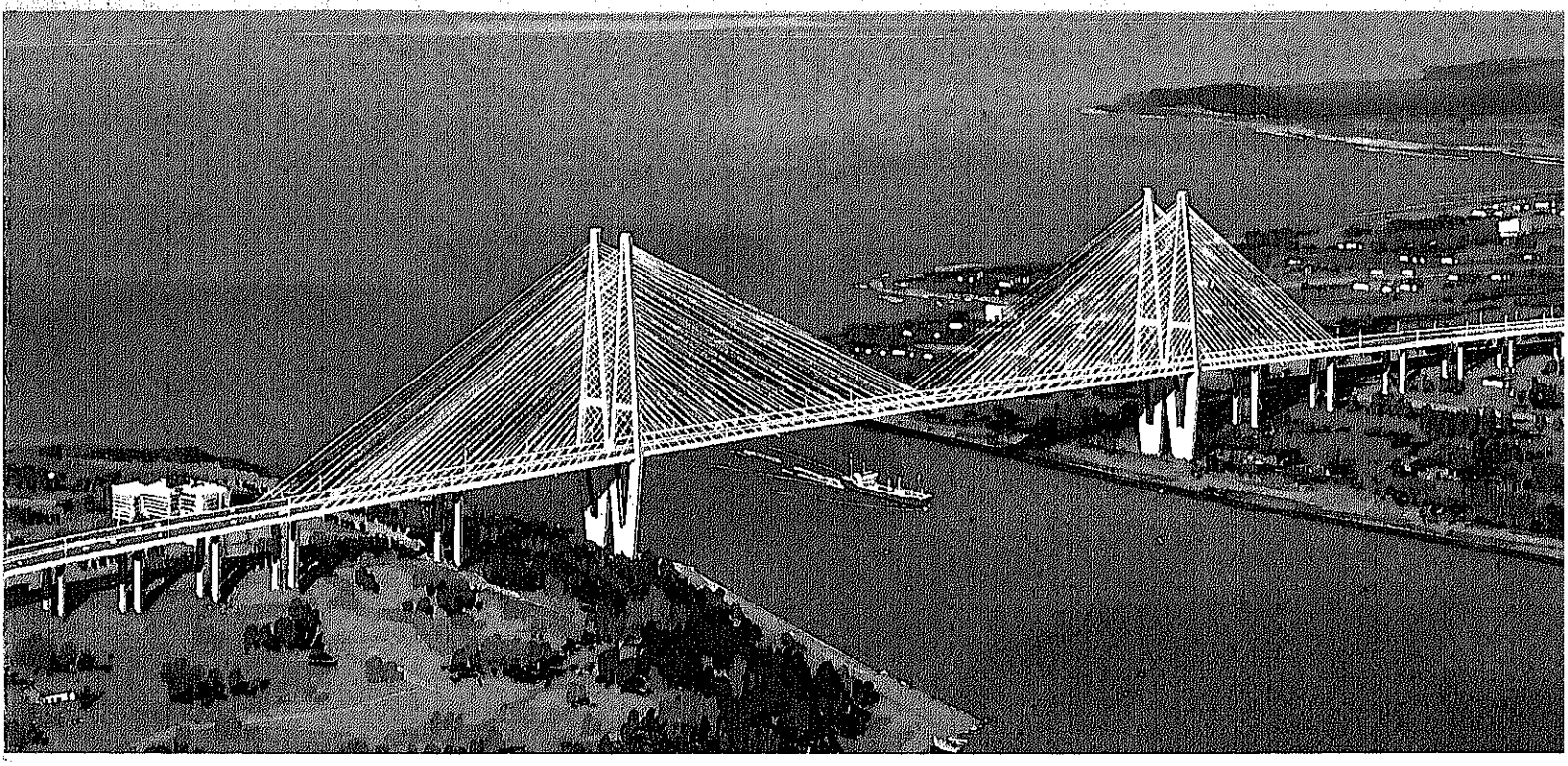
REPUBLIC OF KENYA

MINISTRY OF TRANSPORT AND COMMUNICATIONS

FEASIBITY STUDY ON
LIKONI CROSSING CONSTRUCTION PROJECT

FINAL REPORT
VOL. I MAIN REPORT



APRIL 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

{i.e. feasibility}

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PREFACE

In response to the request of the Government of the Republic of Kenya, the Government of Japan decided to conduct a feasibility study on the Likoni Crossing Construction Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Kenya a study team headed by Mr. Giichi Kataoka (Pacific Consultans International) from February 1983 to September 1983 under the guidance of the Supervisory Committee chaired by Mr. Takeshi Nakayama of Honshu-Shikoku Bridge Authority of Japan.

The team held discussions with the officials concerned of the Government of Kenya on the Project and conducted a field survey in Kenya. Subsequently, further studies were made in Japan and the present report has been prepared.

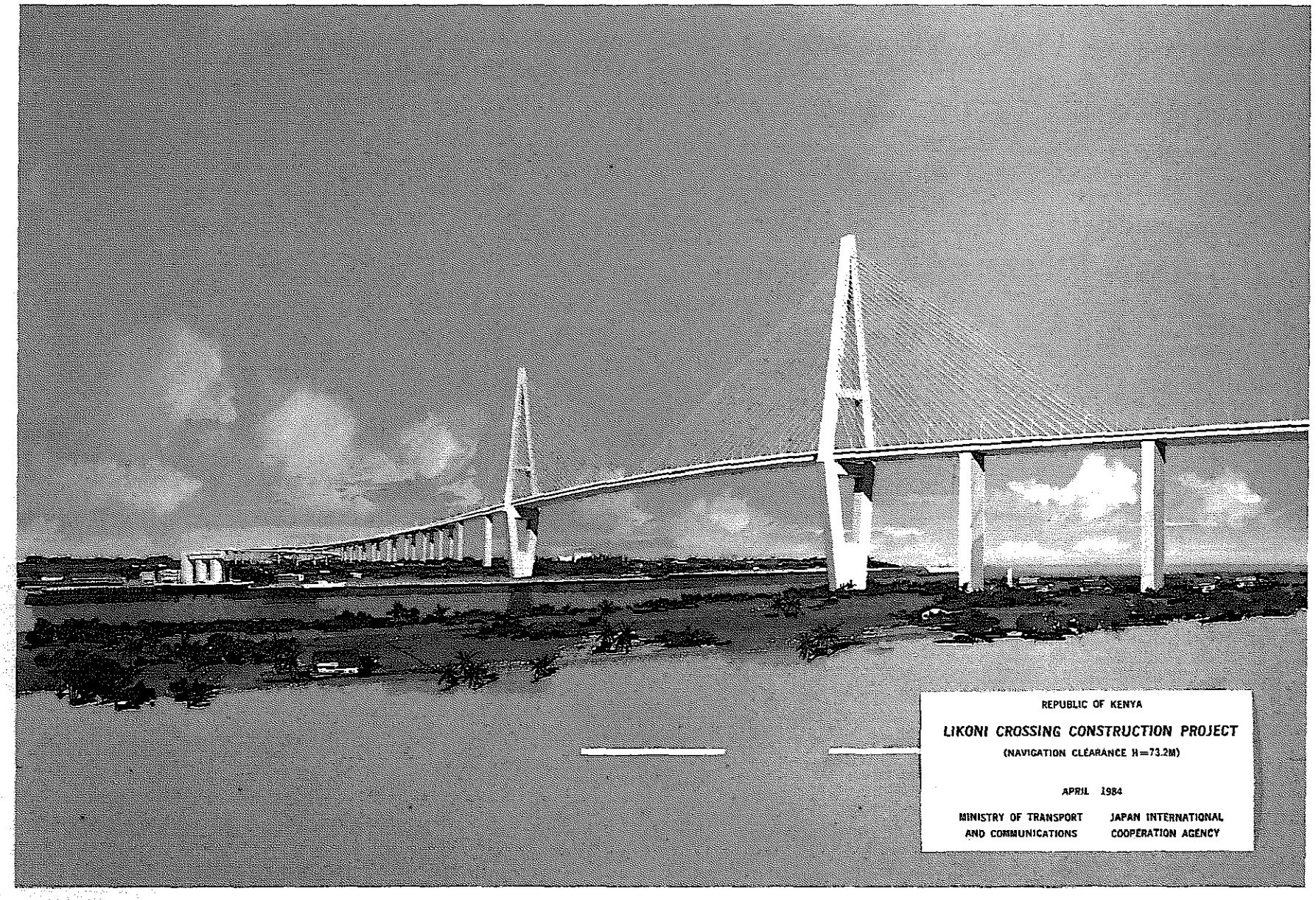
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team.

April 1984

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency



REPUBLIC OF KENYA

LIKONI CROSSING CONSTRUCTION PROJECT

(NAVIGATION CLEARANCE H=73.2M)

APRIL 1984

MINISTRY OF TRANSPORT AND COMMUNICATIONS

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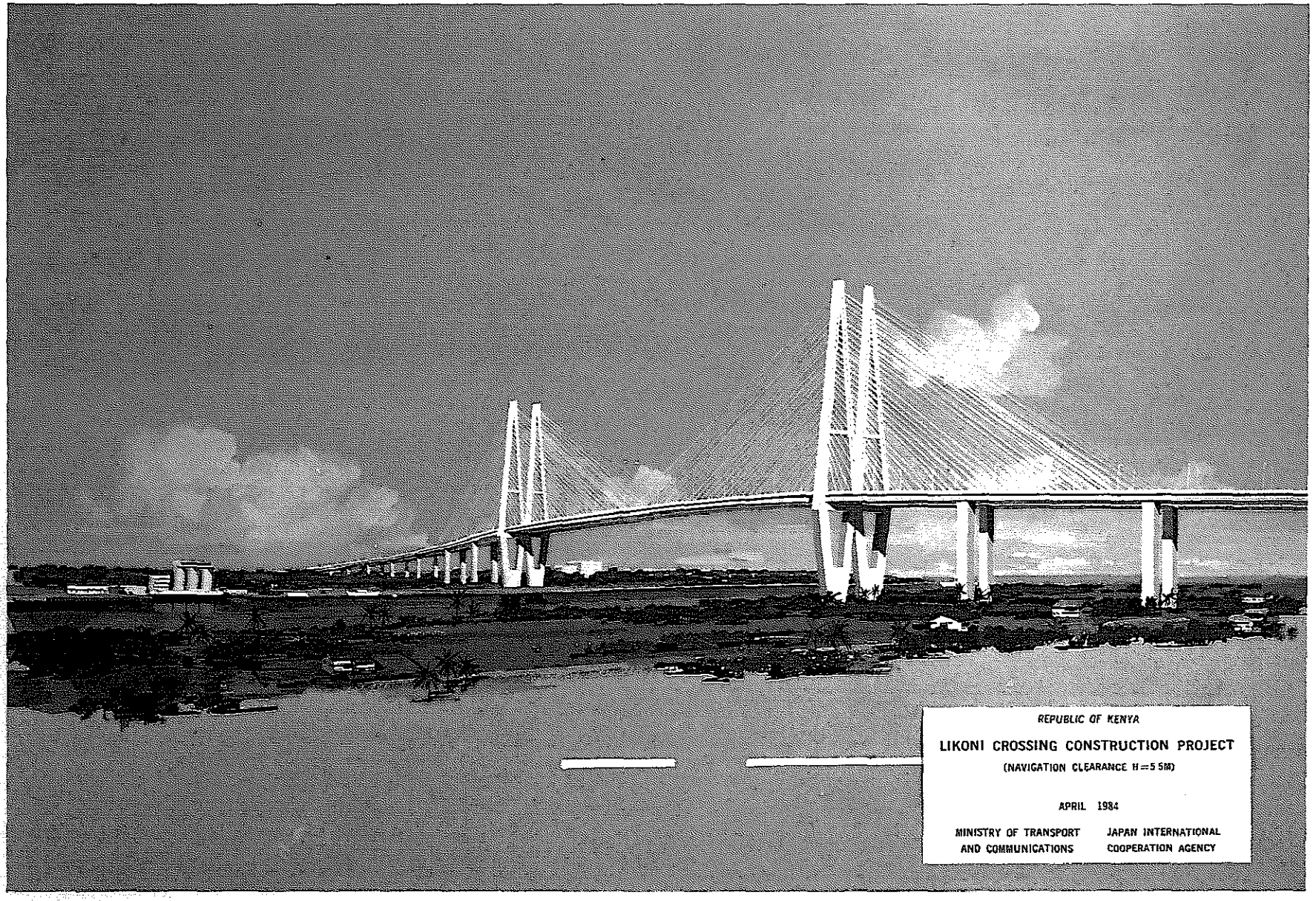

REPUBLIC OF KENYA

LIKONI CROSSING CONSTRUCTION PROJECT

(NAVIGATION CLEARANCE H=5.5M)

APRIL 1984

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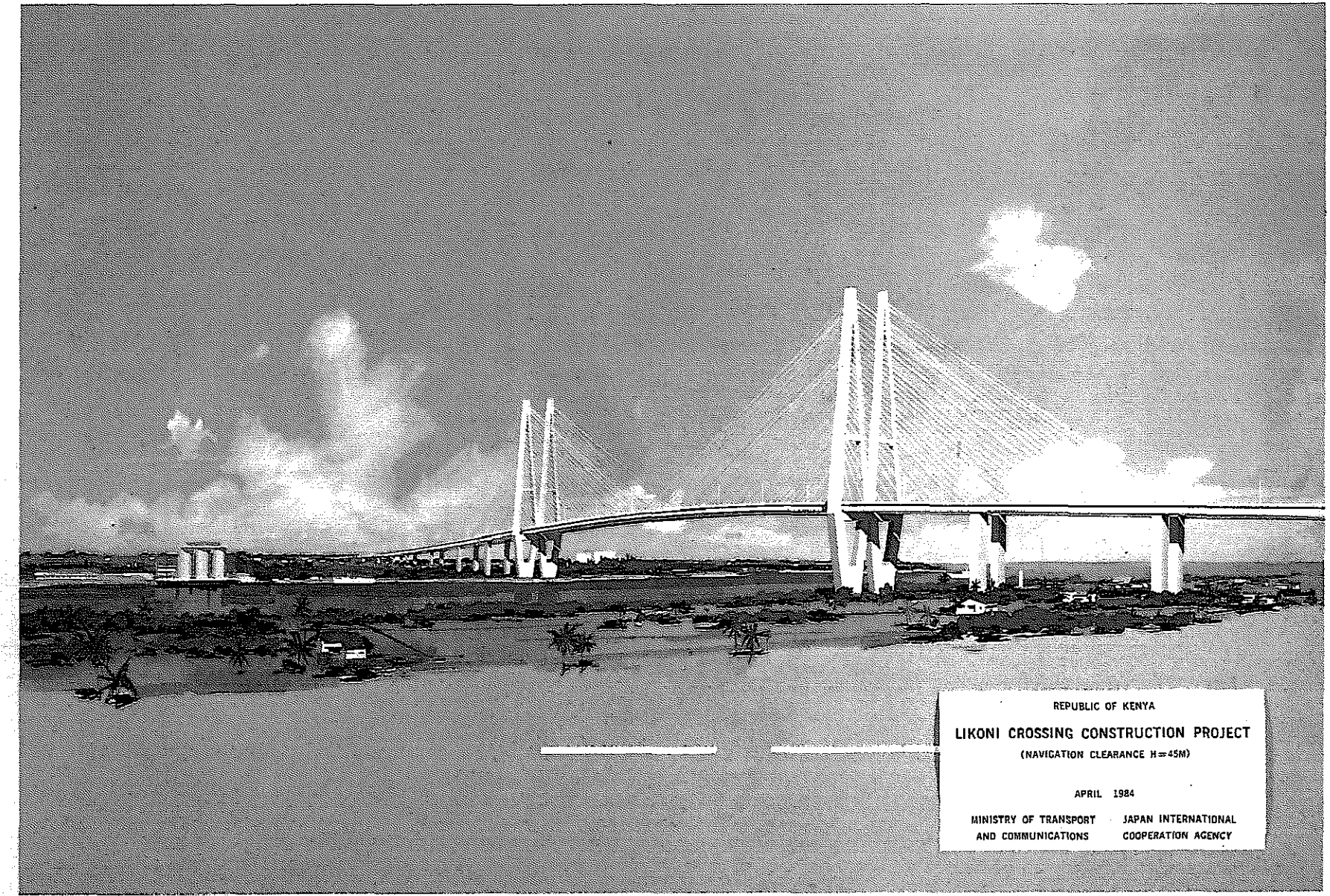


REPUBLIC OF KENYA

LIKONI CROSSING CONSTRUCTION PROJECT

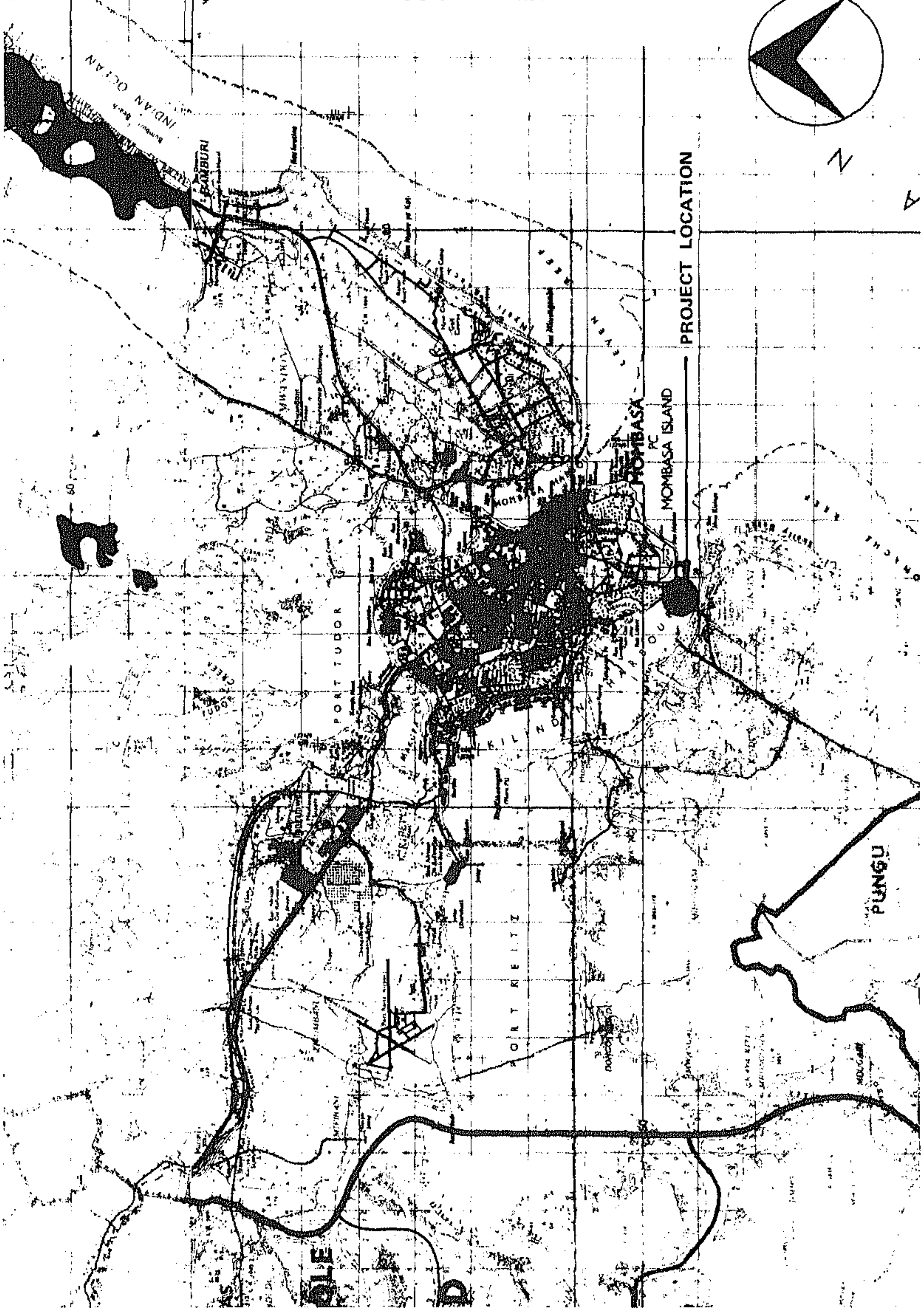
(NAVIGATION CLEARANCE H=45M)

APRIL 1984

MINISTRY OF TRANSPORT AND COMMUNICATIONS

JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT LOCATION MAP



SUMMARY AND RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

This summary and recommendations contain the major findings and results of the Feasibility Study on the Likoni Crossing Construction Project executed from February 1983 to April 1984.

1. Existing Situation in the Study Area

1) Mombasa, the second largest city of Kenya, is the centre of industry, commerce and administration of the Coast Province.

Mombasa island, the core of Mombasa city, is developed on coral and lagoonal deposit due to the pre-historic rise and fall of Sea levels. It is isolated by harbours and creeks and is served by two fixed crossings to the west and north, but to the south only the ferry at Likoni.

2) The population of Mombasa was 340 thousand in 1979 with 3.3% annual growth rate over the past 10 years as shown in Table 1. Amongst the Mainlands the South Mainland showed the highest growth rate of population.

Table 1 POPULATION GROWTH IN MOMBASA, 1962–79

	Area sq. km.	Population 1962	1969	1979	Growth rate 1962-69	1969-79	Increase 1969-79
Island	13	108,872	130,352	138,312	2.6	0.6	1.06
N. Mainland	100	30,257	44,874	80,299	5.8	6.0	1.63
W. Mainland	49	28,252	50,548	82,353	8.7	5.0	1.79
S. Mainland	46	12,194	20,998	40,184	8.1	6.7	1.91
Total Mombasa	210	179,575	247,073	341,148	4.7	3.3	1.38

Mombasa shares approximately 20% in industrial establishment, GDP and earnings of Kenya.

Transportation/communications and the manufacturing sectors are significant in Kenyan. industrial earnings with a high of 45% and 20% respectively..

3) The arterial road on Mombasa island has a network problem which forms a comb pattern, and the road traffic is concentrated and congested centering around the CBD as shown in Fig. 1. The incidence of traffic accidents is remarkable on the arteries in the CBD area and on the national roads in the vicinity of the island. The Likoni ferry is one of the highest accident occurrence points and is a big restriction for smooth traffic due to discontinuity of through traffic, ferry capacity, steep access to the terminal, etc.

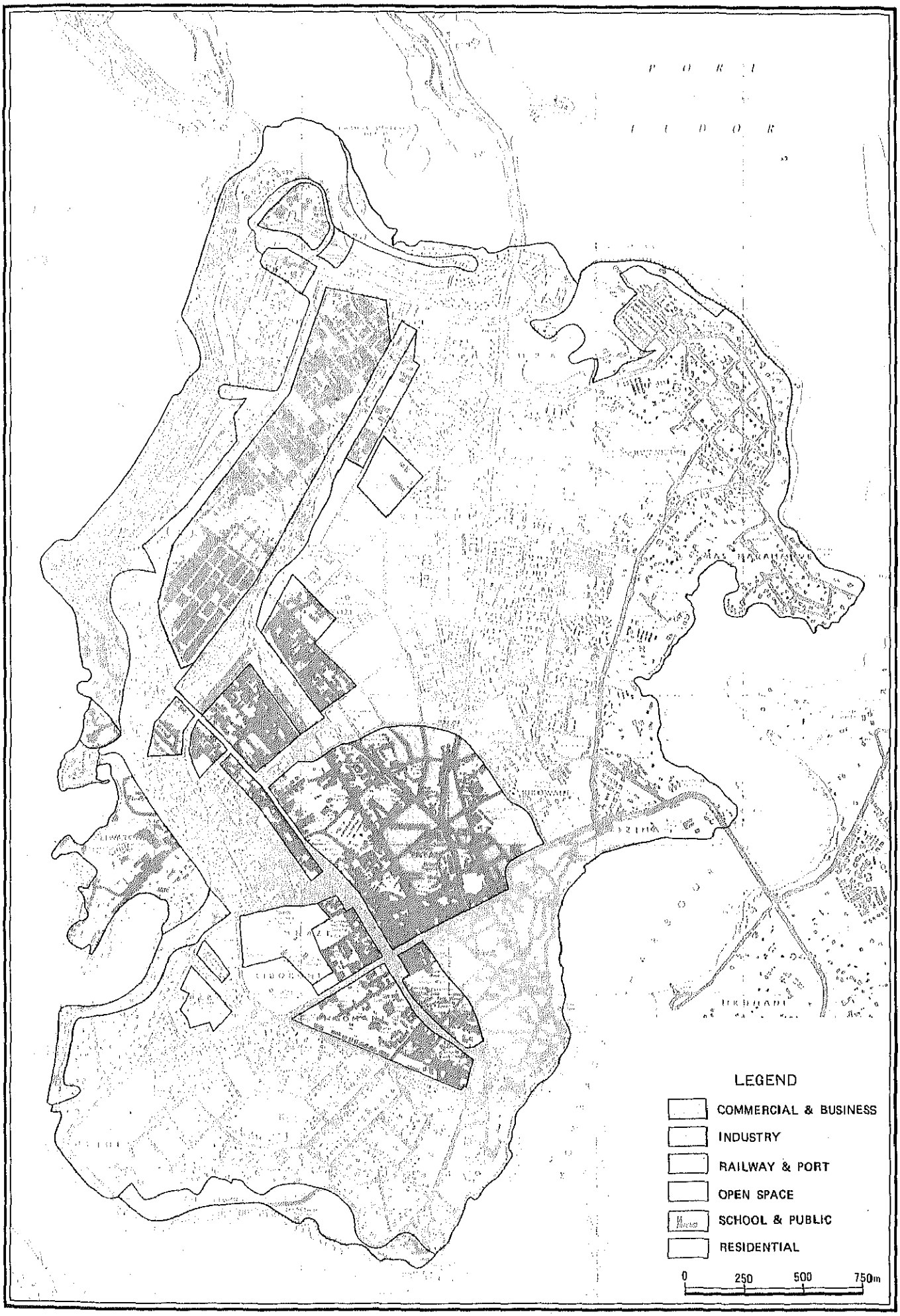


Fig. 1 EXISTING LAND USE ON MOMBASA ISLAND

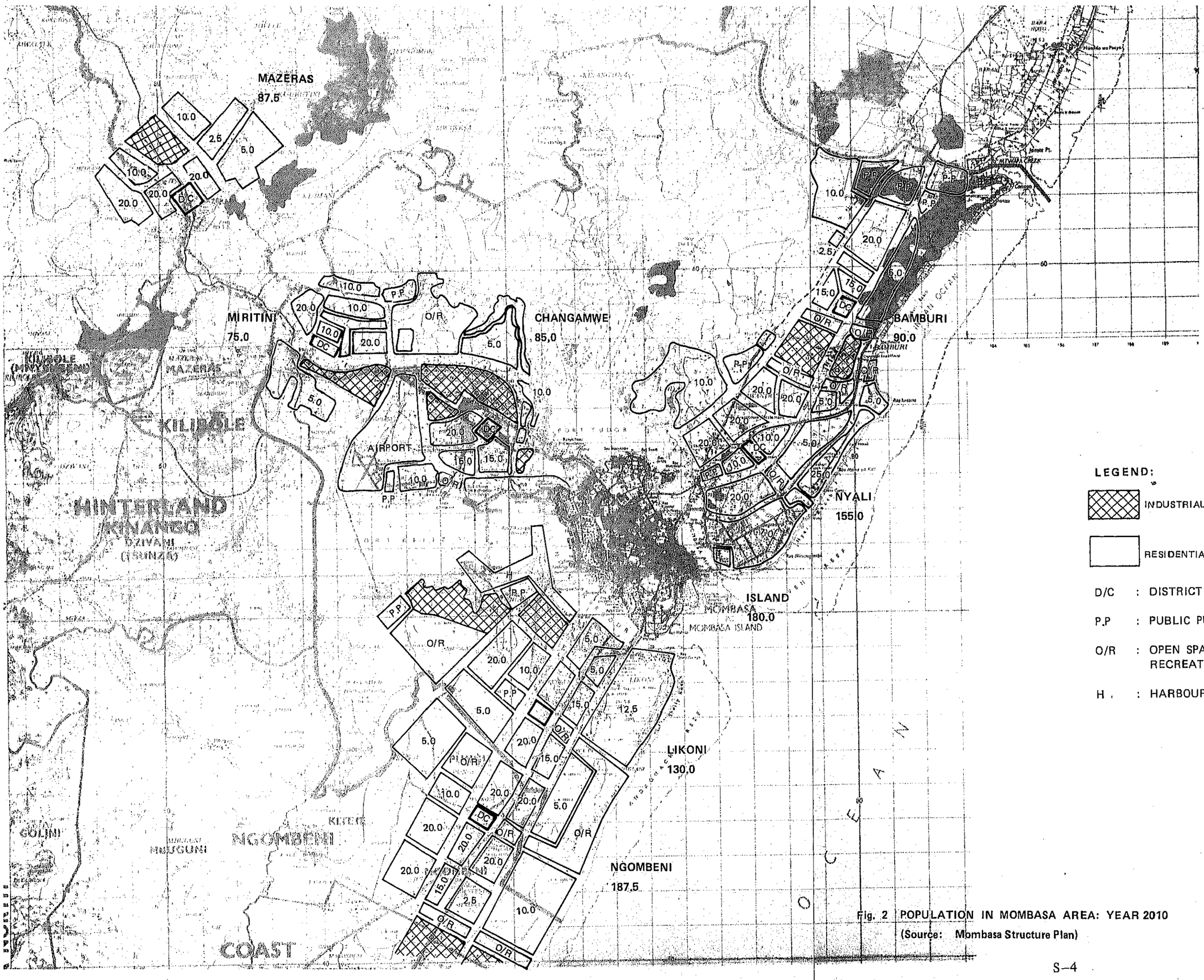


Fig. 2 POPULATION IN MOMBASA AREA: YEAR 2010
(Source: Mombasa Structure Plan)

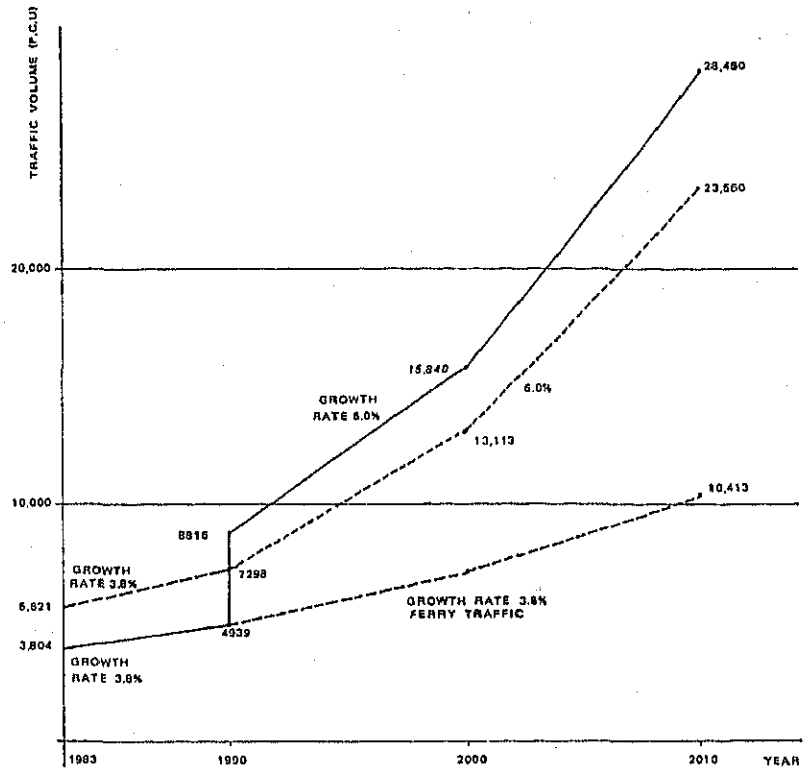


Fig. 3 FUTURE TREND OF TRAFFIC THROUGH LIKONI CROSSING

4. Project Road Planning

1) Road Planning Standard

The project road is classified as an international/national trunk road connecting Nairobi and Tanzania, and should be considered as the initial stage Project of the future trunk road. Based on the design speed of 60 km/hr the geometric design standard was established as shown in Table 2 and Fig. 4 and 5.

Table 2 GEOMETRIC DESIGN STANDARD

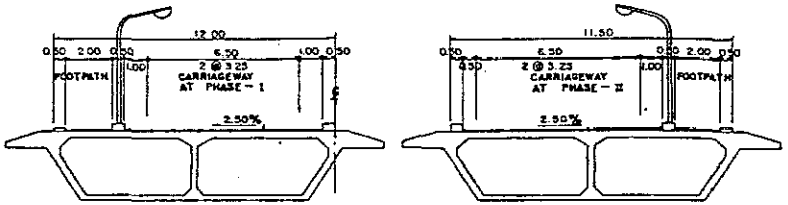
Item	Unit	Recommended Value
Terrain	-	Flat
Design Speed	km/h	60
Min. R.O.W Width	m	40 (30)
Lane Width	m	3.25
Shoulder Width: Outer	m	1.25
: Inner	m	0.75 or 1.00
Median Width	m	1.50 ∿ 2.50
Crossfall of Carriageway	%	2.5
Maximum Superelevation	%	10
Minimum Radii	m	200 (120)
Maximum Gradient:		
General Section	%	5
Crossing bridge section	%	4.3
Stopping Sight Distance	m	75
Minimum Vertical Curve Length	m	50
Minimum Horizontal Curve Length	m	100 or 700/θ
Vertical Clearance of Roadway	m	5.2

Note: 1) θ shows intersection angle for horizontal curve.
2) R=120 m is used for a loop access at Phase–I of the project as the absolute minimum value of 60 km/hr design speed.

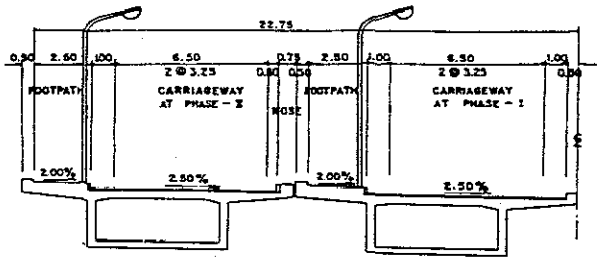
PROJECT	SHEET NO.	TOTAL SHEET
LIKONI CROSSING	2	2
TYPICAL CROSS SECTION	SCALE 1:200	

NAVIGATION CLEARANCE :
H = 55, 45m

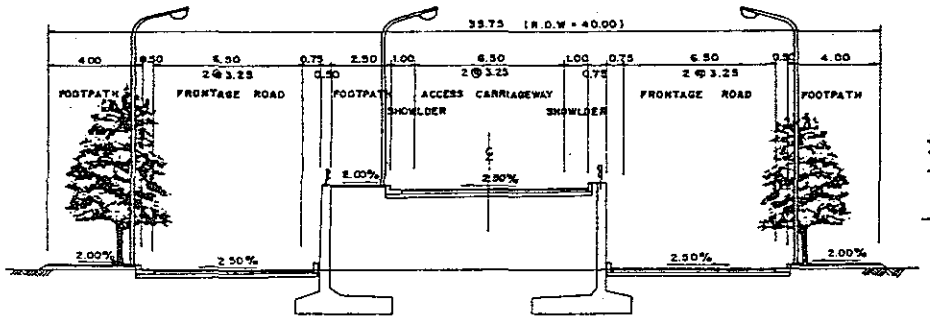
SEPARATE MAIN BRIDGE SECTION



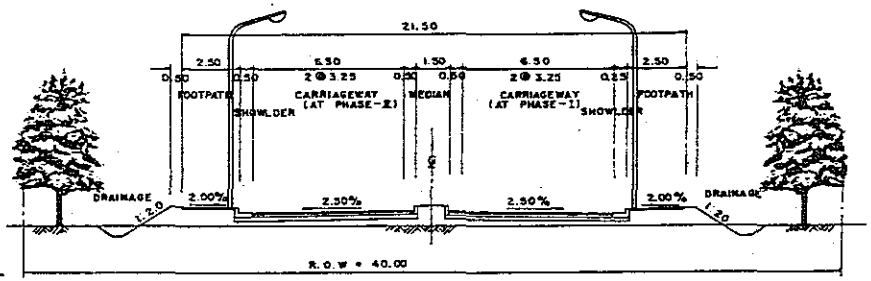
NOSE SECTION FOR FUTURE EXTENSION



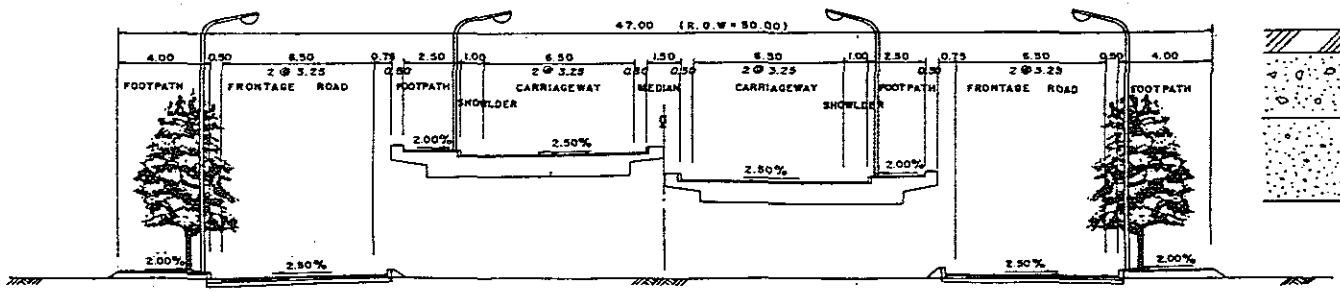
ACCESS SECTION TO NYERERE AVE.
(AT PHASE - I)



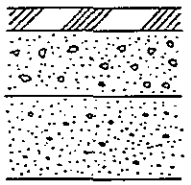
EMBANKMENT SECTION AT LIKONI SIDE



FUTURE EXTENSION SECTION TO MBARAKI ROAD
(AT PHASE - II)



PAVEMENT SECTION



SURFACE COURSE t = 50mm
(ASPHALT CONCRETE TYPE - I)

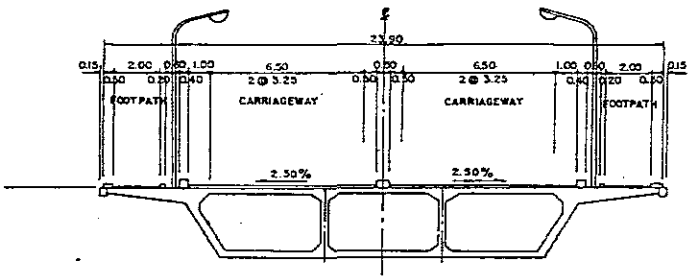
BASE COURSE t = 150
(DENSE BITUMEN MACADAM)

SUB - BASE COURSE t = 175
(GRADED CRUSHED STONE)

Fig. 4 TYPICAL CROSS SECTION FOR 55 AND 45 m

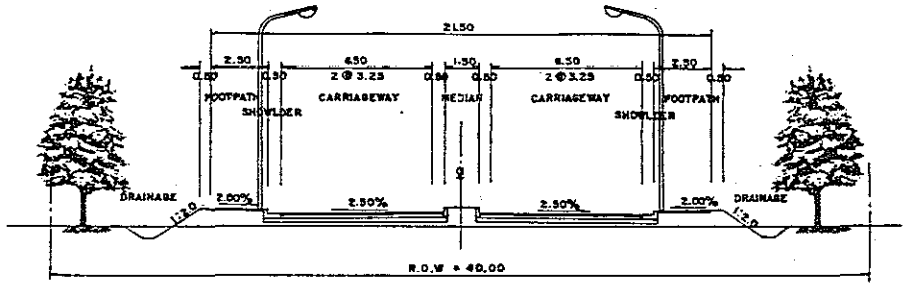
PROJECT	SHEET NO.	TOTAL SHEET
LIKONI CROSSING	1	2
TYPICAL CROSS SECTION	SCALE 1: 200	

MAIN BRIDGE SECTION

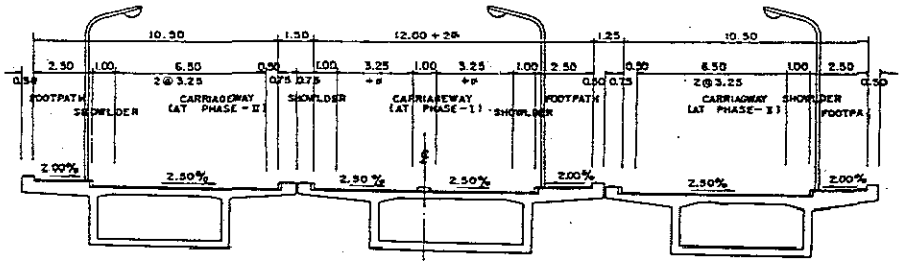


EMBANKMENT SECTION AT LIKONI SIDE

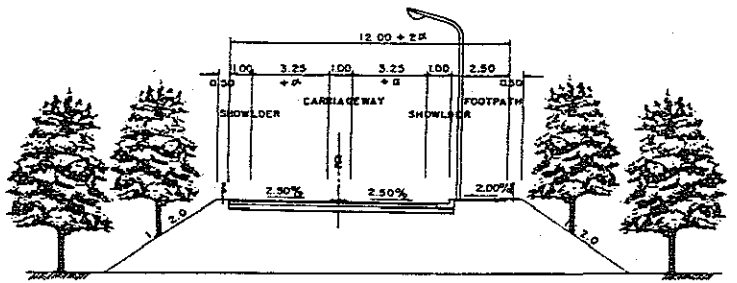
NAVIGATION CLEARANCE : H = 73.2 M



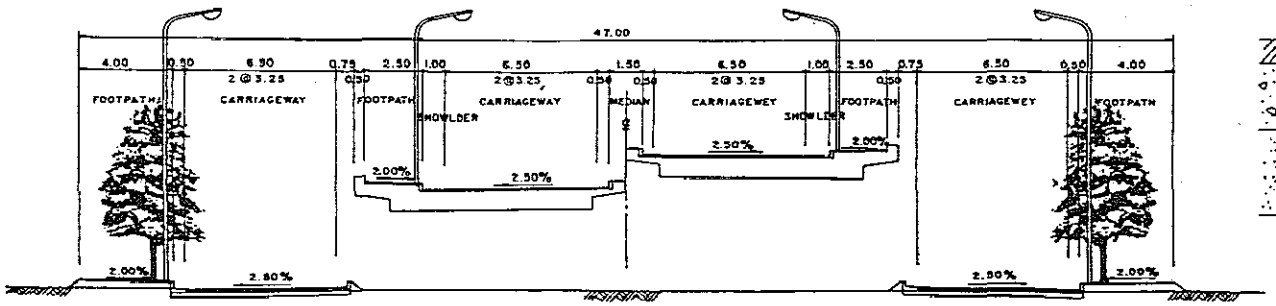
JOINT SECTION TO APPROACH BRIDGE



LOOP ACCESS SECTION (AT PHASE - I)



FUTURE EXTENSION SECTION TO MBARAKI ROAD (AT PHASE - II)



PAVEMENT SECTION

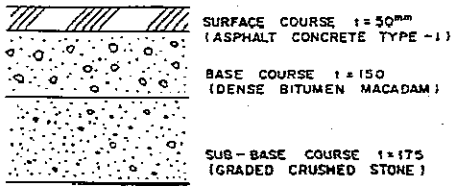


Fig. 5 TYPICAL CROSS SECTION FOR 73.2 m

2) Alternative Studies

In this study many alternatives were studied from various planning and engineering aspects leading to the preliminary design. The subjects studied are listed in accordance with the study process as follows:

(1) Alternative crossing study
(2) Future trunk road route on Mombasa island
(3) Comparative study of bridge (B_1) and tunnel (T_2)
(4) Alternative alignment study of bridge crossing
(5) Alternative navigation clearance study
(6) Alternative access study on Mombasa island
(7) Alternative main bridge study

A total of 7 alternative crossing routes for the full length of Kilindini Harbour, including 12 alternative structures (bridge, conventional and immersed tube tunnel), were studied on the basis of future regional development, road network, land use and technical/engineering aspects.

Finally the bridge passing through the narrowest channel portion of Kilindini Harbour was selected as the most viable plan for advantages in regional development, land use, environment (resort and high class residents), and shorter detour distance.

A tunnel alternative (T_2 : conventional tunnel) was abandoned due to the subsoil conditions, traffic service to the island, tunnel operation, cost, etc.

Immersed tube tunnel (T_2) is studied in the Appendix and has some disadvantages such as environmental problem, cost, operation, etc. This alternative is evaluated in economic terms.

Four alternative routes for the future trunk road (Nairobi–Tanzania) on Mombasa island were studied. As a result, an alignment alongside the Nairobi–Mombasa railway was selected on the advantages of land use (boundary between port/industrial area and commercial/residential area), formation of future trunk road network and traffic service to the island as shown in Fig. 6.

The navigation clearance of 73.2 m (240 feet) was the basic requirement of the Kilindini channel (clearance for all conceivable passing vessels). The lower clearance alternatives were studied for feasibility purposes with 55 m (for commercial and passenger ships) and 45 m (for commercial ships).

A cable stayed bridge was selected for the main bridge with the advantages mainly in cost and aesthetics in comparison with 3 other types (suspension, arch, and cantilever truss bridges).

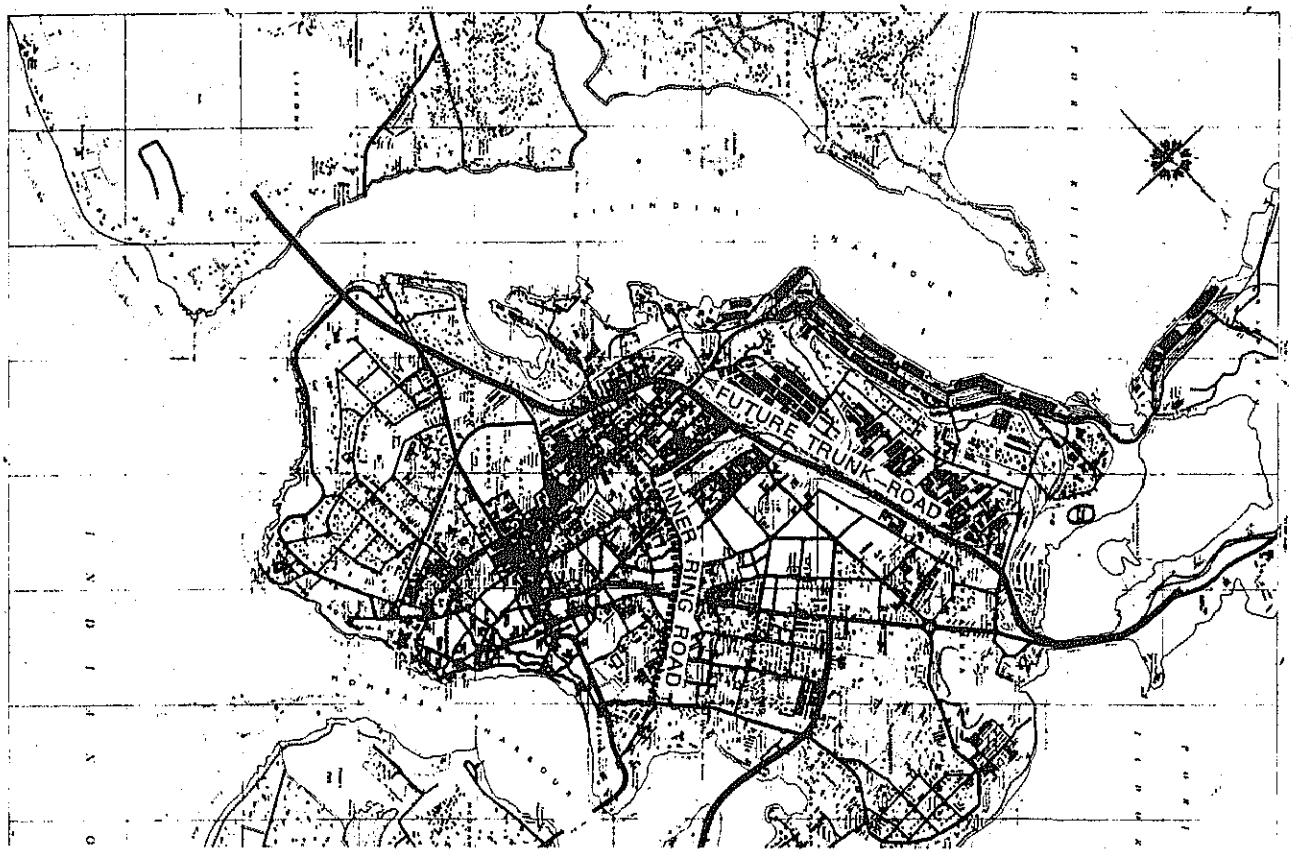


Fig. 6 FUTURE TRUNK ROAD ON MOMBASA ISLAND

5. Outline and Coverage of the Project

1) Outline of the Project

The project crossing proposed will give an immeasurable traffic impact on the existing road network on Mombasa island. Considering traffic distribution, the access of the project road was determined to Nyerere Ave. (H = 55 and 45 m) and the intersection of Nyerere Ave./Mbaraki Road (H = 73.2 m) at Phase I, and the extension for all alternatives to Mbaraki Road (the direction of future trunk road) in Phase-II as shown in Fig. 7 through Fig. 9. The road and bridge length of the project road are shown in Table 3.

Table 3 OUTLINE OF PROJECT

Alt. & Phase		Description of Phase	Road Length (m)	Bridge Length (m)
73.2m	Phase-I	2-lane construction with 4-lane crossing bridge	6,466	3,640
	Phase-II	2-lane construction with 4-lane extension to Mbaraki R.	4,980	4,030
55m	Phase-I	2-lane construction for full length of road	5,294	1,985
	Phase-II	2-lane construction with 4-lane extension to Mbaraki R.	4,340	2,845
45m	Phase-I	Same as 55 m case	5,294	1,690
	Phase-II	Same as 55 m case	4,190	2,400

Note: The figures in the table indicate the length in terms of two lane width.

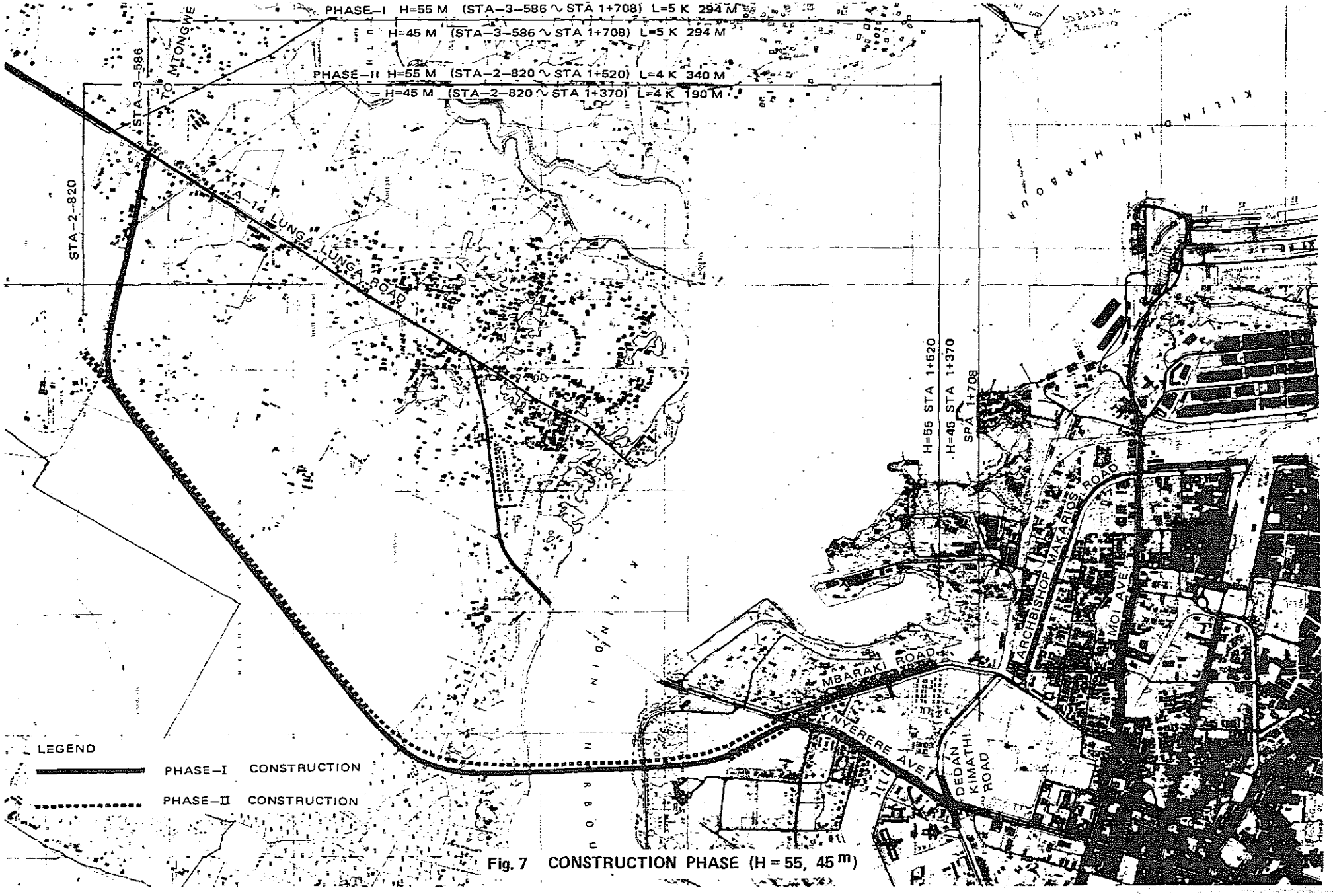


Fig. 7 CONSTRUCTION PHASE (H = 55, 45 m)

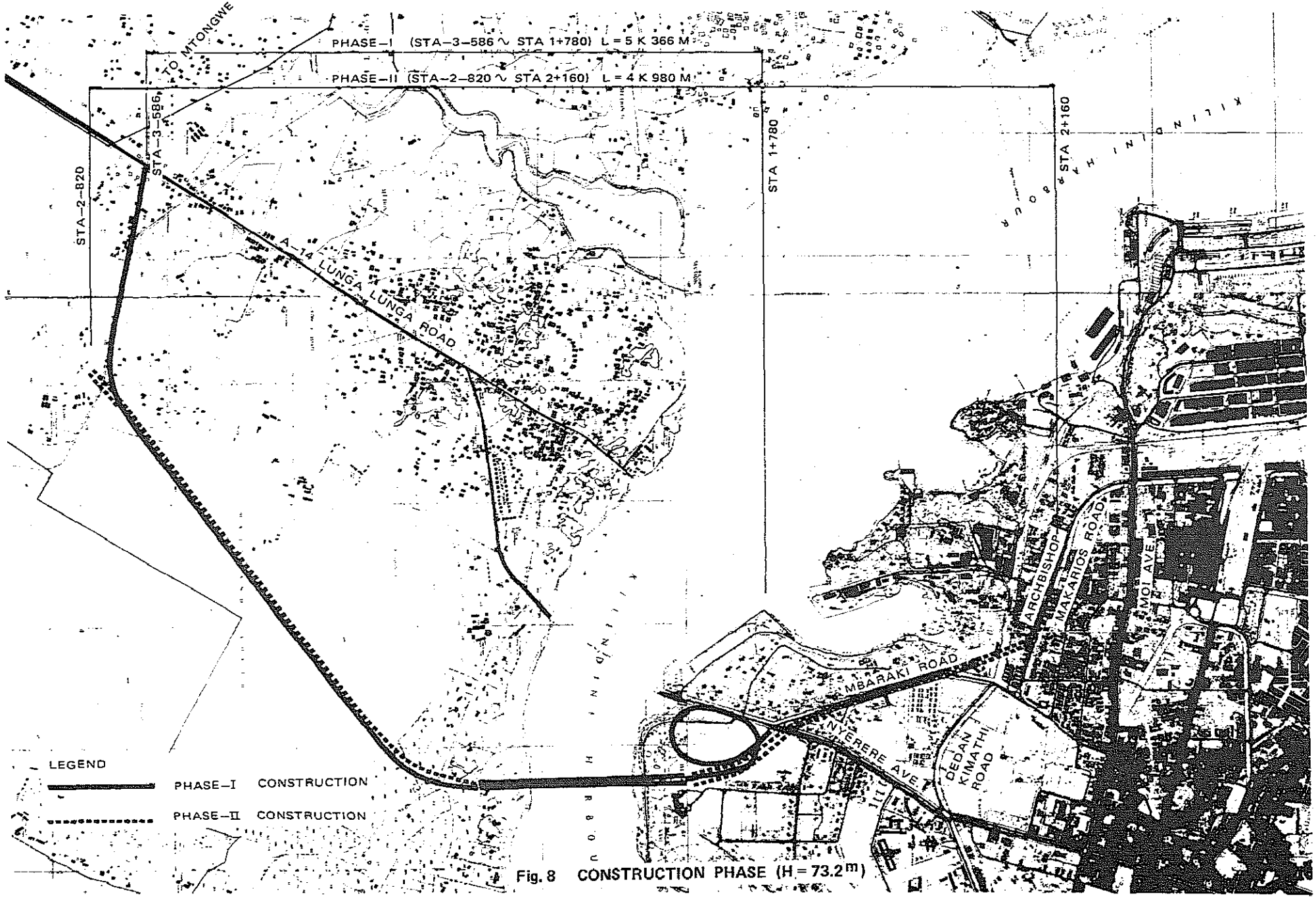


Fig. 8 CONSTRUCTION PHASE (H = 73.2 m)

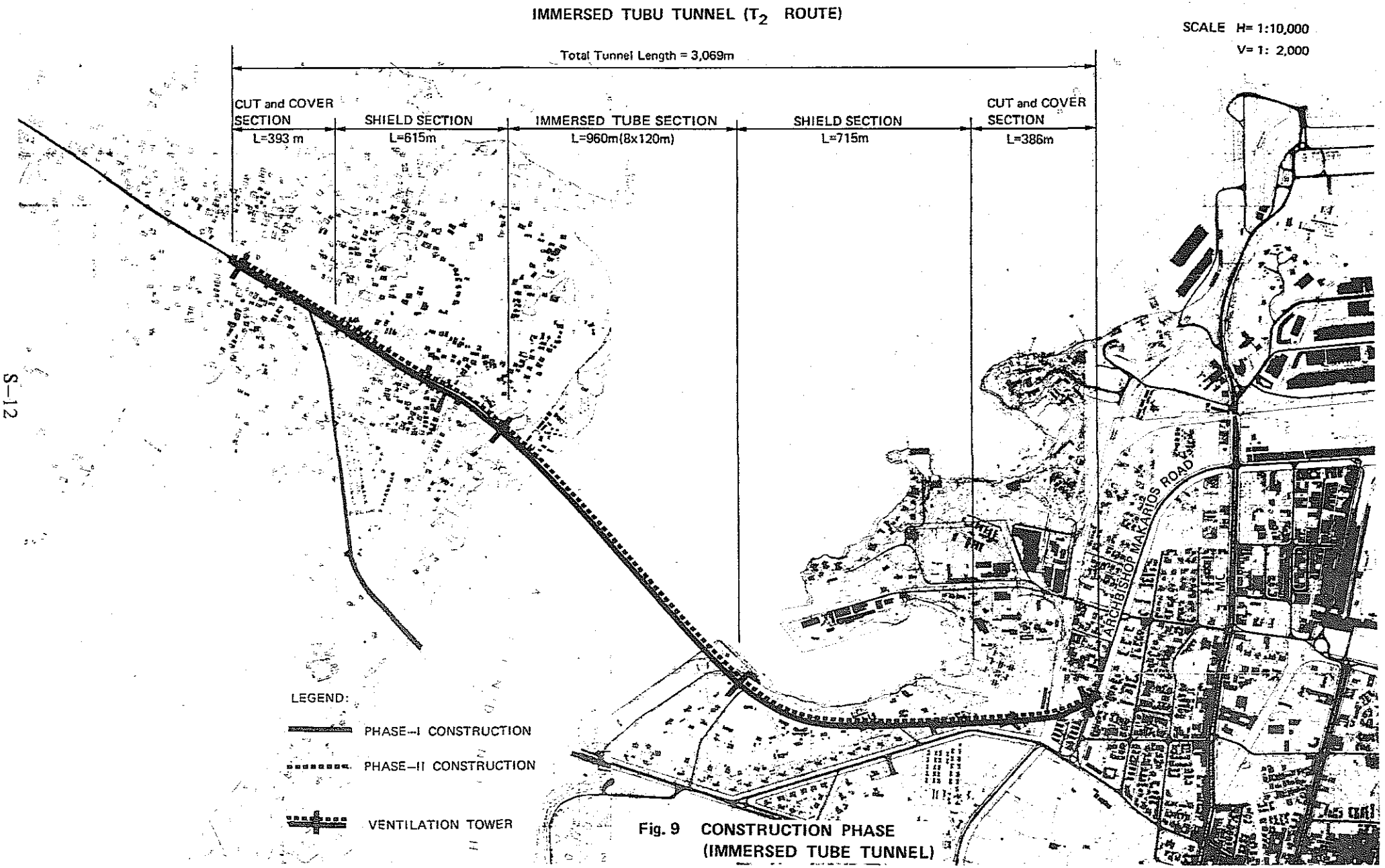


Fig. 9 CONSTRUCTION PHASE (IMMERSED TUBE TUNNEL)

The span of the main bridge was determined as 830 m (main span 460 m, two side spans 92 & 93 m) considering channel topography, construction difficulty and cost as shown in Fig. 10.

The approach bridge was planned as Rigid frame, Post-tensioned T-girder and RC hollow slab bridge considering control points of road and railway, aesthetic relationship between span length and pier height, cost, etc.

2) Extent of the Project

The extent of the project is shown in Fig. 7 through 8.

On the Likoni Side, Lunga Lunga Road is the starting point in Phase-I, and in Phase-II the extension to the south conforms with the 50 m right-of-way set up along an existing electric power line many years ago. On the island side the construction limits are described in 5.1).

6. Construction Costs and Schedules

1) Construction schedule

For the construction of the Project road, staged construction method is applied for the number of lanes and the extension in the future direction of the trunk road considering the large investment and potential traffic demands.

Two phass were considered in the construction schedule, namely Phase-I and Phase-II. The construction schedule for three navigation clearances and an immersed tube tunnel were studied as shown in Fig. 11.

2) Construction Costs

The Project costs including land acquistion and compensation were estimated for various bridge alternatives and an immersed tube tunnel as shown in Table 4.

Table 4 ALTERNATIVE PROJECT COSTS

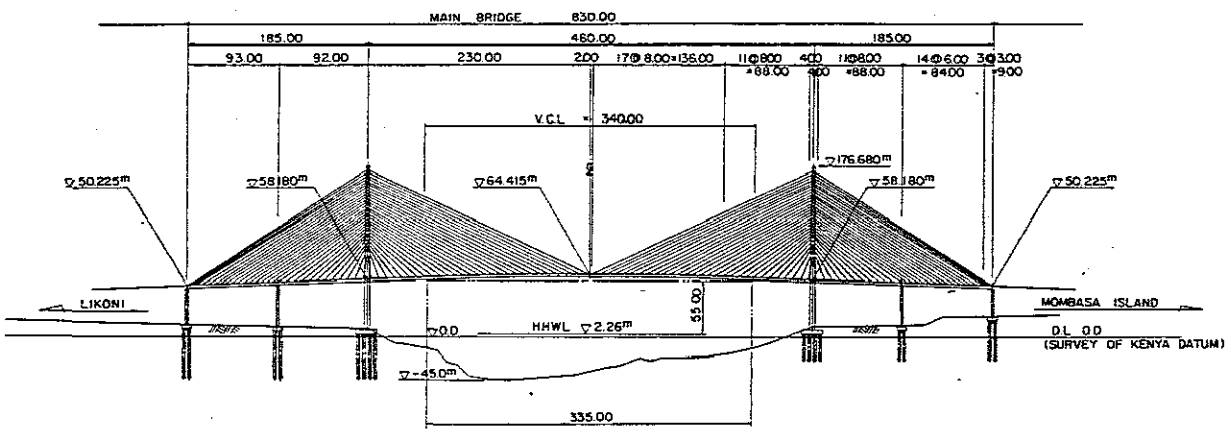
(Unit: 1,000 K.Shs.)

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

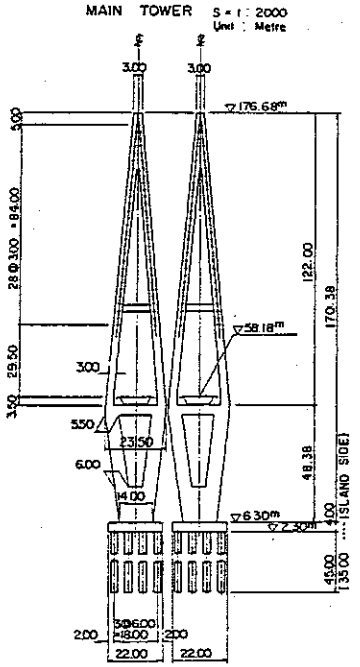
Note: L.C = Local Currency F.C = Foreign Currency

GENERAL VIEW OF MAIN BRIDGE (PC)
(NAVIGATION CLEARANCE H=55m)
Unit : Metre

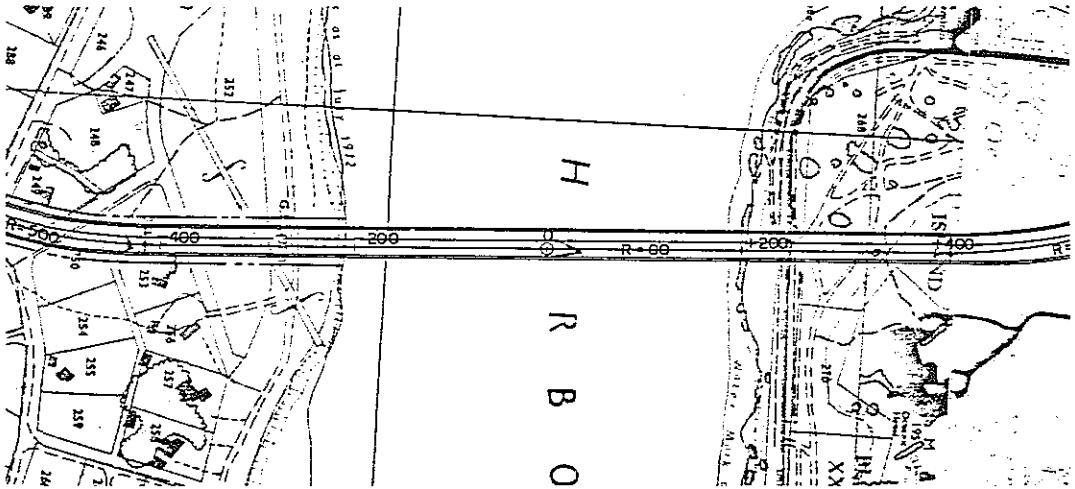
ELEVATION S = 1 : 5000



MAIN TOWER S = 1 : 2000
Unit : Metre



PLAN S = 1 : 5000



GIRDER SECTION S = 1 : 200
Unit : Millimetre

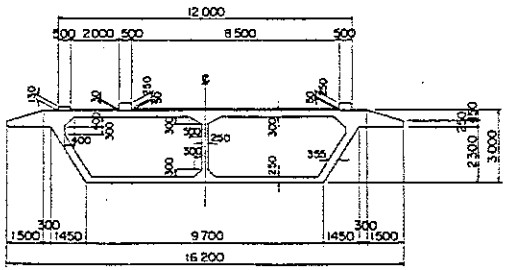


Fig. 10 BRIDGE ALTERNATIVE (CABLE STAYED MAIN BRIDGE ; H = 55 & 45 m)

As shown on the table, the construction cost of the tunnel alternative is more expensive in comparison with that of the bridge alternative. On the other hand, within the concept of the bridge alternative, although PC bridge alternative indicates lower cost slightly as compared with the steel bridge alternative the difference between the two can not be regarded as decisive factor.

Bridge Alternative

Navigation Clearance: 73.2m

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

Navigation Clearance: 55m & 45m

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

Tunnel Alternative

Immersed Tube Tunnel

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

Fig. 11 IMPLEMENTATION SCHEDULE

7. Economic Evaluation

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

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

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

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

The evaluation results are shown in Table 5 and 6 respectively. According to Table 6, Case B is the outcome of calculation under un-imageable condition and if it is put aside *of consideration all other cases indicate approx. more than 10%. Because of this the* project may be regarded as feasible.

Table 5 ECONOMIC INTERNAL RATE OF RETURN

(Economic IRR)

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

Note: IRR of bridge altermatives are estimated for the cases of PC main bridge.

Table 6 SENSITIVITY ANALYSIS FOR 55 m CLEARANCE, P.C MAIN BRIDGE

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

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

8. Financial Studies

1) Financing for Foreign Currency Component

About 80% of the project cost (foreign currency component) will be procured from the foreign financing agencies. Using the following conditions of a uniform annual interest rate of 4.0%, a redemption period of 30 years including a grace period of 10 years from the start of detailed design of the project, the maximum annual amortization amounts to 133.4 million shilling around 2013.

2) Tollway Financing

A toll charge system was examined based on a 55 m clearance (P C main bridge). The toll rate was examined covering the operation and maintenance costs and local currency portion of the project road.

As a result, the project is financially viable, disclosing a financial IRR of 13.8% using a toll rate of 5 shilling for cars and light good vehicles and 40 shilling for big buses and trucks. Some money shortfall appeared with a maximum of 57,824 thousand shillings in 1991.

9. Recommendations

1) Project Evaluation

The alternatives were totally evaluated from regional development, traffic distribution, navigation clearance, cost, operation and economic evaluation as shown in Table 7.

Table 7 TOTAL EVALUATION

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

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

(1) The bridge case of 73.2 m has a big advantage in clearance but is not economically feasible.

(2) The bridge case of 45 m is the most economically feasible, but the clearance is not enough to pass big passenger vessels.

(3) The immersed tube tunnel has less merit, lower EIRR, poor traffic distribution and highest operation/maintenance cost.

(4) The bridge case of 55 m is economically feasible and gives a practical operation of the harbour.

As a result, the cable stayed bridge with the navigation clearance of less than 55 m is revealed as being economically and technically feasible.

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

The project is financially viable with a financial IRR of 13.8% where the toll rate is 5 shilling/car or light goods vehicle per one way crossing, which covers the maintenance and operation costs and local currency portion of the project road.

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

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

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

10. Future Subjects

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

1) Subject for Navigation Clearance

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

2) Considerations to the Main Bridge

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

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

LIKONI CROSSING CONSTRUCTION PROJECT

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ABBREVIATIONS

The following abbratiations have been generally used in the Report:–

MOTC	Ministry of Transport and Communications
MOW	Ministry of Works
KPA	Kenya Ports Authority
KBS	Kenya Bus Service Ltd.
MBA	Mombasa
CBD	Central business District
GDP	Gross domestic Product
Alt.	Avenue
Aot.	Alternative
STA	Station
I.C	Interchange
OD	Origine destination
T/C	Traffic count
ADT	Avarage daily traffic
PCU	Passenger car unit
L.G	Light goods vehicle
M.G	Medium goods vehicle
H.G	Heavy goods vehicle
Q–V	Traffic Volume–Vehicle running speed
H.C.V	Heavy commercial vehicle
GMT	Greenwich mean time
CD	Admiralty Chart Datum
L.L.W.L	Lowest low water level
M.S.L	Mean Sea level
H.H.W.L	Heighest heigh water level
D.W.T	Dead weight tonne
G.T	Gross weight tonne
P.C	Prestressed concrete
R.C	Reinforced concrete
R.C.D	Reverse circulation drill
L.C	Local currency
F.C	Foreign currency
CIF	Cost, insurance and freight
SCF	Standard conversion factor
B/C	Benefit cost ratio
IRR	Internal rate of return

The abbreviations used for units are:–

mm	millimetre
cm	centimetre
ha	hectare
hr	hour
kg	kilogramme
m	metre
L.M	Liner metre
SQ.M	Square metre
CU.M	Cubic metre
Ton	Tonne
min	minute
sec	second
Shs	kenyan shillings
M.shs	kenyan million shillings
Lit	liter

CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The City of Mombasa with Kirindini Harbour, is the second largest city in the Republic of Kenya, and is the centre of the economic and administrative activities of the Coast Province.

In 1975 the Mombasa Structure Plan established the future framework of Mombasa; one million population, 8 district growth poles established by a decentralization policy and with a regional transportation network. In the Plan the development of South Mainland was defined as the first Priority.

Kilindini Harbour, the best sea port in the east coast of Africa, has a significant commerce, tourism and military role, not only for Kenya but also the nearby countries.

To assure continuous economic development of the Republic, Kirindini Harbour has to cope with increasing use and as a consequence, it has become necessary for the Government of the Republic of Kenya (hereinafter called the "Government") to undertake the expansion of the Harbour. The expansion project is currently under study for the port and industrial complex including Ras Hodi causeway (a by-pass to Mombasa city) in the Dongo Kundu area.

Mombasa Island, the core of Mombasa city, is surrounded by creeks and harbours, and two road connections has been provided to the West and North Mainland. Two connections to the West Mainland, Makupa and Kipevu causeways, were constructed many years ago and the New Nyali bridge to the North Mainland was constructed in 1979 by an OECF Loan from Japan. To the South Mainland there are no fixed crossings and only a ferry service is operating to Likoni.

The Mombasa Transportation Plan prepared by the Roads Department of the Ministry of Works in 1972 recommended the construction of the Project Crossing. Recently the Tanzanian border was opened, and the Likoni Crossing is expected to be a part of the international/national trunk road built to high design criteria standards.

Currently the Likoni ferry provides for long distance trip and commutor service amounting to approximate 37,000 passengers, 3,800 vehicles per day. It is a big traffic constraint in its capacity and terminal facilities, especially for large vehicles. The service level has decreased and the facilities expansion must be executed in the very near future in order to solve this problem.

The project crossing will contribute greatly towards the regional development of the Mombasa Metropolitan Area, and is essential for the specialization of the central function of Mombasa island and the development of South Mainland in compliance with decentralization policy. The crossing is to be the initial project of the trunk road.

With this background, the Government of Kenya requested the Government of Japan to conduct a feasibility study for the construction of the Likoni Crossing (hereinafter called the "Project"). The Government of Japan sent a Preliminary Investigation Mission headed by Mr.

Takeshi Nakayama to the Republic in November 1982, and the Mission agreed with the Government on the Scope of Work for the feasibility sutdy (hereinafter called the "Study").

The Government of Japan appointed the Japan International Cooperation Agency (hereinafter called "JICA"), an official agency responsible for the execution of the technical cooperation programmes of the Government of Japan, to conduct the Study, and the JICA organized the Study Team for this purpose.

1.2 Objective of the Study

The objective of the feasibility study on the Likoni Crossing Construction Project is to propose the most feasible crossing facilities in both economic and technical terms, together with engineering consideration for the construction of the crossing.

1.3 Conduct of the Study

The performance of the Study is divided into two phases, namely Phase I and Phase II, and the works for each phase are broadly categorised as shown in Fig. 1.1.1.

Phase I: Overall evaluation of the project environs and selection of the type and route of the crossing.

Phase II: Preliminary engineering and feasibility study on the ultimately-selected alternative for the crossing.

The Study for Phase I commenced in February 1983 upon the submission of the Inception Report and was completed in May 1983 with the presentation of the Progress Report I to the Kenya Government. The Study consisted of an overall evaluation of the project environs, and preliminary selection of the type and location of the alternative crossings based on the review and analysis of traffic, socio-economic indicators as well as future regional development plans, road network, land use and technical/engineering aspects.

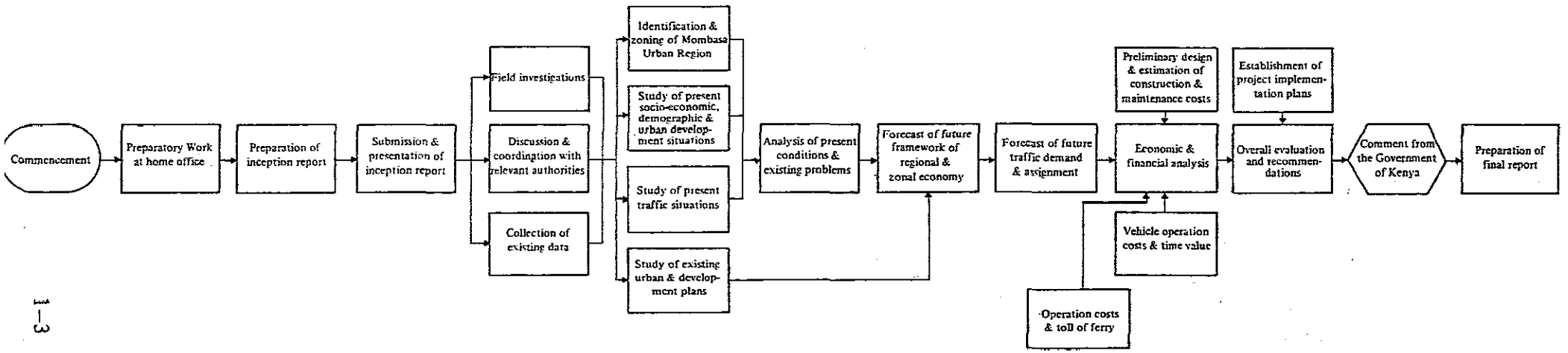
Phase II of the Study covers preliminary engineering and economic evaluation for the ultimately selected alternative crossing. Phase II is further subdivided into the Study in the Republic of Kenya and in Japan.

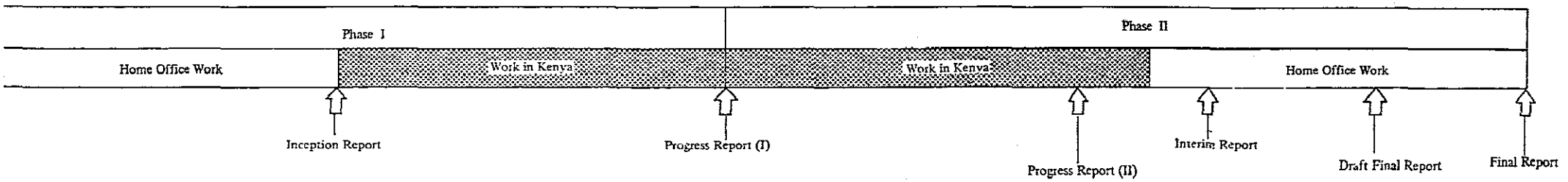
In November 1983 the Interim Report was presented as the intermediate summary of the work mostly conducted in Kenya. In the report the outline of the Project, alignment, structural type of crossing, coverage of the Project, etc., was clarified based on the future traffic demand, topographic survey and soils and materials investigation.

The major context of the Draft Final Report, submitted in February 1984, is the Project evaluation in terms of the economic aspect and the Project implementation.

The economic evaluation was carried out based on the preliminary design, construction cost estimation, and benefit estimation. The Final Report was submitted upon receipt of the review comments in April 1984.

Fig. 1.1.1 WORK FLOW CHART





1.4 Coverage of the Project

The project covers the facilities necessary for the project road embankment and bridge sections, intersections and access roads for the initial stage works.

The Project road will be constructed in two stages, Phase-I and II. In Phase-I Lunga Lunga Road is to be the access road from the Likoni side, whilst on mombasa Island two alternatives – due to navigation clearances of 55 m and 45 m give access to Nyerere Ave. each with two lane carriageways and a length up to 5.3 km long. In phase-II the project road will be extended to Mbaraki Road on the island and the extension to the South on Likoni side will be in accordance with the Mombasa Transportation plan.

Another two lane carriageways with main and approach bridges of 4.3 km will be constructed in this phase.

The project on related road improvements on the island will be separately executed from this project, and will be in accordance to traffic demand.

1.5 Composition of the Report

The study report is composed of three volumes; vol.-I Main Report, Vol.-II Appendix and Vol.-III Drawings.

In the main report, the alternative study leading to the results of the study including the recommendation are described. In the drawings, design features recommended in the main report are clearly shown which will facilitate the detailed design.

CHAPTER 2 OUTLINE OF THE STUDY AREA

CHAPTER 2 OUTLINE OF THE STUDY AREA

2.1 Physical Conditions

2.1.1 Geography

Mombasa is at latitude 4°3′ South and longitude 39°41′ East, about 451 km south of the equator and some 487 km south east of Nairobi. Mombasa island, being the centre of the Study area, is isolated by Kilindini Harbour channel, Mombasa Harbour channel, Port Tudor channel and Makupa Creek, and is linked to the Mainlands (West, South and North) through causeways (Makupa and Cipevu to the west), Likoni Ferry to the south and New Nyali Bridge to the north.

The area of the island is about 13 sq. km, but the Municipal boundaries include 867 sq. km of the Mainland and territorial sea.

2.1.2 Climate

Mombasa's climate is mainly dependent upon the 'north-east' and 'south-west' monsoons which blow from November to March and from April to October, respectively.

The hot season generally occurs from December until March while the long rains and the cool season are heralded by the south-west monsoon around mid-April. During April, May and June more than half of the annual total rainfall occurs. The short rains at the time of the change to the north-east monsoon, are completely unreliable. The effects of high humidity, noticeable during the period after sunrise, are largely dissipated by the diurnal sea breeze, which does much toward making the climate pleasant.

Detailed information given below is based on the data from the Mombasa Airport Meterological Station (1946–1970).

The total yearly mean rainfall is 1,073 mm and monthly mean variation ranges from 19 mm in February to 234 mm in May. The highest monthly rainfall recorded is 772 mm in May and the maximum 24 hours fall is 138.9 mm in May.

The monthly average maximum and minimum temperatures are 30.2°C and 22.4°C, respectively. The highest temperature was recorded as 37.3°C in March and the lowest 14.1°C in August.

The monthly average relative humidity (6:00, GMT) ranges from 77 to 87% and the yearly average is 83%.

The normal wind speed (recorded at 12:00 GMT) does not very much with a range of 11 to 13 knots. Gusts of up to 40 knots, however, are common in Mombasa especially during the months of the south-east monsoon.

According to past records there have been three giant gusts which hit the east coast of Tanzania and Kenya. These are discussed further in the structural design standard in Chapter 6 in order to determine the wind load.

2.1.3 Tide

The tidal conditions in the Killindini Harbour were almost same through the period of 1970 to 1982 based on the data obtained from the Kenya Ports Authority.

The highest tide is 4.1 m and the lowest -0.1 m. The average maximum tidal variation in a month is 3.8 m.

The tidal current speed in the harbour varied with tides (spring and neap) and the channel conditions. The maximum current speed is 2.1 knots at the narrowest channel section near the harbour mouth.

2.2 Socio-Economic Conditions

2.2.1 Population

1) Population Growth of Kenya

The population in Kenya in 1979 was about 15 million, and increased by 40% from 1969.

Since the population census in 1948 a growth rate of 3.4% per annum is recorded.

2) Population of Major Cities

Table 2.2.1 through 2.2.3 show the population growth in the past. There were 11 major cities, which had a population of more than 10,000 in 1969. The urban population of major cities increased on its share gradually from 4.9% in 1948 to 10.7% in 1979.

Out of the total population of major cities, Nairobi and Mombasa account for 71% in 1979. These are moderate growth rates compared with other major cities.

3) Population of Mombasa

Mombasa shows a moderate growth rate of 3.3% per annum from 1969 to 1979. The growth is distributed to the North, West and south Mainland, where the growth rates range from 5.0% to 6.7% and is higher than the Island's rate of 0.6%.

Table 2.2.1 POPULATION CHANGES BY PROVINCE AND DISTRICT, 1969–79

Province & District	1969	1979	% Increase	Rate of Growth p.a.
Nairobi	509,286	827,775	62.5	4.98
Kiambu	475,576	686,290	44.3	3.74
Kirinyaga	216,988	291,431	34.3	2.99
Murang'a	445,310	648,333	45.6	3.83
Nyandarua	176,928	233,302	31.9	2.80
Nyeri	360,845	486,477	34.8	3.03
Central Province	1,675,647	2,345,833	40.0	3.42
Kilifi	307,568	430,986	40.1	3.43
Kwale	205,602	288,363	40.2	3.44
Lamu	22,401	42,299	88.8	6.56
Mombasa	247,073	341,148	38.1	3.28
Taita	110,742	147,597	33.3	2.91
Tana River	50,696	92,401	82.3	6.19
Coast Province	944,082	1,342,794	42.2	3.59
Embu	178,912	263,173	47.1	3.93
Isiolo	30,135	43,478	44.3	3.73
Kitui	342,953	464,283	35.4	3.08
Machakos	707,214	1,022,522	44.6	3.76
Marsabit	51,581	96,216	86.5	6.43
Meru	596,506	830,179	39.2	3.36
Eastern Province	1,907,301	3,719,851	42.6	3.61
Garissa	64,521	128,867	99.7	7.16
Mandera	95,006	105,609	11.1	1.06
Wajir	86,230	139,319	61.1	4.91
North Eastern Province	245,757	373,787	52.1	4.28
Kisii	675,041	869,512	28.2	2.56
Kisumu	400,643	482,327	20.4	1.87
Siaya	383,188	474,516	23.8	2.16
South Nyanza	663,173	817,601	23.3	2.12
Nyanza Province	2,122,045	2,643,956	24.6	2.22
Baringo	161,741	203,792	26.0	2.34
Elegeyo Marakwet	159,265	148,868	-6.5	-0.63
Kajiado	85,903	149,005	73.5	5.66
Kericho	479,135	633,348	32.2	2.83
Laikipia	66,506	134,524	102.3	7.30
Nakuru	290,853	522,709	79.7	6.04
Nandi	209,068	299,319	43.2	3.65
Narok	125,219	210,306	68.0	5.32
Samburu	69,519	76,908	10.6	1.02
Trans-Nzoia	124,361	259,503	108.7	7.63
Turkana	165,225	142,702	-13.6	-1.29
Uasin Gishu	191,036	300,766	57.4	4.64
West Pokot	96,254	158,652	64.7	5.11
Rift Valley	2,224,085	3,240,402	45.7	3.84
Bungoma	345,226	503,935	46.0	3.85
Busia	200,486	297,841	48.6	4.04
Kakamega	782,586	1,030,887	31.7	2.79
Western Province	1,328,298	1,832,663	38.0	3.27
Total Kenya	10,956,501	15,327,061	39.9	3.41

Table 2.2.2 POPULATION GROWTH RATE OF MAJOR CITIES, 1948–79

Cities	Population				Growth rate		
	1948	1962	1969	1979	1948-62	1962-69	1969-79
Nairobi	118,976	342,500	509,286	827,775	7.9	5.8	5.0
Mombasa	84,746	179,575	247,073	341,148	5.5	4.7	3.3
Nakuru	17,625	38,181	47,151	92,851	5.7	3.3	7.9
Kisumu	10,899	23,526	32,431	152,643	5.7	4.7	16.8
Thika	4,435	13,952	18,387	41,327	8.5	4.0	8.4
Eldoret	9,193	19,605	13,196	50,503	6.7	-1.1	14.4
Nanyuki	4,090	10,448	11,624	18,986	7.2	1.4	5.0
Kitale	6,338	9,342	11,573	28,327	3.1	3.3	9.4
Malindi	3,392	5,818	10,757	23,275	4.1	9.2	8.0
Kericho	3,218	7,692	10,144	29,603	6.7	4.0	11.3
Nyeri	2,705	7,857	10,004	35,753	7.9	3.5	13.6
(Share %)	26,577 (4.89)	659,496 (4.64)	932,383 (8.50)	1,642,191 (10.71)	6.7	5.1	5.8
Kenya Total	5,405,966	8,636,263	10,956,501	15,327,061			

Source: Population Census, Kenya, 1948 - 1979.

Table 2.2.3 POPULATION GROWTH IN MOMBASA, 1962–79

	Area	Population			Growth rate		Increase
	sq. km.	1962	1969	1979	1962-69	1969-79	1969-79
Island	13	108,872	130,352	138,312	2.6	0.6	1.06
N. Mainland	100	30,257	44,874	80,299	5.8	6.0	1.63
W. Mainland	49	28,252	50,548	82,353	8.7	5.0	1.79
S. Mainland	46	12,194	20,998	40,184	8.1	6.7	1.91
Total Mombasa	210	179,575	247,073	341,148	4.7	3.3	1.38

2.2.2 Industry

1) Establishment, Number Engaged, GDP and Output

Table 2.2.4 (Industrial production census, 1972) shows that Nairobi and Mombasa (Coast) have more than half of the industries in Kenya, with 65.6% of the total establishments and 72.9% of the total G.D.P. The industrial scale of Nairobi is 2.5 to 3 times larger than that of Mombasa.

2) Earnings

Mombasa has a special character for industrial earnings compared with the other major cities. Transportation/communication and manufacturing sectors show higher figures of 32.7% and 23.0% respectively as shown in Table 2.2.5. This shows that Mombasa port contributes significantly to the district activities.

Table 2.2.4 MANUFACTURING SECTOR, 1972 AND EARNINGS, 1979 BY MAJOR CITIES

Province	Census of Industrial Production, 1972				Earnings, 1979
	Establishment	Number Engaged	Gross Domestic Product	Output	
	No.	No.	K£'000	K£'000	K£'000
Nairobi	815 (48.4)	52,949 (49.8)	43,934 (54.8)	151,525 (50.2)	46,671 (58.1)
Central	125 (7.4)	13,772 (12.3)	7,587 (9.5)	26,549 (8.8)	6,104 (7.6)
Coast	290 (17.2)	17,128 (16.1)	14,516 (18.1)	59,555 (19.7)	16,036 (19.9)
Eastern	56 (3.2)	2,275 (2.1)	2,407 (3.0)	11,168 (3.7)	1,700 (2.1)
Nyanza	105 (6.0)	5,543 (4.9)	2,686 (3.3)	10,690 (3.5)	1,529 (1.9)
Rift Valley	256 (14.7)	13,911 (12.5)	8,776 (10.9)	41,101 (13.6)	2,720 (8.9)
Western	38 (2.2)	836 (0.7)	262 (0.3)	1,424 (0.5)	1,106 (1.4)
Total	1,685 (100.0)	106,414 (100.0)	80,180 (100.0)	301,958 (100.0)	80,332 (100.0)

Table 2.2.5 EARNINGS BY INDUSTRY AND MAJOR CITIES, *1979

Unit: K£'000

	Agriculture and Forestry	Mining and Quarrying	Manufacturing	Electricity and water	Construction	Whole sale and retail Trade Restaurant and hotels	Transport and communication	Finance Insurance Real Estate and Business Services	Community Social and Personnal Services	Total
Nairobi	4,980.1 (2.0)	305.6 (0.1)	46,671.1 (19.1)	3,562.8 (1.5)	24,220.5 (9.9)	35,271.5 (14.4)	23,295.4 (9.5)	34,152.0 (14.0)	71,675.1 (14.0)	244,134.1 (100.0)
Central C.	348.9	-	6,104.5	200.3	761.2	1,081.2	420.6	730.0	4,193.9	13,840.6
Coast C.	529.4 (0.6)	260.1 (0.4)	16,036.7 (23.0)	1,100.2 (1.5)	3,172.4 (4.6)	6,977.1 (9.8)	22,398.7 (32.7)	4,341.7 (6.2)	15,068.6 (20.7)	69,844.9 (100.0)
Eastern C.	416.5	7.2	1,700.8	143.0	416.7	696.8	550.4	494.9	3,092.4	7,525.7
Nyanza C	173.2	-	1,529.1	251.3	663.1	1,201.3	1,201.8	804.8	5,253.0	11,079.6
Rift Valley C.	785.0	39.6	7,183.1	442.2	1,715.3	3,657.4	1,846.5	1,471.1	7,251.1	24,392.6
Western C.	3.2	-	1,106.7	84.0	251.4	155.3	46.9	112.5	1,415.0	3,175.0
Total	7,737.2 (2.0)	612.5 (0.2)	80,332.8 (21.5)	5,783.8 (1.5)	31,212.6 (8.3)	49,040.6 (13.1)	49,760.3 (13.3)	42,104.4 (11.3)	107,949.1 (28.9)	373,032.5 (100.0)

* Cities with 1,000 or more persons engaged since 1972

Central	Coast	Eastern	Nyanza	Rift Valley	Western
Thika	Malindi	Embu	Kisii	Kericho	Kakamega
Murang'a	Mombasa	Machakos	Kisumu	Nanyuki	
Nyahururu	Voi	Athi River		Naivasha	
Nheri		Meru		Kitale	

2.2.3 Tourism

1) Holidays Visitors to Kenya

On the basis of departing visitors by purpose the total number of visitors totalled 352,000 in 1981, in which holiday visitors amounted to 270,000, 76.8%. Since 1977, the number of visitors has decreased due to the world-wide recession.

2) Visitors by Country

60.3% of visitors to Kenya come from Europe. The highest three are from West Germany, United Kingdom and Switzerland.

3) Quarterly Changes of Visitors

As shown in Table 2.2.6 the best season to visit Kenya is in the first quarter (January, February and March) of the year.

The second quarter, in which occurs the rainy season, show the lowest figure.

4) Visiting Area

Accoring to the record of the hotel beds occupied by area in Table 2.2.9, the coastal-beach areas occupied 43.5% of the total beds in Kenya in 1981.

The coastal-beach areas consisted of South (11.3%) and North Mombasa (21.2%), Kilifi/ Watamu (5.3%). The data for these are shown in Fig. 2.2.1.

Table 2.2.6 QUARTERLY CHANGES OF DEPARTING VISITORS, 1981

(Unit: '000)

Qr.	Holiday	Purpose of Visit		Total	Holiday Ratio %	Total Ratio %
		Business	Transit			
1st Qr.	92.7	8.1	10.1	110.9	34.3	31.5
2nd Qr.	49.8	10.9	9.4	70.1	18.4	19.9
3rd Qr.	64.6	10.1	12.0	86.7	23.9	24.6
4th Qr.	63.4	11.5	9.6	84.5	23.4	24.0
Total (Share %)	270.5 (76.8)	40.5 (11.5)	41.2 (11.7)	352.2 (100.0)	100.0	100.0

Table 2.2.7 DEPARTING VISITORS BY VISIT PURPOSE, 1971–1981

(Unit: '000)

Year	Departing Visitors by Purpose			Total
	Holiday	Business	Transit	
1971	295.5	56.3	47.9	399.7
1972	345.0	42.1	41.3	428.4
1973	309.0	43.7	35.4	388.1
1974	310.3	43.4	25.9	379.6
1975	310.2	45.9	30.0	386.1
1976	337.4	49.3	37.6	424.2
1977	288.0	19.7	36.8	344.4
1978	268.4	26.1	38.8	333.3
1979	274.7	37.8	34.7	347.2
1980	282.1	36.0	40.5	363.6
1981	270.5	44.6	41.2	352.2

Table 2.2.8 VISITORS DEPARTURES BY COUNTRY, 1981

	Holiday Visitors (1,000 persons)	Share %	All Visitors (1,000 persons)	Share %
United Kingdom	33.4	12.3	43.5	12.4
West Germany	57.9	21.4	75.3	21.4
Italy	16.8	6.2	21.9	6.2
France	11.1	4.1	14.5	4.1
Switzerland	19.9	7.4	25.9	7.4
Other Europe	24.0	8.9	31.3	8.3
Total Europe	163.1	60.3	212.3	60.3
Total N. America	30.0	11.1	39.1	10.2
Total Asian	19.8	7.3	25.8	6.7
Uganda	4.3	1.6	5.6	1.5
Tanzania	5.3	2.0	6.9	1.8
Zambia	4.6	1.7	5.9	1.5
Other Africa	34.0	12.6	44.2	10.3
Total Africa	48.2	17.8	62.6	12.8
Total Other	9.4	3.5	12.3	2.5
Grand Total	270.5	100.0	352.2	100.00

Table 2.2.9 HOTEL BEDS OCCUPIED BY AREA, 1981

(Unit: '000 Beds)

	Beds Occupied	Share %	Rooms Avail-ble	Share %	Beds Occupied	Share %
Nairobi-High Class	586.9	(12.5)	653	(14.6)	1,268	(14.9)
Other	890.0	(19.0)	934	(21.1)	1,681	(19.7)
Coastal-Beach	2,039.1	(43.5)	1,439	(32.2)	2,959	(34.7)
Other	344.3	(7.3)	354	(7.9)	652	(7.6)
Coast Hinterland	131.3	(2.8)	139	(3.1)	288	(3.4)
Masailand	193.3	(4.1)	164	(3.7)	325	(3.8)
Central	343.8	(7.3)	494	(11.0)	866	(10.2)
Other	162.3	(3.5)	290	(6.5)	487	(5.7)
Total	4,691.0	(100.0)	4,467	(100.0)	8,526	(100.0)

Table 2.2.10 HOTEL ROOMS AND BEDS AVAILABLE OR OCCUPIED BY AREA, 1979

(Unit: '000 Beds)

	No. of Hotels	Rooms		Beds		Share %
		Available	Occupied	Available	Occupied	
Nairobi	80	1,584.2	1,088.6	2,815.1	1,495.1	(34.5)
Beach-						
South/	14	346.2	264.2	729.5	491.5	(11.3)
N. Mombasa	17	653.1	494.1	1,264.5	920.5	(21.2)
Kilifi/Watamu	7	172.1	90.2	371.7	169.3	(3.9)
Malindi/Lamu	15	230.0	134.5	447.6	228.3	(5.3)
Total	53	1,401.4	982.8	2,813.3	1,809.6	(41.7)
Mombasa Island	33	331.3	213.0	613.7	305.4	(7.0)
Coast Hinterland	11	137.0	63.9	285.2	120.5	(2.8)
Masailand	13	156.4	88.0	311.5	161.8	(3.7)
	45	462.0	192.3	777.2	287.0	(6.6)
Other	39	273.4	122.3	459.0	152.6	(3.6)
Total Kenya	383	4,345.7	2,750.9	8,074.9	4,338.1	(100.0)

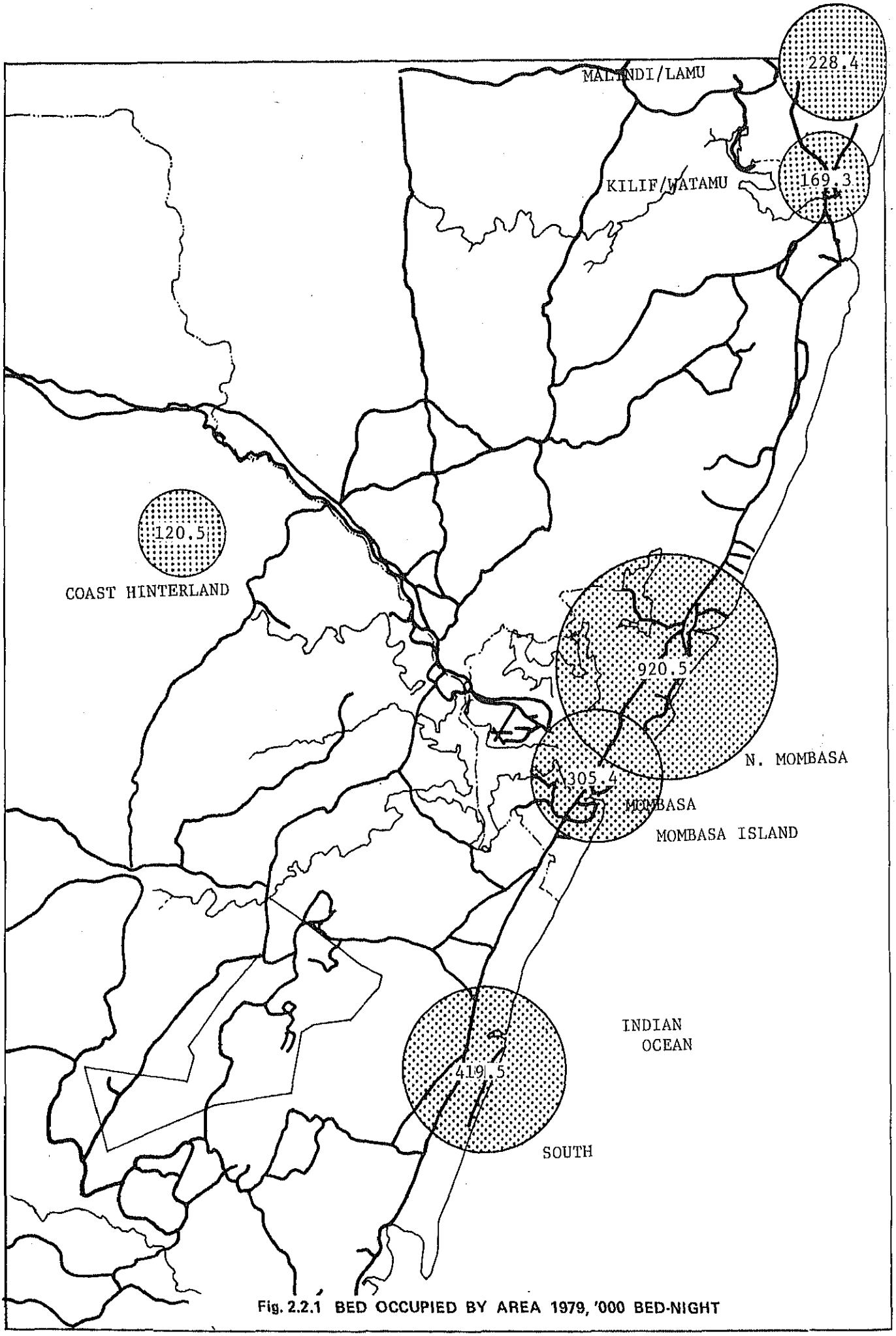


Fig. 2.2.1 BED OCCUPIED BY AREA 1979, '000 BED-NIGHT

2.3 Characteristics of Land Use

2.3.1 Land Use in Mombasa Island and Surrounding Area

1) Mombasa Island

The Municipal functions of Coast Province and Mombasa District concentrate on Mombasa Island with an area of 13 km^2. Fig. 2.3.1 shows the existing land use in Mombasa Island.

The Island can be divided into four areas based on the characteristics of land use:

(1) Town Centre Area

Since the Kilindini Port was developed as a modern port complex, the accumulation of commercial and business function has formed mainly along Moi Ave. (linking Old Port and Kilindini and its extension, Nkrumah Road), and centering around intersections with Digo Road (leading to the north) and Nyerere Ave. (to the south).

The Mombasa Municipality has plans so that this area is encircled by an inner ring road and the area centre is provided with a variety of alternative access roads.

However under the existing circumstances the roads applicable to the plan have only two lanes and that each road can not be functional due to lack of linkage with others proposed by the plan.

(2) Port/Industrial Area

The railway lines runs through the westside of the Island from Makupa to Mbaraki (Bulk Berth) dividing the island area, and the port/industrial area is located in the western division.

(3) Northern Residential Area

Jomo Kenyatte Ave. (the arterial road to West Mainland) and Ronald Ngala Road (the arterial road to North Mainland) run through this area.

(4) Southern Residential Area

This area has the best environment for residential purpose, provided with public facilities such as schools, hospital, etc. and sports clubs and independent houses.

2) Sorrounding Area

The land use of the West Mainland is classified as industrial area, consisting of Changamwe industrial area and Kipevu including Port Reitz and villages, and Vikombani including the Mombasa Airport.

The North Mainland largely consists of resorts (including villas and hotels) on the coastal belt and villages on the hinterland. The Bamburi Cement Factory which is located in the hinterland is the only industrial site.

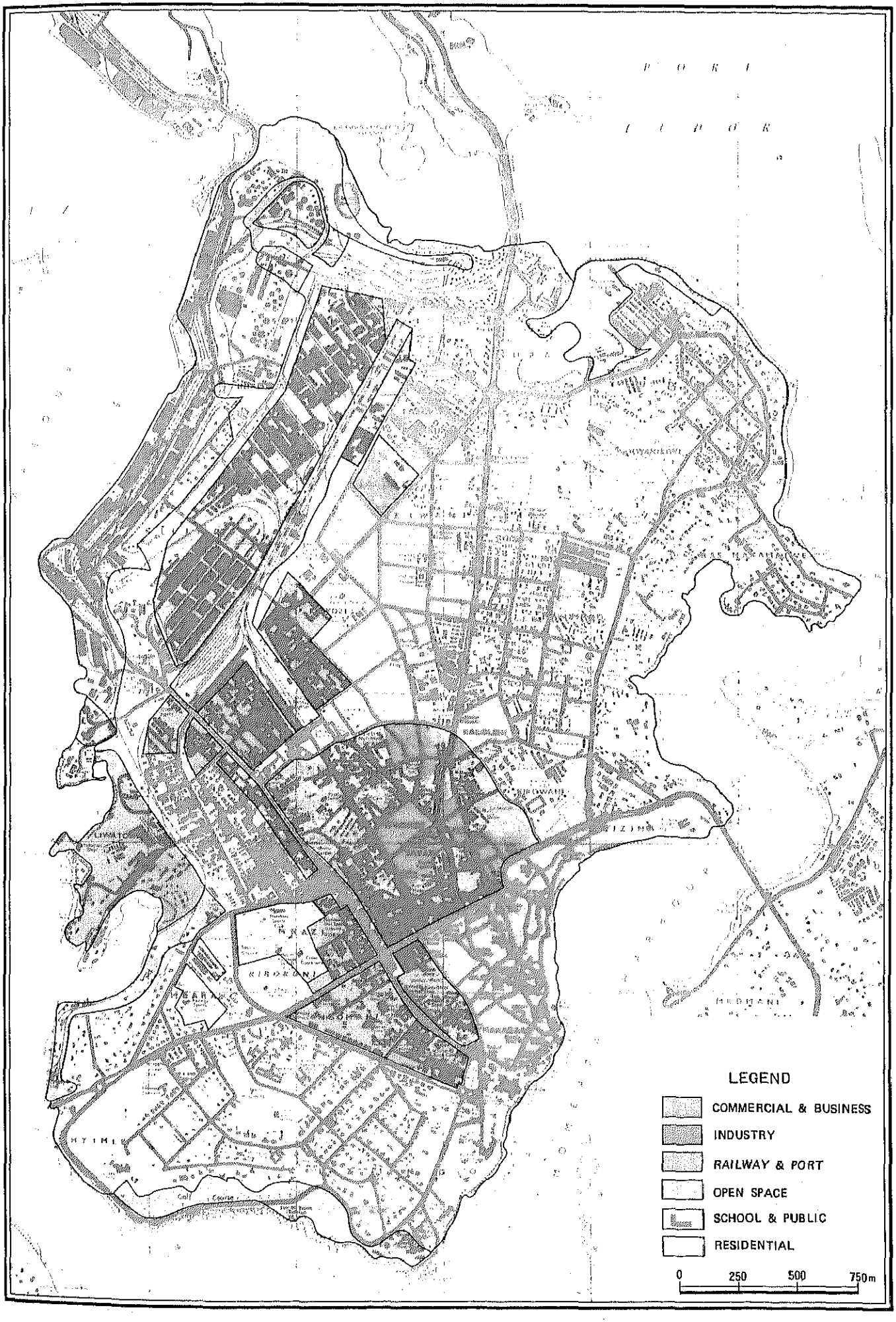


Fig. 2.3.1 EXISTING LAND USE ON MOMBASA ISLAND

The South Mainland is divided into a resort area on the coastal belt and a village area in the hinterland.

The area along Lunga Lunga Road (A14) is used for residential purposes including newly developed residential areas of two-storeyed houses. Commercial establishments are scattered serving the local communicities.

2.3.2 Land Use Adjacent to the Project Corridor

The characteristics in land use in the vicinity of the major roads which would have a relationship with the distribution of the traffic using the proposed Likoni crossing can be described as follows:

1) Shimanzi Road

This road is an arterial road for the traffic in the industrial/warehousing area, port area, and the traffic from these areas uses Makande Road to the north and Moi Ave. to the south. This area is bounded by the above mentioned two roads and is separated from city area by the railway line (Mombasa–Nairobi).

The industrial/Warehousing area located in Shimanzi is well served by the combined system of roads and the railway lines for goods distribution. The industries handled in this area reflect the characteristics of goods to/from Kenya and its hinterland countries, and the following products and establishments can be seen:

- beer, maize, tea, fertilizer, coffee, ice cream, cold meat, sugar, salt
- processed steel materials, canned food, paper bags, cable wire, timber and ply wood, plastic, sponge, aluminum, beverage factories, printing, leather/textile factories
- forklift, drilling company, hardware (window, chair)
- transport companies, container depot, shipping agents, repairing factories, trading companies

The wear of the road surface is heavy. The service roads to warehouses near Moi Ave. and in the industrial area are in a very bad condition due to heavy vehicles and poor drainage in addition to poor pavement structure.

2) Mwangeka Road

This is a 2-lane road having small traffic.
The land use on each side is very different: on the western side are the railway facilities, wheat/flour mill, maize storage, shipping agents, factories of steel/aluminum and concrete products and in the northwest is located a housing complex for rail workers while on the eastern side are the residential complexes for rail workers and houses for low-income residents.

3) Lumumba Road

This is a divided 4-lane road and its roadside development is not in progress except for some for local community purposes. However, the area at its sourthern end between Mijikenda Road and Owen Road is occupied with facilities for furniture, milk, steel, workshop, textile, tyres, scrap yead, etc. Its northern end is built up with community-related facilities such as barber's shops, restaurants, retailshops (bed, hardware, meat, textile and blanket), gas station, school, mosque, transportation agents, church and factories.

4) Railway Right-of-Way (between Moi Ave. and Makande Road)

The northern part of the railway right-of-way is occupied with a residential complex for rail workers. The middle part and the north side of the railway station are occupied with factories facing Mwangeka Road. The south-side of the station is occupied with a shunting yard and warehouses and factories facing Mwakilingo Street. The area near the workshop in the middle part is covered with warehouses and factories but there are open spaces along the right-of-way.

5) Archbishop Makarios Road

This road functions as the east-west arterial road as well as a supplemental road to Moi Ave. This area is mainly built up with 3 to 4 storeyed residential buildings and its roadside is occupied with offices, restaurants, motor vehicles sale shops, laundry, grocery shops, etc.

6) Mbaraki Road

This road is a 2-lane having a wide right-of-way. Its roadside is occupied mainly with independent houses, and a sports club, cemetary, a theatre club, etc.

7) Nyerere Avenue

This road is a 4-lane divided road leading to the Likoni Ferry. Its roadside is not developed, except for the portion near the city centre. The roadside is used mainly for residential purpose including independent houses, and a sports club and some offices.

8) Dedan Kimathi Avenue

This road functions as a supplemental road to Moi Ave. and a major road in the residential area of the south of the Island. Its roadside is occupied with local governmental agencies, medium class residences, sports club, but there are no commercial establishments.