Chapter 6

Selection of High Priority Roads

Chapter 6 Selection of High Priority Roads

The candidate routes for the High Priority Roads are selected from the viewpoints of enhancement of the local economy and improvement of accessibility on the basis of the development criteria mentioned in Section 4.3.2.

6.1 Local Economy Enhancement

(1) Candidate Routes

As mentioned in Section 4.3 "Development Criteria for Rural Roads", the following six routes, including alternatives, were designated as the important ones for fish transport to enhance the local economy.

1 From Port Victoria to B1

1-1 D251-D250-C30
1-2 C29-C90-B1
1-3 C27-B1

2 Usigu to Bondo (C27)

3 Luanda Kotieno to Siaya

2-1 C28-D246-Siaya-C29-B1
2-2 C28-D254-C27

4 Mbita to Homa Bay (C19)

5 Karungu to Homa Bay (C18)

6 Muhuru to A1 (C13)

(2) Criteria to Select the High Priority Routes

The following five evaluation criteria were applied for the selection of the high priority roads.

a) Overlapping Route

Priority should be given to the routes selected by both Accessibility Index analysis and local economy enhancement.

b) Earth and Gravel Roads

Bitumen roads should be excluded since the bitumen roads would be expected to be repaired and maintained under the current road maintenance scheme.

c) Other than El Nino Disaster Rehabilitation Projects

The El Nino disaster rehabilitation projects should be excluded to avoid from double investment.

d) High Priority Roads on the District Development Plan

The high priority roads designated in the District Development Plan should be taken into consideration (see Fig. 4.4.1).

e) Fish Transport

Priority should be given to the candidate routes which are connected to landing beaches having dominant fish products.

(3) High Priority Roads for Local Economic Enhancement

Considering the criteria mentioned above, the candidate routes were evaluated as shown in Table 6.1.1.

Table 6.1.1 Evaluation of the Roads

	Routes with alternatives	Overlapping routes	Earth/Gravel Rds	Other than El Nino Rehabilitation	High Priority on DDP	Fish Products	Evaluation
1	From Port Victoria						
	1-1 D251-D250-C30		O	O	O	O	O
	1-2 C29-C90-B1		O	O	O	O	Δ*1
	1-3 C27-B1			O		O	
2	Usigu to Bondo		O	O			
3	Luanda Kotieno to Siaya						
	3-1 C28-D246-Siaya-C29-B1	O	O	O			
	3-2 C28-D254-C27		O	O			
4	Mbita to Homa Bay(C19)	O	O	O	O	Δ	O
5	Karunga to Homa Bay(C18)			O			
6	Muhuru to A1(C13)			O	O		

Note: *1) 1-1 and 1-2 are almost the same but 1-2 is a little bit longer in distance.

O indicates applicable

Δ indicates partly applicable

2) High Priority Roads

According to the evaluation, the route from Mbita to Homa Bay (C19) was ranked the highest in priority since this route satisfied almost all the basic criteria mentioned above, though the volume of fish products is somewhat lower than at Port Victoria.

As for the routes from Port Victoria to the trunk roads, 1-1 and 1-2 are placed at almost the same priority level. However, the route1-1 (D251-D250-C30) had a shorter distance than route 1-2 (C29-C90-B1). Consequently, the route1-1 (D251-D250-C30) and the Mbita to Homa Bay (C19) route were selected as high priority roads based on the enhancement of the local economy perspective.

6.2 Improvement of Accessibility for Residents

(1) Candidate Routes or Areas

Based on the analysis of the Accessibility Index to major public facilities such as administrative centres, major markets and large hospitals, the order of the roads of upper 25th by load factor is shown in Table 6.2.1. These roads are recognised as initial high priority roads from an accessibility point of view.

Table 6.2.1 High Priority Roads Based on Accessibility Index

Sq. No.	Rd. No.	Accessibility Index	Section	Distance (Km)	Surface Condition
1	C20	83	Homa Bay - C19	2.4	Gravel/Earth
2	C19	50	C20-D213	10.7	Gravel/Earth
3	D246	41	C29 (Siaya)-	18.6	Gravel/Earth
4	C31	38	B1-D256	14.8	Bitumen
5	C20	33	C19 - C18	9.8	Bitumen
6	C29	21	East Siaya	27.9	Bitumen
7	C13	20	A1 - D210	17.0	Gravel/Earth
8	C17	19	B3 -Ogembo	8.5	Gravel/Earth
9	C43	19	Connecting to D256	22.1	Gravel/Earth
10	D210	19	C13-Karungu	29.9	Gravel/Earth
11	E118	19	C19-D210	10.5	Gravel/Earth
12	C43	16	D256-A1	6.9	Gravel/Earth
13	C19	14	C20-D216	10.2	Gravel/Earth
14	D246	14	Siaya-C28	15.7	Gravel/Earth
15	D256	14	C30-C31	16.5	Gravel/Earth
16	C21	13	Kisii-D222	36.6	Gravel/Earth
17	C27	13	B1-D243	11.3	Bitumen
18	C31	12	D256-C32	8.1	Bitumen
19	C18	11	A1-C20	28.3	Gravel/Earth
20	E211	11	C18-C20	6.0	Gravel/Earth
21	C27	10	West Bondo	24.8	Gravel/Earth
22	C13	9	D202-A1	22.1	Gravel/Earth
23	C18	8	C20-D210	43.7	Gravel/Earth
24	C19	8	For Mbita from D213	29.9	Gravel/Earth
25	E212	8	D216-C18	13.3	Gravel/Earth
Total				445.6	

On the other hand, considering the unavailability of sufficient data and information for the analysis of the rural roads, the Accessibility Index stands as not a definitive one but one of the important indicators. It is, however, obvious that the Accessibility Index is not the primary factor in deciding the road improvement priority. In this view, it can be said that the order tabulated in Table 6.2.1 does not represent the order of independent road sections but rather a relative order of a priority group of roads. In other words, a kind of representative area, where the roads need to be improved from the accessibility perspective.

For instance, Fig. 6.2.1 shows the location of the roads tabulated in Table 6.2.1. identifying the following five areas where the roads need to be improved.

1 Nambale Area
2 Siaya Area
3 Homa Bay Area
4 Kisii Area
5 Migori Area

Consequently, priority has to be determined through comparing the five areas mentioned above.

(2) Priority Criteria for Areas

The following different criteria from those being used in examination on local economic enhancement were introduced in order to analyse the improvement priority from the accessibility viewpoint.

a) Establishment of Bitumen Road Network

While applying the criteria to analyse the order of priority among the areas, it is essential to appreciate the urgent need to fill in missing links on the bitumen road network, in order to develop a comprehensive bitumen road network. This can be expected to greatly contribute to the improvement of regional accessibility and integration.

b) Priority According to the District Development Plan Perspective

Each district has a District Development Plan showing the development priorities of roads (see Fig. 6.2.2). In the plan, the first priority is attached to roads connecting to the major towns and / or the existing trunk roads. The identified first priority roads in the District Development Plans are reasonable

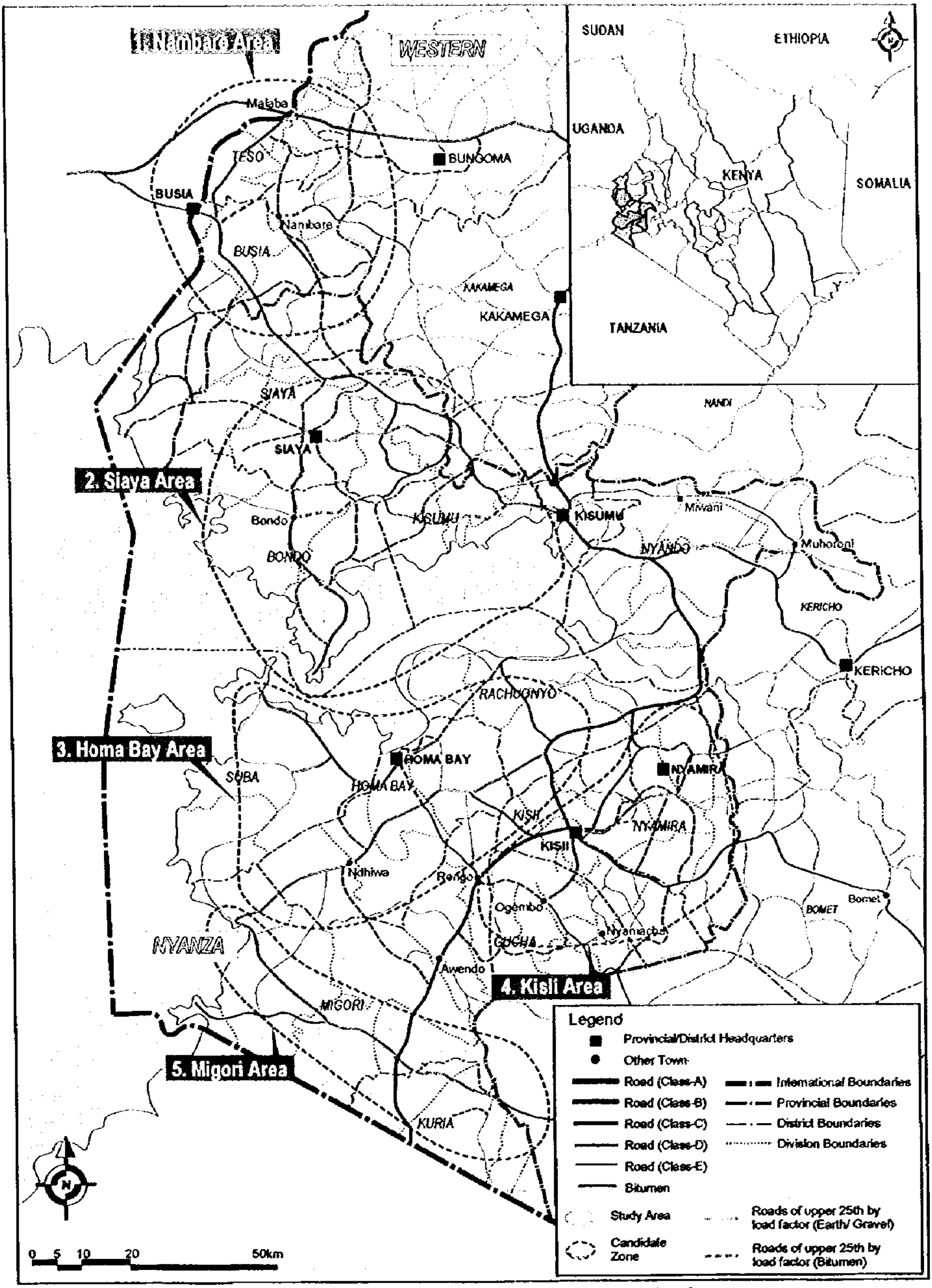

Fig. 6.2.1 The Areas Where Roads to be Improved

and approvable taking into account the effectiveness of the impact generated by road network development. It is, therefore, necessary to take this priority into consideration to select the high priority roads in the Study.

c) Impact on Beneficiaries

When discussing the priority on road improvement among areas, the impact on beneficiaries in the areas becomes crucial. The larger the beneficiaries are, the higher the road priority is.

(3) Evaluation

Table 6.2.2 shows the results of evaluation of the areas where the roads need to be improved from the accessibility viewpoint.

Table 6.2.2 Evaluation from the Accessibility Viewpoint

Areas		Improvement of Missing Links of Bitumen Road Network	Priority on DDP	Beneficaries	Evaluation
1	Nambale Area	O	O	△	△
2	Siaya Area	O		△	
3	Homa Bay Area	△	O	△	
4	Kisii Area	O	O	O	O
5	Migori Area	△	O	△	

Note: O indicates applicable
△ indicates partly applicable

(4) Priority Area

Through the comparison above, Kisii Area was selected as the high priority area. The major points on evaluation are as follows;

a) Dissolution of Missing Links of Bitumen Road Network

An essential point of the criteria is that the establishment of bitumen road network, without doubt, contributes to comfortable and stable transport for users from the viewpoint of accessibility. In this view, the Nambale Area, Siaya Area and Kisii Area were designated from this perspective having high priority. Specifically, although the Kisii Area has a well-developed bitumen road network, the network does not fully function, since the section between Rongo and Ogembo is missing

b) Priority According to DDP Perspective

The District Development Plans show priorities on roads to be improved. However, none of the priority roads in the southern part of Siaya Area have been designated in the District Development Plan. Siaya Area is, therefore, not selected as the High Priority Roads.

c) Impact on Beneficiaries

As illustrated in Chapter 2 "Existing Conditions", Kisii and Nyamira Districts have, in comparison with other areas, dominant population densities as high as 750-1000 persons per km^2 on average.

d) Priority Area

The Kisii Area is, according to the above facts, evaluated as the highest priority area where the roads need to be improved from the viewpoint of improvement of accessibility.

(5) Priority Roads in Kisii Area

The key point to discuss the high priority roads in the Kisii Area is to fill in missing links in the bitumen road network, since this area has comparatively well developed bitumen road network even at present. In addition, this area has a high population density and is comprised of hilly and mountainous terrain, which often makes the roads impassable in the rainy season. The improvement of the road section between Rongo and Ogembo is crucial and this improvement would contribute significantly to the establishment of the regional bitumen road network coupled with serving the daily trips of the residents and tealeaf transport.

6.3 Definitive High Priority Roads

The definitive High Priority Roads were, through the above examination, selected as listed below (see Fig. 6.3.1).

1) Homa Bay – Mbita Road (C19 between Rusinga Island and Homa Bay from C20 to D213 and from D213 to Rusinga Island: L=42.4 km.)

This route was selected for mainly by two reasons. One is its contribution to the improvement of accessibility in the peripheral region, since all the residents have to use this route to go to Homa Bay, which is the centre of the region for shopping, and other daily trips.

Another reason is that the route is expected to improve the transport of fish, which will enhance the local economy. In terms of volume of fish products, Mbita is placed in the second position in the Study Area following Port Victoria.

A causeway of an approximate length of around 300 meters connecting Rusinga Island and the mainland is included in this section. However, the causeway is expected to be improved under the El Nino disaster rehabilitation scheme.

2) From Port Victoria to Bumala (D250/D251/C30 : L=43.0 km.)

Port Victoria shows a dominant position, in terms of volume of fish products, in landing beaches in the Study Area. In the rainy season, many fish products become rotten, since trucks cannot pass through the roads connecting toward inland markets due to muddy condition of the roads. As there are several alternative routes, the priority was given to the establishment of road network coupled with the existing domestic trunk road, B1 in order to ensure prompt accessibility to major inland markets such as in Nairobi and Mombasa.

3) C20 (from Ogembo to Rongo: L=19.0 km.)

The Kisii Area, including Kisii and Nyamira Districts, consists of hilly and mountainous terrain with a high population density. JICA conducted "A Study on Strengthening the District Health System" in this area in 1998. This study revealed a lack of basic health care facilities and insufficient access roads due to its hilly and mountainous topographical condition and few bitumen roads. Especially, this area has higher precipitation in comparison with other regions. Even Matatu cannot provide frequent enough services to meet basic residential demand such as going to referral hospitals due to muddy and rutted conditions in steep longitudinal gradient sections. This condition also makes it difficult for the residents to have access to enough food for their subsistence.

This improvement is expected strongly to support the daily lives of the residents and it will also contribute to filling in the missing link in the bituminous road network in the area.

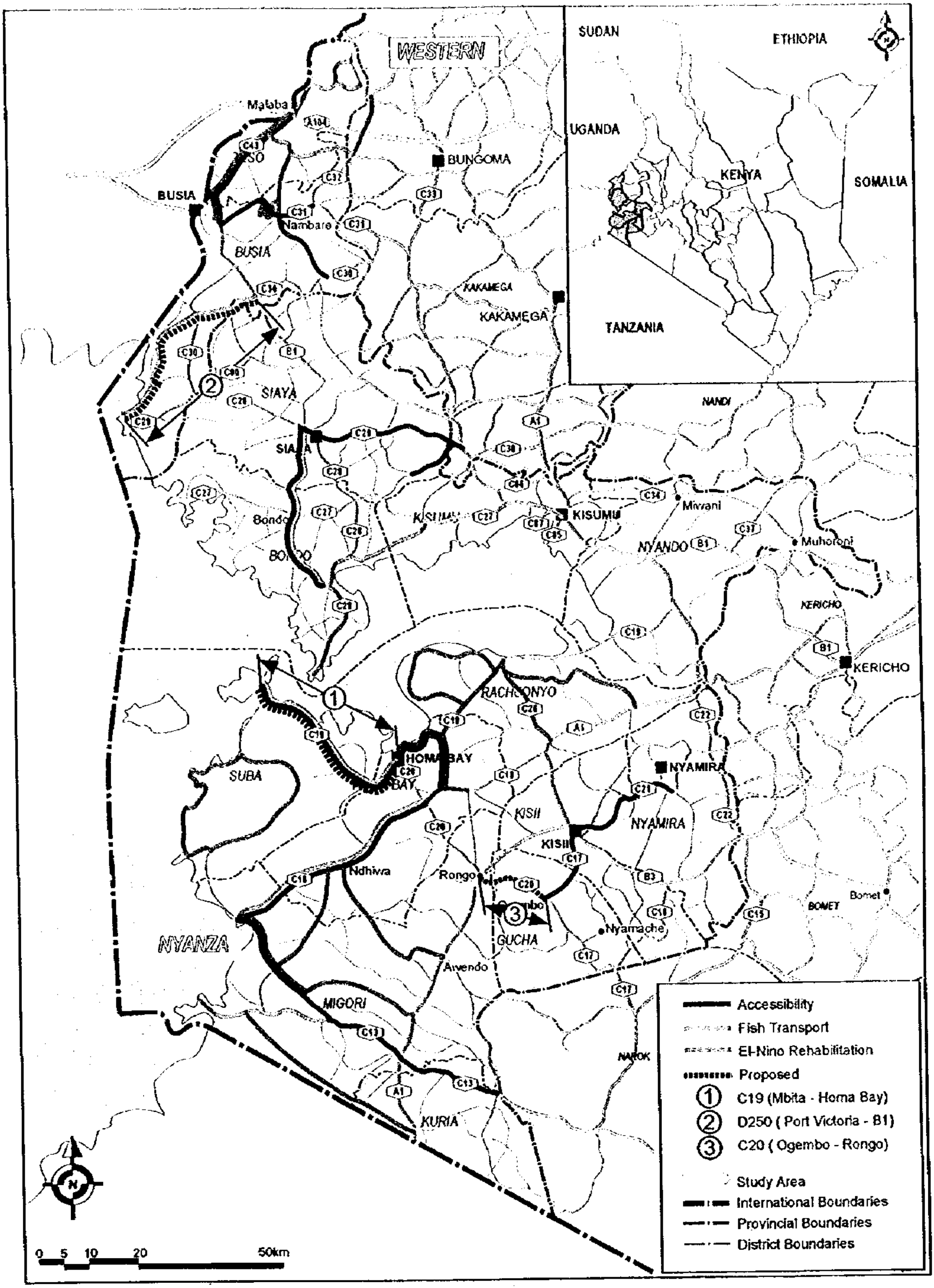

Fig. 6.3.1 Definitive High Priority Roads

6.4 Second Priority Roads

In the previous section of this chapter, high priority roads with a total length of 100 km were selected. Section 6.4 "Second Priority Roads" was prepared in order to discuss the second priority roads following the High Priority Roads, since it would be helpful to have a long list of higher priority roads to be improved over the long term in the Study Area.

However, as the task to decide the priority of all the road sections in the Study Area was not included in the original scope of the work, only the second priority roads were analysed in the section.

(1) Approach of Examination

The basic approach is just same as that of the high priority roads. The second priority group is examined from two viewpoints, local economy enhancement, for which fish transport was the main issue, and the accessibility to major public facilities, for which the load factor was applied, as mentioned in section 4.3.1 "Development Criteria for Rural Roads". In addition, the second priority group was examined from a viewpoint of establishing a bitumen road network, which was also one of the main issues discussed in the priority of the roads.

(2) Fish Transport

Making good use of the outcomes of Section 6.1 "Local Economy Enhancement", the following roads have the second priority from a viewpoint of fish transport as shown in Table 6.4.1.

Table 6.4.1 Second Priority for Fish Transport

Routes	Distance (km)	Surface Condition
1 Usigu to Bondo		
1-1 C27	45.0	Gravel / Earth
2 Luanda Kotieno to Siaya / Kisum		
1-1 D246 - Siaya - C29 - B1	58.7	West side of Siaya is bitumen
1-2 D245 - C27 - B1	67.7	C27 is bitumen
3 Karungu to Homa Bay		
2-1 C18 - C20	35.9	C18 is bitumen
4 Muhuru to A1		
3-1 C13 - A1	47.7	Gravel / Earth

(3) Accessibility to Major Public Facilities

The load factor is also appropriate to discuss the second priority group of the roads. Table 4.3.2 shows the order of the roads from a viewpoint of accessibility to major public facilities.

(4) Establishment of a Bitumen Road Network

Through the "Community Needs Survey" and "Interview Survey" of road users, it was revealed that the establishment of a bitumen road network was crucial to support the daily life of the residents who live in rural areas. In this view, the filling in missing links of the bitumen road network is a focal point. The following were considered as the missing links except the high priority roads.

- C29 (west side of Siaya)
- C27 (Usigu to Bondo)
- D246 (Luanda Kotieno – Bondo- Siaya- B1)
- C19 (Homa Bay to Kendu Bay)
- C26 (Kendu Bay to A1)
- C13 (Muhuru to A1)

(5) Integration of Priority

Although quantitative analysis was not conducted on some evaluation items mentioned above, integration of priority was examined and the following road sections had the second priority.

a) D246 (Luanda Kotieno - Bondo- Siaya- B1)

Bondo is a centre of the new Bondo District, which was separated from old Siaya District. In this view, the importance of D246 is more than C28, which runs in parallel with D246. In addition, this route has a role of fish transport from Luanda Kotieno to local inland markets.

b) C29 and C27 (west side of Siaya)

After improvement of D250 - D254 – C30, which were selected as the high priority roads, C 29 and C27, which are located in the west side of Siaya and Bondo, become important to establish the bitumen road network together with the improvement of D246 mentioned above. In addition, C27 is expected to contribute to adequate fish product transport from Usigu. Another merit is that improvement of C29 also contributes to fish product transport from Port Victoria as an alternative route to D250, D254 and C30.

c) C19 (Homa Bay to Kendu Bay) and C26

After completion of the bitumen standard of C19 (Homa Bay to Mbita), the section between Homa Bay and Kendu Bay(C19) and C26 are missing links of bitumen road which connect other regions. It is efficient to improve C19 and C26 to establish the bitumen road network together with C20, C19 (Homa Bay to Mbita), C 18, C19 (Kendu Bay to A1) and A1 in this area.

d) C13 (Muhuru and A1)

The west-side area of A1 in Migori District has no bitumen standard roads except A1 and C18. In this view, improvement of C13 is expected to contribute to establishment of the effective bituminous road network. In addition, this road is also expected to ensure the fish product transport from Muhuru to inland local markets.

Chapter 7

Preliminary Design

Chapter 7 Preliminary Design

7.1 Surveys for Design

7.1.1 Routes Subject to Preliminary Design

The High Priority Roads, which consist of three sections, were selected as described in Chapter 6 under "Selection of High Priority Roads" and a preliminary design on the High Priority Roads was undertaken in the course of the feasibility study. The basic information of these roads is tabulated in Table 7.1.1. The routes and the locations are shown in Figs. 7.1.1-7.1.3.

Table 7.1.1 Roads for Preliminary Design

Rd. No.	Location	Distance (km.)
C19	Homa Bay - Mbita	42.41
D250/D251/C30	Port Victoria - Bumala	42.99
C20	Rongo - Ogembo	19.02
Total		104.42

7.1.2 Surveys for Design

Topographic and soil investigation surveys were conducted in order to implement a preliminary design on the high priority roads mentioned above; the details of which are as follows:

(1) Route Survey

1) Control Point survey

- Control points were established at every 5km by use of GPS.
- Traverse points were constructed of concrete pillars at intervals not exceeding 500m.
- Traverse points were combined with bench marks.
- Each traverse point was accompanied by a clear and intelligible monograph comprising a brief description of the location and 3 dimension co-ordinates data.

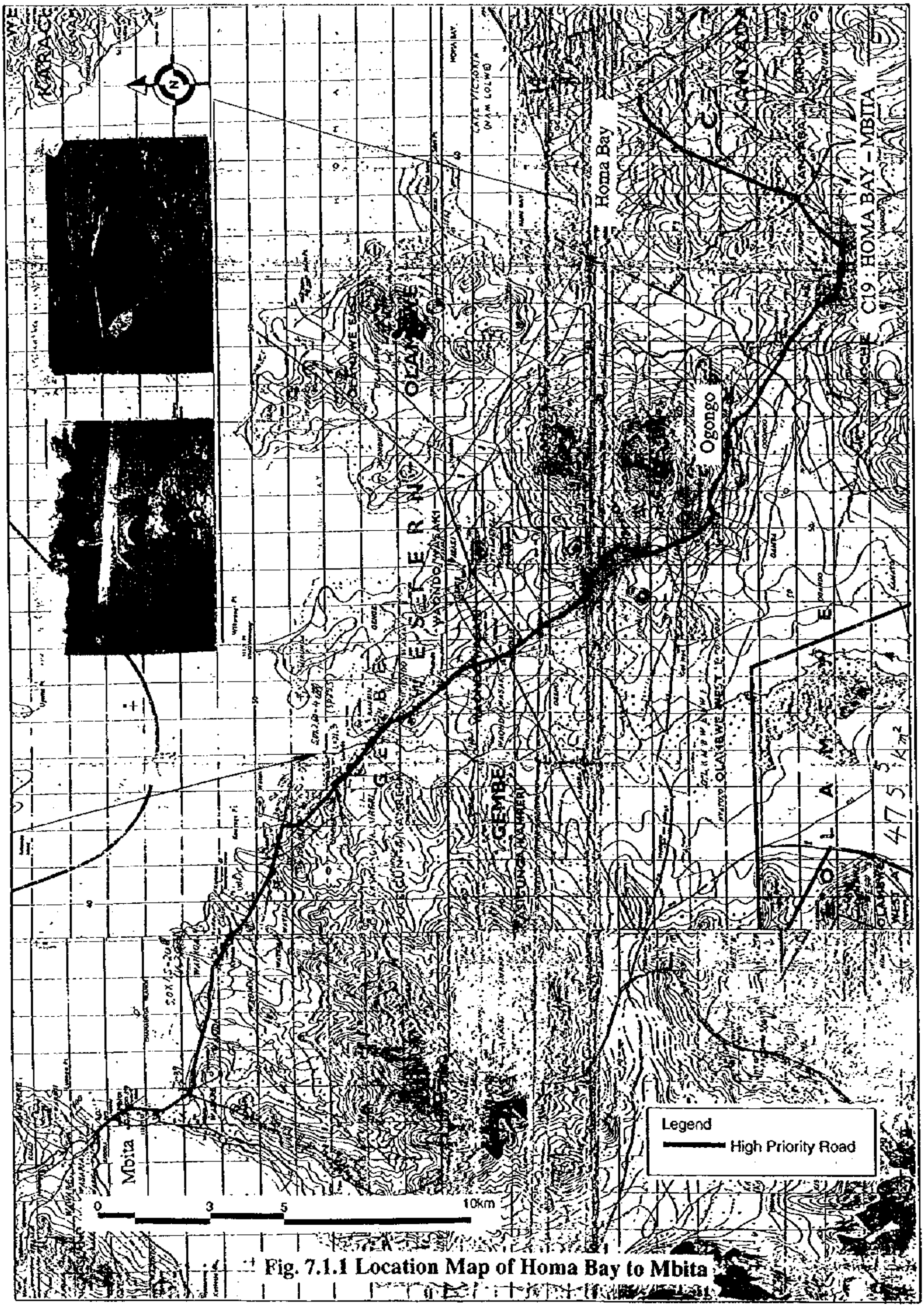

Fig. 7.1.1 Location Map of Homa Bay to Mbita

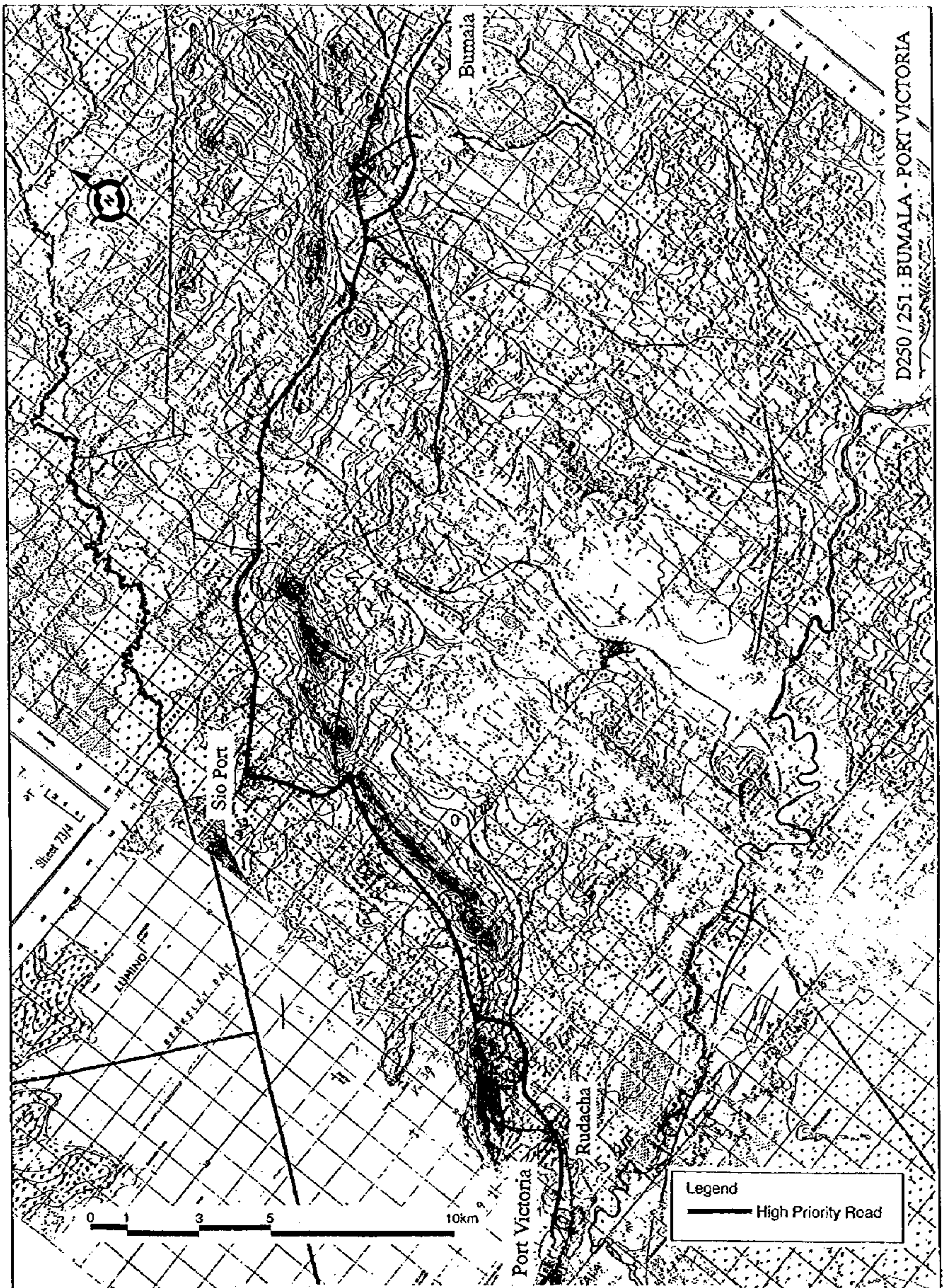

Fig. 7.1.2 Location Map of Bumala to Port Victoria

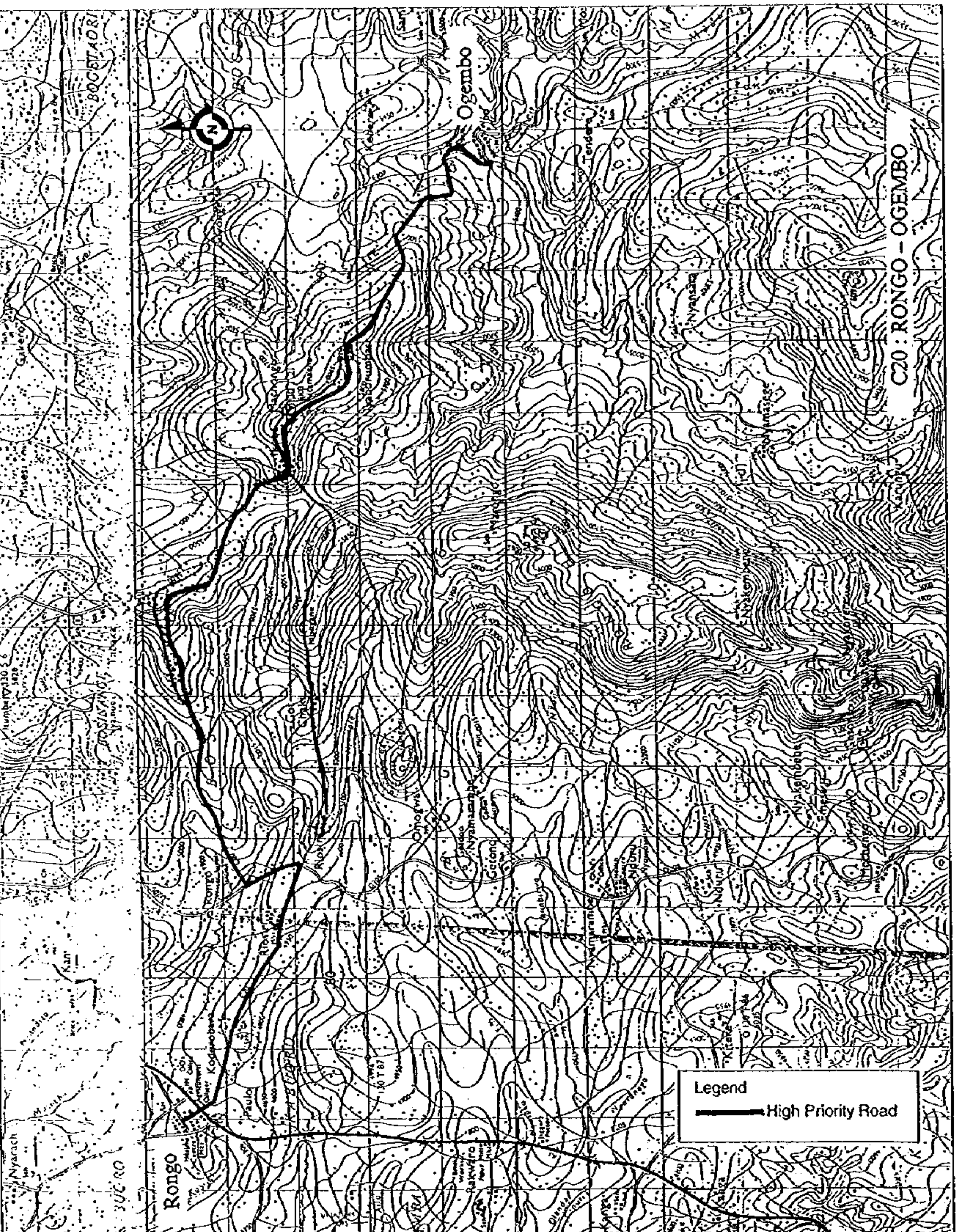

Fig. 7.1.3 Location Map of Rongo to Ogembo

2) Centre Line Survey

- The interval taken for centre poles was 100m along 1,000 stations.
- The topographic centre line map was produced to a scale of 1:2,500.
- The contour line was surveyed at 2m intervals.

3) Profile Survey

- Standard intervals of measurement were 100m and at points of abrupt topographic changes whereby the height of structures was also measured.
- The profile map was produced to a scale of 1:2,500 horizontally and 1:500 vertically.

4) Cross Section Survey

- This was carried out at points where a profile survey had been implemented.
- The area of survey covered a width of 50m (25m from the centre; i.e. 25m in each of the L.H.S. and R.H.S. directions).
- The heights of the edge of the carriageway, the edge of the shoulder, and points of topographic changes were measured.
- The cross section map was produced to a scale of 1:200.

5) Investigation of Road Structures

Measurements of the position, height, water level, quantity and type of culverts were investigated along the whole length of the roads cross sectional structures such as bridges, culverts, and drifts.

(2) Survey Around River Areas

For the purposes of improving river sections, topographic surveys and soundings were carried out.

1) Topographic survey

- The plan was produced to a scale of 1:200.

2) Sounding

- Each river site was investigated along 3 sidings (centre, 30m upstream and 30m downstream).
- The length of each siding was 60m on the average.

- The measurement was undertaken at 20m intervals.

- Traverse map was produced to a scale of 1:200.

7.1.3 Geotechnical Investigation

(1) Auger Boring

Auger boring was carried out for the purposes of analysis of soil improvement for sub-grade by sampling material out of designated burrow pits.

- 6 borings were undertaken at each burrow pit, and the soil profiles noted.

(2) Soil Stabilisation Tests

Sub-grade material from trial pits along the alignments was tested for soil stabilisation. Four types of soil stabilisation tests were carried out on each alignment sample. The modes of stabilisation were basically as follows:

- 2% lime stabilisation test	5 samples
- 3% lime stabilisation test	5 samples
- 5% lime stabilisation test	5 samples
- 2% lime + Con-Aid stabilisation test	5 samples

(3) Material Testing

Geomaterials extracted from 6 trial pits at 60m grid of each of the 5 material sites were tested in order to determine their characteristics and suitability as materials to be adopted for embankment, sub-grade, sub-base and base construction.

(4) Quarry Site Survey

Quarry stones were tested in order to determine their characteristics and suitability as materials to be adopted as aggregate for concrete work and chippings.

7.2 Geometric Design

(1) Design standard

The Road Design Manual of Kenya stipulates the following geometric design standards for the topographic features.

a) Design Speed (km/h)

Level	90 - 100
Rolling	60 - 90
Mountainous	40 - 60

b) Minimum Radius for Horizontal curves (m)

Level	450 - 600
Rolling	160 - 450
Mountainous	60 -160

An increase of the maximum superelevation from 6% to 7% is permitted and this increase would correspond to an approximate reduction of 20% in the values of the Minimum Radius.

c) Maximum Gradients (%)

Level	3.5 - 3.0
Rolling	6.0 - 4.5
Mountainous	10.0 - 8.0

d) Maximum Superelevation (%)

Level	6.0
Mountainous	6.0

(2) Revised Design Standard

1) Asphalt Concrete Pavement in Mountainous Areas

The study team recommended the adoption of asphalt concrete pavement for roads such as the C20 traversing mountainous areas due to the following reasons.

a) When the longitudinal climbing gradient is more than 8 %, the pavement structure is susceptible to rutting and wearing down as a result of heavy loaded vehicles.

b) The surface is also likely to be damaged resulting into increased maintenance costs.

c) Vehicles can safely pass even in the rainy season, if the asphalt pavement is laid correctly.

2) Alignment

More moderate horizontal and vertical alignment was introduced for easy driving in the rainy season (re-alignment was considered in necessary places).

3) Climbing Lane

In cases which the road gradient can not meet the design manual standards in the light of improvement costs and land acquisition, an additional climbing lane was provided.

4) Standard Cross Section

a) The dimensions of the standard cross-section was decided on the basis of traffic conditions including consideration of the existence of many pedestrians and bicycle-riders along the selected high priority roads within the study area.

Carriageway	6.5 m
Shoulder	1.5 m

b) Shoulder width was widened from 1.5m to 2.0m in sections adjacent to villages since many pedestrians and bicycle-riders use the shoulders. The wider shoulder can provide safe and smooth traffic flow for both vehicle traffic and pedestrians as well as bicycle-riders(See Fig.7.2.1).

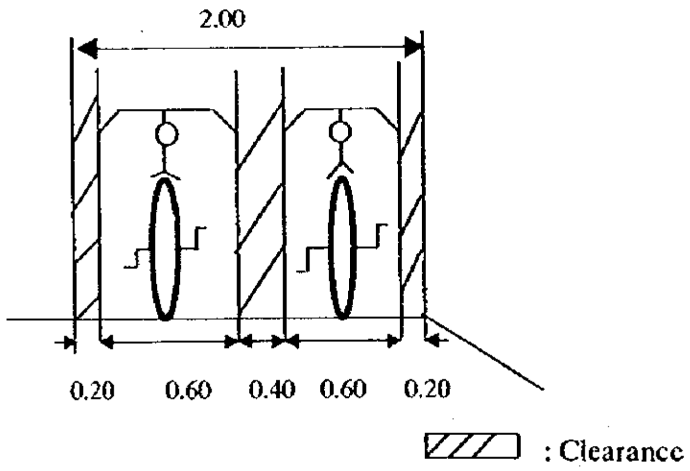

Fig. 7.2.1 Proposed Dimensions of Cycle Tracks/Footpaths Adjacent to Villages

Based on the incorporation of such wider shoulders, the typical cross section would be as drawn in Fig. 7.2.2.

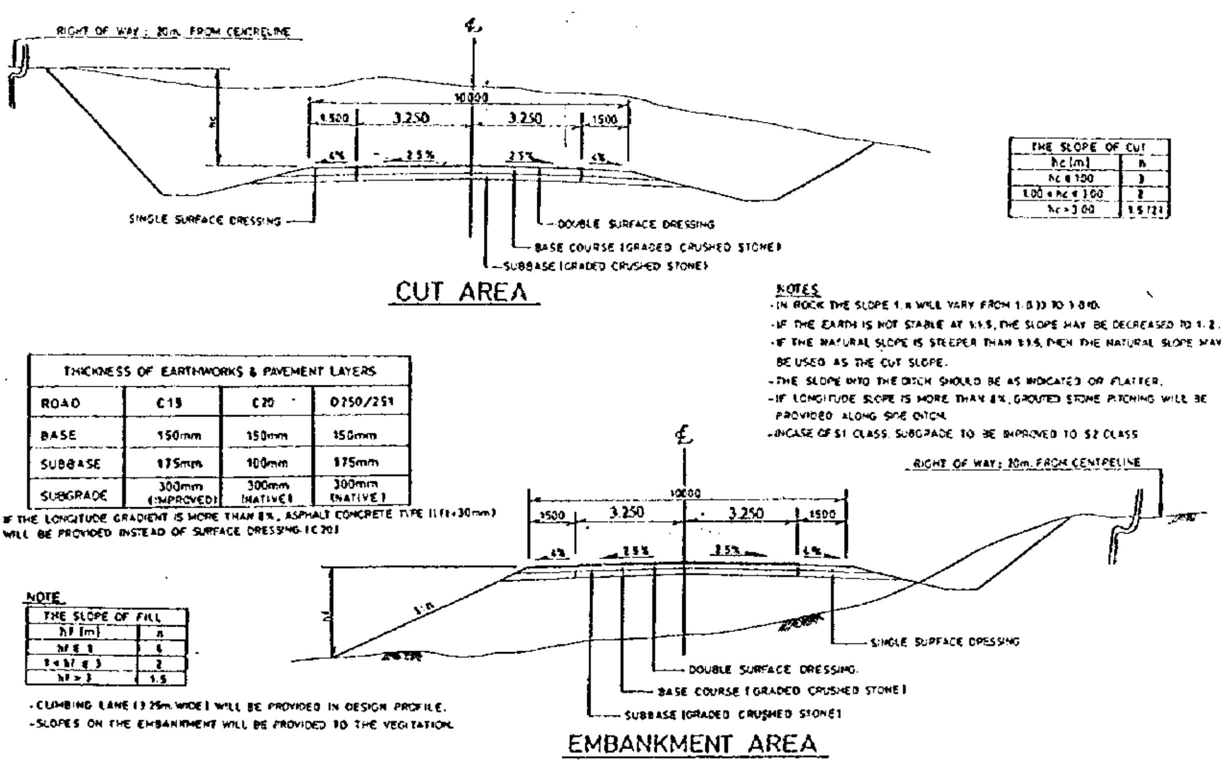

Fig. 7.2.2 Applied Cross Section

(3) Countermeasures for Environmental Preservation

a) Single surface dressing to cover the shoulders in order to prevent soil erosion.

b) Slope Protection

Vegetation should be provided on slopes on the embankment to prevent erosion.

c) If longitudinal slope is over 8%, grouted stone pitching is to be provided alongside the ditch to prevent erosion.

(4) Drainage system

a) The slope into the ditch should be designed as indicated or flatter.

7.3 Hydraulic Design

(1) Culvert Design

1) General

Where a required waterway opening is less than about $15m^2$ and in particular, where a road crosses a stream on a relatively high embankment, it is usually cheaper to provide a culvert in place of a bridge. Before the hydraulic requirements of a culvert can be calculated, an assumption has to be made about the type of construction to be used. The most common forms of culvert construction are:

- precast concrete joined pipes,
- prefabricated corrugated steel pipes, and
- precast or built on site concrete boxes.

Like bridges, culverts are designed to be large enough to let the designated flood pass without damage to the embankment or surrounding land. In practice this usually means limiting the height of the flood on the upstream side. The required size of the culvert is found by calculating the area required to permit a flow that will maintain the upstream head of water below the critical level. The head downstream is taken to be either the designated flood level before the embankment is built or the top of the culvert, depending on whichever is higher.

2) Culvert design of the Study Area

Return periods (storm frequencies) used for highway culvert designs are available in the American Association of State Highway and Transportation Officials, Ins., which are presented in Table 7.3.1.

Table 7.3.1 Return Period for Highway Culvert Design

Type of Highway Facility	Return Period (Storm Frequency) in Year
Interstate highways	50
Limited access freeways and arterial roads	25
Collectors	10
Locals	10
City streets	10

Source: Principles of Highway Engineering and Traffic Analysis

On the other hand, the El Nino disaster was experienced in Kenya in 1961 and 1998. According to the Meteorological Department, the El Nino phenomenon has occurred periodically at an interval of 6-7 years. The Study Team estimated that the probability of flooding in 1998 was around 25 years. Through the interview survey by the Study Team, it was revealed that all existing box culverts and bridges were submerged by the 1998 El Nino disaster. Submerged sections are set forth in Table 7.3.2.

Table 7.3.2 Submerged Sections

Roads	Places	Type	Size	Damages
D250	km. 13.3	Type	Diameter 600mm	Submerged
C19	km. 28	4-Box culverts	5 x 2.6 meters	Submerged
	km. 36.9	2 Box culverts	5 x 1.5 meters	Submerged
	Mbita causeway			Submerged
C21	km. 4.4	Bridge	5 x4	Submerged

Referring to Table 7.3.1 and the damage by the El Nino disaster, the following return period was decided in light of endurance of the culvert and maintenance of the pavement.

Highway Facility	Return period
Bridge	50years
Culvert	50years

The expected flow is estimated using the following formula.

$$Q = 0.278\, C \times I \times A$$

Where Q is the expected flow (m^3/s)
C is the run-off coefficient
I is the intensity of rainfall (mm/h)
A is the Catchment area (km2)

There are four small and medium size rivers in the study area. At this stage of the preliminary design, it was decided to have box culverts across all the rivers. The details are as follows

i) C-19
- Box culvert 3.0 m×3.0 m×2
- Box culvert 4.0 m×4.0 m×4
- Box culvert 3.0 m×2.5 m×3

ii) D-250/251
- Box culvert 3.0 m×2.0 m×3 (2 places)

iii) C20

- Box culvert 3.0 m×3.0 m×3
- Box culvert 3.0 m×3.0 m×4

iv) Size of each Catchment area and the Discharge are as shown in Table 7.3.3.

Table 7.3.3 Results of Hydraulic study in Study area

C.A No.	Km	Catchment area	Discharge	Box Culvert				Pipe Culvert			(+/-)
		km^2	m^3/S	4.0x4.0	3.0x3.0	3.0x2.5	3.0x2.0	φ600	φ900	φ900x2	Capacity
C19											
1	7km - 8km	7.5	83		1(2cell)			3	2		0.00
2	8km - 39.55km	475.5	1343	1(4cell)		1(3cell)		64	40		+54.76
D250.D251.C30											
1	0km - 3.5km	3.5	40					1	6		-17.05
2	3.5km - 7km	2	94					0	7		-36.46
3	7km - 13.5km	22	166				2(3cell)	8	0		0.00
4	13.5km - 27km	19	465					6	0	6	0.00
5	27km - 35km	4	111					7	1	8	+5.28
6	35km - 39km	3.5	162					6	0		0.00
C20											
1	0.0km - 3.5km	0	-					8			-
2	3.5km - 7.5km	8.5	95		1(3cell)			14			+39.00
3	7.5km - 10.0km	0.4	21					7			+0.49
4	11.5km - 14.5km	0.4	21					8			+3.56
5	14.5km - 19.6km	14.5	165		1(4cell)			12			+5.41

Source: JICA Study Team

7.4 Pavement Design

(1) Thickness of Earthworks and Pavement Layers

The thickness of earthworks and pavement layers should be adopted in accordance with the standards of the Road Design Manual of Kenya. Alignment soils are expected to be used as sub-grade material while material sites are to be used as burrow pits for both sub-base and base material sources in accordance with the laboratory tests (see Table 7.4.1). However, in case the burrow pit material does not meet the requirements stipulated in the RDM Part III, material sourced from quarry sites, as indicated hereafter, shall be adopted.

Table 7.4.1 Locations of Burrow Pits and Hard Stone Quarries

No.	Road	Station No.
Borrow Pits (Sub - Base material)		
1	C19 Homa Bay - Mbita	Km.11+000(RHS)
2		Km.32+000
3	C20 Rongo - Ogembo	Km. 7+000(RHS)
4	D250/D251 Bumala -	Km.11+200(500mLHS)
5	- Port Victoria	Km.37+000(30mRHS)
Hard Stone Quarries (Base, Concrete, Chipping for Surfacing layer)		
6	C19 Homa Bay - Mbita	Km. 9+700(LHS)
7		Km.21+000(LHS, A)
8		Km.21+000(LHS, B)
9		Km.33+400(LHS)
10	C20 Rongo - Ogembo	Km. 4+ 000(7.5KmLHS)
11		Km. 9+000(LHS)
12	D250/D251 Bumala -	Km. 6+000(LHS)
13	- Port Victoria	Km.11+000(6Km of Kisia ~Kisumu Road)
14		Km.28+000(LHS)
15		Km.45+000(14Km LHS)

Sources : JICA Study Team

Asphalt concrete type II(t = 30mm) should be provided on the C20 instead of surface dressing as the wearing course.

(2) Black Cotton Treatment

Regarding the embankments of height exceeding 3m, the Study Team has not considered the necessity of providing special treatment for black cotton soils. Only stone pitching will be provided in this area to allow the rain water to permeate the ground. With regard to less than 3m height of the embankment, the soil exhibiting expansive tendencies and low California Bearing Ratio (CBR) values could be improved by treating it with lime or other materials as may be appropriate.

The Engineer will decide the location of rock spreading to prevent heaving for the dynamic loading.

The material for improved sub-grade may be obtained from designated material sites after these are extended. More material sites will have to be identified and investigated during the next stage. The existing alignment soil tests for the sub-grade are shown in Table 7.4.2.

Table 7.4.2 Existing Alignment Soil Tests for the Sub-grade

Properties	Road	C19 Homa Bay - Mbita	C20 Rong - Ogembo	D250-251 Bumala - Port Victoria
ATTERBERG	LL(%)	42 ~ 71	51 ~ 64	39 ~ 54
	PI(%)	18 ~ 41	23 ~ 34	19 ~ 26
	LS(%)	11~ 19	11 ~ 17	11 ~ 13
COMPACTION	OMC(%)	12.1 ~ 18.2	23.5 ~ 24.3	11.03 ~ 25.0
	MDD (kg/m3)	1580 ~ 1785	1584 ~ 1475	1510 ~ 1995
SIEVING	Passing 0.075 BS test Sieve(%)	18 ~ 78	47 ~ 70	38 ~ 70
STRENGTH	ACV(%)			
	LAA(%)			
	CBR (Top/Bottom, %)	1/3 ~ 17/24	7/6 ~ 26/6	4/6 ~ 10/10
	SWELL Under surcharge pressure of 2.9kN/m²	1.10 ~ 5.63	0.24 ~ 0.27	0.25 ~ 1.00
	UCS (kN/m2) Static / Dynamic (kPa)			184 / 940
	MODULUS OF ELASTICITY, (E,kN/m2) (Static/Dynamic)			19320/98700

Source : JICA Study Team

Note : 1) Only the test results on the lowest depth samples at the changes along the alignments were considered.
2) UCS (100x50mm cylindrical moulds used) and hence modulus of Elasticity for Bumala ~ Port Victoria. Only km 21+000 considered.

(3) Field Investigations

1) C19 Homa Bay to Mbita Road.

a) Existing Conditions

Homa Bay - Mbita Road is a gravel /earth road about 43 kilometres in length and has an average width of 4.5m to 5m.

As a result of inadequate maintenance, the carriageway has no camber and thus does not drain effectively resulting in erosion of the gravel-wearing course, which was initially laid and blockage of drainage channels on the carriageway.

Side drains are heavily silted and the carriageway level is lower than the adjoining ground level in several places and thus resulting in ponding in these areas.

Light bush exists on both sides along the carriageway for most of the road section.

b) Geology and Soils

The project road traverses a geological area predominantly defined by Homa Bay clays of miocene age overlying mela nephelinites and kiangata nephelinites agglometerates of tertiary age.

Soils in the section of the road in Homa Bay District are moderately well drained, low to moderately shallow, dark to firm clays, as the road proceeds towards Mbita.

c) Improved Sub-grade

It is desirable to have an improved sub-grade layer not only on the S1 class of soil but also on the S2 class of soil in order to reduce the thickness of the sub-base layer.

An improved sub-grade layer of 300mm thick is considered to be adequate over the class S2 native sub-grade soil and 425mm thick over Class S1, sub-grade soil. The new class of sub-grade bearing strength would be S3.

d) Sub-base Sources

From an estimation of two (2) material sources, it is considered that approximately 53,000 m3 of material is available within the area investigated. However, this material is recommended to be used after some treatment.

e) Base Material Sources

Four locations were identified along the project road and samples from these quarries tests performed to determine their suitability as crushed stone for road base and aggregate for structure concrete and chipping for surfacing layer

2) Rongo to Ogembo (C20)

a) Existing road conditions

Rongo - Ogembo road is a gravel/earth road about 19 kilometres in length with an average width of 5.0 to 6.0 metres.

Side drains along the main road are silted on the flat sections and eroded on the steep sections, which is indicative of a poor maintenance regime.

As a result of extensive agricultural activities on either side of the road, no thick cover of vegetation was noted.

The last 1.0 km of the road passes through Ogembo Township and provision of access to the adjoining business premises should be considered, if an efficient drainage system is to be provided for.

b) Geology and Soils

Soils in the first 3 to 4 kilometres from Rongo have been developed on granites and consist of a complex of well drained, deep, reddish brown, friable sandy clay loam with an acidic humic top soil, and moderately well drained, shallow, dark reddish brown, friable sandy loam. The remainder, of the road lies on soils developed on igneous rocks, being well drained, deep to extremely deep, dark red, friable clay with a thick humic top soil.

c) Improved Sub-grade

In view of the fact that there are no sections of the road with either expansive clay or class S1 sub-grade soil, it is not considered necessary to place any improved sub-grade layer on the native soils.

In addition, burrow pits sites would be constrained by land acquisition problems as the land along the alignment is extensively used for agricultural activities. However, the necessary earthworks and material for embankment sections of the road can be obtained from sidelong sites.

d) Sub-base materials

From the test results, it is considered unnecessary to treat material sourced from burrow pits. The improvement considered critical is only that of plasticity. Evidence of sources of good quality sand within the project road neighbourhood exists. It may therefore be beneficial to mechanically stabilise the gravel by mixing in sand with a view to reducing the plasticity.

e) Base materials

Two quarries appear to be well within the specified limits for class A stone for all the parameters tested.

3) Bumala to Port Victoria (D240/251)

a) Existing road conditions

Bumala - Port Victoria Road is a gravel/earth road about 44 kilometres in length and has an average width of 4.5 to 5.0 meters.

As a result of lack of adequate maintenance, the road surface is deformed in several sections with severe potholing. Motoring during the rainy period is normally difficult especially on the sandy clay sections.

Very few cross culverts were noted and most of the existing ones are silted up. Similarly the side drains are also mainly silted and blocked by overgrown vegetation. Thick bush cover exists all along the road.

The road has inadequate camber rendering cross drainage unsatisfactory.

b) Geology and Soils

The project road traverses an area underlain by banded ironstones of the Samia series, which belong to the oldest precambrian green schists belts. These rocks are believed to have been derived from the low grade metamorphosis of the lavas and tuffs of the acidic group.

Other intervening areas are extensively caterised probably by iron rich solutions formed by leaching of the neighbouring laterised and banded ironstones. They pass at depths probably to the above mentioned tuffs and sediments of the Precambrian group. There, oldest Precambrian groups, also called the Nyanzian are extensively invaded by granites and other instrusives. Soils developed on colluvium from basalts well drained, deep dark brown clays, developed on allulium from basalts, imperfactly/poorly drained vertisols developed from valcanic ashes and on the hilly section, well drained to moderately drained, stony, clay loam developed on undifferential tertiary volcanic rocks are respectively encountered.

c) Improved Sub-grade

In view of the fact that there are no sections of the road with expansive clay and class S1 sub-grade soil, it is not considered necessary to place any improved layer on the native soils.

Actually, some sections of the alignment, for example those near Funyula, the sub-grade soil is comprised of lateritic gravel.

d) Sub-base material

Based on the above mentioned routine laboratory test results, it was found that while silty/gravel materials identified from the two quarries had CBR values within the specified limits for a sub-base layer, they cannot be used in their natural state on account of plasticity modulus and will therefore require treatment in order to meet the materials specification for sub-base in this respect.

It should be noted here that on compaction of the sub-base layer, more fine material (passing 0.425mm sieve size) might be generated and thus even higher values of the plasticity modulus obtained.

It is not considered necessary to treat the samples, as the improvement considered critical is only that of plasticity. As there is evidence of sources of good quality sand within the vicinity of the road, it may be advantageous to mechanically stabilise the gravel by mixing in sand to reduce the plasticity. It is recommended the cost implication of this alternative be investigated further, during the detailed design stage.

e) Base material

Clearly, test results of the two material sites investigated show that the material does not comply with these requirements.

The natural gravel material will therefore have to be treated with either lime or cement to improve on the plasticity and CBR values.

Chapter 8

High Priority Road Maintenance

Chapter 8 High Priority Road Maintenance

8.1 Roads to be Maintained

This chapter examines the road maintenance on the High Priority Roads selected in Chapter 6.

(1) Roads Improved in the Study

These links are selected for upgrading from gravel to bituminous standard. Maintenance activities are for bituminous standard roads. The links are shown below:

Section	Province	District	Length
a. HomaBay – Mbita	Nyanza	Homabay Suba	42.41km.
b. Bumala – Port Victoria	Western	Busia	42.99km.
c. Rongo – Ogembo	Nyanza	Migori Gucha	19.02km.

(2) Maintenance Responsibility

Maintenance of all bituminous roads is under the responsibility of the PWOs at present. However, the following maintenance system is proposed in accordance with the recommendation in Chapter 5.

Routine Patrol and Special Work	Periodic Maintenance
a. HomaBay – Mbita road DWO Suba, Homa Bay	PWO Nyanza (Kisumu)
b. Bumala – Port Victoria road DWO Busia	PWO Western (Kakamega)
c. Rongo – Ogembo road DWO Gucha, Migori	PWO Nyanza (Kisumu)

8.2 Maintenance Costs for High Priority Road

(1) Unit Rates of Maintenance Activities

Unit rates of maintenance activities are estimated in the Chapter 5. Summaries for bituminous standard road maintenance is shown as follows:

1) Routine Maintenance

a. Carriageway repair:		70,324 ksh/km/year
	Major activities: potholes and local crack sealing	
b. Off-carriageway repair:		9,155 ksh/km/year
	Major activities:	vegetation and drainage clearance,
	(by LBM)	local slope and shoulder repair

2) Periodic Maintenance

Carriageway rehabilitation		1,206,884 ksh/km/year
	Maintenance activities:	resealing by the contractor

3) Total Maintenance Cost Estimate

Average maintenance costs of high priority roads are given in Table 8.2.1. These costs cover the maintenance in the first year and the fifth year since the improvement of the roads. The first year maintenance will include only routine maintenance, which consists of carriageway repair against pavement deterioration such as pothole repairs and local crack sealing, and off-carriage maintenance by Labour Based Methods (LBM). However, it does not include periodic maintenance. The periodic maintenance of pavement resealing is proposed every five year. This increases annual maintenance cost.

Total maintenance costs for three improved sections are calculated so as to compare the cases of roads with and without improvement. Details are shown in Appendix 8.1.

8.3 Maintenance Priority and Method

(1) Maintenance Priority

As a result of the Study for upgrading, the High Priority Roads are selected in the three sections, the total of which is approximately 100 km. In addition, it is crucial to maintain the following two kinds of roads in order to take advantage of the development of the High Priority Roads since residents live in widely spread areas and the High Priority Roads cannot cover whole the areas by themselves only.

-Affiliated road networks, which are comprised of Class C and D located around the High Priority Roads.

-Feeder roads, which are mainly comprised of Class E or unclassified roads directly connecting to the High Priority Roads.

Table 8.2.1 Annual Maintenance Cost for High Priority Roads

Homa Bay -Mbita Road (C19)				
Length=	42 km			
	LBM	Carriageway	Resealing	Total
	9,155	*70,324*	*1,206,884*	
First Year	384,510	2,953,608	0	3,338,118
5th Year	384,510	2,953,608	50,689,128	54,027,246
Bumala-Port Victoria				
Length=	44 km			
	LBM	Carriageway	Resealing	Total
	9,155	*70,324*	*1,206,884*	
First Year	402,820	3,094,256	0	3,497,076
5th Year	402,820	3,094,256	53,102,896	56,599,972
Rongo-Ogembo				
Length=	20 km			
	LBM	Carriageway	Resealing	Total
	9,155	*70,324*	*1,206,884*	
First Year	183,100	1,406,480	0	1,589,580
5th Year	183,100	1,406,480	24,137,680	25,727,260
Total Maintenance Cost				
First Year	970,430	7,454,344	0	**8,424,774**
5th Year	970,430	7,454,344	127,929,704	**136,354,478**

Note: Carriageway maintenance cost is increased by increase of traffic of 7.5% per year.
Resealing will be carried out at 5-year interval.

The affiliated road networks mentioned above are shown in Table 8.3.1, and the location is shown in Fig. 8.3.1.

Table 8.3.1 Comprehensive Classified Road Network Maintenance

Code	High Priority and Affliated Roads	Road Section	Province	District	Length (km)	Classification	Surface
I	A. High Priority Rds	Bumala - Port Victoria	Western	Busia	44	D250/D251/C30	Unpaved
I-1	Affiliated Rds	Mundere - Busome-Siaya		Busia/Siaya	38	D251/C30/C29	Unpaved
I-2		Siaya - Bondo		Siaya/Bondo	21	D246	Unpaved
I-3		Lwero - Malaba		Busia/Teso	28	C43	Unpaved
	sub-total				87		
II	B.High PriorityRds	Homa Bay - Mbita	Nyanza	Homa Bay /Suba	42	C19	Unpaved
	C. High Priority Rds	Rongo - Ogembo		Migori /Gucha	20	C20	Unpaved
	sub-total				62		
II-1	Affiliated Rds	Kendu Bay - Homa Bay		Rachuonyo/Homabay	30	C19	Unpaved
II-2		Homa Bay - Rongo		Homabay/Migori	29	C20	Paved
II-3		Kendu Bay - Oyugis		Rachonyo	18	C26	Unpaved
	sub-total				201		
Total	High Priority Rds				106		
Total	Affiliated Rds				288		
	Total				*394*		

Note: Round number is used for the length of the High Priority Roads.
High Priority Roads B and C should be maintained as the same component for work efficiency

(2) Hierarchy of Maintenance Activities

The hierarchy of maintenance activities is established in order to prevent further damages from occurring and to secure the road and traffic safety.

1) First Priority: Emergency work (all by in-house force accountant)

Emergency repairs to blocked or impassable roads and removal of debris and the stabilisation of side slopes (special Work)

2) Second Priority: Cyclic drainage work(contracted out using LBM)

Cleaning out and re-cutting ditches and turnouts, cleaning out bridges and culverts, filling scoured areas, building check-dams and scour controls, and repair of drainage structures (routine work).

3) Third Priority: Reactive work on pavement (in-house or small contractor)

Patching and local sealing (routine work).

4) Forth Priority: Periodic preventive and resurfacing work (medium contractor)

Resealing (periodic work).

5) Fifth Priority: Other cyclic and reactive work (contracted out using LBM)

   Filling in shoulders and slopes, grass cutting, and cleaning, repairing, repainting and replacing road furniture (routine work).

6) Sixth Priority: Periodic overlay and pavement reconstruction (large contractor)

   Overlaying and Pavement reconstruction (periodic work).

8.4 Maintenance Capacity Improvement

It is concluded that maintenance of High Priority Roads will be assured by capacity building of Provincial Works Offices (PWO) and District Works Offices (DWO) for contract management and in-house works.

The major items for maintenance Capacity Improvement are as follows:

a. It is recommended that road maintenance be carried out by private contractors, and that combination of LBM with necessary equipment and community participation be considered. It is essential to provide proper training to the contractors and LBM groups.

b. To secure the maintenance and contract management of the PWOs and the DWOs, a well-elaborated training is required in accordance with the training plan mentioned in Chapter 5.

c. Based on the establishment of Road Board and Road Agents, overall policy of commercialisation and full support of the budget are essential for road maintenance management.

d. Extending maintenance to feeder roads including affiliated roads should increase project effects of High Priority Roads. The feeder road maintenance is considerably important in the Study area. Most of population lives in the rural areas, and their villages and houses are widely located and far from the High Priority Roads. The feeder road maintenance, which has close relationship to the High Priority Roads, should be undertaken simultaneously with the High Priority Roads maintenance.

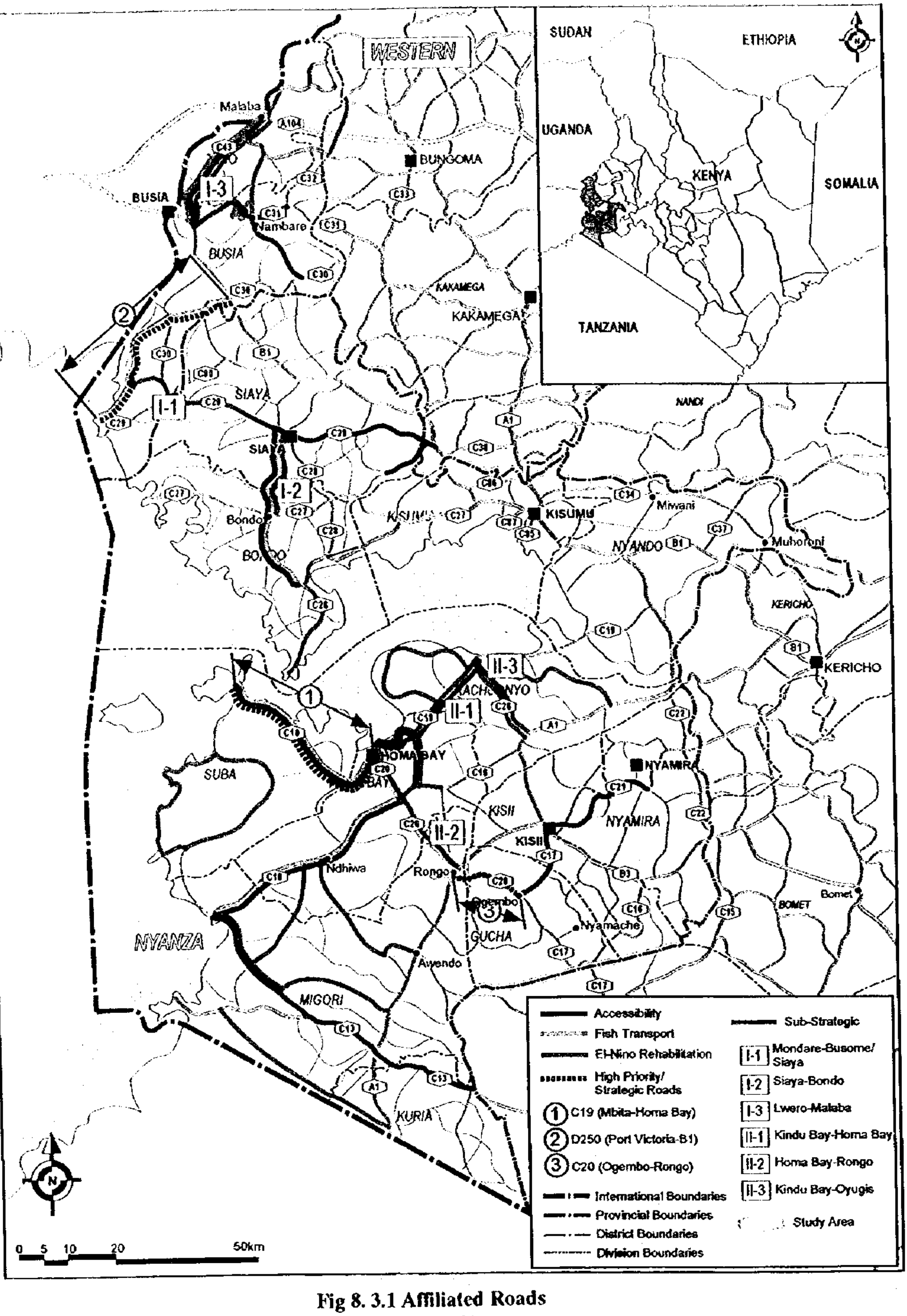

Fig 8. 3.1 Affiliated Roads

Chapter 9

Construction Plan and Cost Estimates

Chapter 9 Construction Plan and Cost Estimates

9.1 Construction Plan

9.1.1 General

The construction plan and schedule of the priority projects are formulated based on the work quantities derived from the preliminary design, and taking into account the topographic, geological and meteorological conditions of the project sites as well as minimising environmental adverse effects.

9.1.2 Construction Plan

(1) Construction Section

The priority project is divided into five construction segments. The segments are determined in due to consideration of each location, segment length and work volume, difficulty of the construction, and location of towns. These sections are shown in Table 9.1.1.

Table 9.1.1 Construction Section

Route No.	Segments	Location		Length (km)
		STA	Place	
C 19	I-1	0+000 - 20+000	Home Bay - Obanda	20.00
	I-2	20+000 - 42+060	Obanda - Mbita	22.06
	(I-3)	41+700 - 42+050	Mbita causeway	(0.3)
D 250/	II-1	0+000 - 20+000	Bumala - Sio Port	20.00
D 251	II-2	20+000 - 42+992	Sio Port - Port Victoria	22.99
C 20	III	0+000 - 19+020	Rongo - Ogembo	19.02

Note: The cost of Mbita causeway is appropriated by El Nino disaster rehabilitation budget

(2) Basic Conditions

The following basic conditions are taken into account in the construction planning:

1) Rainy season

Table 9.1.2 Rainfall Condition at the Project Area

Project Roads	District	Rainfall Condition	Remark
C19	Homa Bay	50 % rainfall February-March 25 % rainfall August- November	Mean annual rainfall : 1000 mm
D 250/D 251	Busia	50 % rainfall March-May 25 % rainfall August- October	Mean annual rainfall : 1500 mm
C 20	Gucha	50 % rainfall March-June 25 % rainfall September-November	Mean annual rainfall : 1500 mm

Source: District Development Plan 1997-2001

2) Mechanical construction method is applied to the work items of earth -work, surface dressing base and sub-base courses, and structural excavation in principle.

(3) Procurement of Material

The main materials provided for the project are as follows:

1) Earth-fill Materials

Earth-fill materials can be obtained from cutting materials and rural reserves in the adjacent to the project sites.

2) Rock

Rock for the slope protection, concrete structures and pavement are available at the quarry sites in the adjacent to the project sites. The quarry sites identified are shown in Table 9.1.3 based on the quarry site survey.

3) Reinforcement Bars

Reinforcement bars can be obtained at Kisumu, Busia and Kisii. The steel production almost meets the domestic needs in Kenya. At Mombasa, reinforcement bars are made from steel material imported from overseas.

Table 9.1.3 Quarry Site Condition

Project Road	Section	Location
C 19 Homa Bay - Mbita	I-1	7+500 10+000 11+700
	I-2	21+700 33+500
D 250/251 Port Victoria - Bumala	II-1	6 +000 11+400
	II-2	26+000 28+000 35+100
C20 Rongo - Ogembo	III	11+500

Source: Soil Investigation Surveys conducted by JICA study Team, 1999

4) Aggregates and Crushed Stone

Aggregates and crushed stone for concrete and pavements can be obtained by erecting temporary crushing plants.

5) Cement and Asphalt

Portland cement and asphalt can be obtained at Kisumu, Homa Bay, Kisii, Migori respectively. The cement produced at Nairobi and Mombasa almost meets the domestic needs for cement in Kenya. Asphalt bitumen is procured from overseas sources if it is not enough to meet domestic needs. Cement is can be obtained at Homa Bay, Busia, Kisii and Migori. Asphalt bitumen is can be obtained at Kisumu.

Table 9.1.4 shows procurement places for main materials in the project road.

Table 9.1.4 Procurement Place for Main material

Route No. and Place	Asphalt Bitumen	Cement	Reinforced bar	Fuel	Wooden
C 19 : Homa Bay - Mbita	Kisumu	Homa Bay	Kisumu	Hom Bay	Homa bay
D 250/251 : Port Victoria - Bumala	Kisumu	Busia	Busia	Busia	Bumala/ PortVictoria
C 20 : Rongo - Ogembo	Kisumu	Kisii/ Migori	Kisii	Kisii/ Migori	Kisii/ Migori

(4) Construction Equipment

The principal item of construction equipment, which are required for the priority projects are listed in Table 9.1.5 to Table 9.1.7 by the type of work. In Kenya, the equipment are available though the workable equipment is not numerous.

1) Earthworks Equipment

Table 9.1.5 Earthworks Equipment

Mains Works	Equipment	
	Hauling distance less than 100 m	Hauling distance more than 100 m
Clearing & Stripping	Bulldozer	
Demolish	Backhoe/Bulldozer	
Cutting	Bulldozer	Tractor Shovel/Back Hoe
Loading	Bulldozer	Tractor Shovel/Back Hoe
Hauling	Bulldozer	Dump Truck
Spreading	Bulldozer/Motor Grader	
Compaction	Tamping Roller/Tire Roller, Road Sprinkler	

2) Pavement Work Equipment

Table 9.1.6 Pavement Work Equipment

Main Work	Equipment
Subgrade Preparation	Motor Grader, Tire Roller, Macadam Roller
Subbase course	Motor Grader, Tire Roller, Macadam Roller, Road Sprinkler
Base Course	Motor Grader, Tire Roller, Macadam Roller, Road Sprinkler
Prime/Tack Coat	Asphalt Distributor
Double Surface Dressing	Chip Spreader, Asphalt Distributor, Macadam Roller, Tire Roller
Asphalt Concrete Surface	Asphalt Finisher, Macadam Roller, Tire Roller

3) Drainage Structure Equipment

Table 9.1.7 Drainage Structure Equipment

Main Work	Equipment
Structural Excavation	Back Hoe, Dump Truck
Foundation	Back Hoe, Tamper, Dump Truck
Box Culvert ,Pipe Culvert and Inlet / Outlet	Concrete Mixer, Concrete Pomp, Truck Crane

9.1.3 Construction Schedule

In the construction schedule, construction period of the main work items is firstly analysed based on the assumed workable day, unit progress rate and the estimated quantities, and subsequently, the construction schedule of the project is established applying the period analysed.

(1) Workable Day

Average workable days per year for earth work which is the most critical item is estimated based on the meteorological data as shown in Table 9.1.2 and it is assumed to be 15 days (50% of a month) during the rainy season from February to June.

(2) Unit Progress Rate

Based on the production rate of each pay item to be implemented by a set of equipment combined or a set of combination of equipment and manpower, or by labour intensive method, unit progress rate of each major work item is analysed. The unit progress rate of major and critical work item are shown in Table 9.1.8.

Table 9.1.8 Unit Progress Rate

Description		Kind of work	Capacity
Earth Work	Cutting (Common)	Mechanical work	400 m^3/day
	Embankment	//	400 m^3/day
Pavement	Double surface dressing or Asphalt surface	//	500 m^2/day
	Base, Sub-base	//	500 m^2/day
Culvert & Drainage	Concrete placing	//	20 m^3/day
	Grouted stone pitching	Hand work	30 m/day

(3) Work Quantity and Construction Period

Referring to the above unit progress rate and the estimated total work quantity of major work items, the construction periods of the major and critical work items are estimated. The total quantity and corresponding construction period of each major work items are shown in Table 9.1.9.

Table 9.1.9 Construction Schedule

Section	Work Item	Construction Year 1	Construction Year 2	Construction Year 3
I-1	Tender preparation			
	Earth Work			
	Pavement Work			
	Culvert & Drainage			
	Road Furniture			
	Black Cotton Soil Treatment			
	Land Acquisition			
I-2	Tender preparation			
	Earth Work			
	Pavement Work			
	Culvert & Drainage			
	Road Furniture			
	Black Cotton Soil Treatment			
	Land Acquisition			
I-3	Tender preparation			
	Earth Work			
	Pavement Work			
	Road Furniture			
II-1	Tender preparation			
	Earth Work			
	Pavement Work			
	Culvert & Drainage			
	Road Furniture			
II-2	Tender preparation			
	Earth Work			
	Pavement Work			
	Culvert & Drainage			
	Road Furniture			
	Land Acquisition			
III-3	Tender preparation			
	Earth Work			
	Pavement Work			
	Culvert & Drainage			
	Road Furniture			

Note: Site clearance is included in earth work

9.2 Cost Estimates

9.2.1 General

The project cost estimate started with a data collection exercise, at several construction sites and interview survey to MOPWH and related agencies to ensure that the unit price analysis and results are firmly based on the real situation in Kenya. The project cost estimate is carried out on the basis of the preliminary design, the construction plan and schedule, assuming that the project implementation is executed by an international contractor.

9.2.2 Basic Condition

The following assumption and conditions are applied in the project cost estimate.

a) Price level of labour, material and equipment is based on July, 1999.

b) The exchange rate applied to convert the US Dollar to Kenya shilling is US$1.00=72.2 (Daily Nation, July 9,1999) Kenya shillings.

c) The cost are divided into foreign currency (indicated in US$) and local currency (indicated in US$) portions. The foreign and local currency components of each unit price are computed based on the following classification of basic cost elements.

The foreign currency component includes the cost of:

- Imported equipment, material and supplies,
- Imported materials in the local market,
- Wages of expatriate personnel,

The local currency component includes the cost of:

- Domestic materials and supplies,
- Wages of local personnel,
- Duties and tax.

Indirect construction cost, engineering services and physical contingency are calculated at both local currency portion and foreign currency portion, reflecting the likelihood of international joint venture.

d) Major material items included in the unit costs are bitumen cut back, chipping, crushed stone, gravel, cement, galvanised gabion wire, reinforcement bars and fuel.

e) Imported equipment and materials are assumed to be exempted from tax and duty by Kenya Government.

f) To estimate rate of the each work item, "Analysis of Contract Rates-1998 "issued by MOPWH, Roads Department, Design branch, is provided for reference.

g) Production rate to analyse costs of main work items are based on standard production rates of Japan after some modification made with due consideration of Kenya local conditions.

h) Except for the direct construction cost, other costs such as indirect construction cost, engineering services, physical contingency are computed using the multiplier factors

9.2.3 Structure of Project Cost

The project cost on a contract basis consists of construction cost, land acquisition and compensation cost, and engineering cost. The construction cost is divided into direct construction cost and indirect construction cost. These cost items are briefly described below:

a) Direct Construction Cost

The direct cost consists of labour cost, material cost and equipment cost.

b) Indirect Construction Cost

This item includes contractor's overhead and profit, transportation cost, expenditures to run contractor's site office and warehouse, and laboratory, and other common temporary works. It is assumed to be 35.0 % of the direct construction cost, taking into account the construction by an international contractor.

c) Engineering Service Cost

The engineering service cost consists for detailed design and supervision and it assumed to be 10.0 % of the direct construction cost.

d) Physical contingency is taken as 15 % of the sum of the direct cost, indirect cost, and engineering cost.

e) Land acquisition and Compensation Cost

The land acquisition and compensation cost are estimated on the basis of unit cost data obtained from Ministry of Land and Settlements (MOLS).

9.2.4 Unit Rate

(1) Material Cost

The material cost applied in the cost estimate is on the basis of price level on July 1999. The unit rates of the major materials are shown in Table 9.2.1 and the transportation unit rates for the major materials are shown in Table 9.2.2.

Table 9.2.1 Material Cost

Unit: US$ (1 US$=72.2 Ksh)

Material	Type	Unit	Foreign currency	Local currency	Total
Crushed stone		m^3	11.63	4.99	16.62
Natural sand		m^3	4.57	10.67	15.24
Chipping	10/14	m^3	7.38	17.23	24.61
Asphalt bitumen	80/100	lit	0.10	0.25	0.35
Bitumen cut back	MC 70	lit	0.14	0.34	0.48
Hydrated lime		t	55.57	129.66	185.23
Portland Cement		ton	37.64	87.83	125.47
Aggregate	10/20	m^3	11.75	5.03	16.78
Reinforcement bar		ton	465.37	199.45	664.82
Wood	Hard-Medium	m^3	3.95	9.21	13.16
Plywood for concrete work		m^2	7.06	16.48	23.54
Gabion wire mesh		m^2	7.27	3.12	10.39
Rock fill to gabion		m^3	3.76	8.77	12.53
C.C pipe	Dia. 600 mm	m	13.85	13.85	27.70
C.C pipe	Dia. 900-1000mm	m	27.70	27.70	55.40
Fuel, Diesel		lit	-	0.44	0.44
Gasoline		lit	-	0.66	0.66

Source: MOPWH, Roads Department, Design Branch, Analysis of Contract Rates, 1999

Table 9.2.2 Transportation Cost for Main Material

Route No. and Place	Asphalt Bitumen	Cement	Reinforced bar	Fuel	Wooden
C 19 : HomaBay- Mbita	1200ksh/100 liter drum (Localtransport)	30ksh/bag (50kg) (Local Matatu)	10ksh/bar (40feet) (Local Matatu)	20ksh/20litre can (Local Matatu)	2ksh/running foot (Local Matatu)
D 250/251 : Bumala – Port Victoria	1200ksh/100 liter drum (Localtransport)	30ksh/bag (50kg) (Local Matatu)	10ksh/bar (40feet) (Local Matatu)	20ksh/20litre can (Local Matatu)	2ksh/running foot (Local Matatu)
C 20 : Rongo - Ogembo	1200ksh/100 liter drum (Localtransport)	30ksh/bag (50kg) (Local Matatu)	10ksh/bar (40feet) (Local Matatu)	20ksh/20litre can (Local Matatu)	2ksh/running foot (Local Matatu)

(2) Manpower's Unit Rate

The unit rate is derived from daily wage rate obtained from the MOPWH. The unit rates by major labour classification are shown in Table 9.2.3.

Table 9.2.3 Manpower's Unit Rate

Unit : US $ (1US$=72.2 Ksh)

Sort of man power		Unit	Total
Engineer	Civil engineer	m. daily	41.55
	Survey engineer	-	20.77
	Foreman	-	13.85
Labour	Skilled labour	-	3.47
	Unskilled labour	-	2.08
Operator	Plant	-	3.46
	Equipment	-	3.46
	Driver	-	2.77
Administration	Administrator	-	4.16
	Secretary	-	2.77
	Clerk	-	2.77

Source: MOPWH, Roads Department, Design Branch, Analysis of Contract Rates, 1999

(3) Equipment Unit Rate

The equipment unit rates are the prevailing prices on July 1999, in Kenya. The equipment rate consists of local currency portion including depreciation cost, spare parts and consumable cost, mechanical repair cost and administration expenses. The unit rates of major construction equipment are shown in Table 9.2.4.

(4) Land Acquisition and Compensation Cost

The land acquisition and compensation costs are calculated based on the area to be acquired and based on the land prices and compensation cost obtained from MOPWH. The unit rates of the land acquisition and compensation costs at the districts located the route aimed at a feasibility study are shown in Table 9.2.5.

Table 9.2.4 Equipment Unit Rate

Unit: US$ (1US$=72.2 Ksh)

Construction equipment	Equipment type	Unit	Foreign currency	Local currency	Total
Bulldozer	15 ton	hr	33.94	14.54	48.48
Bulldozer	21 ton	-	48.48	20.77	69.25
Backhoe	0.6 m3	-	29.09	12.46	41.55
Tractor	1.4 m3	-	25.69	11.01	36.70
Dump Truck	2 ton	-	7.27	3.12	10.39
Dump Truck	11 ton	-	21.81	9.35	31.16
Truck	8 ton	-	16.00	6.86	22.85
Motor grader	3.1 ton	-	33.94	14.54	48.48
Tire roller	8-20 ton	-	16.94	7.26	24.20
Tamping roller	7.5 ton	-	21.81	9.35	31.16
Road sprinkler	5.5 klitre	-	21.81	9.35	31.16
Macadam roller	10 ton	-	15.95	6.83	22.78
Asphalt distributer	4-6 klitre	day	26.66	11.43	38.09
Asphalt Finisher	2.4-4.5 m	-	18.18	7.79	25.97
Concrete mixer	0.1 m3	-	5.52	2.37	7.89
Air compressor	3.7 m3/min	hr	13.09	5.61	18.70
Air compressor	10 m3/min	-	13.09	5.61	18.70

Source: MOPWH, Roads Department, Design Branch, Analysis of Contract Rates, 1999

Table 9.2.5 Unit Cost of Land Acquisition and compensation

Unit: US$/m²

District	Land Use	Unit Rate
Suba & H. Bay	County Council (roadside)	0.2
	Medium/High Potential Area (Residential)	0.2
	Low Potential Area	0.1
	Compensation house (Semi Permanent Structure)	70.0
Busia	County Council (roadside)	0.2
	Medium/High Potential Area (Residential)	0.2
	Low development area	0.1
	Compensation house (Semi Permanent Structure)	70.0
Nyanza province Gucha &Migori	County Council (roadside)	0.3
	Medium/high Potential Area (Residential)	0.2
	Low development area	0.2
	Compensation house (Semi Permanent Structure)	70.0

Source: Ministry of Land & Settlement (MOLS), Recent land , Transfer files, May 1999

9.2.5 Unit Price Analysis for Each work

In order to analyse unit price of the respective work items, required material kinds, equipment types and labour kinds are listed and the unit quantity of each item is firstly calculated deriving from the preliminary design of priority project. However, it is difficult to estimate the accurate production rate of each pay item because of the lack of cost breakdown data in Kenya. For this reason, the following procedures are taken so as to ensure the analysis results are as precise as possible;

a) Basically, to estimate rate of the each unit price and work cost, cost data issued by MOPWH, "Analysis of Contract Rates-1999 " Roads Department, Design branch, is adapted as shown in Table 9.2.6 to 9.2.12.

b) The above data are calibrated by the production rate of the construction manual issued by the Ministry of Construction in Japan, modified taking into account labour's ability, material usage, efficiency of equipment, operator's capability, as well as based on those in the similar projects in Kenya.

Table 9.2.6 Rate for Site Clearance

Unit: US$

Work Item	Description	Unit	Rate		
			Foreign	Local	Total
1, Site Clearance	1, Clear site in open county including removal of trees, hedges, bushes and other vegetation or deleterious organic material.	ha	185.00	277.51	462.52
	2, Demolish and dispose culvert inlet and outlet structures.	m	4.49	6.73	11.22

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates - 1999

Table 9.2.7 Rate for Earth Work

Unit: US$

Item	Description	Unit	Rate		
			Foreign	Local	Total
2, Earth Works	1, Fill in soft material (Soil)	m^3	1.02	1.54	2.56
	2, Fill in hard material (Rock)	m^3	3.36	5.04	8.39
	3, Cut in spoil in soft material	m^3	0.71	1.07	1.78
	4, Cut in spoil in soft material	m^3	2.21	3.31	5.52
	5, Compaction to 150 mm depth of existing ground below fills and cuts to 95 % MDD(AASHTO T99)	m^3	0.28	0.43	0.71
	6, Grass over side slopes in fills and cuts	m^2	0.28	0.41	0.69

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates - 1998

Table 9.2.8 Rate for Culvert and Drainage

Unit: US$

Work Item	Description	Unit	Rate Foreign	Rate Local	Rate Total
4, Culverts and Drainage	1, Provide, lay and joint 600 mm I.D. precast concrete pipes.				
	(a) 450 mm diameter	m	15.9	23.85	39.75
	(b) 600 mm diameter	m	21.06	31.60	52.66
	(c) 900 mm diameter	m	37.08	55.62	92.70
	(d) 1200 mm diameter	m	66.46	99.69	166.15
	2, Excavate in soft material for structures, headwalls, wing walls, aprons, toe walls and drop inlets and compact.	m^3	4.24	6.36	10.6
	3, Provide and place class 15/20 concrete to beds, surrounds and haunches.	m^3	36.55	54.82	91.37
	4, Provide and place class 20/20 concrete to head walls, wingwals, aprons, toe walls, inlets and outlets to pipe culverts including formwork.	m^3	61.77	92.66	154.43
	5, Provide and place A 142 Fabric mesh reinforcement for item 3.	m^2	1.77	2.65	4.42
	6, Rock fill to Gabions & mesh	m^3	5.52	8.28	13.8
	7, Provide, place and compact gravel for foundation	m^3	2.44	3.66	6.1

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates - 1998

Table 9.2.9 Rate for Concrete Work

Unit: US$

Work Item	Description	Unit	Rate Foreign	Rate Local	Rate Total
6, Concrete Work	(Concrete)				
	1, Provide, place and compact Class 25/20 reinforced concrete to substructure, beams and deck slab.	m^3	41.84	62.76	104.60
	2, Provide, place and compact Class 15/20 concrete for blinding to foundations.	m^3	34.26	51.40	85.66
	(Form-work)				
	3, Form-work to provide Class F3 finish.	m^2	11.70	17.58	29.30
	(Reinforcement)				
	4, High yield steel bars to BS 4461 of size 16 mm diameter or less.	t.	312.43	468.65	781.08

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates - 1998

Table 9.2.10 Rate for Pavement Work

Unit: US$

Item	Description	Unit	Rate Foreign	Rate Local	Rate Total
5, Pavement Work	1, Splay MC 30 cut-back bitumen as prime coat at 1.0-1.2 litre/m²	lit.	0.20	0.30	0.50
	2, Provide, heat and spray 80/100 bitumen (cutback by kerosene) at a rate of 1.0-1.4 m² for first seal and 0.8 to 1 l/m2 for second seal.	lit.	0.19	0.28	0.47
	3, Provide, lay and roll precoated 10/14mm size chippings on carriageway.	m³	13.92	20.88	34.80
	4, Provide, lay and roll precoated 6/3 mm size chippings on the carriageway	m³	15.64	23.47	39.11
	5, As for item 15.02 but MC 3000 for tackcoat at the spray rate of (0.3 to 0.5 l/m²)	lit.	0.20	0.30	0.50
	6, Provide kerosene and blend into 80/100	lit.	0.17	0.26	0.43
	7, Provide, lay and roll asphalt concrete type II at nominal bitumen content 5-6 % by weight of total mix.	m³	35.62	53.42	89.04
	8, Provide, place and compact crushed stone for base material.	m³	9.51	14.26	23.77
	9, Provide, place and compact crushed stone for sub-base material.	m³	8.80	13.20	22.00
	10, Provide, place and compact gravel for sub-base material	m³	2.36	3.55	5.91

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates - 1999

Table 9.2.11 Rate for Road Furniture

Unit: US$

Work Item	Description	Unit	Rate Foreign	Rate Local	Rate Total
7, Road Furniture	1, Provide and elect traffic signs (Priority & warning type) 1000 mm size	no.	92.89	139.34	232.23
	2, Guardrail	m	22.98	34.46	57.44
	3, Provide and erect Kilometer marker post.	no.	24.78	37.17	61.95
	4, Provide and install reflective delineator.	no.	5.35	8.03	13.38
	5. Paint 0.1 m wide centerline on the road	m²	2.10	3.15	5.25

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates – 1998

Table 9.2.12 Rate for Other work

Unit: US$

Work Item	Description	Unit	Rate		
			Foreign	Local	Total
8, Other work	1. Sub-grade replaced by lime soil	m^3	14.04	21.07	35.11
	2. Provide, place and compact boulder	m^3	11.52	17.27	28.79

Source: MOPWH, Roads Department, Design branch, Analysis of Contract Rates - 1998

9.2.6 Quantity Estimate

Construction work items of the projects consist of the site clearance, earth work, pavement, culvert and drainage, road furniture, land acquisition and house compensation. Each work consists of the quantity items to estimate the direct construction cost. Quantities of the each route and section are shown in Appendix 9.1 "Quantity Estimation".

9.2.7 Direct Construction Cost

The direct construction costs on the priority roads selected for a feasibility study is estimated on the basis of the quantities estimated in the preliminary design and the unit price analysis for each work item. The direct construction costs for the priority roads are estimated at US$ 3,522,341 for Homa Bay-Obanda, US$ 4,135,167 for Obanda-Mbita, US$ 62,603 for Mbita causeway, US$ 2,748,155 for Bumala- Sio Port, US$ 3,658,221 for Sio Port-Port Victoria, and US$ 3,004,197 for Rongo- Ogembo, respectively, and are summarised in Table 9.2.13 to 9.2.18.

Table 9.2.13 Direct Construction Cost of Route C19 (Section I-1, L= 20.0 km)
(Home Bay – Obanda)

Unit: US$

Work Item		Unit	Quantity	Unit Price			Cost		Total cost
				Foreign	Local	Total	Foreign	Local	
(1) Site Clearance	1) Site clearance & stripping	ha	40.1	185.0	277.5	462.5	7,418	11,127	18,546
	2) Demolish & dispose structure	m	451.0	4.5	6.7	11.2	2,020	3,031	5,051
(2) Earth work	1) Cutting Common	m³	24,101.2	0.7	1.1	1.8	17,353	26,029	43,382
	2) Embankment	m³	150,467.9	1.0	1.6	2.6	156,487	234,730	391,217
	3) Sub-grade preparation	m²	75,131.5	0.3	0.4	0.7	21,037	31,555	52,592
	4) Slope compaction with vegetation	m²	240,000.0	0.3	0.4	0.7	67,200	100,800	168,000
(3) Pavement	1) Bitumen cut back	lit	340,438.3	0.2	0.3	0.5	68,088	102,131	170,219
	2) Chipping (6/10,10/14)	m³	5,106.6	15.6	23.5	39.1	79,888	119,831	199,719
	5) Base course (crushed stone)	m³	21,087.7	9.5	14.3	23.8	200,755	301,132	501,887
	6) Sub-base course (crushed stone)	m³	39,500.0	8.8	13.2	22.0	347,600	521,400	869,000
	7) Tack coat	lit	70,000.0	0.2	0.3	0.5	14,000	21,000	35,000
	8) Prime coat	lit	240,525.9	0.2	0.3	0.5	48,105	72,158	120,263
(4) Black cotton soil treatment	1) Soil replaced by lime soil	m³	75,000.0	2.4	3.6	6.0	180,000	270,000	450,000
	2) Stone	m³	48,000.0	2.0	3.0	5.0	96,000	144,000	240,000
(5) Culvert & drainage	1) Box Culvert a) Culvert 25/20 concrete	m³	90.4	73.2	31.4	104.6	3,782	5,674	9,456
	Reinforcement bar	t	7.2	312.4	468.7	781.1	2,249	3,374	5,623
	b) Leveling concrete (15/20 concrete)	m³	7.5	34.3	51.4	85.7	257	385	642
	c) Foundation (Compacted gravel)	m³	15.0	2.4	3.7	6.1	37	55	92
	2) Pipe Culvert a) Pipe Dia. 600	m	308.0	21.1	31.6	52.7	6,492	9,739	16,231
	Dia. 900	m	132.0	37.1	55.6	92.7	4,894	7,342	12,236
	b) Bed, surround, Haunch (15/20 concrete)	m³	250.8	36.6	54.8	91.4	9,169	13,754	22,923
	3) Head wall, wing wall, apron, inlet, outlet, toe wall (20/20 concrete)	m³	142.1	61.8	92.6	154.4	8,776	13,164	21,940
	4) Fabric mesh	m²	1,656.4	1.8	2.6	4.4	2,915	4,373	7,288
	5) Gabion	m³	9.3	5.5	8.3	13.8	51	77	128
	6) Structure excavation & fill/compaction	m³	3,068.0	4.2	6.4	10.6	13,008	19,513	32,521
	7) Grouted stone pitching	m³	397.5	10.0	15.1	25.1	3,991	5,986	9,977
(6) Road furniture	1) Traffic sign	no.	20	92.9	139.3	232.2	1,858	2,786	4,644
	2) Guardrail	m	1,700	40.2	17.2	57.4	39,032	58,548	97,580
	3) Kilometer post	no.	20	43.4	27.9	62.0	496	744	1,240
	4) Delineator	no.	340	9.3	4.0	13.3	1,818	2,726	4,544
	5) Centerline mark	m²	2,000	3.6	1.6	5.2	4,160	6,240	10,400
Ground total direct construction cost :							1,408,936	2,113,405	3,522,341

Table 9.2.14 Direct Construction Cost of Route C19 (Section I-2, L= 22.06 km) (Obanda – Mbita)

Unit: US$

Work		Item	Unit	Quantity	Unit Price Foreign	Unit Price Local	Unit Price Total	Cost Foreign	Cost Local	Total cost
(1) Site Clearance	1)	Site clearance & stripping	ha	44	185.0	277.5	462.5	14,245	6,105	20,350
	2)	Demolish & dispose structure	m	891	4.5	6.7	11.2	3,992	5,987	9,979
(2) Earth work	1)	Cutting								
		Common	m³	39,560	0.7	1.1	1.8	28,483	42,725	71,208
	2)	Embankment	m³	122,506	1.0	1.6	2.6	127,406	191,110	318,516
	3)	Sub-grade preparation	m²	82,725	0.3	0.4	0.7	23,163	34,745	57,908
	4)	Slope compaction with vegetation	m²	264720	0.3	0.4	0.7	74,122	111,182	185,304
(3) Pavement	1)	Bitumen cut back	lit	375,020	0.2	0.3	0.5	75,004	112,506	187,510
	2)	Chipping (6/10, 10/14)	m²	5,207	15.6	23.5	39.1	8,158	12,236	203594
	3)	Base course (crush stone)	m³	23,163	9.5	14.3	23.8	220,512	330,767	551,279
	4)	Sub-base course (crush stone)	m³	43,569	8.8	13.2	22.0	383,407.2	575,110.8	958,518
	5)	Tack coat	lit	77,210	0.2	0.3	0.5	15,442	23,164	38,605
	6)	Prime coat	lit	261,444	0.2	0.3	0.5	52,289	78,433	130,722
(4) Black cotton soil treatment	1)	Soil replaced by lime soil	m³	112,500	2.4	3.6	6.0	270,000	405,000	675,000
	2)	Rock	m³	72,000	2.0	3.0	5.0	144,000	216,000	360,000
(5) Culvert & Drainage	1)	Box Culvert								
		a) Culvert 25/20 concrete	m³	354.7	41.8	62.8	104.6	14,840.6	22,260.9	37,101.6
		Reinforcement bar	t	35.7	312.4	468.7	781.1	11,154.1	16,731.2	27,885.3
		b) Leveling concrete (15/20 concrete)	m³	24.9	34.3	51.4	85.7	853.6	1,280.3	2,133.9
		c) Foundation (Compacted gravel)	m³	48.8	2.4	3.7	6.1	119.1	178.6	297.7
	2)	Pipe Culvert								
		a) Pipe Dia. 600	m	495.0	21.1	31.6	52.7	10,34.6	15,651.9	26,086.5
		Dia. 900	m	374.0	37.1	55.6	92.7	13,867.9	20,801.9	34,669.8
		b) Bed, surround, Haunch (15/20 concrete)	m³	495.3	36.6	54.8	91.4	18,108.2	27,162.2	45,270.4
	3)	Head wall, wing wall, apron, inlet, outlet, toe wall (20/20 concrete)	m³	318.8	61.8	92.6	154.4	19,689.1	29,533.6	49,222.7
	4)	Fabric mesh	m²	3,355.1	1.8	2.6	4.4	5,905.0	8,857.4	14,762.4
	5)	Gabion	m³	24.5	5.5	8.3	13.8	135.2	202.9	338.1
	6)	Structure excavation & fill/compaction	m³	7,071.5	4.2	6.4	10.6	29,983.2	44,974.7	74,957.9
(6) Road furniture	1)	Traffic sign	no.	22	92.9	139.4	232.2	2,043.2	3,065.2	5,108.4
	2)	Guardrail	m	600	23.0	34.4	57.4	24,108.0	10,332.0	34,440.0
	3)	Kilometer post	no.	22	24.8	37.2	62.0	545.6	818.4	1,364.0
	4)	Delineator	no.	120	5.3	8.0	13.3	638.4	957.6	1,596.0
	5)	Centerline mark	m²	2,200	2.1	3.1	5.2	4,576.0	6,864.0	11,440.0
Ground total direction construction cost:								1,654,067	2,481,100	4,135,167

Table 9.2.15 Direct Construction Cost of Route C19 (Section I-3, L= 0.35 km) (Mbita course-way)

Unit: US$

Work Item			Unit	Quantity	Unit Price			Cost		Total cost
					Foreign	Local	Total	Foreign	Local	
(1) Site Clearance	1)	Site clearance & stripping	ha	1	185.0	277.5	462.5	186	279	465
(2) Earth work	1)	Embankment	m^3	3,724	1.0	1.6	2.6	3,873	5,809	9,682
	2)	Sub-grade preparation	m^2	1,313	0.3	0.4	0.7	368	551	919
	3)	Slope compaction	m^2	4,200	0.3	0.4	0.7	1,176	1,764	2,940
(3) Pavement	1)	Bitumen cut back	lit	5,950	0.2	0.3	0.5	1,190	1,785	2,975
	2)	Chipping (6/10,10/14)	m^3	90	15.6	23.5	39.1	1,408	2,111	3,519
	3)	Base course (crush stone)	m^3	368	9.5	14.3	23.8	3,503	5,255	8,758
	4)	Sub-base course (crush stone)	m^3	692	8.8	13.2	22.0	6,090	9,134	15,224
	5)	Tack coat	lit	1,225	0.2	0.3	0.5	245	368	613
	6)	Prime coat	lit	4,200	0.2	0.3	0.5	840	1,260	2,100
(4) Rock slop protection (Boulder)			m^3	2,450	2.4	3.6	6.0	5,880	8,820	14,700
(5) Road furniture	1)	Traffic sign	no.	2	92.9	139.3	232.2	186	278	464
	2)	Kilometer post	no.	1	24.8	37.2	62.0	25	37	62
	3)	Centerline mark	m^2	35	2.1	3.1	5.2	73	109	182
Ground total direct construction cost:								25,041	3,562	62,603

Note: Section III, STA 41+485-41+875

Table 9.2.16 Direct Construction Cost of Route D250/251 (Section II-1, L= 20.0 km)
(Bumala – Sio Port)

Unit: US$

Work		Item	Unit	Quantity	Unit Price Foreign	Unit Price Local	Unit Price Total	Cost Foreign	Cost Local	Total cost
(1) Site Clearance	1)	Site clearance & stripping	ha	40.0	185.0	277.5	462.5	7,400.0	11,100.0	18,500.0
	2)	Demolish & dispose structure	m	396.0	4.5	6.7	11.2	1774.1	2661.1	4,435.2
(2) Earth work	1)	Cutting								
		Common	m³	139,929	0.7	1.1	1.8	100748.9	151123.3	251,872.2
	2)	Embankment	m³	63,364	1.0	1.6	2.6	65898.4	98847.6	164,746.0
	3)	Sub-grade preparation	m²	75,125.0	0.3	0.4	0.7	21,035.0	31,552.5	52,587.5
	4)	Slope compaction with vegetation	m²	240,000.0	0.3	0.4	0.7	67,200.0	100,00	168,000.0
(3) Pavement	1)	Bitumen cut back	lit	340,356.0	0.2	0.3	0.5	68,071.2	102106.8	170,178.0
	2)	Chipping (6/10,10/14)	m³	5,145.0	15.6	23.5	39.1	80,467.8	120701.7	201,169.5
	3)	Base course (crush stone)	m³	21,076.0	9.5	14.3	23.8	200,643.5	300965.3	501,608.8
	4)	Sub-base course (crush stone)	m³	39,500.0	8.8	13.2	22.0	347,600.0	521,400.0	869,000.0
	5)	Tack coat	lit	70,000.0	0.2	0.3	0.5	14,000.0	21,000.0	35,000.0
	6)	Prime coat	lit	240,450.0	0.2	0.3	0.5	48,090.0	72,135.0	120,225.0
(4) Culvert & drainage	1)	Box Culvert								
		a) Culvert (25/20 concrete)	m³	252.2	41.8	62.8	104.6	10,552.0	15,828.1	26,380.1
		Reinforcement bar	t	25.2	312.4	468.7	781.1	7,873.5	11,810.2	19,683.7
		b) Leveling concrete (15/20 concrete)	m³	22.2	34.3	51.4	85.7	761.0	1,141.5	1,902.5
		c) Foundation (Compacted gravel)	m³	44.4	2.4	3.7	6.1	108.3	162.5	270.8
	2)	Pipe Culvert								
		a) Pipe Dia. 600	m	156.0	21.1	31.6	52.7	3,288.5	4,932.7	8,221.2
		Dia. 900	m	247.0	37.1	55.6	92.7	9,158.8	13,738.1	22,896.9
		b) Bed, surround, Haunch (15/20 concrete)	m³	195.3	36.6	54.8	91.4	7,140.2	7,140.2	17,850.4
	3)	Head wall, wing wall, apron, inlet, outlet, toe wall (20/20 concrete)	m³	214.7	61.8	92.6	154.4	13,259.9	19,889.9	33,149.8
	4)	Fabric mesh	m²	1,557.0	1.8	2.6	4.4	2,740.3	4,110.5	6,850.8
	5)	Gabion	m³	22.6	5.5	8.3	13.8	124.8	187.1	311.9
	6)	Structure excavation & fill/compaction	m³	3,493.5	4.2	6.4	10.6	14,812.4	22,218.7	37,031.1
(5) Road furniture	1)	Traffic sign	no.	20	92.9	139.3	232.2	1,857.6	2,786.0	4,644.0
	2)	Kilometer post	no.	20	24.8	37.2	62.0	496.0	744.0	1,240.0
	3)	Centerline mark	m²	2,000	2.1	3.1	5.2	4,160.0	6,240.0	10,400.0
Ground total direction construction cost:								1,099,262	1,648,893	2,748,155

Table 9.2.17 Direct Construction Cost of Route D250/251 (Section II-2, L= 22.99 km) (Sio Port – Port Victoria)

Unit: US$

Work		Item	Unit	Quantity	Unit Price Foreign	Unit Price Local	Unit Price Total	Cost Foreign	Cost Local	Total cost
(1) Site Clearance	1)	Site clearance & stripping	ha	46.0	185.0	277.5	462.5	8,510.0	12,765.0	21,275.0
	2)	Demolish & dispose structure	m	403.0	4.5	6.7	11.2	1,805.4	2,708.0	4,513.4
(2) Earth work	1)	Cutting								
		Common	m³	237,524.0	0.7	1.1	1.8	171,473.0	257,209.6	427,543.2
	2)	Embankment	m³	262,203.0	1.0	1.6	2.6	272,691.1	409,036.7	681,727.8
	3)	Sub-grade preparation	m²	83,268.0	0.3	0.4	0.7	23,315.0	23,315.0	58,287.6
	4)	Slope compaction with vegetation	m²	277,560.0	0.3	0.4	0.7	77,716.8	116,575.2	194,292.0
(3) Pavement	1)	Bitumen cut back	lit	343,795.0	0.2	0.3	0.5	68,759.0	103,138.5	171,897.5
	2)	Chipping (6/10,10/14)	m³	5,993.2	15.6	23.5	39.1	93,733.6	140,600.5	234,334.1
	3)	Base course (crush stone)	m³	24,392.7	9.5	14.3	23.8	232,218.5	348,327.8	580,546.3
	4)	Sub-base course (crush stone)	m³	45,682.0	8.8	13.2	22.0	402,001.6	603,002.4	1,005,004.0
	5)	Tack coat	lit	80,955.0	0.2	0.3	0.5	16,191.0	24,286.5	40,477.5
	6)	Prime coat	lit	279,219.0	0.2	0.3	0.5	55,843.8	83,765.7	139,609.5
(4) Culvert & drainage	1)	Pipe Culvert								
		a) Pipe Dia. 600	m	208.0	21.1	31.6	52.7	4384.6	6,577.0	10,961.6
		Dia. 900	m	182.0	37.1	55.6	92.7	6748.6	10,122.8	16,871.4
		b) Bed, surround, Haunch (15/20 concrete)	m³	189.0	36.6	54.8	91.4	6909.8	10364.8	17,274.6
	2)	Head wall, wing wall, apron, inlot, outlet, toe wall (20/20 concrete)	m³	57.0	61.8	92.6	154.4	3520.3	5280.5	8,800.8
	3)	Fabric mesh	m²	1,107.3	1.8	2.6	4.4	442.9	18160.1	1,107.3
	4)	Structure excavation & fill/compaction	m³	1,755.0	4.2	6.4	10.6	7441.2	11,161.8	18,603.0
(5) Road furniture	1)	Traffic sign	no.	24	92.9	139.3	232.2	2,229.1	3,343.7	5,572.8
	2)	Guardrail	m	100	23.0	34.4	57.4	2,296.0	3,444.0	5,740.0
	3)	Kilometer post	no.	24	24.8	37.2	62.0	595.2	892.8	1,488.0
	4)	Delineator	no.	20	5.3	8.0	13.3	106.4	159.6	266.0
	5)	Centerline mark	m²	2,313	2.1	3.1	5.2	4,811.0	7,216.6	12,027.6
Ground total direct construction cost:								1,463,288	2,194,933	3,658,221

Table 9.2.18 Direct Construction Cost of Route C20 (Section III, L= 19.02 km) (Rongo – Ogembo)

Unit: US$

Work Item			Unit	Quantity	Unit Price			Cost		Total cost
					Foreign	Local	Total	Foreign	Local	
(1) Site Clearance	1)	Site clearance & stripping	ha	47.5	185.0	277.5	462.5	8,788	13,181	21,969
	2)	Demolish & dispose structure	m	550.0	4.5	6.7	11.2	2,464	3,696	6,160
(2) Earth work	1)	Cutting								
		Common	m³	171,331.0	0.7	1.1	1.8	123,358.3	185,037.5	308,395.8
	2)	Embankment	m³	172,261.0	1.0	1.6	2.6	179,151.4	268,727.2	447,878.6
	3)	Sub-grade preparation	m³	71,302.5	0.3	0.4	0.7	1,964.7	2,947.1	4,911.8
	4)	Slope compaction with vegetation	m³	380,280.0	0.3	0.4	0.7	106,478.4	159,717.6	266,196.0
(3) Pavement	1)	Asphalt concrete (type II)	m³	3,992.9	35.6	53.4	89.0	142,147.2	213,220.9	355,368.1
	2)	Base course (crush stone)	m³	20,290.2	9.5	14.3	23.8	193,162.7	144,872.0	482,906.8
	3)	Sub-base course (crush stone)	m³	27,570.3	8.8	13.2	22.0	242,618.6	363,927.9	606,546.6
	4)	Bitumen cut back	lit	57,043.0	0.2	0.3	0.5	11,408.6	17,112.9	28,521.5
	5)	Chipping(10/14)	m³	880.0	15.6	23.5	39.1	13,763.2	20,644.8	34,408.0
	6)	Prime coat	lit	230,122.7	0.2	0.3	0.5	46,024.5	69,036.8	115,061.3
(4) Culvert & drainage	1)	Box Culvert								
		a) Culvert (25/20 concrete)	m³	289.1	41.8	62.8	104.6	12,096.0	18,143.9	30,239.9
		Reinforcement bar	t	28.9	312.4	468.7	781.1	9,029.5	13,544.3	22,573.8
		b) Leveling concrete (15/20 concrete)	m³	24.9	34.3	51.4	85.7	853.6	1,280.3	2,133.9
		c) Foundation (Compacted gravel)	m³	49.8	2.4	3.7	6.1	121.5	182.3	303.8
	2)	Pipe Culvert								
		a) Pipe Dia. 600	m	539.0	21.1	31.6	52.7	11,362.1	17,043.2	28,405.3
		b) Bed, surround, Haunch (15/20 concrete)	m³	307.2	36.5	54.8	91.4	11,231.2	8,423.4	28,078.1
	3)	Head wall, wing wall, apron, inlet, outlet, toe wall (20/20 concrete)	m³	261.9	61.8	92.6	154.4	16,174.9	24,262.5	40,437.4
	4)	Fabric mesh	m²	2,247.8	1.8	2.6	4.4	3,956.1	5,934.2	9,890.3
	5)	Gabion	m³	24.5	5.5	8.3	13.8	135.2	202.9	338.1
	6)	Structure excavation & fill/compaction	m³	4,658.5	4.2	6.4	10.6	19,752.0	29,628.1	49,380.1
	7)	Grouted stone pitching	m³	307.5	10.0	15.1	25.1	3,087.3	4,631.0	7,718.3
(5) Road furniture	1)	Traffic sign	no.	20	92.9	139.3	232.2	1,858	2,786	4,644
	2)	Guardrail	m	1,500	23.0	34.4	57.4	34,440	51,660	86,100
	3)	Kilometer post	no.	20	24.8	37.2	62.0	496	744	1,240
	4)	Delineator	no.	30	5.3	8.0	13.3	1,596	2,394	3,990
	5)	Centerline mark	m²	2,000	2.1	3.1	5.2	4,160	6,240	10,400
Ground total direct construction cost:								1,201,679	1,802,518	3,004,197

9.2.8 Total Project Cost

The project cost on the priority roads selected for a feasibility study is estimated on the basis of the quantities estimated in the preliminary design and the unit price analysis for each work item. The project costs for each section estimated are summarised in Table 9.2.19 to Table 9.2.24. The project costs for each year during construction period indicated in Table 9.1.9 are shown in Table 9.2.25.

Table 9.2.19 Project Cost of Route C19 (Section I-1, L= 20 km)

(Homa Bay - Obanda)

Unit: in US$

Cost Component	Currency portion		Total Cost	Remark
	Foreign	Local		
(1) Direct Construction	1,408,936	2,113,405	3,522,341	
(2) Indirect Construction	493,128	739,692	1,232,819	35 % x (1) Overhead/profit, office/laboratory, transportation, other common temporary works.
(3) Engineering Services	246,564	105,670	352,234	10 % x (1) Detail design: 2 %, Supervision: 8 %
(4) Contingency	306,444	45,967	766,109	15 % x ((1) + (2) + (3))
Sub total	2,455,072	3,418,431	5,873,503	(1)+ (2)+ (3) + (4)
Land acquisition & compensation	-	142,400	142,400	
Project Cost	2,455,072	3,560,831	6,015,903	

Note: 1US$=72.2 Ksh , July 9, 1999

Table 9.2.20 Project Cost of Route C19 (Section I-2, L= 22.06 km)

(Obanda - Mbita)

Unit: in US$

Cost Component	Currency portion		Total Cost	Remark
	Foreign	Local		
(1) Direct Construction	1,654,067	2,481,100	4,135,167	
(2) Indirect Construction	578,923	868,385	1,447,308	35 % x (1) Overhead/profit, office/laboratory, transportation, other common temporary works.
(3) Engineering Services	289,462	124,055	413,517	10 % x (1) Detail design: 2 %, Supervision: 8 %
(4) Physical Contingency	359,760	539,639	899,399	15 % x ((1) + (2) + (3))
Sub total	3,170,433	3,724,958	6,895,391	(1)+ (2)+ (3) + (4)
Land acquisition & compensation	-	52,500	52,500	
Project Cost	3,170,433	3,777,458	6,947,891	

Note: 1US$=72.2 Ksh

Table 9.2.21 Project Cost of Route C19 (Section I-3, L = 0.35 km)

(Mbita causeway)

Unit: in US$

Cost Component	Currency portion		Total Cost	Remark
	Foreign	Local		
(1) Direct Construction	25,041	37,562	62,603	
(2) Indirect Construction	8,764	13,147	21,911	35 % x (1) Overhead/profit, office/laboratory, transportation, other common temporary works.
(3) Engineering Services	4,383	1,878	6,261	10 % x (1) Detail design: 2 %, Supervision: 8 %
(4) Physical Contingency	5,447	8,169	13,616	15 % x ((1) + (2) + (3))
Sub total	43,635	60,756	104,391	(1)+ (2)+ (3) + (4)
Land acquisition & compensation	-	-	-	
Project Cost	43,635	60,756	104,391	

Note: 1US$=72.2 Ksh

This cost is appropriated by the El Nino disaster rehabilitation budget.

Table 9.2.22 Project Cost of Route D250/251 (Section II-1, L= 20 km)

(Bumala – Sio Port)

Unit: in US$

Cost Component	Currency portion Foreign	Local	Total Cost	Remark
(1) Direct Construction	1,099,262	1,648,893	2,748,155	
(2) Indirect Construction	384,742	577,112	961,854	35 % x (1) Overhead profit, office/laboratory, transportation, other common temporary works.
(3) Engineering Services	192,371	82,445	274,816	10 % x (1) Detail design: 2 %, Supervision: 8 %
(4) Physical Contingency	239,090	358,635	597,724	15 % x ((1) + (2) + (3))
Sub total	1,915,465	2,667,084	4,582,549	(1)+ (2)+ (3) + (4)
Land acquisition & compensation	-	-	-	
Project Cost	1,915,465	2,667,084	4,582,549	

Note: 1US$=72.2 Ksh

Table 9.2.23 Project Cost of Route D250/251 (Section II-2, L= 22.99 km)

(Sio Port – Port Victoria)

Unit: in US$

Cost Component	Currency portion Foreign	Local	Total Cost	Remark
(1) Direct Construction	1,463,288	2,194,933	3,658,221	
(2) Indirect Construction	512,151	768,226	1,280,377	35 % x (1) Overhead profit, office/laboratory, transportation, other common temporary works.
(3) Engineering Services	256,075	109,747	365,822	10 % x (1) Detail design: 2 %, Supervision: 8 %
(4) Physical Contingency	318,265	477,398	795,663	15 % x ((1) + (2) + (3))
Sub total	2,549,779	3,550,304	6,100,083	(1)+ (2)+ (3) + (4)
Land acquisition & compensation	-	5,470	5,470	
Project Cost	2,549,779	3,555,774	6,105,553	

Note: 1US$=72.2 Ksh

Table 9.2.24 Project Cost of Route C20 (Section III, L= 19.02 km)

(Rongo – Ogembo)

Unit: in US$

Cost Component	Currency portion		Total Cost	Remark
	Foreign	Local		
(1) Direct Construction	1,201,679	1,802,518	3,004,197	
(2) Indirect Construction	420,588	630,881	1,051,469	35 % x (1) Overhead/profit, office/laboratory, transportation, other common temporary works.
(3) Engineering Services	210,294	90,126	300,420	10 % x (1) Detail design: 2 %, Supervision: 8 %
(4) Physical Contingency	261,365	392,048	653,413	15 % x ((1) + (2) + (3))
Sub total	2,093,926	2,915,573	5,009,499	(1)+ (2)+ (3) + (4)
Land acquisition & compensation	-	-	-	
Project Cost	2,093,926	2,915,573	5,009,499	

Note: 1US$=72.2 Ksh

Table 9.2.25 Project Cost

Unit: in US$

Section	1st Year			2nd Year			3rd Year			Total		
	Currency		Total	Currency		Total	Currency		Total	Currency		Total
	Foreign	Local		Foreign	Local		Foreign	Local		Foreign	Local	
I-I	1,579,593	2,341,829	3,921,422	875,479	1,219,002	2,094,481			0	2,455,072	3,560,831	6,015,903
I-2	533,264	105,459	638,723	2,022,389	2,815,978	4,838,367	614,780	856,021	1,470,801	3,170,433	3,777,458	6,947,891
I-3				325	451	776	43,310	60,305	103,615	43,635	60,756	104,391
Sub-total	2,112,857	2,447,288	4,560,145	2,898,193	4,035,431	6,933,624	658,090	916,326	1,574,416	5,669,140	7,399,045	13,068,185
II-1	1,375,183	1,914,794	3,289,977	540,282	752,290	1,292,572			0	1,915,465	2,667,084	4,582,549
II-2	31,049	48,702	79,751	1,865,448	2,597,442	4,462,890	653,282	909,630	1,562,912	2,549,779	3,555,774	6,105,553
Sub-total	1,406,232	1,963,496	3,369,728	2,405,730	3,349,732	5,755,462	653,282	909,630	1,562,912	4,465,244	6,222,858	10,688,102
III			0	578,637	805,681	1,384,318	1,515,289	2,109,892	3,625,181	2,093,926	2,915,573	5,009,499
Grand total	3,519,089	4,410,784	7,929,873	5,882,560	8,190,844	14,073,404	2,826,661	3,935,848	6,762,509	12,228,310	16,537,476	28,765,786

Note: Land acquisition and compensation costs are included in the above project cost

Chapter 10

Environmental Impact Assessment

Chapter 10 Environmental Impact Assessment

10.1 Initial Environmental Examination

The initial environmental examination (IEE) process was applied to three selected projects. The IEE examines a series of environmental items, which project implementation may have an adverse impact not only on the project sites but also on surrounding areas, which may be directly or indirectly affected during the construction and operational stages. The IEE was carried out at early stage when concrete development plan, such as the location of road, the items of construction, existence of alignment, and forecast traffic volume, were not yet decided. The screening and scoping of environmental items, which may be potentially impacted by the proposed projects, was completed and 13 items were selected for inclusion in the IEE process (Table 10.1.1). The comprehensive IEE listing includes 23 items; however, it is judged that 10 environmental items will not be impacted by the projects and are thus excluded from further examination (Table 10.1.2).

Table 10.1.1 Screening and Scoping

Major Facilities / Activities		Roads / Roadside Facilities / Construction Roads				
		Construction Stage		After Construction Stage		
Activities which may cause impacts		Trespassing on Land *1	Operation of Construction Equipment *2	Land Acquisition *3	Traffic *4	Concentration of People and Goods *5
Social Environment						
1	Resettlement	O		O		
2	Economic Activities			O		
3	Traffic and Public Facilities				O	
4	Split of Communities			O		
5	Cultural Property	O				
6	Water Rights/ Rights of Common	O				
7	Public Health Condition					
8	Waste					
9	Hazards (Risk)					
Natural Environment						
10	Topography and Geology					
11	Soil Erosion	O				
12	Groundwater					
13	Hydrological Situation	O				
14	Coastal Zone					
15	Flora and Fauna	O				

16	Meteorology					
17	Landscape			O		
Pollution						
18	Air Pollution		O		O	
19	Water Pollution	O			O	
20	Soil Contamination					
21	Noise and Vibration		O		O	
22	Land Subsidence					
23	Offensive Odor					

Note 1 : O: The environmental items which may have a significant impact depending on the scale of the project and site conditions

*1: Activities trespassing on land for preparation work of road construction.

*2: Activities which may cause impacts by construction equipment under construction.

*3: Situations which may cause impacts by permanent use of land after construction.

*4: Activities which may cause impacts by traffic on the project roads after construction.

*5: Situations which may cause impacts by concentration of people and goods at public facilities such as administrative facilities, hospitals, schools, and markets after construction.

Table 10.1.2 Excluded Environmental Items

Environmental Item	Reason for Exclusion
Public Health Condition	The deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin will not occur.
Waste	The generation of construction and demolition waste, debris and logs will occur. However the volume of waste will be very small, because the projects are mainly rehabilitation ones. Adequate implementation of construction will be able to manage the impact.
Hazards (Risk)	The increase in danger from landslide will not occur, because the projects are not including large-scale land reclamation such as excavation or filling.
Topography and Geology	The changes of valuable topography and geology will not occur, because the projects are not including large-scale land reclamation such as excavation or filling.
Groundwater	The exhaustion of groundwater will not occur, because the projects are not including the activities of drafting groundwater.
Coastal Zone	The coastal erosion and sedimentation will not occur, because the projects are not located at coastal zone.
Soil Contamination	The contamination of soil by dust and chemicals, such as herbicides, will not occur, because the projects are not including the activities of causing soil contamination.
Meteorology	The changes of temperature, precipitation, wind, etc. will not occur, because the projects are not including large-scale land reclamation and building construction.
Land Subsidence	The deformation of land and land subsidence will not occur, because the projects are not including lowering of the groundwater table.
Offensive Odor	The projects, being road construction ones, are not expected to generate adverse levels of offensive odor.

10.2 Environmental Impact Assessment

The environmental impact assessment (EIA) for the proposed projects was carried out by data collection, field reconnaissance, and hearing after decision of concrete development plan. The items for EIA were those, which were selected at the IEE stage. The approach and methodology for conducting this EIA is based on the NEAP draft environmental guidelines (NEAP, August 1996) and JICA's Environmental Guidelines for Infrastructure Projects, Volume III Roads (September 1992). The results of EIA are as follows:

10.2.1 Existing Environmental Conditions

(1) Homa Bay - Mbita Road (C19)

1) Social Environment

a) Locations

The Homa Bay - Mbita Road (C19) begins about 4 km south out of the Homa Bay town centre, at the junction of the Homa Bay - Rongo Road (C20). The length of the road is 42.4 km. It initially heads southwest until the junction of E117 to Ongeng, then swings northwest to roughly follow the shoreline of Lake Victoria to Mbita. It passes through 2 districts, namely Homa Bay and Suba Districts, and 3 administrative divisions: Asego and Ndhiwa Divisions in the Homa Bay District and Mbita Division in the Suba District.

b) Population

The growth rates are expected to be 3.19% for the Suba District and 2.29% for the Homa Bay District from 1989 to 2005, (Suba and Homa Bay District Development Plans 1997 - 2001). The population density is moderately high at present in all three divisions. Over the period of the year in 1979 and 1989, the population of Homa Bay municipality grew at a yearly rate of 21.2%. Since 1989, it is believed that the annual growth rate has slowed down considerably to 2.96%. Thus the population estimate for the town in 1999 is 53,035 people.

c) Economic Activities

Much of income along the C19 road is derived from fishing (mainly in the Suba District), agriculture and livestock (mainly in the Homa Bay District). Wage employment is concentrated primarily in the urban centres, such as Homa Bay and Mbita, and estimated average per capita wage earnings range between KShs 900 to 2,000/month. Comparing these figures with the rural and urban poverty lines of KShs 978 and 1,490/month, respectively, would indicate that in general the people around the project area are living on the poverty line.

Small holder farming is dominant along the project road, and the average farm holding is between 2 and 4 hectares. Food crops, such as maize, beans, sorghum, sweet potato and cassava, are mainly grown. Cash crops include cotton and rice. No large farms are located or likely to be developed along the project road. Livestock keeping is also an important activity, although there are no ranches. Types of livestock kept include Zebu cattle, goats, sheep and poultry.

Fishing is an important activity pursued at lakes, rivers and in ponds. There are more than 5,000 fishermen operating about 1,300 boats along the project road. The major fish species are Nile Perch (*Lates niloticus*), Tilapia (*Oreochromis niloticus*) and Omena (*Rastrineobola argentea*). In the Suba District there are 39 designated fish landing beaches, while Asego Division of the Homa Bay District has only 2 landing beaches. In 1995, over 21,000 tonnes and in 1998, 8,000 tonnes of fish were landed in the Suba District, valued at approximately KShs 560 and 180 million respectively. In contrast, only 3,000 tonnes were landed at Asego in 1995.

There are no significant forest reserves within the area of influence of the project road. Forestry activities focus on seedling production and on-farm tree planting.

Tourism in the area is largely confined to Rusinga and Mfangano Islands, both of which can be accessed through Mbita, although tourists usually fly directly these destinations. Ruma National Park attracts mainly domestic tourists. The potential for future development of tourism in this area is limited as there are few attractions along the route, and poor facilities to accommodate tourists.

d) Infrastructure

Homa Bay town itself is connected to the National Electricity Grid, none of the other centres along the road, including Mbita have electricity.

In the area of influence of the project road, only Homa Bay municipality has piped water facilities, while Mbita Water Supply is currently under construction. There is also a water facility at Kakaeta Kamungu. The most common sources of water along the road are dams, wells (protected and unprotected), rivers and the lake. Due to the geological structure in the area, boreholes have been largely unsuccessful.

Infant mortality and the incidence of disease in both Suba and Homa Bay Districts are high. For the two districts, infant mortality is 143/1,000 live births (national average is 60/1,000 live births). Malaria and respiratory diseases account for more than 50% of the morbidity rate in both districts. Malnutrition levels among children are also high along the project road. In Asego Division, 22% of the children are stunted. In Mbita Division 38% of the children are stunted while 51% are underweight. There is a hospital at Homa Bay, Mbita has a dispensary, while health centres are found at Kitare and Ogongo, in the road's area of influence. Homa Bay and Kisum are placed as major marketplaces for the residents and they go to the Homa Bay District Hospital in serious cases. It takes 1.5 hours for Hama Bay by Matatsu, of which frequency service is around 17 per day.

In all the divisions along the project road, education facilities are well distributed in relation to the population, but they are under-utilised. Drop-out rates are high for both boys and girls because of their poverty.

The road passes through a number of market and administrative centres, including Weno, Rambusi, Kakaeta Kamungu, Ogongo, Obanda, Waondo, Nyamasare, Luanda, Kirindo, and finally Mbita.

The number of accidents along the project road was small, although little attention has been given to road safety. There is a general lack of warning or directional signs, especially near hospitals and schools. Pedestrians and cyclists accounted for the largest percentage of traffic. There are no pathways for these categories of road users, nor any signs to warn motorists of their presence.

2) Natural Environment

a) Topography and Geology

At the beginning of the road (at the junction with the C20) the landscape is gently undulating rising up to the Kanyamwa Escarpment which forms part of the western border between the Homa Bay and the Suba Districts. The project road then descends into generally flat low-lying terrain. Various types of soils are found along the project road, and they are of high fertility in general.

There are several perennial and seasonal rivers close to or cutting across the project road, including Olando, Ogongo, Petokiri, Minarot, and Olambwe. All the rivers drain northwards into the lake.

The drainage in culverts was one of the problems along the Homa Bay - Mbita Road (C19), particularly along the flat sections where black cotton soil is predominant. Such a problem was noticed at a culvert at Km 6.6. The stagnant water encourages the breeding of mosquitoes and so its accumulation should be discouraged.

At approximately Km 37 along the Homa Bay - Mbita Road (C19), there is a box culvert, which was originally constructed to cater to a large seasonal river. The river apparently changes its course quite often, and for many years now it has not passed under the box culvert. Instead it passes to the east of the culvert, which is evident from the siltation on either side of the road at that point.

b) Climate

The area along the project road has an inland equatorial climate heavily influenced by its proximity to the lake. Temperatures range between 17°C and 35°C; the hottest month is February. There are two rainy seasons. The long rains fall between March and May, while the short rains fall between August and November. Annual rainfall averages between 700 and 1,000 mm. The section of the road along the lakeshore has semi-humid to semi-arid conditions while the rest of the road lies in a semi-humid moisture availability zone.

c) Flora and Fauna

The vegetation along the project road is no longer natural, as there is considerable agricultural activity in the area. However, the original vegetation type at the beginning of the road was a combination of moist woodland and bushed grassland (still apparent in the Ruma National Park), consisting of grassland with scattered or grouped trees and bushes, and is the original savannah. As the road changes towards the lake and follows its shoreline, the vegetation changes to dry woodland and bushland.

The area around the project road is heavily cultivated and therefore there is no wildlife. However, Ruma National Park is located some 11 km from the junction at Ogongo.

Most of the shoreline of Lake Victoria can be considered wetland. However, none of the shoreline affected by the project road from Homa Bay to Mbita has been gazetted, as it is not regarded as being wetland of special significance in terms of plant and animal species.

3) Pollution

a) Air Quality

Air quality was sampled at just outside Homa Bay at the junction of the Homa Bay - Road (C20) and the Homa Bay - Mbita Road (C19). Table 10.2.1 shows that all the parameters are well below the recommended WHO maximum allowable limits. This would be expected since Homa Bay is a small non-industrialised town. The results show that at present there are no serious air pollution problems along the Homa Bay - Mbita Road (C19).

Table 10.2.1 Results of Air Quality Test at Homa Bay

Sampling Point	NO_x (ppm)	SO_x ($\mu g/m^3$)	CO (ppm)	SPM (mg/m^3)
Homa Bay	0.03 – 0.048	128.3 – 131.6	4.0 – 9.0	0.0025 – 0.0052
WHO limits	0.2	350	23	≤ 0.10 (daily av. value)

b) Water Quality

Water quality was measured at two sampling points: 1) upstream and downstream of the bridge across the River Olambwe at Km 27 on the C19, 2) north and south of the causeway at Mbita. Table 10.2.2 shows that all the parameters are well below the recommended WHO maximum allowable limits. The samples taken at the bridge, upstream and downstream, show that water quality in the river is generally acceptable, apart from levels of suspended solids (SS) which far exceed permissible limits. The river is reportedly always turbid anyway, but rains during the two nights prior to sampling will also have contributed to high suspended solids concentrations. Faecal coliform counts for samples taken at the bridge were low, which suggests that human waste is not discharged into the river.

The approach to Mbita Causeway on the C19 is on downhill slopes. During the rains, stormwater is channelled along the roads into the lake. This then causes pollution of the lake waters around these towns. In wetland areas and the lake where the C19 runs adjacent to the lake, it is possible that some siltation has occurred, and that oil and lubricants have flowed into the lake.

Table 10.2.2 Results of Water Quality Test at Homa Bay

Sampling Point	Parameter				
	pH	DO (mg/l)	BOD_5 (mg/l)	SS (mg/l)	Faecal Coliform (Count/100)
Upstream of bridge on R. Olambwe	7.5	4.0	10	70	<2
Downstream of bridge on R. Olambwe	7.7	4.5	12	155	<2
North of Causeway at Mbita	8.9	7.5	5	2	11
South of Causeway at Mbita	9.0	8.5	9.0	13	10
WHO limits	6.5 - 8.5	5 (min)	30	30	0

c) Noise

Traffic noise levels were measured at 1 km from the beginning of the C19 from the junction with the Homa Bay - Rongo Road (C20). At present in Kenya there is no firm policy with regard to noise pollution level limits, and therefore for this analysis standards from the EU, Japan and USA were referred to.

The findings of the noise survey are summarised in Table 10.2.3. Target standard values are also indicated for the sake of comparison. Recommended peak noise levels for L_{10} is normally 68 dB (A). The peak levels were about 70 dB(A), which is within the accepted practical range (70±2 dB(A)). The higher levels are due to increased traffic activity at peak times, and also the rough road conditions. Table 10.2.4 summarises the results from traffic noise level measurements at different times of the day. The noise level L_{90} was acceptable.

Table 10.2.3 Results of Noise Test at Homa Bay (1)

Measurement Station	Noise Level		
	Range of L_{10} dB(A)	Range of L_{50} dB (A)	Range of L_{90} dB (A)
Homa Bay	50.00 – 70.60	40.00 – 55.60	30.50 – 44.50
Recommended maximum levels	68.0	-	43.0

L_{10} the noise level in dB(A) exceeded for 10% of the measured time
L_{50} the noise level in dB(A) exceeded for 50% of the measured time
L_{90} the noise level in dB(A) exceeded for 90% of the measured time

Table 10.2.4 Results of Noise Test at Homa Bay (2)

Measurement Station	Area	Noise Levels					
		Morning (06:00-12:00)		Afternoon (12:00-18:00)		Night (21:00-23:00)	
		Measured in dB(A)	Target in phones (A)	Measured in dB(A)	Target in phones (A)	Measured in dB(A)	Target in phones (A)
Homa Bay	Rural	43.60	55.00	45.80	60.00	37.50	50.00

(2) Rongo - Ogembo Road (C20)

1) Social Environment

a) Locations

The Rongo - Ogembo Road (C20) is an extension of the Homa Bay - Rongo Road (C20). Rongo is located at the junction of the C20 from Homa Bay and A1 from Kisii to Tarime on the Tanzanian border. Ogembo lies on C17 Kisii to Kilgoris Road. The length of the project road is 19.6 km, and it links C17 to the A1. From Rongo the project road takes a generally eastward direction towards Ogembo. The road from Rongo to Ogembo (C20) traverses Rongo Division in the Migori District, and Ogembo and Nyamarambe Divisions in the Gucha District.

b) Population

Annual growth rates are expected to be 3.8% for the Migori District and 2.72% for the Gucha District from 1989 to 2005 (Migori and Kisii District Development Plans 1997 - 2001). The growth rate for Migori is much higher than the national average of 3.4%. Estimated urban populations for Rongo and Ogembo towns for 1999 are 6,385 and 1,784 respectively, with yearly growth rates of 6.5% and 2.70% respectively. Rongo town, therefore, has a very high growth rate.

c) Economic Activities

Income along the C20 is mainly generated from agricultural and livestock activities. Wage employment is concentrated mainly in the urban centres, such as Rongo and Ogembo. Per capita income in Rongo Division is estimated at between KShs 15,000 to 17,400/month. This has been attributed to earnings from sugar cane. The Welfare Monitoring Survey of 1994 indicated that the per capita income in the Kisii District was KShs 23,700/month. Thus in general people along the project road would not be considered poor or very poor in terms of the government's definition of poverty.

Small holder farming is the dominant land use, and the sizes of the farms are small with holdings between 0.5 and 4 acres. Food crops grown include maize, beans, sorghum, finger millet, sweet potato and cassava. The major cash crops nearer Ogembo are tea, coffee and bananas, while around Rongo tobacco and sugar cane are grown. Livestock are kept on a small scale and types of animals include Zebu and dairy cattle, sheep, goats and poultry.

Fishing is done mainly in the Kuja River by families living in the proximity of the river, and is for subsistence only. The type of fish caught is mainly *Clarius* spp. (catfish).

There are no significant forest reserves within the area of influence of the project road. In general forestry activities along the road focus on seedling production and on-farm tree planting.

Another important activity is quarrying for soapstone. There is little potential for the development of tourism in this area as it is mainly an agricultural area, and does not lie on the traditional or proposed tourist circuits. Although the road is in the heart of the soapstone industry, it is likely that business people rather than tourists will visit this area.

d) Infrastructure

Both Ogembo and Rongo are connected to the National Electricity Grid, via a 33 kV supply line from Kisii.

There are a number of water supplies and facilities in the area of influence of the project road. Rongo town has a piped water supply that was over-utilised, and has now stalled. Other sources of water around Rongo include rivers, wells, protected springs and boreholes. The Ogembo and Nyamarambe Divisions are well-supplied with water, The Ogembo Division has 3 water schemes and 170 protected springs, while the Nyamarambe Division has 8 water schemes and 127 protected springs.

Infant mortality rates around the project area range from 62/1,000 live births in the Gucha District to 127/1,000 births in the Migori District. This is very high, when compared to the national average. Malaria is the major cause of morbidity, but anaemia is also prevalent. Approximately 23% of the children in this area are under-weight.

Kisii is a major marketplace for the residents and it takes 70 minutes by Matatsu of which frequency is around 8-10 per day. In the vicinity of the road from Rongo to Ogembo there are 3 health centres, one hospital at Tabaka and 2 dispensaries. It takes 30 minutes to Tabaka by Matatsu.

In all the divisions along the project road, education facilities are well distributed in relation to the population. Drop-out rates are high for both boys and girls because of their poverty.

The road passes through a number of market and administrative centres, including Nyaborumbasi, Ikuba, Tabaka and Riosi.

2) Natural Environment

a) Topography and Geology

The entire road is located in fairly hilly terrain with several ridges near Ogembo. Soils around the project road are highly fertile.

The project road is located between two main rivers, the Kuja (or Gucha) to the south and the Riano to the north. These rivers, which flow westwards initially then turn south west to join the Migori River before reaching Lake Victoria. Therefore the area to the south of the road drains towards the Kuja while that to the north of the project road drains north into the Riano. There are also several small rivers close to or cutting across the project road, such as the Musache, Nyamsore, and Itabago.

b) Climate

The area around the project road can be regarded as having a highland equatorial climate (warm temperate). Minimum and maximum average temperatures range between 14°C and 24°C. There are two rainy seasons. The long rains fall between March and June, while the short rains are between September and November. Annual rainfall averages about 1,500 mm and is very reliable. The entire road lies in a humid zone.

c) Flora and Fauna

The vegetation along the project road is no longer untouched nature, as there is considerable agricultural activities in the area. However, the original vegetation type was a combination of moist forest and wooded and bushed grassland. The area of influence of the project road has no areas of significance in terms of wildlife. There are no wetlands of significant value that will be affected by the project road.

3) Pollution

a) Noise

Traffic noise levels were measured at 2 km from Rongo town along the C20 to Ogembo. At present in Kenya there is no firm policy with regard to noise pollution level limits, and therefore for this analysis, standards from the EU, Japan and USA were referred to.

The findings of the noise survey are summarised in Table 10.2.5. Target standard values are also indicated for the sake of comparison. Recommended peak noise levels for L_{10} is normally 68 dB (A). The peak levels were about 68 dB(A), which is within the accepted practical range (70±2 dB(A)). The higher levels are due to increased traffic activity at peak times, and also the rough road conditions. Table 10.2.6 summarises the results from traffic noise level measurements at different times of the day. The noise level L_{90} was exceeded during night. This is attributed to insects, particularly cicadas and crickets, which produce high frequency noise and distort the readings. Background noise also affects the noise climate and has a masking effect on the peak values.

Table 10.2.5 Results of Noise Test at Rongo (1)

Measurement Station	Noise Level		
	Range of L_{10} dB(A)	Range of L_{50} dB (A)	Range of L_{90} dB (A)
Rongo	54.00 – 68.50	45.60 – 54.00	36.50 – 40.50
Recommended maximum levels	68.0	-	43.0

L_{10} the noise level in dB(A) exceeded for 10% of the measured time
L_{50} the noise level in dB(A) exceeded for 50% of the measured time
L_{90} the noise level in dB(A) exceeded for 90% of the measured time

Table 10.2.6 Results of Noise Test at Rongo (2)

Measurement Station	Area	Noise Levels					
		Morning (06:00-12:00)		Afternoon (12:00-18:00)		Night (21:00-23:00)	
		Measured in dB(A)	Target in phones (A)	Measured in dB(A)	Target in phones (A)	Measured in dB(A)	Target in phones (A)
Rongo	Rural	48.10	55.00	41.30	60.00	53.00	50.00

(3) Port Victoria - Bumala Road (D250/D251/C30)

1) Social Environment

a) Locations

The Port Victoria - Bumala Road (D250/D251/C30) begins at the junction with the Kisumu - Busia Road (B1) about 37 km before Busia town. The road proceeds in an east-south-east direction along the D250 until it reaches Sio Port, then follows the lakeshore in a southerly direction to Port Victoria along the D251. The project road is 43.6 km in length. It is located solely in Busia District, and passes through Matayos, Funyula and Budalangi Divisions.

b) Population

The growth rate is expected to be 2.95% for the district from 1989 to 2005 (Busia District Development Plan 1997 - 2001). This growth rate is lower than the national average of 3.4%. The influential area under the project road can be considered to be moderately densely populated at present. However, by the year 2005, Matayos Division will have a high population density. Again this implies increased pressure on land, food and other resources in order to sustain the growing population. Meanwhile, the population of the Budalangi Division in which Port Victoria is located is around 50,000 in 1999.

c) Economic Activities

Most of income along the project road and in its area of influence is generated from activities such as fisheries, trade and commerce, and to some extent agriculture. Wage earners are predominantly found in the urban centres such as Sio Port and Port Victoria, where incomes are higher. Average per capita income for waged labour ranges between KShs 1,500 to 4,000/month, while in the informal sector average daily income may range from 50 to 1,000/month.

Along the project road, agricultural activity takes the form of small holder farming. Crops grown include maize, cassava, sorghum, finger millet and beans, and rice is grown under irrigation around the Bunyala swamp. The major cash crops are sugar cane, beans and cotton. There are no large farms along the project road. Livestock keeping is also an important activity, although there are no ranches. Types of livestock kept include Zebu cattle, goats, sheep and poultry. Bee keeping is becoming increasingly popular.

Fishing is the most important economic activity along most of the project road, and takes place in the lake, rivers and swamps. The major fish species caught from the lake are Nile Perch (*Lates niloticus*), Tilapia (*Oreochromis niloticus*) and Omena (*Rastrineobola argentea*). Eels and mudfish are caught in the rivers and swamps. There are 17 designated fish landing beaches of which about 10 are active (water hyacinth is making the beaches increasingly inaccessible). The project road serves most of these landing beaches, so that fish can be transported to Kisumu and Nairobi (via Siaya) or to Busia for cross border trade. In 1995, over 10,000 tonnes and in 1998, 15,000 tonnes of fish products were landed in Busia District, valued at approximately KShs 274 and 400 million in respective year. These figures reflect the importance of fishing in the area of influence of the project road.

There are approximately 579 ha of gazetted forest in the proximity of the project road in the Budalangi Division. The Port Victoria Forest Station covers various hills around the town. These forests are important as water catchment areas. However wood from the forest is being used for fuel, timber for construction, furniture making, etc, and the demand for timber has overtaken supply. This puts considerable pressure on the forest resources.

There is no significant tourist activity along the project road at present, and potential for development in the near future is low.

d) Infrastructure

Parts of Matayos and Sio Port are served by the Rural Electrification Programme under the Ministry of Energy. The sub-station at Bumala serves part of Funyula, Sio Port and some areas in Budalangi Division.

The main sources of surface water along the project road are the seasonal rivers, natural dams and streams, and Lake Victoria. Groundwater potential is good in Matayos Division, while potential for shallow wells in Funyula and Budalangi Divisions is good, although salinity is quoted as a problem.

Infant mortality in the district is 86/1,000, which is above the national average of 60/1,000. Malaria is the major cause of morbidity followed by respiratory infections. Malnutrition levels among children are also high, especially in Budalangi Division, where 20% of the children are under-nourished. There are a number of health facilities along the project road. Nangina and Port Victoria have hospitals, and there are 9 health centres or dispensaries within the road's area of influence.

Education facilities are reportedly low in Budalangi Division, but Funyula Division has a high number of educational institutions. Most of the facilities are under-utilised; this is attributed to low enrolment, and high drop out rates for boys because of poverty.

The road connects a number of market and administrative centres, such as Odiado, Funyula, Nangina, Sio Port, Mundere and Rudacha.

2) Natural Environment

a) Topography and Geology

The whole of the project road traverses gently undulating terrain, and is flanked by the Samia and Funyula Hills which run from the north-east to the south-west up to Rudacha. South of Rudacha up to Port Victoria the terrain is low-lying and flat. The soils have low natural fertility. The very end of the road from Rudacha to Port Victoria has very poorly drained, very deep, very dark grey to black firm cracking clay with an acid humic topsoil. These soils are associated with seasonal swamps.

The project road is flanked to the north and south by the permanent Sio and Nzoia Rivers, respectively. Along the road, numerous streams are found. The entire drainage system of the area of influence of the project road flows westwards into Lake Victoria.

b) Climate

The climate along the project road is greatly influenced by the lake. Temperatures range between a minimum of 14°C and a maximum of 30°C, the hottest months are January and February. There are two rainy seasons. The long rains fall between March and May, while the short rains are experienced between August and October. Annual rainfall around Bumala is approximately 1,300 mm, while along the lakeshore annual rainfall is between 760 mm and 1,020 mm. The road falls into four moisture availability zones: humid at Bumala, sub-humid at Nangina, semi-humid at Sio Port and semi-humid to semi-arid at Port Victoria.

c) Flora and Fauna

The natural vegetation has largely been replaced by cultivation. Along the road from Bumala to Port Victoria, the original vegetation consisted of moist and dry forest, to moist woodland and dry wooded grassland. Further along the road vegetation type is affected by its proximity to the lake, where the vegetation along the lakeshore is swamp land, having plant communities such as reeds, sedges and rushes.

There are no areas considered important in terms of wildlife in the area of influence of the project road. From Sio Port to Port Bumala, the project road lies close to swampy or wetland areas. However, apparently these areas have not been gazetted as wetlands, and are not regarded as having special significance in terms of animal or plant species.

3) Pollution

a) Air Quality

Air quality was sampled at Bumala (at the junction of the Port Victoria - Bumala Road (D250/D251/C30) with the Kisumu - Busia Road (B1)). Table 10.2.7 shows that all the parameters are well below the recommended WHO maximum allowable limits. The results show that at present there are no serious air pollution problems along the Port Victoria - Bumala Road (D250/D251/C30).

Table 10.2.7 Results of Air Quality Test at Bumala

Sampling Point	NO_x (ppm)	SO_x ($\mu g/m^3$)	CO (ppm)	SPM (mg/m^3)
Bumala	0.0365 – 0.0405	116.0 – 133.4	2.0	0.0027 – 0.009
WHO limits	0.2	350	23	≤ 0.10 (daily av. value)

b) Noise

Traffic noise levels were measured at 1.5 km along the D250/251 from the junction at Bumala with the Kisumu - Busia Road (B1). At present in Kenya there is no firm policy with regard to noise pollution level limits, and therefore for this analysis standards from the EU, Japan and USA were referred to.

The findings of the noise survey are summarised in Table 10.2.8. Target standard values are also indicated for the sake of comparison. Recommended peak noise levels for L_{10} is normally 68 dB (A). The peak levels were about 62 dB(A), which is within the standard. The higher levels are due to increased traffic activity at peak times, and the rough road conditions. Table 10.2.9 summarises the results from traffic noise level measurements at different times of the day. The noise level L_{90} was acceptable.

Table 10.2.8 Results of Noise Test at Bumala (1)

Measurement Station	Noise Level		
	Range of L_{10} dB(A)	Range of L_{50} dB (A)	Range of L_{90} dB (A)
Bumala	48.60 – 62.50	40.00 – 47.50	31.00 – 39.20
Recommended maximum levels	68.0	-	43.0

L_{10} the noise level in dB(A) exceeded for 10% of the measured time
L_{50} the noise level in dB(A) exceeded for 50% of the measured time
L_{90} the noise level in dB(A) exceeded for 90% of the measured time

Table 10.2.9 Results of Noise Test at Bumala (2)

Measurement Station	Area	Noise Levels					
		Morning (06:00-12:00)		Afternoon (12:00-18:00)		Night (21:00-23:00)	
		Measured in dB(A)	Target in phones (A)	Measured in dB(A)	Target in phones (A)	Measured in dB(A)	Target in phones (A)
Bumala	Rural	45.50	55.00	43.10	60.00	44.80	50.00

10.2.2 Forecast of Environmental Impacts

(1) Social Environment

1) Impact by Resettlement

The projects are mainly rehabilitation ones, therefore the scale of resettlement will be very small. However, the resettlement may occur by land acquisition and transfer of rights of residence and land ownership. It may conduct the impacts such as: 1) the loss of living foundation of inhabitants to be relocated, and the deterioration of living standard after resettlement in case of the poor compensation system or the status of illegal occupants. Therefore the compensation for impacts on resettlement will be required.

2) Impact on Economic Activities

Economic benefits derived from the project road are obviously noticeable, as it provides the quickest access routes to markets for fish and agricultural produce. Therefore the impact on economic activities might be positive rather than negative.

In some of the settlements/centres along the road, shops and kiosks are located within the road reserve, so that activities in the trading centres and settlements along the project road might be disturbed. However, the traffic volume is not so large, and change in land use will not occur. Therefore there are no impact economic activities.

3) Impact on Traffic and Public Facilities

The traffic volume will not be so large, therefore the projects will not lead the replacement of transport means by road traffic emergence and increase of vehicular traffic. So that the impacts on schools, hospitals and present traffic conditions, such as increased traffic congestion and accidents might not be occur.

However there will be some danger to pedestrians, cyclists, and livestock along the road. Therefore the mitigation measures on road safety will be required..

4) Impact by Split of Communities

The projects are mainly rehabilitation ones, and the traffic volume will be not so large. Therefore, community split due to interruption of area traffic will not occur by interruption of existing route by the construction of roads, and interruption of traffic of inhabitants and commercial distribution.

5) Impact on Cultural Property

There are no sites of cultural, historic or traditional value on/ around the project area according to data collection and field reconnaissance. Therefore there are no impact to cultural property.

6) Impact on Water Rights/ Rights of Common

Around the project area, some residents engage in fishing in river and lake, and residents use river and lake water for living water. Therefore, obstruction of fishing rights in rivers, water rights obstruction or alteration of fishing grounds where the roads traverse rivers or pass by lake side areas, and increase in traffic will occur by water pollution and soil erosion. Therefore obstruction of fishing rights in rivers, water rights and land use rights might occur by water pollution and soil erosion. Therefore, the mitigation measures for water pollution and soil erosion will be required.

(2) Natural Environment

1) Impact by Soil Erosion

According to field reconnaissance, muddy soil, soil erosion, and flooding at some part of the project area were observed in rainy season. Therefore, topsoil erosion by rainfall might occur especially at construction stage. Earthworks (for road construction and quarries) will have a major impact on soil erosion, which may continue after construction. Therefore the mitigation measures for soil erosion will be required.

2) Impact on Hydrological Situation

There are some seasonal or permanent rivers around the projects area, and the Victoria Lake is located near the projects area. The project roads pass over some rivers, and some part of these roads run near the lake. The drainage facilities such as side drains along the roads, and box culverts or pipe culverts at the crossing points of rivers, will be established with adequate capacities. These drainage facilities can manage drainage adequately, therefore the change of river discharge and riverbed condition due to the inflow of drainage might not occur. The hydrological regime might also not be altered by the construction of roads. So that the impacts to hydrological situation might not be forecast.

3) Impact on Flora and Fauna

The projects are mainly rehabilitate ones, and the flora and fauna along/ around the project roads is no longer natural. Therefore the impact to flora and fauna might not be forecast.

4) Impact on Landscape

The new structures and buildings will not be appeared, because he projects are mainly rehabilitation ones. Therefore the impact to landscape at the operation stage might not be forecast. The visual intrusion will occur due to roadwork including quarries and traffic at construction stage, however the scale of construction and the construction term is small. Therefore the impact to landscape at the construction stage might not be forecast.

(3) Pollution

1) Impact by Air Pollution

Air pollutants will be exhausted by construction vehicles and equipment at construction stage, and by running vehicles at operation stage. However the scale of construction and the construction term is small, and the traffic volume will not be expected so large. Therefore the impact by air pollution might not be forecast.

2) Impact by Water Pollution

The project roads pass over some seasonal or permanent rivers. The diffusion of sediments by construction, where the roads passes over rivers, will occur at construction stage. However the scale of construction and the construction term are small, therefore the impact by water pollution at crossing points might not be forecast.

Soil erosion, which will occur at construction and operation stages, will lead water pollution. Oil wastes from vehicles at operation stage will have a bigger and longer-term impact, particularly when they enter wetlands or the lake.

These wastes will also affect settlements/households along the road. Therefore the mitigation measures for soil erosion and water pollution will be required.

Information from the residents around Mbita indicates that fish die around the causeway, because of water pollution after construction of causeway. However, this conclusion is not obvious, because of lack of water quality test around the causeway. Therefore, the implementation of detail water quality survey is recommended.

3) Impact by Noise and Vibration

Noise and vibration generated by vehicles might occur by operation of construction equipment and vehicles at construction stage, and operation of vehicles at operation stage. However the scale of construction, the construction term, and traffic volume are small, therefore the impact by noise and vibration might not be forecast.

10.2.3 Mitigation Measures for Environmental Impacts

(1) Compensation

Loss of land, crops and housing will be mitigated through compensation. The Commissioner for Lands in the Ministry of Lands and Settlement (Ardhi) assesses the amount of land required for deviations, road reserves and realignments, depth and area of quarries, the market value of the land itself, value of crops lost, value of buildings on the land that may be affected, environmental and social implications, etc. The Commissioner for Lands then determines the amount of compensation to be paid for private land.

Compensation to landowners who must submit their land for the project road must be fair and paid promptly. It should cover crops, all structures and land. Compensation also needs to be prepared to address issues such as amount of payment, methods of payment, etc.

It is recommended that a detailed Compensation Plan is prepared during the detailed design stage of the project to address the above-mentioned issues satisfactorily.

(2) Erosion Control

Earthworks should be controlled during construction, so that land that is not required for deviations, realignments or quarries is not disturbed. The earthworks should be carried out during the dry season to prevent soil from being washed away by the rain. The embankments should be planted with shrubs and grasses to reduce erosion of road embankments. Unnecessary clearing of vegetation should be avoided to preclude additional erosion.

Changes to the hydrological regime will be taken into account on the road design through the construction of box and pipe culverts so that flow in the rivers is not disturbed, and by having side drains to direct road runoff away from the road.

It is recommended that a detailed Construction Plan and Maintenance Plan is prepared during the detailed design stage of the project.

(3) Water Pollution Control

Contamination of soil and/or water sources resulting from oil in stormwater drains can be controlled through installing oil sumps at truck parking bays and at the point where stormwater drains meet the lake. Sediment loads in the rivers and streams can be reduced by installing culverts during the dry season, wherever possible.

It is recommended that a detailed Maintenance Plan is prepared during the detailed design stage of the project.

(4) Road Safety

The danger posed to pedestrians, cyclists and livestock due to increased traffic volumes and higher speeds can be mitigated by installing clear and frequent road signs and markings (both directional and warning). Signs are also necessary near health centres and schools. The provision of shoulders will also contribute to making the roads safer, in that they can be used as foot and cycle paths.

(5) Environmental Monitoring

For EIA system, it is under consideration by the Kenyan Government through Ministry of Environment. So that it will be established in the near future. The importance of environmental units of MOR&PW will be increasing. The establishment of EIA system and environmental monitoring system is most important items. The environmental units of MOR&PW, which would be responsible for the monitoring, should established this monitoring system as soon as possible. Table 10.2.1 shows the environmental monitoring plan for sample.

Table 10.2.10 Monitoring Programs

Environmental/ Social parameter	Frequency of monitoring
Unimpeded drainage/efficiency of drainage structures	3 - 4 times a year
Erosion of road embankment and roadside erosion	3 - 4 times a year
Quarry rehabilitation	Twice a year for seasonal variations
Establishment of replanted areas	Twice a year for seasonal variations
Social assessment of people from whom land was acquired	Once a year
Sanitation at workmen's camp	Once a month
Impact on public health	Once a year
Air/water/noise quality	Every 2 - 3 years
Impact on wetlands	Every 2 - 3 years
Impact on road safety (number of accidents)	Once a year
Impact on economic development in project area	Every 5 years

10.2.4 Evaluation of Environmental Impacts

The impacts on resettlement, on traffic and public facilities, on water rights/ rights of common, by soil erosion, and by water pollution, might be forecast by the implementation of the projects. Therefore, the mitigation measures including compensation, erosion control, water pollution control, and road safety are proposed. When these mitigation measures and maintenance work will be implemented adequately, these impacts can be solved. The implementation of the projects leads positive impacts on social environment such as benefits to agricultural and fishing activities, improvement of traffic accessibility to public facilities by residents. Therefore the projects is evaluated to produce good results without environmental impacts under the appropriate mitigation measures.

10.2.5 Recommendations

The preparation of a detailed Compensation Plan, Construction Plan, and Maintenance Plan, and implementation of detail water quality survey at Mbita are recommended during the detailed design stage of the project.

These recommendations and mitigation measures will be not effective, if these are not implemented actually. Therefore, the implementation of the following items is recommended strongly.

- Establishment of project designing, construction plan, and detail mitigation measures plan with careful attention for environment at detail design stage
- Implementation of construction in accordance with project design, construction plan, and detail mitigation measures plan

MOR&PW is responsible authority for these items. MOR&PW has recently set up an environmental unit under its Planning Branch whose responsibility is to oversee environmental compliance in all road related activities. However the environmental units do not functioned yet, because of lack of staff, equipment, budget, and system. Therefore capacity building, such as the establishment of staff training scheme and environmental laboratory, the preparation of budget, and related rules, is strongly recommended.