0
2032	0	0	0	0
2033	0	0	0	0
2034	0	0	0	0

(4) Construction cost of a tollgate is estimated in Chapter 8, and 420 thousand shilling in 1991 and 600 thousand shilling in 2001 is invested.

The construction cost of tollgate is repaid in ten years with the annual interest rate of 16% and one year grace period. The life of tollgate is 30 years and the salvage value is nil.

(5) Maintenance and operation costs were estimated in Chapter 8 and are listed as follow:

- For the project road

Up to 2001	3,205,000 Shs/Year
From 2002	6,797,000

- For the tollgate

Up to 2001	266,000 Shs/Year
From 2002	356,000

(6) Income tax is nil.

(7) The traffic demand will not decrease, although the toll fare is collected.

(8) The interest from the toll revenue and an accumulated surplus is reserved in the toll road accounts.

As a result the financial B/C ratio disclosed the high rate of 1.49 as shown in Table 10.11.2. The statement of profit and loss is presented in Table 10.11.3. From the statement the following results are obtained:

- The stable surplus can be obtained from the beginning of operation (1992).
- The interest amount on accumulated surplus will exceed the toll revenue at around 2014.

The balance sheet is shown in Table 10.11.4. From this Table the emergency loan (short term debt) is not required since the loan for the tollgate construction is repaid on schedule.

10.11.3 Tollway Financing

Tollway accounting covering the maintenance/operation cost of the project road was performed in para. 10.11.2. The financing of the tollway covering the local portion of the project cost as well, is estimated for the case of 55 m clearance (P.C main bridge).

The conditions for testing the financial opeation are as follows:

(1) Toll rates by vehicle type are set up to be considerably cheaper than the existing ferry toll as follows:

Car & Light Truck	:	5 Shs.
Small Bus	:	5
Big Bus	:	40
Medium Truck	:	20
Big Truck	:	40

Table 10.11.2 CASH FLOW FOR TOLL BRIDGE (H = 55 M, P.C Bridge)

(Unit : 1,000 shs., 1983 price, financial value)

Year	Investment	Maintenance and Administration Cost	Total Cost	Toll Revenue	Residual Value	Total Revenue	Cash Flow	Accumulated Cash Flow in Present Value
1991	420	0	420	0	420	0	-420	-420
1992	0	3471	3471	3968	406	3968	497	32
1993	0	3471	3471	4323	392	4323	852	736
1994	0	3471	3471	4677	378	4677	1206	1643
1995	0	3471	3471	5032	364	5032	1561	2709
1996	0	3471	3471	5387	350	5387	1916	3898
1997	0	3471	3471	5741	336	5741	2270	5180
1998	0	3471	3471	6096	322	6096	2625	6527
1999	0	3471	3471	6450	308	6450	2979	7917
2000	0	3471	3471	6805	294	6805	3334	9331
2001	600	3471	4071	7160	880	7160	3089	10521
2002	0	7153	7153	7514	846	7514	361	10648
2003	0	7153	7153	8031	812	8031	878	10928
2004	0	7153	7153	8549	778	8549	1395	11332
2005	0	7153	7153	9066	744	9066	1912	11835
2006	0	7153	7153	9583	710	9583	2430	12417
2007	0	7153	7153	10100	676	10100	2947	13058
2008	0	7153	7153	10617	642	10617	3464	13744
2009	0	7153	7153	11135	608	11135	3981	14460
2010	0	7153	7153	11652	574	11652	4498	15195
2011	0	7153	7153	12169	540	12169	5016	15941
2012	0	7153	7153	12686	506	12686	5533	16689
2013	0	7153	7153	13204	472	13204	6050	17432
2014	0	7153	7153	13721	438	13721	6567	18165
2015	0	7153	7153	14238	404	14238	7085	18885
2016	0	7153	7153	14755	370	14755	7602	19586
2017	0	7153	7153	15272	336	15272	8119	20267
2018	0	7153	7153	15790	302	15790	8636	20926
2019	0	7153	7153	16307	268	16307	9153	21561
2020	0	7153	7153	16824	234	17058	9905	22185

B/C = 1.492467 Discount Rate = 0.1

Table 10.11.3 ESTIMATED PROFIT AND LOSS STATEMENT FOR TOLL BRIDGE (H = 55 M, P.C Bridge)

(Unit : 1,000 shs., 1983 price, financial value)

Year	Toll Revenue	Salvage Value	Interest on Depreciation Allowance	Interest on Accumulated Surplus	Total Revenue	Interest Payable	Maintenance and Administration Cost	Depreciation Cost	Income Tax	Total Cost	Net Profit	Surplus	Accumulated Surplus
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	3968	0	0	0	3968	67	3471	14	0	3552	416	396	396
1993	4323	0	1	40	4364	64	3471	14	0	3549	815	792	1188
1994	4677	0	3	119	4799	60	3471	14	0	3545	1254	1227	2416
1995	5032	0	4	242	5278	56	3471	14	0	3541	1737	1706	4122
1996	5387	0	6	412	5804	51	3471	14	0	3536	2268	2233	6354
1997	5741	0	7	635	6384	46	3471	14	0	3531	2853	2812	9166
1998	6096	0	8	917	7021	39	3471	14	0	3524	3497	3449	12615
1999	6450	0	10	1261	7722	31	3471	14	0	3516	4206	4150	16765
2000	6805	0	11	1676	8493	22	3471	14	0	3507	4985	4921	21685
2001	7160	0	13	2169	9341	12	3471	14	0	3497	5844	5769	27454
2002	7514	0	14	2745	10274	96	7153	34	0	7283	2990	2962	30417
2003	8031	0	17	3042	11091	91	7153	34	0	7279	3812	3779	34196
2004	8549	0	21	3420	11989	86	7153	34	0	7274	4715	4677	38873
2005	9066	0	24	3887	12977	80	7153	34	0	7268	5710	5666	44539
2006	9583	0	28	4454	14065	73	7153	34	0	7261	6804	6753	51292
2007	10100	0	31	5129	15260	65	7153	34	0	7252	8008	7949	59241
2008	10617	0	34	5924	16576	56	7153	34	0	7243	9333	9264	68505
2009	11135	0	38	6851	18023	45	7153	34	0	7232	10791	10711	79217
2010	11652	0	41	7922	19615	32	7153	34	0	7219	12395	12303	91520
2011	12169	0	45	9152	21366	17	7153	34	0	7205	14161	14054	105574
2012	12686	0	48	10557	23292	0	7153	34	0	7187	16104	16104	121678
2013	13204	0	51	12168	25423	0	7153	34	0	7187	18235	18235	139914
2014	13721	0	55	13991	27767	0	7153	34	0	7187	20579	20579	160493
2015	14238	0	58	16049	30345	0	7153	34	0	7187	23158	23158	183651
2016	14755	0	62	18365	33182	0	7153	34	0	7187	25994	25994	209646
2017	15272	0	65	20965	36302	0	7153	34	0	7187	29114	29114	238760
2018	15790	0	68	23876	39734	0	7153	34	0	7187	32547	32547	271307
2019	16307	0	72	27131	43509	0	7153	34	0	7187	36322	36322	307628
2020	16824	0	75	30763	47662	0	7153	34	0	7187	40475	40475	348103

Table 10.11.4 ESTIMATED BALANCE SHEET FOR TOLL BRIDGE (H = 55 M, P.C Bridge)

(Unit : 1,000 shs., 1983 price, financial value)

Year	Fixed Asset	Current Asset	Deficit of This Year	Debit Side Total	Long Term Debt	Depreciation Allowance	Short Term Debt	Capital Surplus	Net Profit of This Year	Credit side Total
1991	420	0	0	420	420	0	0	0	0	420
1992	406	821	0	1227	400	14	0	396	416	1227
1993	392	2017	0	2409	377	28	0	1188	815	2409
1994	378	3684	0	4062	351	42	0	2416	1254	4062
1995	364	5870	0	6234	320	56	0	4122	1737	6234
1996	350	8627	0	8977	285	70	0	6354	2268	8977
1997	336	12010	0	12346	243	84	0	9166	2853	12346
1998	322	16083	0	16405	195	98	0	12615	3497	16405
1999	308	20914	0	21222	139	112	0	16765	4206	21222
2000	294	26578	0	26872	75	126	0	21685	4985	26872
2001	880	33158	0	34038	600	140	0	27454	5844	34038
2002	846	33307	0	34153	572	174	0	30417	2990	34153
2003	812	37942	0	38754	539	208	0	34196	3812	38754
2004	778	43554	0	44332	501	242	0	38873	4715	44332
2005	744	50238	0	50982	457	276	0	44539	5710	50982
2006	710	58102	0	58812	406	310	0	51292	6804	58812
2007	676	67264	0	67940	347	344	0	59241	8008	67940
2008	642	77853	0	78495	279	378	0	68505	9333	78495
2009	608	90011	0	90619	199	412	0	79217	10791	90619
2010	574	103894	0	104468	107	446	0	91520	12395	104468
2011	540	119675	0	120215	0	480	0	105574	14161	120215
2012	506	137791	0	138297	0	514	0	121678	16104	138297
2013	472	158225	0	158697	0	548	0	139914	18235	158697
2014	438	181217	0	181655	0	582	0	160493	20579	181655
2015	404	207021	0	207425	0	616	0	183651	23158	207425
2016	370	235920	0	236290	0	650	0	209646	25994	236290
2017	336	268223	0	268559	0	684	0	238760	29114	268559
2018	302	304269	0	304571	0	718	0	271307	32547	304571
2019	268	344434	0	344702	0	752	0	307628	36322	344702
2020	234	389130	0	389364	0	786	0	348103	40475	389364

(2) The loan conditions are of 8% interest rate (long term) and 20 years amortization period with 5 years grace period. The interest rate of 8% is also assumed for the interest receivable from deposit and short term loans. These conditions are generally accepted by the international financing agencies.

(3) Other Conditions

The other conditions are described in para. 10.11.2. These are the construction cost of the tollgates, maintenance/operation costs, income tax, traffic demand and reserved interest from toll revenue. The local portion of the project cost is estimated in Chapter 8.

As a result the financial performance of the toll road is quite good, disclosing a fianncial IRR of 13.8% as shown in Table 10.11.5. The estimated profit and loss statement (Table 10.11.6) shows that a net profit will be obtained from the start of the toll road (year 1992) and accumulated deficit turn to accumulated surplus in 1996. The interest receivable will surpass the interest payable in 2008 and also surpass the toll revenue in 2019.

The amortization schedule is presented in Table 10.11.7. The toll revenue mostly surpasses the total expenditure (amortization amount + maintenance/operation cost) through the evaluation period. Up to 1995 some money shortage appears with a maximum of 57,824 thousand shilling in 1991 as shown in Table 10.11.8.

The results are quite good with a high economic return for the government. If the conditions assumed here are changed in the future, the analysis will be made by others using the new conditions.

Table 10.11.5 CASH FLOW (H=55 M, P.C BRIDGE)

Year	Investment	Maintenance and Administration Cost	Total Cost	Toll Revenue	Residual Value	Total Revenue	Cash Flow	Accumulated Cash Flow in Present Value
1985	7300	0	7300	0	7300	0	-7300	-7300
1986	7300	0	7300	0	14478	0	-7300	-13714
1987	18949	0	18949	0	33184	0	-18949	-28344
1988	75349	0	75349	0	107974	0	-75349	-79457
1989	64438	0	64438	0	170597	0	-64438	-117865
1990	41207	0	41207	0	208915	0	-41207	-139446
1991	32820	0	32820	0	238159	0	-32820	-154549
1992	0	3471	3471	37591	234037	37591	34120	-140753
1993	0	3471	3471	40951	229914	40951	37480	-127437
1994	0	3471	3471	44310	225791	44310	40839	-114689
1995	0	3471	3471	47669	221668	47669	44198	-102566
1996	0	3471	3471	51028	217546	51028	47557	-91105
1997	19899	3471	23370	54388	233322	54388	31018	-84537
1998	74167	3471	77638	57747	303035	57747	-19891	-88238
1999	80187	3471	83658	61106	377531	61106	-22552	-91925
2000	55944	3471	59415	64466	426448	64466	5051	-91199
2001	36794	3471	40265	67825	455283	67825	27560	-87721
2002	0	7153	7153	71184	446710	71184	64031	-80620
2003	0	7153	7153	76088	438138	76088	68935	-73902
2004	0	7153	7153	80993	429565	80993	73839	-67580
2005	0	7153	7153	85897	420993	85897	78743	-61657
2006	0	7153	7153	90801	412420	90801	83648	-56127
2007	0	7153	7153	95705	403847	95705	88552	-50984
2008	0	7153	7153	100610	395275	100610	93456	-46215
2009	0	7153	7153	105514	386702	105514	98360	-41804
2010	0	7153	7153	110418	378130	110418	103265	-37736
2011	0	7153	7153	115322	369557	115322	108169	-33991
2012	0	7153	7153	120226	360985	120226	113073	-30552
2013	0	7153	7153	125131	352412	125131	117977	-27398
2014	0	7153	7153	130035	343840	130035	122881	-24513
2015	0	7153	7153	134939	335267	134939	127786	-21876
2016	0	7153	7153	139843	326694	139843	132690	-19470
2017	0	7153	7153	144748	318122	144748	137594	-17278
2018	0	7153	7153	149652	309549	149652	142498	-15284
2019	0	7153	7153	154556	300977	154556	147403	-13471
2020	0	7153	7153	159460	292404	159460	152307	-11825
2021	0	7153	7153	164365	283832	164365	157211	-10332
2022	0	7153	7153	169269	275259	169269	162115	-8980
2023	0	7153	7153	174173	266686	174173	167020	-7755
2024	0	7153	7153	179077	258114	179077	171924	-6648
2025	0	7153	7153	183981	249541	183981	176828	-5647
2026	0	7153	7153	188886	240969	188886	181732	-4743
2027	0	7153	7153	193790	232396	193790	186636	-3928
2028	0	7153	7153	198694	223824	198694	191541	-3193
2029	0	7153	7153	203598	215251	203598	196445	-2530
2030	0	7153	7153	208503	206679	208503	201349	-1933
2031	0	7153	7153	213407	198106	213407	206253	-1396
2032	0	7153	7153	218311	189533	218311	211158	-913
2033	0	7153	7153	223215	180961	223215	216062	-478
2034	0	7153	7153	228120	172388	400508	393354	217

B/C= 1.001016 IRR= .1381

Table 10.11.6 ESTIMATED PROFIT AND LOSS STATEMENT (H=55 M, P.C BRIDGE)

Year	Revenue	Salvage Value	Interest on Depreciation Allowance	Interest on Accumulated Surplus	Total Revenue	Interest Payable	Maintenance and Administration Cost	Depreciation Cost	Income Tax	Total Cost	Net Profit	Surplus	Accumulated Surplus
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	584	0	122	0	706	-706	-706	-706
1987	0	0	10	-56	-47	1168	0	243	0	1411	-1458	-1458	-2164
1988	0	0	29	-173	-144	2684	0	559	0	3243	-3387	-3387	-5551
1989	0	0	74	-444	-370	8712	0	1815	0	10527	-10897	-10897	-16448
1990	0	0	219	-1316	-1097	13867	0	2889	0	16756	-17852	-18012	-34460
1991	0	0	450	-2757	-2307	17151	0	3576	0	20726	-23033	-23365	-57824
1992	37591	0	736	-4626	33702	19750	3471	4123	0	27343	6358	5586	-52239
1993	40951	0	1066	-4179	37838	19688	3471	4123	0	27282	10556	8075	-44163
1994	44310	0	1396	-3533	42173	19489	3471	4123	0	27083	15090	11002	-33161
1995	47669	0	1726	-2653	46742	19162	3471	4123	0	26756	19986	14671	-18490
1996	51028	0	2056	-1479	51605	18737	3471	4123	0	26331	25274	18817	327
1997	54388	0	2385	26	56799	18221	3471	4123	0	25814	30985	24011	24338
1998	57747	0	2715	1947	62409	19255	3471	4454	0	27180	35229	27697	52035
1999	61106	0	3072	4163	68341	24586	3471	5690	0	33747	34594	26459	78495
2000	64466	0	3527	6280	74272	30350	3471	7027	0	40848	33424	24639	103134
2001	67825	0	4089	8251	80165	34123	3471	7959	0	45553	34612	25124	128258
2002	71184	0	4726	10261	86170	36307	7153	8573	0	52033	34137	23456	151714
2003	76088	0	5412	12137	93637	35453	7153	8573	0	51178	42458	29302	181016
2004	80993	0	6097	14481	101571	34400	7153	8573	0	50126	51445	35484	216499
2005	85897	0	6783	17320	110000	33123	7153	8573	0	48849	61151	42690	259189
2006	90801	0	7469	20735	119005	31646	7153	8573	0	47372	71633	50891	310080
2007	95705	0	8155	24806	128666	29987	7153	8573	0	45713	82954	60552	370632
2008	100610	0	8841	29651	139101	28195	7153	8573	0	43921	95180	70987	441619
2009	105514	0	9526	35330	150370	26259	7153	8573	0	41985	108384	82256	523874
2010	110418	0	10212	41910	162540	24169	7153	8573	0	39895	122645	95170	619044
2011	115322	0	10898	49524	175744	21971	7153	8573	0	37697	138047	109117	728161
2012	120226	0	11584	58253	190063	19657	7153	8573	0	35382	154681	125366	853527
2013	125131	0	12270	68282	205682	17311	7153	8573	0	33037	172645	148660	1002187
2014	130035	0	12955	80175	223165	15393	7153	8573	0	31118	192047	172706	1174892
2015	134939	0	13641	93991	242572	13845	7153	8573	0	29571	213000	196309	1371202
2016	139843	0	14327	109696	263866	12510	7153	8573	0	28236	235631	220947	1592148
2017	144748	0	15013	127372	287132	11335	7153	8573	0	27061	260071	244213	1836361
2018	149652	0	15699	146909	312259	10067	7153	8573	0	25793	286467	269340	2105701
2019	154556	0	16384	168456	339397	8696	7153	8573	0	24422	314974	296477	2402178
2020	159460	0	17070	192174	368705	7217	7153	8573	0	22943	345762	325785	2727963
2021	164365	0	17756	218237	400358	5618	7153	8573	0	21344	379013	357438	3085401
2022	169269	0	18442	246832	434543	3892	7153	8573	0	19618	414924	393650	3479051
2023	174173	0	19128	278324	471625	2190	7153	8573	0	17916	453708	438286	3917337
2024	179077	0	19813	313387	512278	957	7153	8573	0	16683	495595	487106	4404443
2025	183981	0	20499	352355	556836	278	7153	8573	0	16004	540832	537363	4941805
2026	188886	0	21185	395344	605415	0	7153	8573	0	15726	589689	589689	5531494
2027	193790	0	21871	442520	658180	0	7153	8573	0	15726	642454	642454	6173948
2028	198694	0	22557	493916	715167	0	7153	8573	0	15726	699441	699441	6873389
2029	203598	0	23242	549871	776712	0	7153	8573	0	15726	760986	760986	7634375
2030	208503	0	23928	610750	843181	0	7153	8573	0	15726	827455	827455	8461829
2031	213407	0	24614	676946	914967	0	7153	8573	0	15726	899241	899241	9361070
2032	218311	0	25300	748886	992496	0	7153	8573	0	15726	976771	976771	10337840
2033	223215	0	25986	827027	1076228	0	7153	8573	0	15726	1060502	1060502	11398340
2034	228120	0	26671	911867	1166658	0	7153	8573	0	15726	1150932	1150932	12549270

Table 10.11.7 AMORTIZATION SCHEDULE (H=55 M, P.C BRIDGE)

Year	Loan Residual	Total Loan Redemption	Loan Interest	Total Amortization	Maintenance Cost	Total Expenditure
1985	7300	0	0	0	0	0
1986	14600	0	584	584	0	584
1987	33549	0	1168	1168	0	1168
1988	108898	0	2684	2684	0	2684
1989	173336	0	8712	8712	0	8712
1990	214383	160	13867	14026	0	14026
1991	246872	332	17151	17482	0	17482
1992	246099	772	19750	20522	3471	23993
1993	243619	2481	19688	22169	3471	25640
1994	239531	4087	19489	23577	3471	27048
1995	234216	5315	19162	24477	3471	27948
1996	227759	6457	18737	25194	3471	28665
1997	240685	6974	18221	25194	3471	28665
1998	307320	7532	19255	26786	3471	30257
1999	379373	8134	24586	32720	3471	36191
2000	426532	8785	30350	39135	3471	42606
2001	453838	9488	34123	43610	3471	47081
2002	443157	10682	36307	46989	7153	54142
2003	430000	13157	35453	48609	7153	55763
2004	414038	15962	34400	50362	7153	57515
2005	395577	18461	33123	51584	7153	58737
2006	374835	20742	31646	52388	7153	59541
2007	352434	22401	29987	52388	7153	59541
2008	328241	24193	28195	52388	7153	59541
2009	302112	26129	26259	52388	7153	59541
2010	274636	27476	24169	51645	7153	58798
2011	245706	28930	21971	50901	7153	58054
2012	216392	29315	19657	48971	7153	56124
2013	192406	23985	17311	41297	7153	48450
2014	173065	19341	15393	34733	7153	41887
2015	156374	16691	13845	30536	7153	37690
2016	141690	14684	12510	27194	7153	34347
2017	125832	15858	11335	27194	7153	34347
2018	108705	17127	10067	27194	7153	34347
2019	90208	18497	8696	27194	7153	34347
2020	70231	19977	7217	27194	7153	34347
2021	48656	21575	5618	27194	7153	34347
2022	27381	21274	3892	25167	7153	32320
2023	11959	15422	2190	17613	7153	24766
2024	3470	8489	957	9446	7153	16599
2025	0	3470	278	3748	7153	10901
2026	0	0	0	0	7153	7153
2027	0	0	0	0	7153	7153
2028	0	0	0	0	7153	7153
2029	0	0	0	0	7153	7153
2030	0	0	0	0	7153	7153
2031	0	0	0	0	7153	7153
2032	0	0	0	0	7153	7153
2033	0	0	0	0	7153	7153
2034	0	0	0	0	7153	7153

Table 10.11.8 ESTIMATED BALANCE SHEET (H=55 M, P.C BRIDGE)

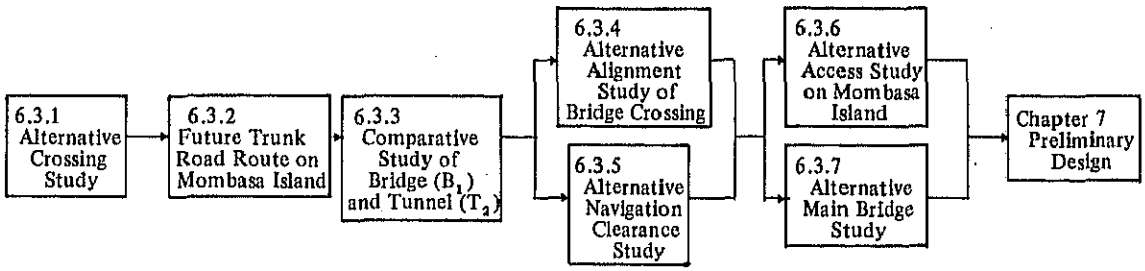
Year	Fixed Asset	Current Asset	Deficit of This Year	Debit Side Total	Long Term Debt	Depreciation Allowance	Short Term Debt	Capital Surplus	Net Profit of This Year	Credit Side Total
1985	7300	0	0	7300	7300	0	0	0	0	7300
1986	14478	243	706	15427	14600	122	706	0	0	15427
1987	33184	1436	1458	36078	33549	365	2164	0	0	36078
1988	107974	4012	3387	115373	108898	924	5551	0	0	115373
1989	170597	11029	10897	192523	173336	2739	16448	0	0	192523
1990	208915	27704	17852	254471	214383	5628	34460	0	0	254471
1991	238159	52708	23033	313900	246872	9204	57824	0	0	313900
1992	234037	83986	0	318023	246099	13326	52239	0	6358	318023
1993	229814	85873	0	315787	243619	17449	44163	0	10556	315787
1994	225791	83563	0	309354	239531	21572	33161	0	15090	309354
1995	221668	76718	0	298387	234216	25695	18490	0	19986	298387
1996	217546	65631	0	283177	227759	29817	0	327	25274	283177
1997	233322	96625	0	329947	240685	33940	0	24338	30985	329947
1998	303035	129944	0	432979	307320	38394	0	52035	35229	432979
1999	377531	159015	0	536546	379373	44085	0	78495	34594	536546
2000	426448	187754	0	614202	426532	51112	0	103134	33424	614202
2001	455283	220496	0	675779	453838	59071	0	128258	34612	675779
2002	446710	249941	0	696652	443157	67644	0	151714	34137	696652
2003	438138	291553	0	729690	430000	76216	0	181016	42458	729690
2004	429565	337206	0	766772	414038	84789	0	216499	51445	766772
2005	420993	388286	0	809279	395577	93361	0	259189	61151	809279
2006	412420	446062	0	858482	374835	101934	0	310080	71633	858482
2007	403847	512679	0	916527	352434	110507	0	370632	82954	916527
2008	395275	588844	0	984119	328241	119079	0	441619	95180	984119
2009	386702	675320	0	1062023	302112	127652	0	523874	108384	1062023
2010	378130	774420	0	1152550	274636	136224	0	619044	122645	1152550
2011	369557	887153	0	1256711	245706	144797	0	728161	138047	1256711
2012	360985	1016984	0	1377968	216392	153369	0	853527	154681	1377968
2013	352412	1176768	0	1529180	192406	161942	0	1002187	172645	1529180
2014	343840	1366680	0	1710519	173065	170515	0	1174892	192047	1710519
2015	335267	1584396	0	1919663	156374	179087	0	1371202	213000	1919663
2016	326694	1830435	0	2157129	141690	187660	0	1592148	235631	2157129
2017	318122	2100375	0	2418496	125832	196232	0	1836361	260071	2418496
2018	309549	2396128	0	2705677	108705	204805	0	2105701	286467	2705677
2019	300977	2719760	0	3020737	90208	213377	0	2402178	314974	3020737
2020	292404	3073502	0	3365906	70231	221950	0	2727953	345762	3365906
2021	283832	3459761	0	3743592	48656	230523	0	3085401	379013	3743592
2022	275259	3885192	0	4160451	27381	239095	0	3479051	414924	4160451
2023	266686	4363985	0	4630671	11959	247668	0	3917337	453708	4630671
2024	258114	4901634	0	5159748	3470	256240	0	4404443	495595	5159748
2025	249541	5497909	0	5747451	0	264813	0	4941805	540832	5747451
2026	240969	6153600	0	6394569	0	273385	0	5531494	589689	6394569
2027	232396	6865964	0	7098360	0	281958	0	6173948	642454	7098360
2028	223824	7639536	0	7863360	0	290531	0	6873389	699441	7863360
2029	215251	8479212	0	8694463	0	299103	0	7634375	760986	8694463
2030	206679	9390282	0	9596960	0	307676	0	8461829	827455	9596960
2031	198106	10378450	0	10576560	0	316248	0	9361070	899241	10576560
2032	189533	11449900	0	11639430	0	324821	0	10337840	976771	11639430
2033	180961	12611280	0	12792240	0	333393	0	11398340	1060502	12792240
2034	172388	13869780	0	14042170	0	341966	0	12549270	1150932	14042170

CHAPTER 11 TOTAL EVALUATION

CHAPTER 11 TOTAL EVALUATION

11.1 Study Conducted

The study process conducted for this project is shown in Fig. 1.1.1 and the scope of work attached in the Main Report. In the study the alternative studies were rather complicated and to simplify the study process the work flow used is shown in Fig. 11.1.1.



Note: The figures in the boxes indicate paragraph number in the Report.

Fig. 11.1.1 ALTERNATIVE STUDY PROCESS

The result of each alternative study is described in the respective paragraph in chapter 6 and is summarized as follows:

- Future trunk road on Mombasa island has advantages if located on the Nairobi-Mombasa Railway side of the city, which is the land use boundary between the Port and industrial area and the residential area. The route has also advanteges on forming the future trunk road network to Malindi and traffic distribution to local arteries.

- The comventional tunnel (T_2) is not selected due to poor soil condition (silty sand and dense sand), traffic service to the island, cost, environmental effects, etc.

- The bridge crossing (B_1) through the narrowest channel portion of Kilindini Harbour is selected due to the merits of vehicle running cost, small environmental effect on coastal resort and high class residences, etc.

- The cable-stayed bridge with 830 m total length (93 +92 + 460 + 92 + 93 m) is selected as the main bridge due to the most suitable span ranges, aesthetic merits, cost, etc.

- The project road has an advantage if constructed in two stages. Three access alternatives are selected according to the navigation clearance. Considering the effects of traffic distribution and road planning aspects, the highest clearance (H = 73.2 m) accesses to the intersection of Mbaraki and Nyerere Ave. on Mombasa island and the lower clearance (H = 55 and 45 m) accesses Nyerere Ave. in Phase-I. In Phase-II all alternatives extend to Mbaraki Road (the direction of future trunk road).

  On the Likoni side all alternatives start from the intersection of Lunga Lunga Road (A-14) and Mtongwe Road in Phase-I, and extend to the south in accordance with the Mombasa transportation plan.

11.2 Total Evaluation

The alternatives, immersed tube tunnel and bridge (P.C & Steel main bridge) are totally evaluated from regional development, traffic distribution, navigation clearance, cost and economic evaluation. The immersed tube tunnel (T_2) was reviewed on the planning conditions (the same conditions; traffic volume, pedestrian, etc. as of bridge alternative) and cost in Appendix I.

1) Regional Development

The regional development plan recommended that the South Mainland has the highest priority for regional development. There are two key areas to be developed; Dongo Kundu Area (including Mtongwe) and the coastal Area along the Indian Ocean.

Observing the route location of tunnel (T_2, Lunga Lunga Road) and bridge (B_1, 700 m east of Lunga Lunga Road) alternatives, the tunnel route has marginally less effect on the development of the coast belt, compared with the bridge route. The development effects for the Dongo Kundu area of both routes are almost same due to the distance of 6 km and 6.7 km to the area.

2) Traffic Distribution

This is a more important subject for Mombasa island than for the South Mainland. The bridge alternatives (navigation clearance H = 55 and 45 m) access to Nyerere Ave in Phase-I (major traffic flow to CBD) and extend to Mbaraki Road in Phase-II. These road plans are evaluated to give a quite reasonable traffic distribution.

The tunnel alternative (Immersed tube tunnel, T_2) has a longer access than the bridge alternative and the tunnel portal reaches Archbishop Makarios Road. This results in less traffic service to CBD in Phase-I, and further the tunnel does not serve pedestrians as well as the bridge.

3) Navigation Clearance

The navigation clearance of 73.2 m (240 feet) vertical clearance, 1,100 feet width and 45 feet depth was originally instructed for the ship's passage in the Kilindini channal. For the project feasibility purpose the lower clearance of 55 and 45 m are also studied.

The tunnel alternative is not affected by the required clearance. For the bridge alternatives, the highest clearance (h = 73.2 m) has the best advantages for all conceivable passing vessels, 55 m clearance for commercial and passenger ships and the lowest of 45 m for commercial ships.

4) Cost

The project costs for construction including land acquisition and compensation engineering fee and contingency are estimated for all alternatives as shown in Table 11.2.1. The maintenance and operating costs are also estimated as shown in Table 11.2.2.

Table 11.2.1 ALTERNATIVE PROJECT COSTS

(Unit: 1,000 K.Shs.)

Alternatives \ Phase & Currency Portion	Phase–I			Phase–II			Total
	L.C	F.C	Sub-total	L.C	F.C	Sub-total	
P.C Main Bridge							
73.2 M	370,533	1,440,138	1,810,671	306,757	1,065,541	1,372,298	3,182,969
55	234,359	842,599	1,076,958	278,995	969,824	1,248,819	2,325,777
45	203,123	722,390	925,513	229,361	827,611	1,056,972	1,982,485
Steel Main Bridge							
73.2 M	380,371	1,464,339	1,844,710	306,757	1,065,541	1,372,298	3,217,008
55	265,628	965,505	1,231,133	310,235	1,092,698	1,402,933	2,634,066
45	236,070	851,995	1,088,065	262,275	957,187	1,219,462	2,307,527
Tunnel (Immersed Tube Tunnel)	607,684	2,179,936	2,787,620	521,510	2,086,040	2,607,550	5,395,170

Table 11.2.2 MAINTENANCE COSTS

(Unit: 1,000 Shs, 1983 Price)

Alternative \ Phase \ Value			Phase–I		Phase–II	
			Financial Cost	Economic Cost	Financial Cost	Economic Cost
Bridge Clearance	73.2M	P.C	3,452	3,176	8,272	7,610
		Steel	4,782	4,399	9,602	8,834
	55M	P.C	3,205	2,949	6,797	6,253
		Steel	4,275	3,933	8,937	8,222
	45M	P.C	3,085	2,838	6,186	5,691
		Steel	4,154	3,822	8,326	7,660
Tunnel			10,500	9,660	16,000	14,720

Note: The conversion factor of 0.92 (SCF) to be used.

For both costs the tunnel is the highest among the alternatives, and the bridge alternative of 45 m clearance is the lowest.

For the main bridge, P.C construction has the advantage of the lowest construction and maintenance costs.

5) Operation

Observing the existing traffic conditions, vehicle maintenance and traffic rules are the basic requirement to realize safe and comfort of the traffic either on a bridge or tunnel. Especially in the tunnel these aspects are essential to avoid the incidents leading to serious damage to the structure and long stoppage of traffic.

To ensure the everyday operation of the tunnel, stable supply of electric power is another essential aspect due to many facilities installed to the tunnel, since the bridge has less problem in this respect.

6) Economic Evaluation

With respect to the economic evaluation, the benefit – Cost analyses for the project were carried out based on the implementation schedule and the cost estimate.

The benefits were calculated for the vehicle operating cost savings, the time cost savings and the flow effect of the investment. But the benefit from the regional development was not considered.

A total of 8 alternatives were evaluated for bridge and tunnel alternatives including phasing and navigation clearance. The sensitivity analysis for the case of the 55 m clearance and P.C main span, was conducted for economic cost, benefit and project life span.

Currently the general market interest rate in Kenya is around 16%. This rate includes an inflation hedge. The substantial interest rate of approximately 10% is used excluding the inflation hedge.

The evaluation results are presented in Table 11.2.3 and 11.2.4. According to Table 11.2.4, Case B is the outcome of calculation under un-imageable condition and if it is put aside of consideration all other cases indicate approx. more than 10%. Because of this the project may be regarded as feasible.

Table 11.2.3 ECONOMIC INTERNAL RATE OF RETURN

(Economic IRR)

Alternative	Bridge Clearance			Tunnel
	H = 45 M	H = 55 M	H = 73.2 M	
Non-staged Construction	0.1025	0.0887	0.0585	0.0536
Staged Construction	0.1190	0.1055	0.0600	0.0561

Note : IRR of bridge alternatives are estimated for the cases of P.C main bridge.

Table 11.2.4 SENSITIVITY ANALYSIS FOR 55 M CLEARANCE, P.C MAIN BRIDGE

Case	Cost +10%	Benefit −10%	Evaluation Period + 9 Years	EIRR
A	O	–	–	0.098
B	O	O	–	0.088
C	–	–	O	0.112
D	O	–	O	0.104

Note: "O" means the case conducted for sensitivity analysis.

7) Total Evaluation

Total 11 alternatives are evaluated based on the description made above as shown in Table 11.2.5. The evaluation is made using A, B, C, D.

Table 11.2.5 TOTAL EVALUATION

Item \ Alternative	Bridge Alternative			Immersed Tube Tunnel
	H=73.2M	H=55M	H=45M	
1) Regional Development	A	A	A	A
2) Traffic Distribution	B	A	A	C
3) Navigation Clearance	A	B	C	A
4) Cost	C	B	A	D
5) Operation	C	B	A	D
6) Economic Evaluation	D	B	A	D

Note: Mark "A" is evaluated as the highest value, and "D" the lowest.

As a result, the bridge alternative of 55 m or 45 m is evaluated to have a favourable aspect on average.

On the other hand, within the concept of the bridge alternative, although PC bridge alternative indicates lower cost slightly as compared with the steel bridge alternative the difference between the two can not be regarded as decisive factor.

11.3 Recommendations

1) The cable stayed bridge with the navigation clearance of less than 55 m is technically and economically feasible.

2) A toll levy system should be introduced considering the Government financial situations. The toll rate should be determined by the Government.

   The project is financially viable disclosing a financial IRR of 13.8% where the toll rate at 5 shilling/car and light goods vehicles per one way crossing, covering the maintenance and operation costs and local currency portion of the project road.

3) The staged construction method for the number of traffic lanes is used for the project road implementation, and is based on the evaluation of the investment cost and traffic demand.

4) The Project road forms part of the future international/national trunk road. In order to enhance the regional activities through smooth traffic distribution, it is necessary to construct the trunk road extension and its related local arteries. Among the related road construction projects, some fly-overs on the trunk road including a missing link behind Mombasa station and inner ring road are to be separately executed from the Project road.

5) The Phase-I Project has urgent objectives, with a scope for a 2-lane road 5.3 Km long, including a 2.0 Km bridge. The Phase-II will be executed in accordance with the traffic demand and the Project related road construction (the trunk road and Inner Ring Road, etc.).

11.4 Future Subjects

In this study there are two major subjects; the navigation clearance controlling the future port function and the main bridge design involving high technical judgement. These subjects remaine undetermined in this study but are indispensable pre-conditions for the detailed design. Therefore these should be fully investigated prior to starting detailed design.

1) Subject for Navigation Clearance

In this study the navigation clearance of Kilindini Harbour was investigated to some extent using the data on the future port prospects and on previous ship visits. The clearance is a political Governmental matter and should be determined from many complehensive aspects.

2) Considerations to the Main Bridge

The Cable Stayed Bridge proposed in this Study will be ranked as one of the longest bridges in the world, which will involve high level of technology, consequently in determining the type of material for the bridge (either PC or steel), a further study should be carried out thoroughly on invididual structural characteristics, wind effects (based on the wind tunnel test), economy, reliability and maintenance aspects.

On one hand, a question with regard to whether a staged construction method for the main bridge should be employed or not, under normal circumstance, will await determination that can be made on the basis of the economy as well as the traffic demands envisaged, however, in case of this proposed main bridge having a long span (particularly in case of steel structure), the matter will significantly effect upon the structural characteristics and economy. Because of this, in determining the type of material for the main bridge (either PC or steel), it would be necessary to re-evaluate the staged construction method.

ANNEX :

STUDY PARTICIPANTS

1) Ministry of Transport and Communications

1.	Mr. W.P. WAMBURA	Permanent Secretary
2.	Mr. J.K. KIRIKA	Engineer-in-Chief
3.	Mr. S.M. KIGURU	Chief Engineer (Roads & Aerodromes)
4.	Mr. S. ASFAW	Chief Engineer (Planning)
5.	Mr. D.M. MWASI	Chief Executive Engineer
6.	Mr. G. WABUKE	Chief Superintending Engineer (Construction)
7.	Mr. S.N. OTONGLO	Chief Superintending Engineer (Design)
8.	Mr. C.M. KAMAU	Provincial Engineer, Coast Province
9.	Mr. T. KAI	Senior Superintending Engineer (Bridges)
10.	Mr. T. KNOTTEN	Senior Superintending Engineer (Bridges)
11.	Mr. L. BLOM-BAKKE	Senior Superintending Engineer (Bridges)
12.	Mr. J.M. WANYOIKE	Senior Superintending Engineer (Design)
13.	Mr. Y. MAEKAWA	Superintending Engineer (Bridges)
14.	Mr. O. MOKRID	Superintending Engineer (Design)
15.	Mr. P.M. WAKORI	Superintending Engineer (Planning)
16.	Mr. M.E. AGALOCHIENG	O/ic Traffic Engineering Unit
17.	Mr. J.P. MURAGURI	Assistant Engineer (Counterpart Staff) (Bridges)
18.	Mr. F.D. KARANJA	Assistant Engineer (Planning)
19.	Mr. P.M. OJWAKA	Assistant Engineer (Bridges)
20.	Mr. V.B. OCHIENG	Assistant Engineer (Planning)
21.	Mr. KLEM	Material Branch

2) Kenya Railways

1.	Mr. IKAMBA	Traffic Section
2.	Mr. M. ARSHAD	District Civil Engineer

3) Kenya Ports Authority

1.	Mr. B.A.O. ONGOLA	Chief Planning Officer
2.	Mr. A.O. ROGO	Chief Engineer
3.	Mr. A.P. BURNARD	Chief Engineer (Special duties)
4.	Mr. E.T. WAIYAKI	Secretary & Leagal Officer
5.	Mr. A.C. MUMBA	Principal Planning Officer
6.	Mr. E.A. KARANGA	Operations Manager
7.	Mr. A.J. KENTOYO	Senior Harbour Master

4) Mombasa Airport

1.	Mr. E.N. NYARANGI	Airport Manager
2.	Mr. P.B. YATICHI	Airport Assistant Manager
3.	Mr. S. MAGALASIA	Senior Meteorological Officer

5) Mombasa Municipality

1. Mr. P.C. PATEL	Municipal Engineer
2. Mr. KIAYE	Chief Planner
3. Mr. T. MBOGHOLIO	Chief Evaluer
4. Mr. H. SINGH	Road Engineer

6) Japanese Team

(1) Supervisory Committee

1. Mr. TAKESHI NAKAYAMA	Head of Mukaijima Construction Office Honshu Shikoku Bridge Authority
2. Mr. TAKASHI MATSUURA	Deputy Director of Construction Constructor Division, Planning Bureau (MOC)
3. Mr. KAZUYA OHSHIMA	Head of Foundation Engineering Division, Public Works Research Institute (MOC)
4. Mr. KOICHIRO KUMAGAI	Deputy Director of the Local Road Division Road Bureau (MOC)
5. Mr. KENJI MURAOKA	Deputy Head of the Tokyo Bay Crossing Bridge and Tunnel Planning Section Planning and Research Department Japan Highway Public Corporation

(2) Embassy of Japan

1. Mr. TAKAYOSHI HAGIO	First Secretary

(3) JICA

1. Mr. SUSUMU YANAI	President Representative of JICA, Nairobi Office
2. Mr. TOSHIKAZU NAGASHIMA	Deputy President Representative of JICA, Nairobi Office
3. Mr. TETSUO KOMATSUBARA	Project Coordinator, JICA Tokyo

(4) Study Team

1. Mr. GIICHI KATAOKA	Team Leader Pacific Consultants International (PCI)
2. Mr. YOSHINOBU NOMURA	Team Member, Traffic Planner, PCI
3. Mr. ISAMU GUNJI	Team Member, Traffic Survey, PCI
4. Mr. HIDEO ARIKAWA	Team Member, Traffic Analysis, PCI
5. Mr. YAICHI KOBAYASHI	Team Member, Economist, PCI

6.	Mr. HIDEMOTO NOJIMA	Team Member, Highway Engineer, PCI
7.	Mr. YASUHARU OHGA	Team Member, Bridge Engineer, PCI
8.	Mr. TAKEHARU OGIWARA	Team Member, Structure Engineer, PCI
9.	Mr. KOHJI OHI	Team Member, Facility Engineer, PCI
10.	Mr. SHOSUKE ITO	Team Member, Soil Engineer, PCI
11.	Mr. MASAO OHWADA	Team Member, Tunnel Engineer, PCI

MINUTES OF DISCUSSIONS BETWEEN MINISTRY OF TRANSPORT AND COMMUNICATIONS STAFF AND JAPANESE PRELIMINARY SURVEY TEAM CONCERNING THE PROPOSED KILIFI BRIDGE AND LIKONI CROSSING ~~STUDIES~~ IN KENYA (T.IV)
STUDIES

1. PREAMBLE

i) The Japanese Government, on the request of Kenyan Government dispatched a preliminary survey team to Kenya from October 31st to 12th November, 1982 through programme arranged by Japan International Cooperation Agency (JICA); in order to carry out preliminary survey for the planned study of KILIFI BRIDGE and LIKONI Crossing.

ii) The team carried out field surveys and had a series of discussions with the Kenyan Authorities concerned during their stay in the country. The main items on which understandings were reached by both sides were shown in the following paragraphs:

2. ITEMS CONCERNING THE SCOPE OF WORK:

i) Draft Scope of Work proposed by the Team was discussed in detail and agreed upon as attached herewith.

ii) The Japanese Government will dispatch two teams for the full scale studies. One team is for KILIFI Bridge and the other one is for LIKONI Crossing.

iii) Concerning article VI.3 of the attached scope of work, offices with telephone will be provided for each Study Team in NAIROBI and MOMBASA during the Teams' stay in Kenya.

iv) The Kenyan Team asked the Japanese Team to consider two alternatives for the Likoni Crossing feasibility study namely; a high level bridge with a clearance of 76.2m above high water tide and a tunnel. Both sides agreed upon this issue.

v) Kenyan Team and Japanese Team agreed that as the study progresses more attention will be focused on the alternative which appears (T.I) to be technically and financially more feasible.

3. TRAINING OF ENGINEERS

On the request of the Kenyan Team the Japanese Team agreed to convey to the Japanese Authorities concerned to accept Kenyan counterparts in Japan for training scholarships on related courses.

4. LIST OF PARTICIPANTS

Japanese Team

1.	Mr. Takeshi NAKAYAMA	Leader Director of the Second Engineering Division First Engineering Department Honshu Shikoku Bridge Authority
2.	Mr. Koichiro KUMAGAI	Road Planner Deputy Director of the Local Road Division Road Bureau Ministry of Construction
3.	Mr. Kenji MURAOKA	Bridge Planner Deputy Head of the Tokyo Crossing Bridge & Tunnel Planning Section Planning & Research Department Japan Highway Public Corporation
4.	Mr. Kimiaki YAMAGUCHI	Coordinator Japan International Cooperation Agency (JICA)
5.	Mr. Takayoshi HAGIO	First Secretary of Japanese Embassy
6.	Mr. Toshikazu NAGASHIMA	Deputy Resident Representative JICA NAIROBI OFFICE

Kenyan Team

1.	Mr. W.P.WAMBURA	Chief Engineer (Roads and Aerodro
2.	Mr. S.N. OTONGLO	Chief Superintending Engineer (Design)
3.	Mr. T. KNOTTEN	Senior Superintending Engineer (Bridges)
4.	Mr. T. KAI	Senior Superintending Engineer (Bridges)
5.	Mr. S. ASFAW	Chief Engineer (Planning)

5. ADOPTION OF MINUTES

The minutes were reviewed thoroughly after which they were adopted as reflecting the true record of the understandings reached by both sides.

Takeshi Nakayama

TAKESHI NAKAYAMA
Leader of Japanese
Preliminary Survey Team

Date. NOV. 11, 1982

W.P. WAMBURA
Chief Engineer (Roads and Aerodro
Ministry of Transport & Communicati
Republic of Kenya.

Date. Nov. 11, 1982

SCOPE OF WORK

FOR

THE FEASIBILITY STUDY ON

PROPOSED KILIFI BRIDGE & LIKONI CROSSING

CONSTRUCTION PROJECT

IN

THE REPUBLIC OF KENYA

AGREED UPON

BETWEEN

MINISTRY OF TRANSPORT AND COMMUNICATIONS

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

DATED : NOVEMBER 1982

S.J. MBUGUA
PERMANENT SECRETARY
MINISTRY OF TRANSPORT & COMMS.
P.O. BOX 52692
NAIROBI

TAKESHI NAKAYAMA
LEADER OF THE PRELIMINARY
STUDY TEAM

COUNTERSIGNED

PERMANENT SECRETARY
MINISTRY OF FINANCE
TREASURY
NAIROBI

I. INTRODUCTION

In response to the request of the Government of the Republic of Kenya, the Government of Japan has decided to conduct feasibility studies on the KILIFI BRIDGE AND LIKONI CROSSING CONSTRUCTION PROJECTS (hereinafter referred to as "the Studies"), in accordance with laws and regulations in force in Japan and Kenya. The Japan International Cooperation Agency (hereinafter referred to as "JICA") the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will carry out the Studies in close cooperation with the Ministry of Transport and Communications (hereinafter referred to as MOTC) of the Republic of Kenya.

This Scope of Work was set forth in accordance with the results of the JICA's preliminary studies on the captioned projects in November 1982.

II. OBJECTIVE

The objective of the Studies are

To carry out feasibility studies for the construction of KILIFI BRIDGE and LIKONI CROSSING including their approaches and connecting roads.

III. SCOPE OF THE STUDIES

In order to achieve the above objective the JICA will carry out following studies taking alternatives into consideration.

1. Traffic and Socio-Economic Studies
   (a) Traffic data collection, traffic survey and analysis
   (b) Socio-economic data collection and analysis

(c) Review of population and socio-economic conditions

(d) Forecast of future traffic demand

2. Engineering Studies

(a) Topographic map collection

(b) Engineering data collection and analysis

b-1 soil and geological data

b-2 hydrological and hydrographic data

b-3 materials data

b-4 meteorological data

(c) Surveying

c-1 soil and geological surveying including drilling & testing.

c-2 Hydrographic surveying (cross-sectional surveying, etc.)

(d) Design criteria

d-1 geometric design standards

d-2 structural design standards

(e) Engineering works

e-1 design works

e-2 quantity estimation

(f) Construction Program

f-1 construction method

f-2 construction schedule

(g) Cost estimates

g-1 right-of-way aquisition cost

g-2 construction cost

g-3 maintenance cost

3. Economic Evaluation

(a) Estimates of benefit

(b) Estimates of NPV, IRR, and B/C

(c) Sensitivity analysis

4. Budgetal and Financial Studies

5. Implementation Program

An implementation program will be prepared based on the construction program and the study of budgetal and financial aspect.

IV. STUDY SCHEDULE

The survey will be conducted according to the tentative schedule attached hereto as Appendix I, II.

V. REPORTS

JICA will prepare and submit to the Government of Kenya the following reports in English.

1. Inception Report (30 copies)
   within one month after the outset of the study in Kenya
2. Progress Report (30 copies) every three months during course of the study in Kenya
3. Interim Report (30 copies) at the end of the study in Kenya
4. Draft Final Report (30 copies)
   within four months after presentation of Interim Report
5. Final Report (100 copies)
   within two months after receiving comments by the Government of Kenya on the said Draft Final Report.

VI. UNDERTAKINGS BY THE GOVERNMENT OF KENYA

1. To furnish the Study Team with available relevant data, information, materials and conveniences of availing data processing devices for execution of the Studies.

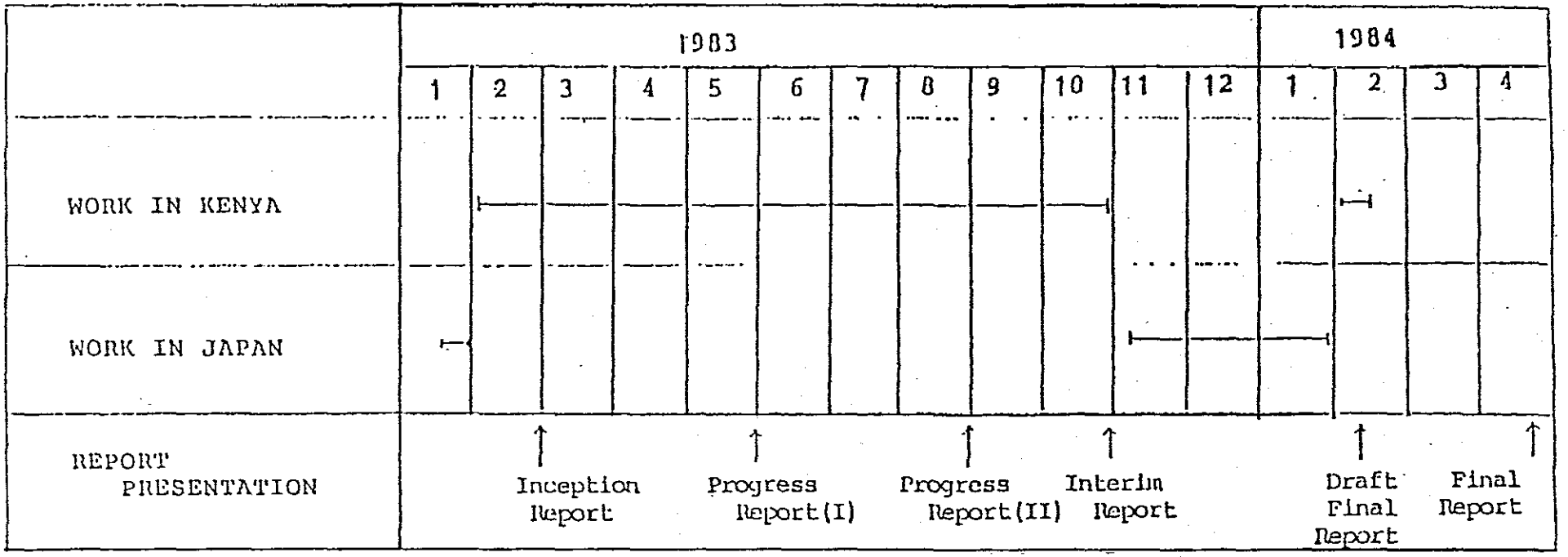
2. To exempt the Study Team from any taxation or duty on the income and any other emoluments as well as equipment, materials and personal effects which are to be brought into Kenya in connection with the Studies.

3. To provide the Study Team with appropriate office space, office equipment and clerical services for the Studies.
4. To appoint counterpart personnel for execution of the Studies well as effective transfer of expertise.
5. To secure the security of the Study Team when and as it is required.
6. To assist the Study Team in securing other facilities and conveniences which are deemed necessary for the accomplishment of the Studies.
7. To provide identification card to the members of the Japanese Study Team for the execution of their activities.

I. UNDERTAKINGS OF THE GOVERNMENT OF JAPAN

1. To delegate a full-scale Study Team to Kenya to conduct the Studies and to bear all expenses for the Studies.
2. To bear travel expenses and fares between Japan and Kenya and those necessary for moving in Kenya as well as charges of accommodation and living expenditure for the members of the Study Team.
3. To bear expenses necessary for the telecommunications between Japan and Kenya which stem from the Studies.
4. To transfer to Kenya counterpart personnel the technology and expertise related to the Studies.
5. To provide the Study Team with transport (vehicles & drivers).

TENTATIVE WORK SCHEDULE OF LIKONI BRIDGE



TENTATIVE WORK SCHEDULE OF KILIFI BRIDGE