only for the purpose of analysis and planning of road functions. A part of Chapter 6 in this report covers such an analysis.

4.3.3 Intra-regional Aspects

(1) Agricultural Development

The major functional relationships between agricultural development and the road network are summarized as follows :

- Enlargement of the cultivated area
- Commuting to the farm land from the residence
- Collecting and distributing agricultural products and other necessities to market centers
- Transportation of products to regional centers.

The objectives of this study is to established a most suitable network of classified roads A, B and C. This indicates that the study's focus should be placed on arterial roads. The transportation of agricultural products to regional centers is, therefore, a key issue in this study.

Especially, problems from the agricultural development aspect are as follows:

a Transport facilities in Semi Arid Areas

Poor road facilities, such as gravel and earth roads exist in this semi arid area, because of less traffic volume and scattered population. However, a fundamental road facility has to be provided with appropriate minimum standard currently applied in Kenya, including the necessary periodical maintenance.

b Accessibility to Regional Centers

As previously mentioned in section 4.3.2 "Traffic Flow and Network Pattern", to secure the accessibility to regional centers from peripheral rural areas becomes important for transporting agricultural products without any damages. It is, therefore, imperative to improve the access to arterial roads.

(2) Industrial perspective

As far as the industrial perspective is concerned, almost all of the industrial estates are established around urbanized areas, due to the availability of factory workers. Problems with the current road facility from the industrial perspective are summarized as follows :

a Maintaining the way to Mombasa

As described in the preceding section, a major part of traffic movement of manufacturing products are concentrated on the road between Mombasa and Nairobi. Therefore, this road has to be maintained periodically to keep a smooth traffic flow and safety.

b Countermeasures to Heavy Loaded Traffic

Although definitive rules and regulations have to be determined and enforced to alleviate the deterioration of road conditions, many of over loaded large trucks are currently observed. The over loaded trucks cause crucial damages to roads and shorten the road's life cycle. The introduction of severe traffic control devices should be immediately taken into account.

(3) Tourism Promotion

From a view point of tourism promotion, there are two kinds of issues to be considered. They are :

a Accessibility to Tourism Resources

The tourism industry is one of the promising industries to earn foreign exchange in Kenya. This means that many improvements and countermeasures to the road problems have to be implemented to promote an overall development of the tourism sector. It is imperative to provide a suitable road network to enable tourists to move smoothly and comfortably.

In the various tourism activities in Kenya, the road facility plays a key role as a means of transport. Road conditions, especially those of minor roads, to access national parks and reserves are not well maintained to satisfy foreign tourists. In

order to incorporate the tourism promotion into the formulation of the road network master plan, the following measures have to be examined :

- Improvement of the road section from airport and major cities to tourism resources
- Securing total accessibility from minor roads to arterial roads
- Providing the diversification of routes that enable tourists to select where to go
- Providing roads which assure traffic safety on their tours.

4.3.4 Environmental Aspects

Information on road related environmental constraints is not yet well organized.; There only a few documents covering this matter. Some examples are given below.

(1) Complaints Regarding Road Projects

The Ministry of Environment & Natural Resources has received several environmental complaints related to road projects (Table 4.3.10 refers).

No grave complaints regarding environmental damage caused by roads have been made. So far, however, the three cases shown in Table 4.3.10 occurred during the road construction stage in the suburb of Nairobi, a relatively highly populated area.

Table 4.3.10 Complaints Regarding Road Projects

Place	Contents	Period
Embakasi-Nairobi Road	Dust and fumes from asphalt mixing	1992-93
Limuru - Kabeta, A 104 Road	Split of community by the existence of a wall in the center of the road	1993
Nanyuki Road	Chemical dust from a pre-mix plant	-

Source: National Environment Secretariat

(2) Other Environmental Problems

Other environmental problems regarding roads are described as follows :

-Disturbance of migratory routes and habitat of wildlife. For example, collisions between vehicles and wildlife sometimes occur on the Nairobi-Mombasa Road (A 109), which lies between Tsavo East and Tsavo West N.P. However, the number of collisions has not been studied.

-Discharge of accumulated water into agricultural land causing erosion and soil loss.

Chapter 5 Road Transport Modeling and Demand Forecast

Chapter 5 Road Transport Modeling And Demand Forecast

5.1 Planning Horizon

This chapter outlines the methodologies employed in the development and application of transport modeling procedures. It presents furthermore the prevailing situation for the base year 1994 and the simulation results for the future year 2013.

The transport analysis is consistent with the approach of the overall study, that is :

- The year 1994 is termed the "base year" against which changes in future transport activities is measured

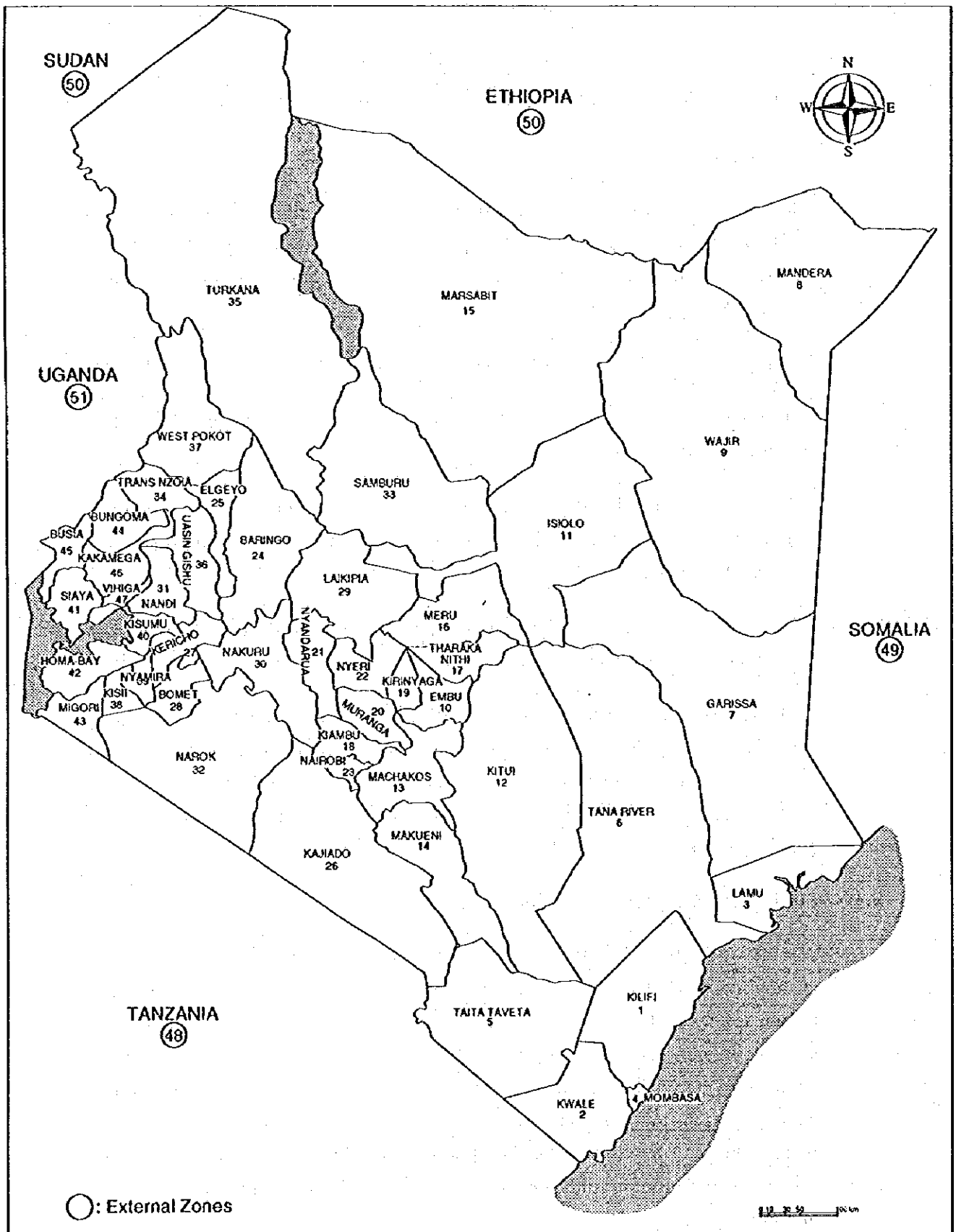
- The years 2000 and 2005 are adopted as the short and medium term planning horizons, within which priority improvement and new construction projects are designated; and

- The year 2013 is termed the "target year", which serves as the long-term horizon for which demand potential is estimated.

It should, however, be noted that the designation of an ultimate planning year represents a somewhat artificial, if necessary, target horizon. It is, from a transport perspective, more correct to state that future year demand projections reflect the achievement of a stated socio-economic condition, which may or may not occur precisely in the postulated year.

5.2 Study Area And Zoning System

A transport study such as the current effort rests on the fact that transport systems channel demand, that is flows, between a series of geographic subdivisions, that are termed zones. Kenya's 47 districts, whose traffic activities can be described by socio-economic and demographic conditions and parameter, are designated as comprising the study area's internal zone structure. Additional four external zones, which represent transport activities between the 47 Kenya internal zones and the five neighboring countries; Somalia, Ethiopia, Sudan, Uganda and Tanzania, have been defined. Thus, the study area includes a total of 51 zones. They are identified in Figure 5.2.1.



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 5.2.1
Traffic Zone System

All analysis of road based vehicle trip activity is performed by using the 51-zone study area. It should, however, be noted that vehicle trips within one zone (that is intra-district and/or urban trips) can not be taken into account by this zoning system.

5.3 Methodology And Modeling Procedure

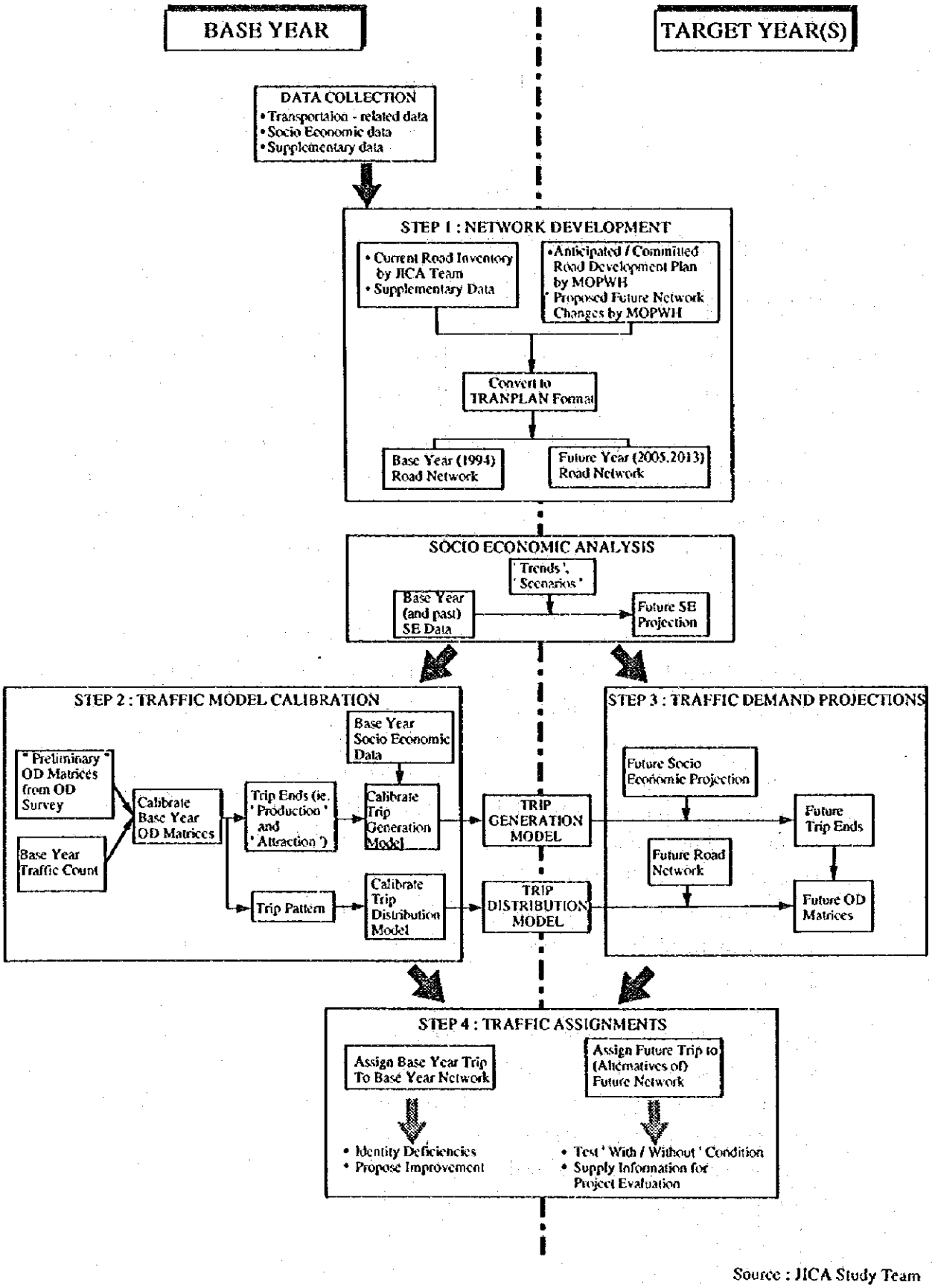
5.3.1 Overview

The modeling approach can in its most basic sense be summarized as consisting of four essential steps as depicted in Figure 5.3.1.

STEP 1 - Network development : road inventory data are, after conversion to TRANPLAN format, assembled to simulate the 1994 base year road network. Inclusion of anticipated improvements, such as upgrading of existing sections or construction of new segments, leads to the development of alternative future - year networks.

STEP 2 - Traffic model calibration : The 1994 vehicle trip matrices are calibrated via data derived from the road side interview and traffic volume surveys. The calibrated base year zonal demand is correlated with the base year socio-economic data of each respective zone. Thus, zonal demand functions (that is trip production and attraction) are developed using regression analysis. The traffic demand at national level, which is adopted as a "control total demand" for an aggregation of individual zonal trip demands, is correlated with the number of registered vehicles. This number has a very close relationship with the level of the national economy and demography. The trip pattern is analyzed by using the above calibrated OD matrices. An appropriate trip distribution model is then developed.

STEP 3 - Traffic demand projections : The framework of the national and regional socio-economic conditions is utilized as "inputs" for the traffic demand models developed in the Step 2. Key aspect of this process are that the estimated future traffic demands are regarded as a consequence of achieving the future national and regional goals. The estimated future traffic demand is then distributed through the trip distribution model.



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 5.3.1
Overviewing of Simulation

STEP 4 - Traffic assignments : The trip demand is loaded onto the base year and future networks, thus providing the basis for evaluation of the base year road system and designation of the future Master Plan road system.

For the execution of these tasks, the capability of TRANPLAN/NIS[1] software was employed during all steps of the modeling process. It is also desirable, given the extensive nature of the transport model, that coordination with other studies be optimized to the highest degree possible. This is achieved by using, among others, the MOPWH road inventory and traffic count data base, which have been supplemented with the data from the road side OD and traffic count surveys undertaken by the JICA team, and MOPWH's road design manual.

However, little research exists in Kenya, which is related to road operations, particularly the empirical interplay of speed, capacity and volume. Three sources were principally used to overcome this deficiency : the "Highway Capacity Manual" (HCM)[2] for the Level of Service (LOS) concept, the IBRD - sponsored " Road User Cost Model"(RUCM)[3] and the "Highway Design and Maintenance Standards Model" (HDM-III model) for road capacity and speed relationships.

5.3.2 Road Network Development Procedure

(1) Inventory Data

Physical descriptive data for road links are available for class A, B and C from the MOPWH data base, supplemented with the JICA field survey[4]. Information includes drainage, geometry (among others, length, rise & fall, carriage way-width, shoulder-width, effective number of lanes), surface type, pavement thickness, and International Roughness Index (IRI), among other things.

(2) System Digitizing

The MOPWH road inventory identifiers (road class, number, and section) were transferred to a 1: 1,000,000 map covering the study area. Node and centroid (1 to 51) numbers were subsequently assigned in line with TRANPLAN requirements.

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1) TRANPLAN(Transportation Planning Modeling Software) and NIS(Network Information System), a set of linked proprietary transportation planning programs distributed by The Urban Analysis Group, Danville, California, U.S.A.
2) "Highway Capacity Manual, Special Report 209", Transportation Research Board, USA 1985
3) "Road User Cost Model", for the Government of Indonesia, Ministry of Public Works, Directorate General of highways, by Hoff & Overgaard, et al, May, 1992.
4) Details are presented in "Road Inventory Survey Report for Road Network Development Master Plan Study in Kenya Vol. I and II", July 1994

The road network, as well as visual identifiers such as towns and district boundaries, were then digitized. That is, the capabilities of AUTOCAD software was applied to assign 6-digit X and Y coordinates to each node. Thus, visual system displays are possible under a variety of mediums, including NIS.

(3) Conversion to TRANPLAN Format

The TRANPLAN highway network simulation programs require the following information for each link :

1) Node Locations

A and B node locations are defined by their X and Y coordinates obtained from the digitizing process. These two nodes provide the starting and ending points of a link.

2) Link Distance

Link distance defines the length of a link in kilometers.

3) Free Flow Speed

Free Flow Speed is defined as the safe speed at which a vehicle would travel on a link in the absence of other traffic. The average free flow speeds for paved road were calibrated based on carriage way width and road roughness equations developed by the RUCM study.

Width - based equations

For road segments between 3.75 m and 7.20 m carriage way width:

Light Vehicles : $FFS_{LV} = 85 - (25*WTF)$
Heavy Vehicles : $FFS_{HV} = 70 - (20*WTF)$

where,

FFS = Free Flow Speed (km/h)
WTF(width transition factor) = $-5.155 + 3.958*W - 0.801*W^2 + 0.0487W^3$
W = carriage way width (m).

Roughness - based equations

The RUCM study provides equations for two different vehicle types and terrain conditions.

Light Vehicles:
FFS_{LV} = 80.678 - (2.267*IRI) (Flat terrain)
= 75.772 - (2.007*IRI) (Rolling terrain)
= 67.677 - (1.607*IRI) (Mountainous terrain)

Heavy Vehicles:
FFS_{HV} = 73.517 - (2.494*IRI) (Flat terrain)
= 63.591 - (1.915*IRI) (Rolling terrain)
= 50.603 - (1.247*IRI) (Mountainous terrain)

where,
FFS = Free Flow Speed (km/h)
IRI = International Roughness Index.

The width and roughness - based vehicle - type equations were combined into link width and roughness equations via identical relationships :

$$S_{W/IRI} = (FFS_{LV} + FFS_{HV}) / 2$$

where,

$S_{W/IRI}$ = Average width-based or IRI-based link free flow speed (km/h).

The final average link speed used in network analysis was derived via :

$$S_{TPP} = (S_W * 0.4) + (S_{IRI} * 0.6)$$

or, outside of 3.75 - 7.20 meter carriage way width range

$$S = S_{IRI}$$

or, for some links at which IRI is not available

$$S_{TPP} = S_W$$

where,

S_{TPP} = TRANPLAN link free - flow speed for paved roads (km/h).

The average free flow speed for unpaved roads termed Earth and Gravel roads was calculated based on an idea presented in the Highway Design and Maintenance Standards Model (the HDM - III Model) and results obtained during preliminary traffic simulation calculations.

The HDM study provides the relationship that the free flow speed for unpaved road is around 15% less than that for paved road. However, during the process, it

was deemed necessary to adopt a somehow lower reduction factor to achieve a technically reasonable speed between paved and unpaved road. After repeatedly conducted calibration routines, it was finally decided to employ a 30 % reduction factor.

4) Link Capacity

Link capacity is defined in terms of maximum capacity, effective capacity and assignment capacity.

- Maximum capacity (MC) represents an absolute limit regarding the number of hourly vehicles (PCU's), which can be accommodated on a given road section. Calculations are based on equations derived by the RUCM study.

- Effective capacity is defined as a maximum capacity modified to reflect the amount of non-motorized traffic, such as bicycles, on a carriage way.

- Assignment capacity represents a trip - making threshold for modeling purposes, at which alternative route choices (as practical and possible) are likely. This is generally adopted as a Level of Service C/D (LOS C/D) condition, as per the Highway Capacity Manual's (HCM) definition.

The RUCM relationship calibrates maximum capacities for road segments between 3.0 and 7.5 meter carriage way width as follows :

MC (flat) = -1,146 + 492 * W
MC (rolling) = -1,041 + 443 * W
MC (hilly) = -948 + 391 * W

where,

MC = Maximum capacity in PCU/hour by terrain type
W = Width of pavement in meters (carriage way width)
Flat, Rolling, Hilly terrain definition is described in Table 5.1

The above equations suggest that maximum hourly two - way capacities for two - lane roads range up to 2,500 - 2,600 PCU under ideal conditions as presented in Table 5.3.2.

Table 5.3.1 Definition of Terrain Type

Terrain	Definitions
FLAT	<10 m/km Rise plus Fall
ROLLING	10 - 30 m/km Rise plus Fall
HILLY	>30 m/km Rise plus Fall

Source : Road User Cost Model (1992); Second Technical Advisory Services on Planning to The Directorate of Planning (IBRD Loan N0.3133 IND), Indonesia

Table 5.3.2 Assumed Maximum Capacities in PCU / hour by road width and terrain

Width (m)	Terrain		
	Flat	Rolling	Hilly
3.0	330	288	225
3.5	576	510	421
4.0	822	731	616
4.5	1,068	953	812
5.0	1,314	1,174	1,007
5.5	1,560	1,396	1,203
6.0	1,806	1,617	1,398
6.5	2,052	1,839	1,594
7.0	2,298	2,060	1,789
7.5	2,544	2,282	1,985

Note : capacity assumes usable shoulders
Source : Road User Cost Model (1992); Second Technical Advisory Services on Planning to The Directorate of Planning (IBRD Loan N0.3133 IND), Indonesia

In the application of the RUCM Road Capacity Model in other countries, maximum capacities are usually further adjusted to account for impacts of non-motorized vehicle (NMV) on the carriage way. However, for Kenya, such kind of adjustment is considered not applicable, because of the small amount of NMV on class A, B, and C roads. For traffic modeling purposes, TRANPLAN link capacities (that is assignment capacity) were taken to be 80% of the maximum hourly capacity to represent Level of Service C/D condition. They were then converted to daily capacities assuming a 9.5% peak hour factor. Table 5.3.3 identifies the assumed maximum daily two way capacities for two lane roads in PCU and by road width and terrain.

Table 5.3.3 Assumed Daily Maximum Capacities in PCU by Road Width and Terrain

Width (m)	Terrain		
	Flat	Rolling	Hilly
3.0	3,473	3,031	2,368
3.5	6,063	5,368	4,432
4.0	8,652	7,695	6,484
4.5	11,242	10,032	8,547
5.0	13,832	12,358	10,600
5.5	16,421	14,695	12,663
6.0	19,011	17,021	14,716
6.5	21,600	19,358	16,779
7.0	24,189	21,684	18,832
7.5	26,779	24,021	20,895

Note: peak hour ratio is assumed to be 9.5 %

The RUCM investigations did not extend to high-order, multi-lane highway facilities. Previous investigations conducted by Pacific Consultants International suggest that daily, two-way PCU capacity may be estimated as follows (not all facilities exist at present) :

Road Type	Capacity
Four-lane Rural Arterial	50,000
Six-lane Rural Arterial	80,000
Four-lane Freeway	73,000

5) Assignment Group Code(ASG)

ASG is used to identify links to which a common capacity restraint functions is to be applied. This means that link speed is reduced by a pre-determined function as the link volume to capacity (V/C) ratio increases. For TRANPLAN input, ASG codes were defined as follows :

- Link type grouping are in accordance with facility type and width
- Free Flow Speed (at V/C = 0) as estimated by the STP calculation on RUCM width-based and IRI-based equations
- The V/C = 1.0 condition is based on Level of Service (LOS) C / D link capacity
- The maximum V/C ratio is estimated by RUCM at 1.33, at which time link speeds are expected to drop considerably. This conditions represent unstable traffic flow conditions prior to operational LOS C/D break-down.

ASG codes and capacity restraint functions are summarized in Annex I.

6) Link Group (LG) Code

The LG code is a numeric code to group links with common characteristics for subsequent referencing, updating, and reporting. Link grouping employed in the Master Plan study address District as LG1, Road function class (Class A,B and C) as LG2, and Roughness Index as LG3.(see Annex I).

Table 5.3.4 presents a summary of the TRANPLAN-coded road network, in which paved roads are shown as being slightly overrun by unpaved roads with a 45% and 55% share, respectively. However, as expected, road condition tends to improve with facility status; that is, an ASG4 road typically exhibits superior characteristics than those of a ASG6 road.

Table 5.3.4 (1/2) 1994 Road Characteristics Summary

ASG code	Road Classification	Width (m)			IRI			FFS (km/h)		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
0	Centroid Connector 1)									
1	Special Function 2)									
2	Four lane Freeway 3)	-	-	-	-	-	-	-	-	-
3	Four lane Rural Arterial	-	-	-	-	-	-	-	-	-
4	Two lane Rural Arterial	6.5	9.2	7.0	2	16	5	55	77	69
5	Two lane Rural Arterial	5.5	6.4	6.1	2	16	8	52	73	65
6	Two lane Rural Arterial	5.0	5.4	5.2	3	12	8	54	66	60
7	Two lane Rural Arterial	-	-	-	-	-	-	-	-	-
8	Two lane Rural Arterial	5.0	5.0	5.0	NA	NA	NA	43	50	45
9	Two lane Rural Arterial	4.0	4.0	4.0	NA	NA	NA	40	40	40

Table 5.3.4 (2/2) 1994 Road Characteristics Summary

ASG code	Road Classification	Length (km)	Assignment Capacity (pcu/day)		
			Min	Max	Avg
0	Centroid Connector 1)				
1	Special Function 2)				
2	Four lane Freeway 3)	-	-	-	-
3	Four lane Rural Arterial	-	-	-	-
4	Two lane Rural Arterial	2650.2	7039	10712	8585
5	Two lane Rural Arterial	3401.0	5557	8433	7034
6	Two lane Rural Arterial	395.0	4240	5689	5291
7	Two lane Rural Arterial	-	-	-	-
8	Two lane Rural Arterial	7650.4	4240	7604	5102
9	Two lane Rural Arterial	386.7	2594	3461	3072

5.3.3 Trip Matrix Development Procedure

The derivation and calibration of the 1994 trip matrices was accomplished through a series of cascading work tasks, which were as follows :

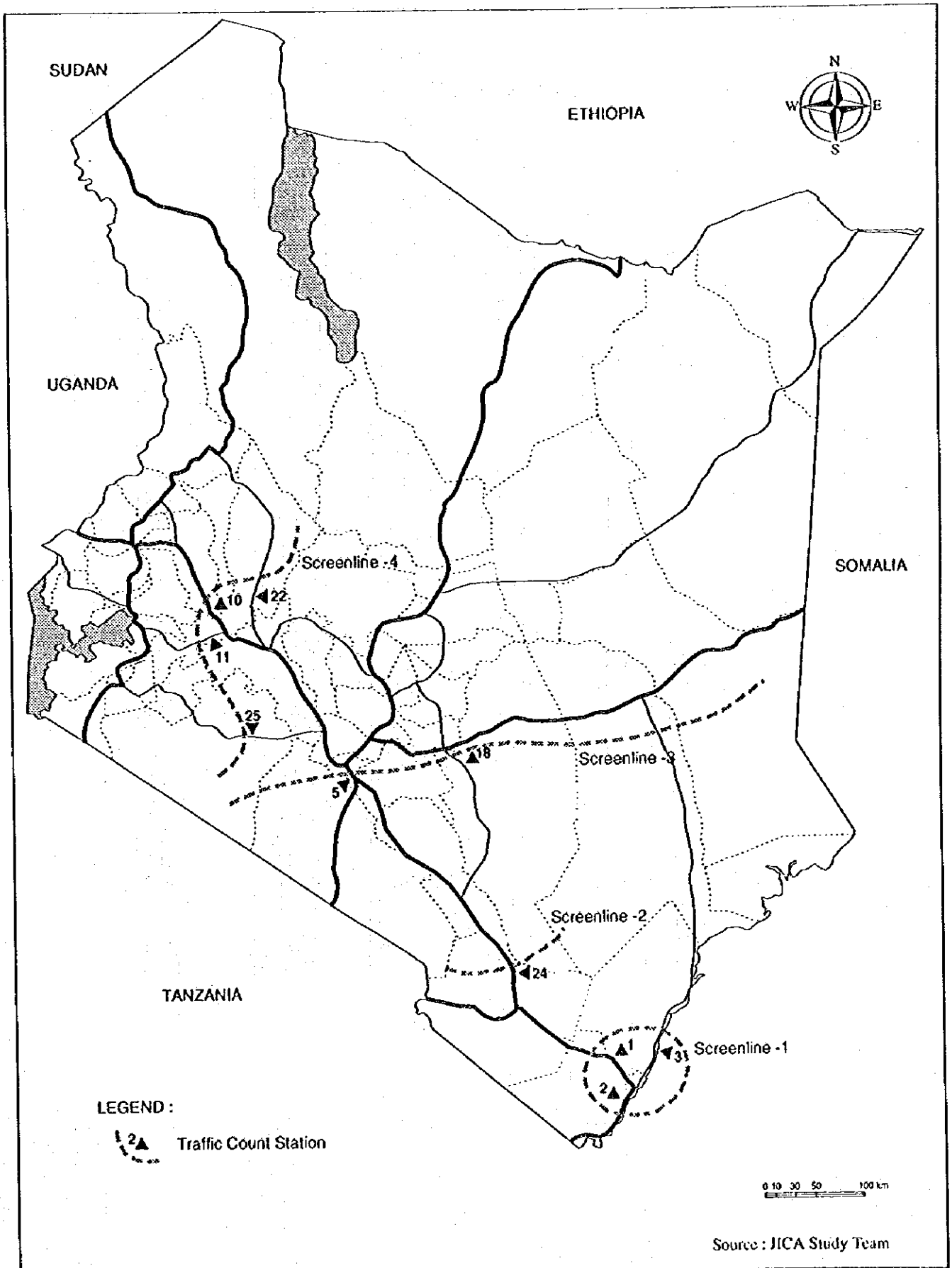
1) A roadside interview and traffic volume count survey was conducted to develop preliminary base year trip matrices. The matrices are composed of 8 vehicle types, namely, passenger car (CAR), motor cycle (MC), light goods vehicle (LG), medium goods vehicle (MG), heavy goods vehicle (HG), tanker (TNK), bus (BUS), and Matatu (MTT). The survey was conducted for 12 hours, thus, following necessary verification and checking procedures, the volume was expanded to a 24-hour basis.

2) Four separate screen lines were designated essentially crossing the primary traffic corridor as depicted in Figure 5.3.2. Screen line-1 encircled Mombasa, delimiting trips in three directions of travel. Screen line-2, together with Screen line-3, mainly controls the Mombasa-Nairobi route, while Screen line-4 handles the movements in the northern location of the study area. All these screen lines work together in the calibration process of the inter-district traffic movements.

3) The preliminary (uncalibrated) trip matrices were assigned onto the base year network, and resultant traffic volumes on each screen line were compared to observed traffic count data obtained via the above traffic count survey.

4) Because of the nature of the preliminary (uncalibrated) trip matrices, discrepancies on almost all of the screen lines were found ("double counting" might be one of the reason). Therefore, the content of each trip matrix was interactively modified using analogies available in TRANPLAN, in which the uncalibrated matrices were used as "seed" matrices and the traffic count as "constraints" in such a way, until assigned interzonal traffic volume trip demand correlated closely with observed traffic volume. This task was done via the capability of "Fast Matrix Calibration" (FMC) function of TRANPLAN developed by Bureau Goudappel Coffeng in the Netherlands.

The results of screen line checking are presented in Table 5.3.5. While the percent difference for some vehicle types was as high as 20 %, the nominal values were practically negligible. It can therefore be stated with confidence that the calibrated 1994 vehicle trip matrices are capable of reproducing base year road demand.



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 5.3.2
Screenline Location

Table 5.3.5 Comparison of 1994 Observed and Modeled Demand

SCREENLINE NUMBER	VEHICLE TYPE	COUNTS (pcu/day)	LOADING (pcu/day)	RATIO L/C	NOMINAL DIFF.
SL-1	Car	3884	3957	101.88%	73
	LiteGoods	3092	3175	102.68%	83
	MedGoods	1812	1878	103.64%	66
	HvyGoods	2222	2344	105.49%	122
	Tanker	896	901	100.56%	5
	Bus	804	860	106.97%	56
	Matatu	2052	2132	103.90%	80
	Total	14762	15247	103.29%	485
SL-2	Car	196	204	104.08%	8
	LiteGoods	204	209	102.45%	5
	MedGoods	360	371	103.06%	11
	HvyGoods	2030	2046	100.79%	16
	Tanker	316	344	108.86%	28
	Bus	424	419	98.82%	-5
	Matatu	52	57	109.62%	5
	Total	3582	3650	101.90%	68
SL-3	Car	1878	1848	98.40%	-30
	LiteGoods	1572	1562	99.36%	-10
	MedGoods	1372	1354	98.69%	-18
	HvyGoods	4228	4127	97.61%	-101
	Tanker	736	713	96.88%	-23
	Bus	352	362	102.84%	10
	Matatu	1752	1714	97.83%	-38
	Total	11890	11680	98.23%	-210
SL-4	Car	1370	1162	84.82%	-208
	LiteGoods	990	886	89.49%	-104
	MedGoods	1138	945	83.04%	-193
	HvyGoods	1746	1426	81.67%	-320
	Tanker	484	420	86.78%	-64
	Bus	892	792	88.79%	-100
	Matatu	1148	984	85.71%	-164
	Total	7768	6615	85.16%	-1153

5.4 Sufficiency Analysis of Base Year Network

The sufficiency of the 1994 roadway network against the current traffic demand was examined in order to provide a status which can suggest currently problematic road segments.

The calibrated 1994 matrices were, based on the incremental process, assigned on to the base year network. Overall performance of the roadway vis-a-vis all vehicles was checked, particularly the volume to capacity (V/C) ratio, whereas volume consisting of total demand, and capacity represented by approximately Level C/D condition. The Key indicators are presented in Table 5.4.1 and Table 5.4.2. Figure 5.4.1 illustrates the base year loading condition.

Table 5.4.1 1994 Loaded Network Parameters by Road Type

ASG#	DESCRIPTION	km	pcu-km	v/c
0	Centroid connector	13.6	15146.6	0.00
1	Special function links	0.8	784.6	0.16
2	4-lane freeway	0	0	0.00
3	4-lane rural (14m)	0	0	0.00
4	2-lane rural (> = 6.5m)	523.6	647948.3	0.15
5	2-lane rural (5.5-6.4m)	680.2	426525.3	0.09
6	2-lane rural (4.5-5.4m)	79	14753.5	0.03
7	2-lane rural (<4.5m)	0	0	0.00
8	2-lane rural, unpaved (> =4.5m)	1530.1	47682	0.01
9	2-lane rural, unpaved (<4.5m)	77.3	706.7	0.00
	Total	2903.8	1152762	

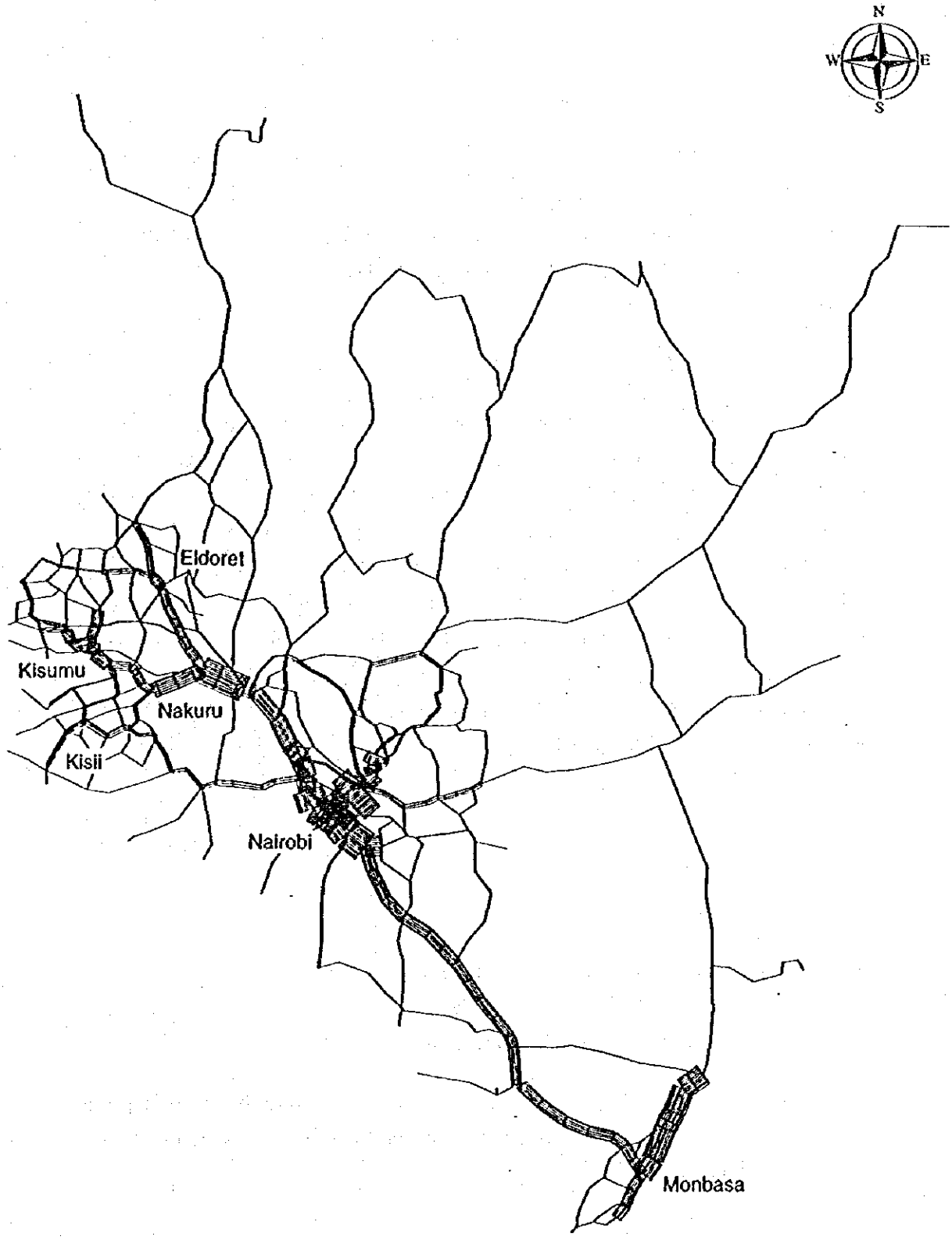
As expected, the Mombasa-Nairobi-Kisumu/Eldoret axis proves to be the primary corridor of traffic, serving for virtually all inter-zonal traffic movements within the study area. Some "sub-corridors" exist, however, leading to/from the major cities of Nairobi and Mombasa. Traffic in other roads is generally very modest and probably more concentrated toward intra-district movements.

The system wide V/C ratio indicates that, in general, there is practically no sufficiency problem throughout the road network. The detailed summary by super link group (i.e. a special link grouping, which aggregates road links having common loading characteristics, see Annex I), however, reveals that a section stretching some 18 kilometers north from Nairobi is currently approaching its capacity.

It is again noted at this point that volume includes inter-zonal trip and excludes intra-zonal trips, which do not cross district boundary. Thus, the V/C ratio condition within urban area is likely to be more severe than indicated by the current analysis.

Table 5.4.2 Loading of 1994 PCU Trips onto 1994 Network
Top Ten Performers by Road Class

LG#	ROAD DIST [km]	PCU-KM	VOLUME [pcu/day]	CAPACITY [pcu/day]	SPEED [km/h]	V/C RATIO
ROAD CLASS : 'A'						
31	18.0	278238	15458	15768	20.65	0.98
28	16.5	205176	12435	16392	25.21	0.76
29	7.5	91740	12232	16823	27.67	0.73
63	15.0	175165	11678	18335	39.33	0.64
68	10.0	104030	10403	16716	32.79	0.62
96	26.0	287723	11066	18395	39.19	0.60
30	1.0	8766	8766	15856	40.00	0.55
67	4.0	46096	11524	21424	39.34	0.54
32	10.0	87660	8766	17348	43.17	0.51
66	8.0	87928	10991	21424	40.34	0.51
74	52.5	505486	9628	19385	39.70	0.50
ROAD CLASS : 'B'						
53	57.5	439778	7648	15982	46.18	0.48
54	16.0	122800	7675	16038	46.60	0.48
52	45.0	341955	7599	17833	48.25	0.43
3	7.0	39868	5695	14525	44.84	0.39
1	45.0	250650	5570	14736	45.69	0.38
21	20.0	116780	5839	16228	45.11	0.36
18	3.0	16190	5397	16191	43.56	0.33
11	3.0	11952	3984	12870	51.43	0.31
2	12.5	40288	3223	14736	52.45	0.22
4	19.0	60877	3204	14658	51.75	0.22
ROAD CLASS : 'C'						
LG2-44	15.00	110139	7343	14932	41.07	0.49
LG1-98	11.5	55996	4869	12209	49.94	0.40
LG2-15	29.00	171897	5927	14685	43.86	0.40
LG1-95	16.0	52128	3258	12102	54.55	0.27
LG2-36	40.00	157765	3944	14699	42.64	0.27
LG2-5	14.00	35904	2565	12778	57.51	0.20
LG2-35	11.50	23459	2040	12216	51.24	0.17
LG1-99	31.0	49234	1588	11033	51.79	0.14
LG2-13	23.00	28014	1218	8480	30.73	0.14
LG2-1	16.50	24301	1568	11676	57.02	0.13



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 5.4.1
1994 Loading Resuite onto
1994 Base Year Network

5.5 Forecast of Future Demand

5.5.1 Trip Generation/Attraction Model

Vehicle ownership projection models were developed first, the results of which were adopted as independent constraints for future traffic demand at national level. Trip generation/attraction models were developed for each of the eight vehicle modes to forecast the number of daily inter-zonal vehicle trips originating in and destinating to each internal zones.

(1) Vehicle Ownership Projection Model

Vehicle ownership is one of the most important factors to determine magnitude of traffic volume. Assuming that an average daily trip demand per a vehicle type within a certain area is relatively stable within a certain period, future total daily trip demand generated by the vehicle type can be estimated via registered vehicle numbers of the area. Numbers of registered vehicles have generally very close relationship with macro socio-economic indicators, such as Gross Domestic Product (GDP) and demographic data. In this section, future vehicle ownership forecasting models by type of vehicle are developed as a function of such indicators at national level. This is done in order to ensure that the total level of forecasted zonal trips is reasonable.

1) Model Form

A linear regression of the form :

$$Y = a + b_1x_1 + b_2x_2 + \ + b_nx_n$$

where Y = registered vehicle numbers
a = constant
b_i = coefficients
x_i = zonal socio-economic data

was selected for developing the vehicle ownership forecasting model. A stepwise approach is preferred so that only statistically significant variables are drawn into the regression process[5].

[5]. Regression analysis was performed using the Macintosh based Stat View Ver 4.0 statistical analysis software.

2) Regression Results

Suitable regression based models for each vehicle type were obtained as presented below :

Car	= 37.212 x GDP (147.1)	$R^2 = 0.99$	DF=8
MC	= 5.530 x GDP (155.2)	$R^2 = 0.99$	DF=8
Pick up	= 20.272 x GDP (97.4)	$R^2 = 0.99$	DF=8
Truck	= 7.651 x GDP (111.5)	$R^2 = 0.99$	DF=8
Trailer	= 2.685 x GDP + 2639 (15.4) (4.2)	$R^2 = 0.97$	DF=7
Bus	= 1.341 x POP - 17,678 (16.0) (-10.6)	$R^2 = 0.97$	DF=7

where,

GDP = Gross Domestic Product at 1982 constant prices in million K£
POP = Population
DF = Degrees of Freedom
Numbers in parenthesis are t-values.

Changes in future vehicle ownership derived from the regression equations are presented in Table 5.5.1. The annual average growth rate over the period 1994 to 2013 for cars is 5.66%, that for motor cycles 5.66%, for pick up 5.57%, for busses 3.89%, for trucks 5.65% and that for trailers 4.99%.. These numbers indicate that traffic demands of all vehicle modes in 2013 is expected to be nearly three times that of the present traffic demand.

As the categories of vehicle types used in the JICA traffic survey are slightly different from those of the vehicle ownership statistics, the weighted average vehicle ownership growth of truck and trailer was adopted for medium and heavy goods vehicles and for tankers. In the same way, bus ownership changes for bus and Matatu matrices, and pick up for light goods vehicle matrices (refer to the last row of Table 5.5.1).

Table 5.5.1 Changes in Vehicle Ownership (1994=100)

Year	Car	MC	Pick up	Bus	Truck	Trailer	TRK/TRL
1994	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1995	105.04	105.04	104.91	105.42	105.01	104.15	104.76
2000	138.33	138.31	137.35	128.99	138.15	131.54	136.18
2005	183.93	183.89	181.79	161.32	183.54	169.05	179.23
2010	239.80	239.74	236.23	189.55	239.16	215.02	231.96
2013	284.85	284.76	280.12	206.49	284.00	252.08	274.48
Annual Average Growth Rate	5.66%	5.66%	5.57%	3.89%	5.65%	4.99%	5.46%
Adopted Trip Matrix	CAR	MC	LG	BUS Matatu			Tanker MG, HG

Note: MC : Motor Cycle, LG: Light goods vehicle, MG : Medium goods vehicle, HG : Heavy goods vehicle

(2) Internal Trip Generation/Attraction Model

The model structure was constrained by socio-economic data availability as well as reliability with which forecasts of these data can be prepared for future years. For these reasons, population, urban population, rural population and wage employment were selected as zonal socio-economic parameters for the interzonal trip generation/attraction model (Chapter 3 refers). Other potentially promising variables such as Regional Gross Domestic Product, could not be used as they are not maintained to the detailed District level by Governmental authorities.

1) Model Form

As used in the vehicle ownership forecasting models, a stepwise linear regression of the form;

$$Y = a + b_1x_1 + b_2x_2 + \quad + b_nx_n$$

where Y = zonal trip demand (both direction)
a = constant
b_i = coefficients
x_i = zonal socio-economic data

were adopted for developing the trip generation/attraction model.

2) Regression Results

The result of zonal trip generation/attraction models were used to provide a future relative pattern of zonal traffic demand. In other words, as previously indicated, the absolute totals of forecasted vehicle trips were constrained by a control total calculated through the vehicle ownership forecasting models.

Suitable regression based models for each vehicle type were obtained as presented below:

Car = 0.029 x WEP + 319 x DUM1 $R^2 = 0.94$ DF=44
(23.9) (7.0)

MC = 10.151 x WEP/TP $R^2 = 0.58$ DF=45
(7.95)

LG = 0.017 x WEP + 2,388 x DUM2 $R^2 = 0.96$ DF=44
(23.8) (12.7)

MG = 4.032 x 10-3 x WEP + 481 x DUM3 + 517 x DUM4
(18.9) (7.5) (9.6) $R^2 = 0.95$ DF=43

HG = 3.765 x 10-3 x WEP + 1.406 x UP/TP $R^2 = 0.93$ DF=44
(15.4) (4.2)

TNK = 2.322 x 10-3 x WEP $R^2 = 0.94$ DF=45
(27.8)

BUS = 5.230 x 10-4 x UP $R^2 = 0.92$ DF=45
(23.4)

MTT = 0.012 x WEP-349 x DUM5+1,617 x DUM6 $R^2 = 0.95$ DF=43
(22.9) (-.3.0) (12.3)

where

WEP : number of wage employment
TP : total zonal population
UP : zonal urban population
WEP/TP : wage employment ratio(%)
UP/TP : urban ratio(%)
DUM1 : Kiambu, Kilifi, Kwale = 1, others = 0
DUM2 : Mombasa, Kilifi, Kiambu = 1, others = 0
DUM3 : Monbasa, Kilifi = 1, others = 0
DUM4 : Kiambu, Kisumu, Nakuru = 1, others = 0
DUM5 : Mombasa, Kericho, Nandi, Bungoma = 1, others = 0
DUM6 : Kiambu, Kisumu, Nyandarua = 1, others = 0
DF = Degrees of Freedom
Numbers in parenthesis are t-values.

Vehicle trips crossing the international border are very small, less than one percent of the total as indicated previously. Their future status is virtually impossible to predict with reasonable accuracy, inter alia, because of the instability of the economies of these countries. Therefore, the growth factor for external zones has been assumed to be same as the national growth of Kenya by each vehicle type.

5.5.2 Trip Distribution Model

The technique through which trips generated by each zone are linked with all other zones is termed trip distribution. The approach used in this study is the Fratar model. By this technique, which is available as a function of TRANPLAN, each trip interchange between zones is iteratively expanded until the row and column totals replicate an indicated target year total trip generation.

A special consideration was made for developing the Tanker matrices. The pipeline, which exists between Mombasa and Nairobi, is expected to be expanded by 1996 from Nairobi (zone 23) to Kisumu (zone 40) and Eldoret (Uasin Gishu : zone 36) via Nakuru (zone 30). Thus, the expanded preliminary tanker trip matrices had to be modified through the Fratar model. That is, the amount of tanker interchanges originated or attracted from/to Nairobi and to/from zones, which are closely located around the above three zones 30, 36, and 40, had to be moved in terms of relative travel time distance to interchanges originated or attracted from/to the three zones. Table 5.5.2 represents the interchanges, which were modified due to the expected pipeline construction.

Table 5.5.2 Interchange Modification of Tanker Matrices

Preliminary expanded future interchanges		Newly identified interchanges	
Nairobi (23)	- Nyandarua(21) - Laikipia(29) - Nakuru(30)	Nakuru (30)	- Nyandarua(21) - Laikipia(29) - Nakuru(30)
Nairobi (23)	- Baringo(24) - Elgeyo Marakwet(25) - Nandi(31) - Trans Nzoia(34) - Turkana(35) - Uasin Gishu(36) - West Pokot(37) - Bungoma(44) - Uganda(51)	Uasin Gishu (36)	- Baringo(24) - Elgeyo Marakwet(25) - Nandi(31) - Trans Nzoia(34) - Turkana(35) - Uasin Gishu(36) - West Pokot(37) - Bungoma(44) - Uganda(51)
Nairobi (23)	- Kericho(27) - Bomet(28) - Kisii(38) - Nyamira(39) - Kisumu(40) - Siaya(41) - Homa Bay(42) - Migori(43) - Busia(45) - Kakamega(46) - Vihiga(47)	Kisumu (40)	- Kericho(27) - Bomet(28) - Kisii(38) - Nyamira(39) - Kisumu(40) - Siaya(41) - Homa Bay(42) - Migori(43) - Busia(45) - Kakamega(46) - Vihiga(47)

Note: Number in parenthesis indicates zone number
SOURCE : JICA Study Team computations.

5.5.3 Future Zonal Trip Activity

The 2013 forecasted vehicle trip matrices contain almost 265 thousand vehicle trip ends in total (excluding intra traffic). This figure is as almost factor 2.75 times than the calibrated 1994 vehicle trip ends. It implies that the average annual growth rate between the periods is 5.5%.

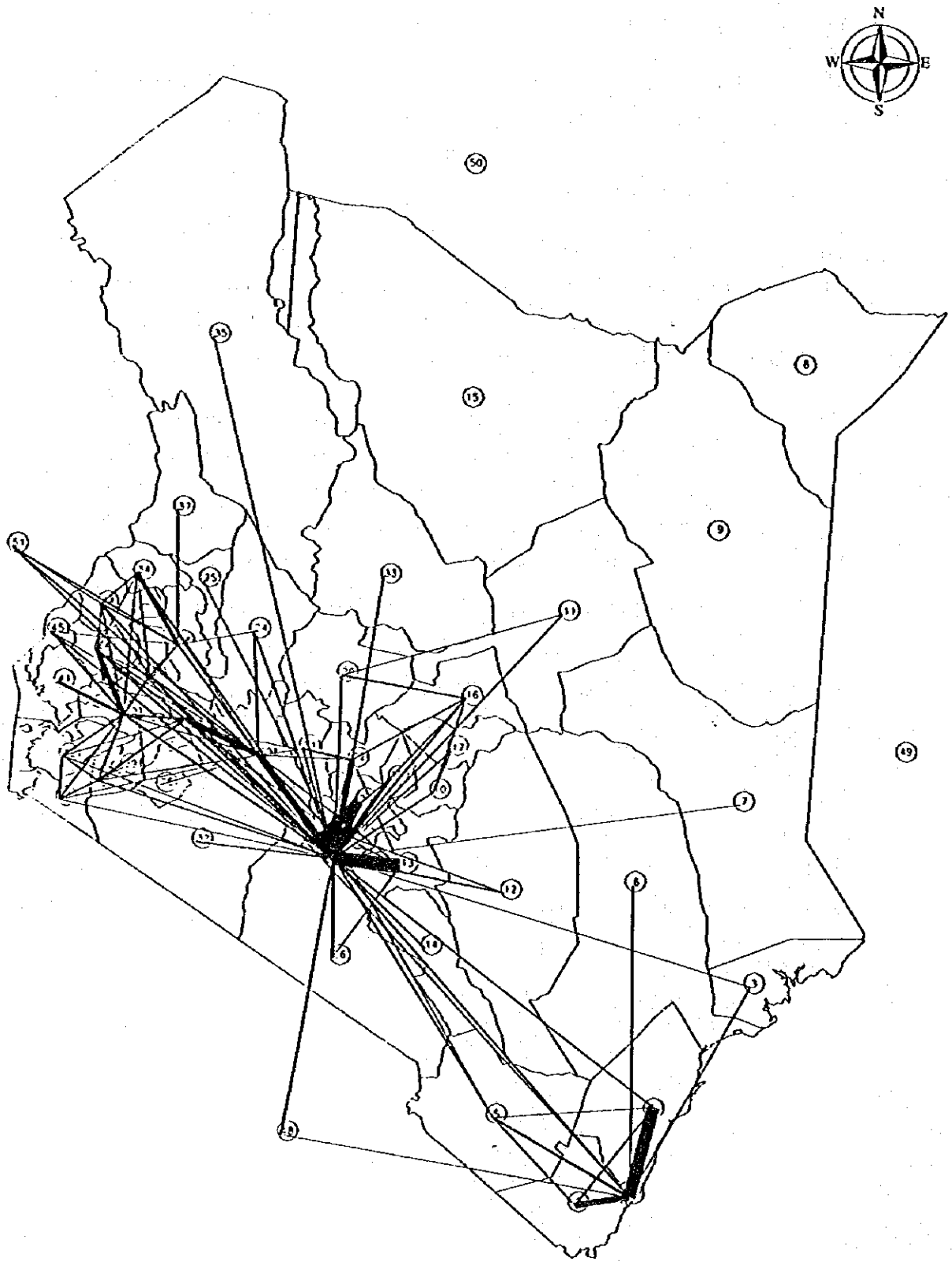
The categories passenger car, light goods vehicle, and Matatu constitute 35.1%, 27.7% and 15.9% of total vehicle trips, respectively. In terms of actual impact on road capacity, that is demand in terms of PCU, the role of passenger car is also most pronounced followed by that of Matatu.

The most dominant zone is still Nairobi (zone 23), accounting for some one-fourth to one-fifth of total trips by each vehicle type. That is followed by Kiambu, Mombasa, and Kilifi (see Annex I). This indicates that Kenya is divided into two principal areas in terms of traffic demand; namely the Nairobi basis area, and the Mombasa basis area (Figure 5.5.1 refers and Table 5.5.3 refer).

Table 5.5.3 Comparison of Traffic Demand by Vehicle Type

Vehicle Type	2013 Vehicle Trips		1994 Vehicle Trip	
	Number	Share (%)	Number	Share (%)
Car	92,980	35.1	31,516	32.7
Motor Cycle	3,862	1.5	1,070	11.1
Light Goods	73,468	27.7	24,954	25.9
Medium Goods	22,954	8.7	7,974	8.3
Heavy Goods	15,236	5.8	5,634	5.8
Tanker	7,770	2.9	3,056	3.2
Buses	6,554	2.5	3,146	3.3
Matatu	42,134	15.9	19,156	19.8
Total	264,958	100.0	96,506	100.0

SOURCE : JICA Study Team computations.



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 5.5.1
Year 2013 pcu Desire Lines
(trips less than 100 not shown)

5.5.4 1994 Road System Performance against 2013 Traffic Demand

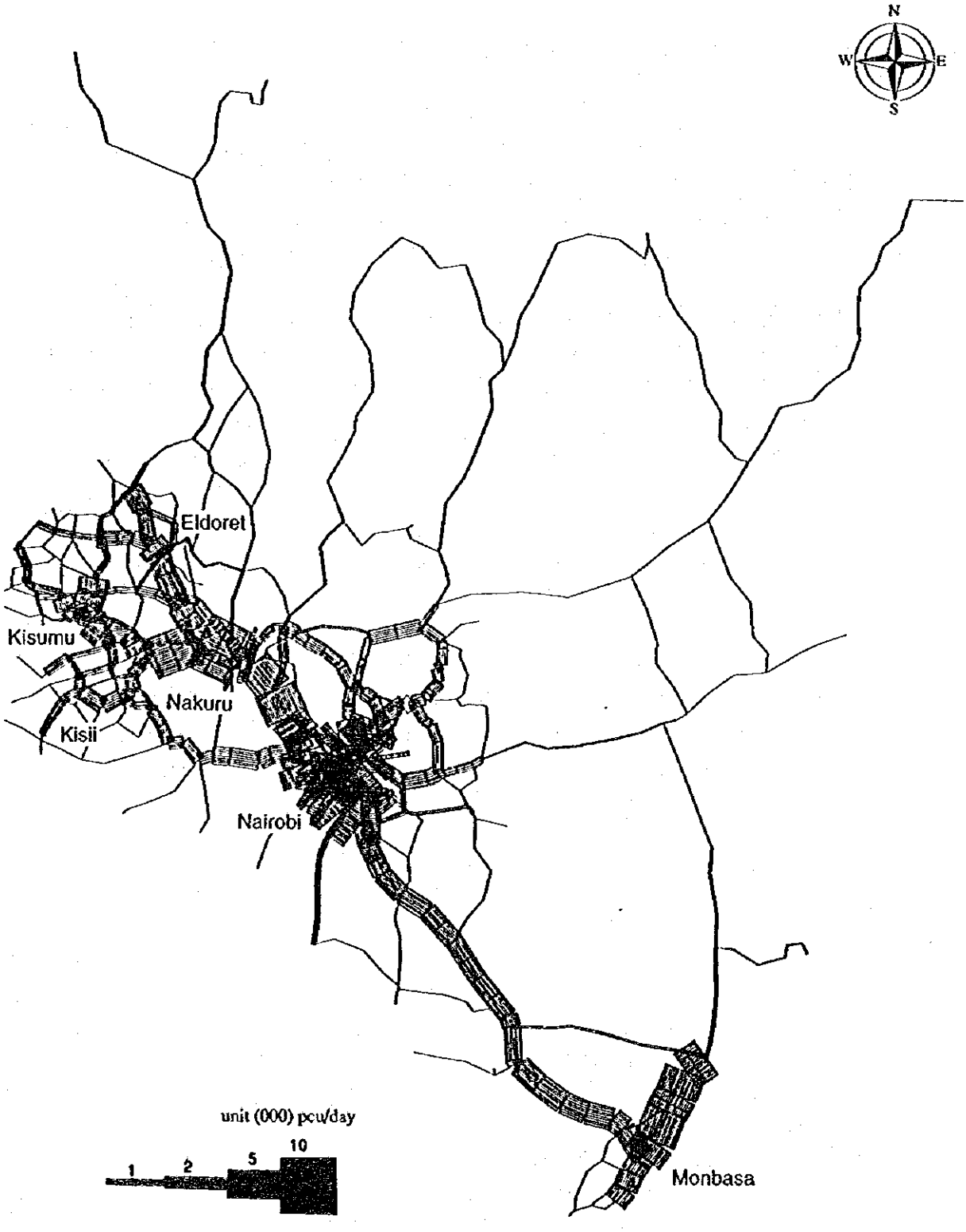
An additional traffic simulation was performed as one of the elements for the determination of future road network improvement programs. In this simulation, the projected 2013 traffic demand was loaded into the capability of the base year 1994 network. This is needed to establish whether or not the present network can cope with future traffic and, if not, where problems are likely to arise.

Figure 5.5.2 shows that the previously indicated major corridor "Mombasa-Nairobi-Kisumu" maintains its traffic carrying importance. System wide V/C ratio by facility type is still low (Table 5.5.4), and the road transport supply on its entity can still cope with the ultimate year demand. However, a closer examination on a link by link basis indicates that there are some sufficiency problems (see Annex I). The most extreme condition is found on Route A2 north of Thika up to the Route C70 intersection. This particular section becomes a "bottle neck" for traffic movement, forcing road user to detour via a longer path on Route B7 and Route A3.

It might be suggested that roads in the hinterland of Nairobi and Mombasa as well as a section between Kisumu and Nakuru are the "black spots", which need special attention. At least from a traffic point of view, these are the links, which have higher priority for inclusion in the Master Plan. This point is further elaborated on in Chapter 6.

Table 5.5.4 Year 2013 Loaded Network Parameters By Road Type

ASG#	DESCRIPTION	km	pcu-km	v/c
0	Centroid connector	13.6	40294.5	0
1	Special function links	0.8	1812	0.38
2	4-lane freeway	0	0	0
3	4-lane rural (14m)	0	0	0
4	2-lane rural (>= 6.5m)	523.6	1645332	0.38
5	2-lane rural (5.5-6.4m)	680.2	1220791	0.26
6	2-lane rural (4.5-5.4m)	79	40071	0.09
7	2-lane rural (<4.5m)	0	0	0
8	2-lane rural, unpaved (>=4.5m)	1530.1	227490	0.03
9	2-lane rural, unpaved (<4.5m)	77.3	3146.2	0.01
	Total	2903.8	3177124.	



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 5.5.2
2013 Loaded Traffic Demand
onto 1994 Base Year Network

Chapter 6 Major Conclusions

Chapter 6 Major Conclusions

6.1 Road Network Development Policy

6.1.1 Strategic Options and Alternatives

(1) General

In the context of Kenya's 7th National Development Plan (1994 to 1996), the following two phrases describe key issues for a regional development strategy :

- To slow down urbanization in higher population growth provinces, and
- To encourage growth center development.

It is easily understood that these concerns come from limited development resources. However, there is trade-off relationship between rapid and sustainable national development on the one hand, and maintaining a balance between rural and urban development. Future road network development in Kenya has to address this proposition. From this point of view, strategic options and alternatives are taken into consideration in this section as is described below.

(2) Intensive Road Network Development

In principle, there are two approaches for road network, which take the above mentioned national and regional development aspects into account, namely :

- Comparatively uniform road development throughout the regions, and
- Intensive road development in selected regions.

In order to meet the solution of this trade-off relationship mentioned above, the following two steps have been taken in establishing a future road network in Kenya :

- Formulation of a hierarchy of cities and towns to intensively and efficiently develop regions with the limited investment resources

- Establishment of functions of the road network in support of both, this city hierarchy and traffic characteristics.

The designation of cities and tows in the city hierarchy as regional centers, sub centers and district centers allows to execute intensive investments in urban and rural areas, while at the same time maintaining an economic balance between urban and rural areas. The establishment of a functionally well defined road network supports such a hierarchy of cities and towns in a practical manner. In other words, the establishment of a well functioning road network enables a development path of the country that meets both strategic objectives, sustainable economic growth and minimizing the economic gaps between urban and rural areas. Two alternatives can be taken into account to formulate the future road network. They are as follows :

a Plan Depending on Existing Road Function

This would typically focus on implementing road improvements, which are based on the existing road classification system and are in accordance with the existing design standard manual currently applied in Kenya. This type of plan would be a rather conservative one, in line with the current administrative conditions.

b Plan to Induce Future National and Regional Development.

The key features of this type of the plan, which aims at inducing national and regional development, are as follows :

- Clarification of road functions with the aim to formulate a cluster road network, which is in line with the city hierarchy
- Implementation of a super highway between Mombasa and the Uganda border and through Nairobi, and
- Intensive road development in selected areas, mainly because of overall industrial development.

c Consideration

It is the considered opinion of the JICA Study Team that, from a strategic point of view, the approach, which induces future national and regional development takes a dominant position among the two options outlined above. This approach is, therefore, adopted in the formulation of the Master Plan.

d Balance between New Road Construction and Road Maintenance

According to the results of the assessment of the existing of road network (refer to Chapter 4.3.1), almost all of the present road cross sections do not meet the current design standard. However, the shortage in width of these cross sections is, on average, not so large. Consequently, the shortage does not always imply the immediate need for improvement, such as widening to meet fully the current design standard.

It is likewise important to note that exceedingly large traffic volumes cannot be observed even in future, with the exception of some specified sections around Nairobi or other big cities. This would imply that only little attention has to be paid for new road construction in the sense of modifying the overall networks configuration. Under some conditions, grading up to meet the standard will have to be executed, once road maintenance has reached its limitations. However, it is also clearly mentioned that bypasses to relieve prevailing traffic congestion and such grading up as from gravel/earth road to bitumen road are essential, taking physical conditions and regional development aspects into account.

6.1.2 Road Network Planning Policy

(1) Overview

Figure 6.1.1. describes the sequential steps of consideration for establishing the policy adopted in this Master Plan study. Issues to be focused on are categorized in the following four integrated steps, which are described in detail below.

STEP 1 : Background of Current Development.
STEP 2 : Issues for National and Regional Development.
STEP 3 : Roles of Road Network Plan and Coordination
STEP 4 : Road Network Development Policy.

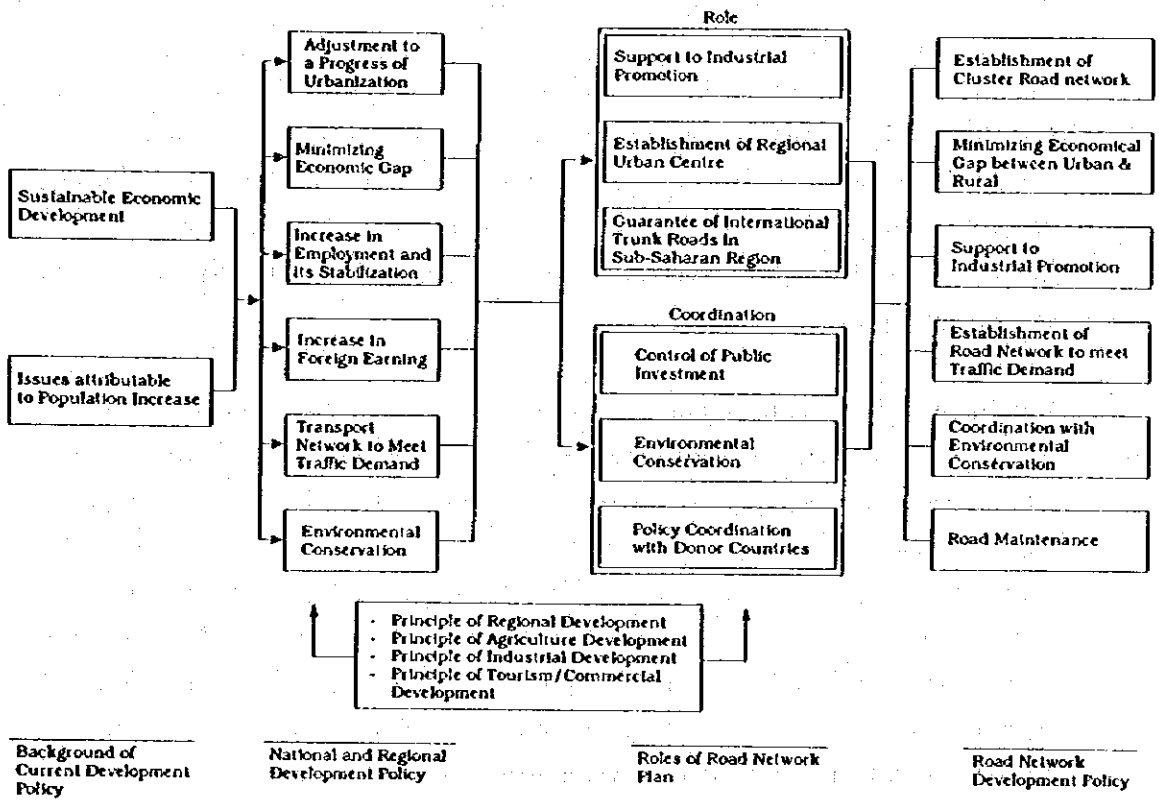


Figure 6.1.1 Relationship of Socio-Economic Issues and Coordination

(2) Road Network Development Policy

1) Background of Current Development

A sharp fall in the price of coffee and the doubling of oil prices forced Kenya to adopt a stabilization program, in order to ensure reducing macroeconomics imbalances. Faced with such situation, Kenya decided to implement structural adjustment measures, when the country serious foreign exchange shortages and payment pressures.

The major issues presented below are derived from the past series of Kenya's national development plans :

- Encouragement of a mixed economy with well defined roles for both, government and the private sectors.

- A high priority for agricultural development, while industrialization is to be undertaken
- An open economy that takes full advantage of the opportunities available in the world market.
- Concentration of government efforts on the provisions of economic infrastructure and social services.

2) Issues on National Development

In line with the above, the issues for national development are summarized as follows :

a Adjustment to Progress of Prospective Urbanization

Due to expected accelerated growth of Kenya's industrial sector, rapid migration from rural areas into such major regional core cities such as Mombasa, Nairobi, Eldoret, Kisumu and Kisii from can be anticipated. The surplus population engaged at present in the mainly traditional agricultural sector in rural area is likely to migrate to urbanized areas. Modernization of the agricultural sector through the utilization of mechanical equipment and agricultural chemicals will also accelerate this tendency.

If this urbanization process takes place nationwide, public investment costs for infrastructure and social welfare facilities' development would be very large and maybe lead to an inefficient use of the budget. Urbanization is ,therefore, favored to occur in a limited number of vital cities , which have a role as regional center in terms of economic and administrative activities. Some guideline to adjust the progress of urbanization seems to be essential therefore in the future.

b Minimizing Income Gaps

There is, of course, a principal income gap between urban and rural areas. Manufacturing factories are usually located in surrounding urbanized areas, with commercial and other service facilities. On the other hand, rural areas consist mainly of agricultural land and semi arid areas. Regional characteristics will, therefore, also bring about per capita income gaps and will induce population migration from rural to urbanized area. Obviously, heavy urbanization, which exceeds the absorptive capacities of the cities will deteriorate their facilities, such

as their social and economic infrastructure. Minimizing economic gaps between urban and rural area becomes thus a key policy for regional development.

c Increase in Employment and its Stabilization

According to the structural adjustment approach, which is being followed for around 10 years in Kenya, enhancement of the role of the private sector and reforming public administrative sector constitute key issues. Raising per capita income is an overall national objective. In order to attain this objective, industrial promotion becomes essential. Rapid increase in employment and its stabilization are also key issues for national development.

d Increase in Foreign Earnings

The shortage of foreign currency is one of Kenya's crucial problems. Export-oriented industrial promotion is one of the countermeasures take. Another is the enhancement of tourism development. Foreign currencies earnings from tourism reached at present some 9% of total GDP in Kenya. This indicates that the tourism sector is one of the most promising foreign currencies earners. Thus, it can be observed that foreign currency earnings is one of the important issues to develop the country.

e Transport Network Corresponding with Increase in Traffic Volume

The current transport system consists of road, railway, airway, pipeline and maritime transport modes.. The road transport mode occupies a dominant position so far and this is unlikely to change, even in the future. The transport network comprising all modes is one of the most basic infrastructures to support national development. From this point of view, a transport network, which functions well and meets the demand is a strong asset to support the development of the country.

Kenya has one rather clearly configured trunk road line transport corridor, which reaches from Mombasa via Nairobi to Uganda. All imported and exported cargoes are transported alongside this corridor. A super highway, which has rather high standard criteria and which goes along this trunk corridor is proposed in the future road network.

f Environmental Conservation

As has been mentioned in item d) above, the tourism sector plays an important role in Kenya's economy. Kenya has many natural tourism resources and natural spectacles. Preservation of these natural resources has become one of the important key issues. These resources are also a key factor to develop other national industries.

In this respect, it is important to maintain a balance between national economic growth and environment conservation.

3) Road Network Development Policy

a Establishment of Cluster Road Network

Regional territory consideration is an important point of view for national and regional development as well. A regional territory is defined by the strength of interchanges between cities (in analogy to the "Gravity Model" as described in Chapter 3). A territory indicates an integrated spatial unit of industrial and commercial activities and of consumption and employment opportunities within it. In this context, a functional hierarchy of cities comprising regional centers, sub core cities and satellite cities, is established within the, in line with the strength of interchanges between the cities. In addition, cities populated with more than 10,000 in 1989 are taken into account as district centers. This used to formulate a further pyramid hierarchy of cities for establishing the actual cluster network mentioned below. The overall hierarchy pattern is shown in Table 6.1.1.

Figure 6.1.2 shows a sketch drawing of this hierarchy of cities and Figure 6.1.3 identifies the physical location of each center.

The present road network system in Kenya comprises both, rather simple arterial roads including international trunk roads and other feeder roads. The present road network system is not harmonized and in line with the above mentioned city hierarchy system. Formulation of a "cluster road network" is, therefore, required to meet this objective. Figure 6.1.4 shows the concept of this cluster road network system.

Table 6.1.1 Classification of Cities

Regional Center (Primary Stage)	Sub Center (Secondary Stage)	District Center (Local Stage)
Mombasa	Mombasa	Mombasa Kilifi
	Malindi	Mamubrui
Nairobi	Nairobi City	Nairobi,,Athi River, Ruiru Karui, Machakos, Thika, Tala Namanga, Naivasha, Maragwa Narok, Taveta, Kerugoya, Embu Gilgil, Garissa, Nanyuki, Wajir, Nyahururu, Maralal, Voi Marusabit
	Nakuru	Nakuru, Eluburgon, Molo
	Nyeri	Nyeri
	Meru	Meru, Isiolo
	Lamu	Lamu
Kisumu	Kisumu	Kisumu, Kakamega, Siaya, Homa Bay, Mumias,
	Eldoret	Eldoret, Kitale, Kapsabet
	Kisii	Kisii, Kericho
	Bungoma	Bungoma, Webuue
	Border	Busia

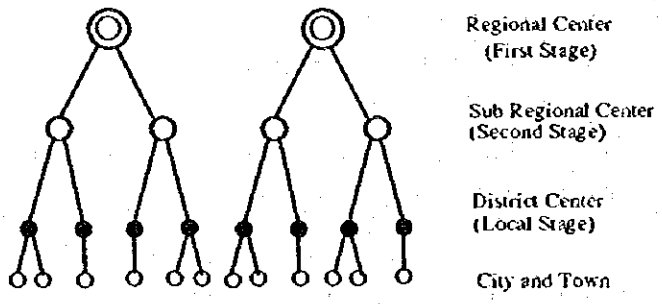
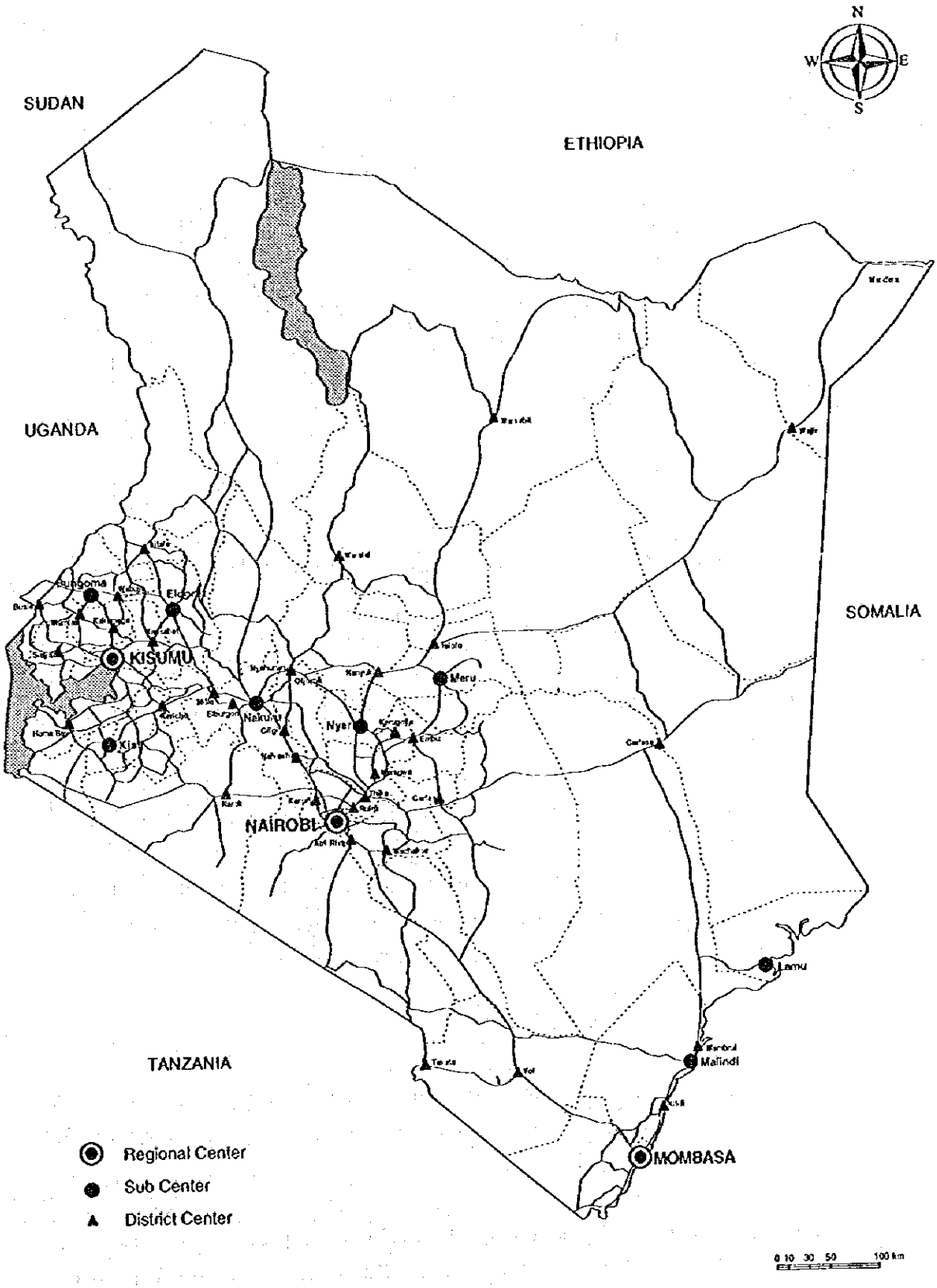


Figure 6.1.2 Hierarchy of Cities



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 6.1.3
Location of Centers

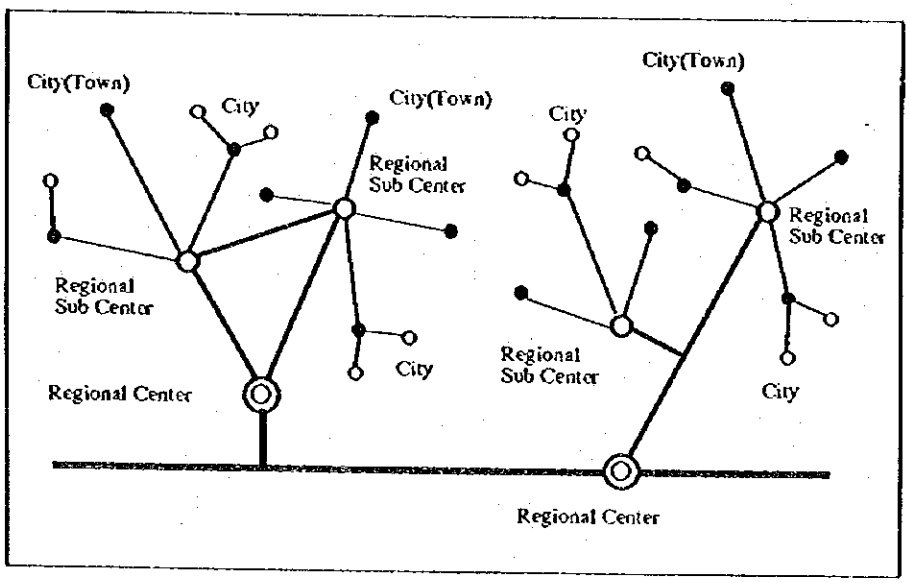


Figure 6.1.4 Conceptual Drawing of Cluster Road Network

b Minimizing Economic Gaps and Support to Industrial Promotion

Following items are key factors to attain sustainable economic growth and to raise per capita income :

- Enhancement of agricultural activity to minimize economic gaps between urban and rural area
- Strengthen manufacturing industry to keep high economic growth more than that of population growth and to create new jobs for unemployed
- Promotion of tourism development to earn foreign currencies.

- Enhancement of Agricultural Activity

The enhancement of agricultural development has two aspects. Firstly, the required balance between rural development and urbanization and, secondly, the promotion of agriculture itself.

Balancing the urbanization and rural development processes is always a fundamental issue in national development. Rural regions usually depend on agricultural activities. They also tend to keep, from a workforce point of view, a rather big surplus population. This is one of the direct reasons to promote

urbanization, namely population movement from rural to urban areas. This means that it becomes essential to attain both, a stable urbanization process to reduce rural population and to increase per capita productivity in the agricultural sector.. Such accomplishments seem to minimizing the economic gaps between urban and rural areas.

It can be mentioned from an agricultural development point of view that agricultural activities in semi-humid and semi arid areas will have to be encouraged. This is, because other high potential areas have been already cultivated thoroughly. The establishment of a proper total road network system, comprised arterial and feeder roads in the area, becomes a key factor to develop and promote appropriate agricultural productivity. Another essential issue is that the suitable road network be coordinated from major arterial to local and feeder roads throughout the whole country.

- Strengthen Manufacturing Industry

Most major manufacturing industries are located in the area around big cities such as Nairobi, Mombasa Eldoret, Kisumu and others. This illustrates the following three points :

- Providing ways to connect to Mombasa
- Establishment of an arterial road network to connect major cities
- Securing traffic safety, especially by large and heavy trucks.

Formulation of a prospective road network is essential to support cargo transportation as well as transportation derived from various business activities. Based on the experiences of other countries, provision of a comprehensive road network and especially arterial roads, is essential for the promotion of the manufacturing industry.

- Promotion of Tourism Development

From the point of view of promoting tourism development, the following three points seems to be essential :

- Establishment of a comprehensive road network that functions appropriately as a system

- Improvement of feeder roads accessing such tourism resources as national parks and reserves from peripheral arterial roads
- Taking environmental conservation into account.

c Establishment of Road Network to meet Traffic Demand

With references to the traffic demand, the following issues are taken into consideration to discuss the policy on road network development :

- Viewpoint on Geometric Standard

With respect to technical standard, some discrepancies and defects on it have been observed sometimes in developing countries. However, the technical standard for road design and planning which had been formulated bases on that of in United Kingdom has been built up and widely applied in Kenya as road design manual. Any big problems could not be found through the comparison to that of developed countries in the world and the technical examination of about this standard. It is also considered that this standard has been systematically established and no special necessity on sub technical standard can be observed. All road construction by donors has been undertaken in accordance with this standard so far. Consequently, appropriate road facilities should be provided to meet the traffic volume and traffic characteristics based on the prevailing geometric design standard manual widely applied in Kenya at present.

- Clarification of Functions of the Road Network

Current Classification

Prior to discussing any road classifications and functions, functions of cities, towns and villages are to be decided from a national and regional development point of view. After such an exercise, the most suitable functions of the road network are to be examined. This Study pays much attention to the hierarchy of cities, because suitability of the road network cannot be decided only based on Kenya's traffic characteristics (a more detailed examination is given in Chapter 3.2.2 City Ordering System).

At present, Kenya's road functions are officially classified into class A, B, C, D, E and SPR roads. According to the published design standard manual, the following are the definitions of each current road classification :

- Class A

  Roads linking centers of international importance and crossing international boundaries or terminating at international ports.

- Class B

  Roads linking nationally important centers (principal towns/urban centers).

- Class C

  Roads linking provincially important centers to each other or to higher class roads.(urban/rural centers).

With reference to the above road classification, the following is also mentioned in the design criteria :

-Roads of the highest classes A and B have the major function to provide mobility, while the function of class E is to provide access. (Road Design Manual, 2.2 Road Classification).

New Classification in this Study

It is, however, considered desirable to supplement the above criteria with additional ones such traffic characteristics and city hierarchy. For this purpose, the following new classification has been taken into consideration in this study. It should be noted in this context, however, that this new classification is for analyzing road functions only and not meant to be a new administrative classification system.

Classification being adopted

-Major arterial road	international trunk road and roads connecting regional centers with each other.
-Arterial road	roads connecting regional sub centers and important substitutional routes to major arterial roads.
-Minor arterial road	roads connecting local centers with each other and access roads to major higher arterial roads.

A detailed discussion of this subject area with actual classifications is provided in the following Chapter 6.1.3, Functional Classification.

d Coordination with Environmental Conservation

The following items are taken into consideration in the formulation of the prospective road network development in Kenya :

- Soil erosion
- Deforestation
- Desertification
- Wildlife conservation
- Pollution alongside roads

A balance between national development and environmental conservation seem to be a key factor to formulate a prospective roads network in Kenya. The balance itself, however, has to be decided in the course of a prudent consensus on the Kenyan side.

e Road Maintenance

High inflation and a shortage of the public investment budget seem to indicate that more cost-efficiency will be required for road network development, even in the future. The following issues are to be examined in this context :

- Establishment of technical measurements as follows :
  overall maintenance system
  administrative system
  and others.

- Policy on the proportion of the budgetary allocation
  appropriate budgetary allocation between maintenance and construction every following period is essential.

6.1.3 Functional Classification

(1) City Role according to City Hierarchy

According to the results of city ordering analysis and taking population size into account, the expected role and classification of cities in the future have been obtained as is shown in the previous Table 6.1.1 (refer to Chapter 6.1.2.(2) 3)).

(2) Functional Classification of Roads

Although the existing road classification system currently applied in Kenya is sufficient from an administrative point of view, the following new analytical road classification was applied, also for the purpose of avoiding terminological confusion :

- Major arterial road
- Arterial road
- Minor arterial road.

(3) Classification through Combination

This is to introduce a classification which combines city pair load with traffic volume :

1) City Pair Load Factor

City pair load factor have been calculated as follows :

-Using three dominant territories, such as Mombasa, Nairobi, and Kisumu
-Assuming that all cities included in each territory reach to their regional centers respectively, namely Mombasa , Nairobi and Kisumu
-Counting the number of routes from cities to a respective regional center on every link
-This number of routes on each link is defined as city pair load factor.

The actual city pair load factor on each link, indicated by the width of the line, are shown in Figure 6.1.5.

2) Traffic Volume

For the purpose of combined classification, assigned traffic volume on each link is applied (existing network and 2013 OD matrix).

3) Classification

Such two indices as city pair load factors and traffic volume on every link enable the road network to be classified according to the following method :

-Calculating city pair load factor and traffic volume on links between major node points on road network (so-called super link which is applied for traffic assignment in this study)
-Plotting these data of links on the criteria chart (see Figure 6.1.6)

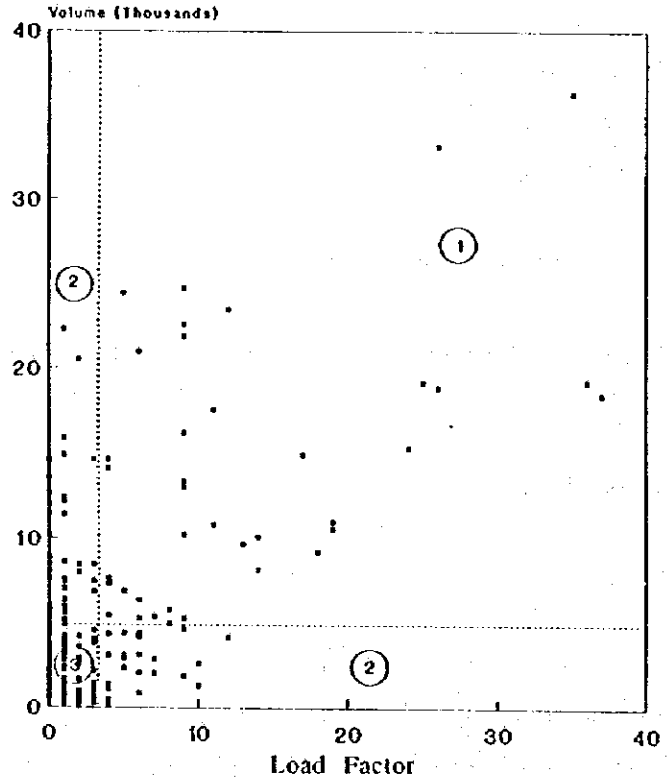
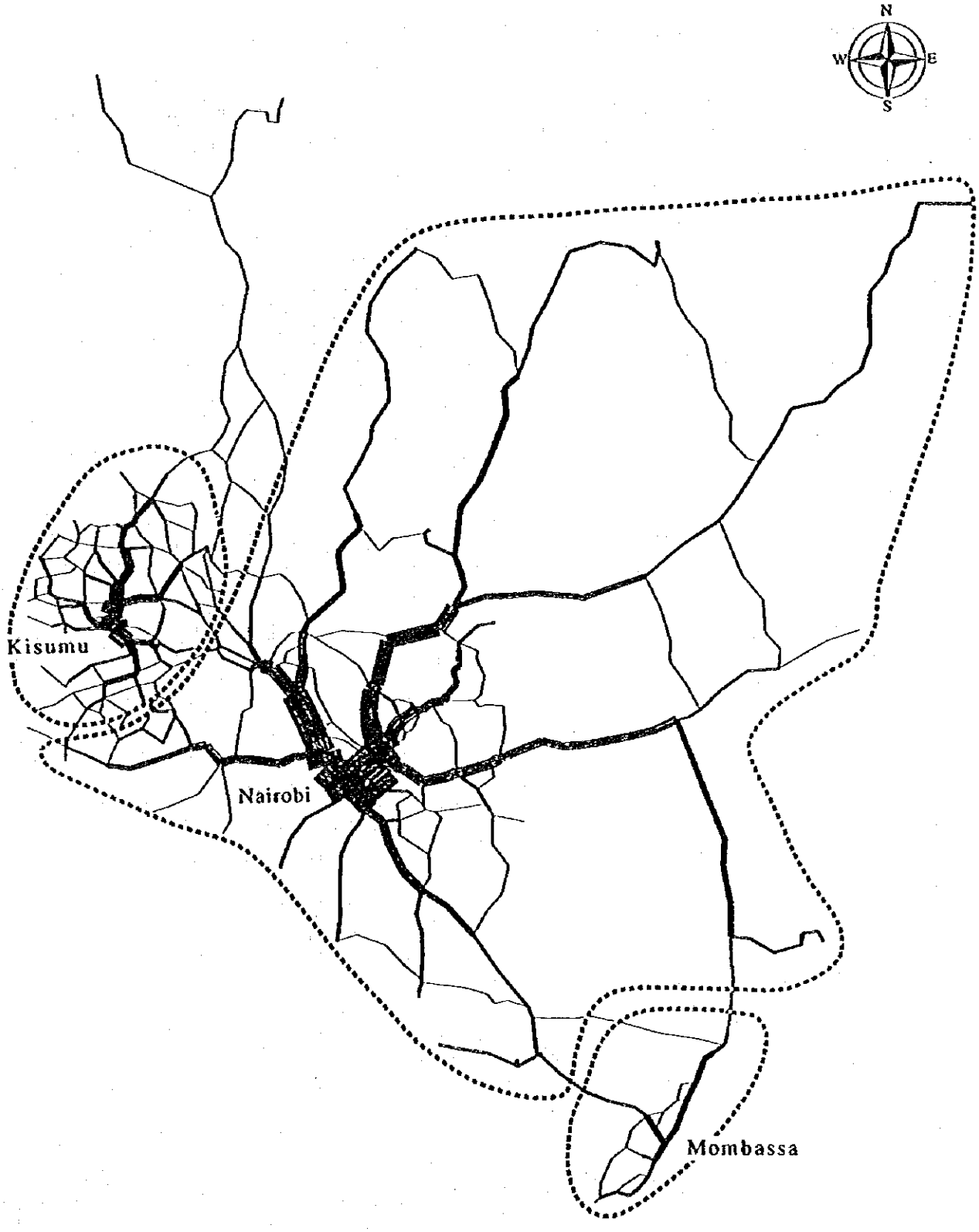


Figure 6.1.6 Criteria Chart

After plotting these data a categorization corresponding to tentative road functions is applied.

- Major arterial road(tentative) category (1)
- Arterial(tentative) category (2)
- Minor arterial (tentative) category (3)

This tentative road function might indicate improvement priority.



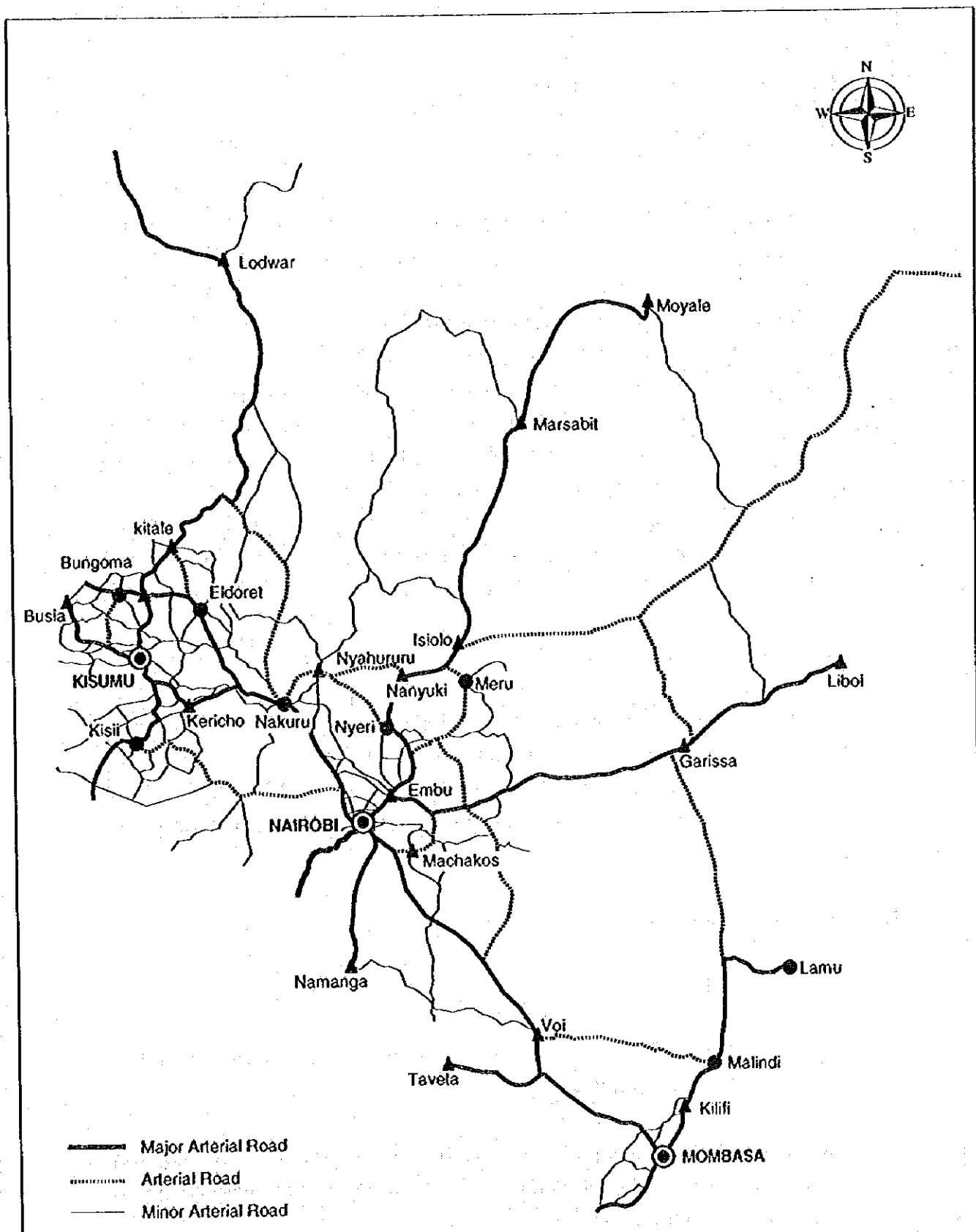
Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 6.1.5
City Pair Load Factor on Each Link

(4) Definitive Road Functional Classification

According to the methodology described above, the definitive and adjusted road function and classification system is presented in a graphic manner in Figure 6.1.7.



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 6.1.7
Definitive Road Classification

6.2 Recommended Future Road Network

6.2.1 New and Upgrading Requirements

Although the study roads in this study are class A, B and C roads, it is anticipated that all the study roads can not be upgraded by the 2013, due to limitation of public investment resources in Kenya. Minimum requirement for new roads and such upgrading on class A, B and C roads as improvement to meet the current design standard and from earth/gravel to bitumen is examined in this chapter. Not to distribute resources too thinly everywhere, but concentrate them effectively is a reason why minimum new and upgrading requirement are taken into account for the future road network. On the other hand, maintenance requirement are expected not only for minimum required roads but for all the study roads. From this point of view, minimum new and upgrading requirements for the road network are proposed in this chapter as a first priority for the future road network. Chapter 6.3 deals with road maintenance on all the study roads.

(1) View Point of Road Function

According to the result of the functioned classification, major arterial road (categorized group 1) and arterial road (categorized 2) have to be given high priority for improvement in order to establish an efficient road network as a basis for the overall future network. (refer to project kind No. 2 in Project List, Appendix 4)

(2) Traffic Demand Aspect

1) Congestion Ratio

Two criteria have been used to decide for improvement to dual road section (four lanes road). They are as follows :

- 8,000 pcu is applied for maximum traffic volume for the super highway mentioned later in this chapter.(exactly 7000 pcu is applied considering intra zonal traffic to that of forecasted)
- 15,000 pcu is applied for maximum traffic volume for other study roads. (13,000 pcu is applied same as above).

(refer to project kind No. 9 in Project List 2, Appendix 4)

2) Missing Links and Alternative Routes

Figure 6.2.1 is obtained by laying the OD flow pattern on the existing road network. The existing road network has a rather simple pattern. Definite missing links therefore cannot be observed, except for areas far from the corridor alongside Mombasa-Nairobi-Uganda. Although short missing links might exist to some extent in certain areas or districts, it can be clearly mentioned that such missing links would be thoroughly covered by peripheral roads in those areas and districts.

The following are the above-mentioned missing links.

a Inter Regional Network View Point

A Mombasa to Samburu(zone 33) ,Marsabit (zone 15)
B Nairobi to Lamu (zone 3)
C Garissa to Mado Gashi

As regards the missing link, A above, it can be stated that providing such a long route is somewhat unrealistic. The route from Embu-Kitui-Kibwezi (existing B7 route) should be strengthened instead.

Concerning a possible route linking Nairobi to Lamu, the following existing roads should be strengthened for the same reason :

Lamu-(C112)-Garsan-(B8)-Garissa-(A3)-Thika
Nairobi-(A109)-Voi-(C103)-Malindi-(B8)-Lamu

In strengthening of these routes, there are two other implications, which are as follows :

-To provide an alternative route to the Nairobi- Mombasa road, which has a crucial role in the whole road network in Kenya. Both such routes would have important roles and functions in the event of contingency on the Nairobi-Mombasa road

-To provide a circular trip route for tourists going to Lamu, which is one of the important tourism resources.

Moreover, the Garissa-Kangonde section of the A3 route plays a key role in the Garissa and Wajir areas in order to secure a contingency alternative route, it becomes essential to improve C81, which connects with major arterial and international trunk road A3 and arterial road B9.

b Local Network

-Near Nairobi

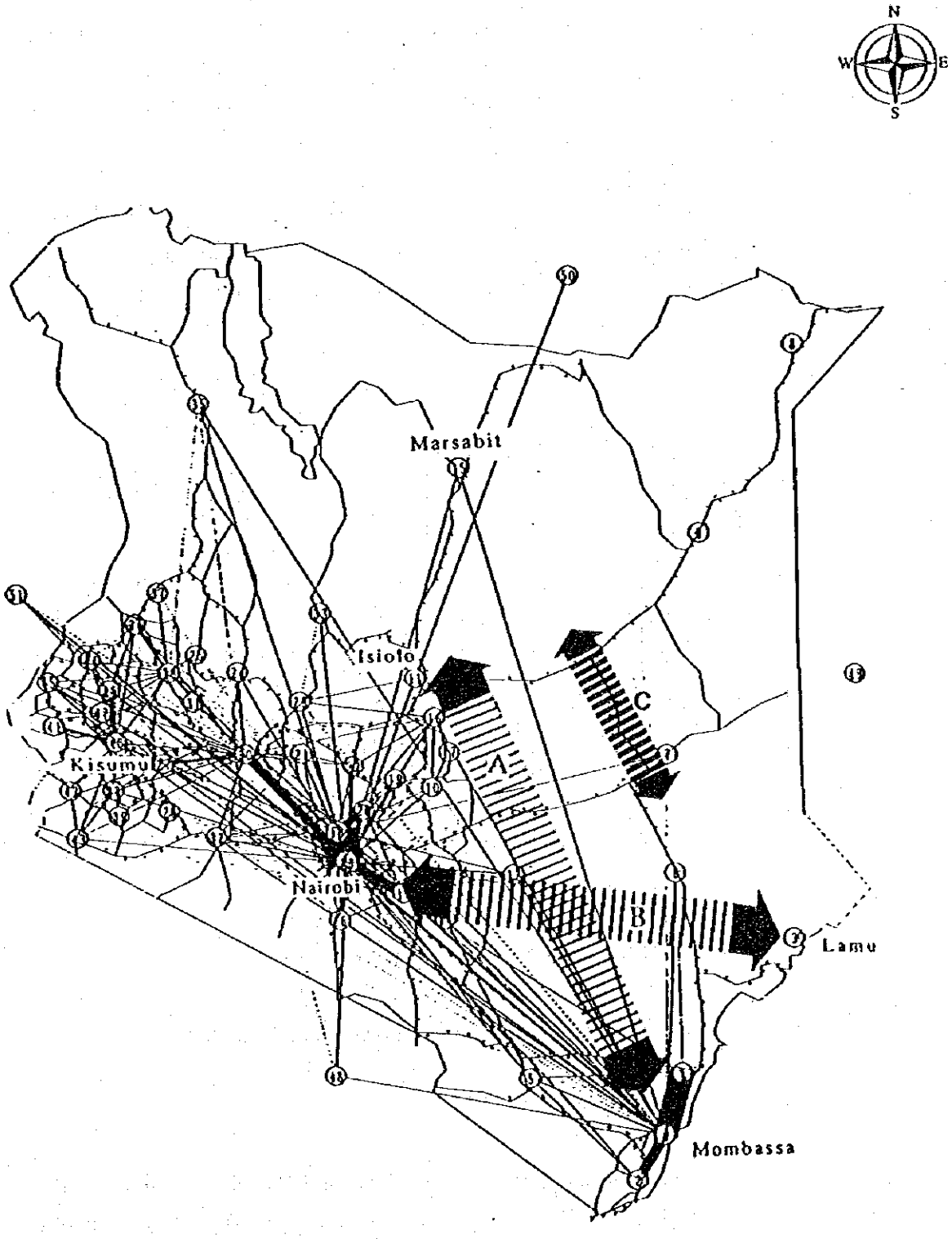
The Western Region has a rather widely spread and systematic road network catering for this populated area, while the Central Region has somewhat special features in its road network caused by the presence of Mount Aberdare and Mount Kenya. There is a missing link from the viewpoint of local road network in the suburban agricultural area near Nairobi, that is the road section between C70 and C64. Further agricultural development is expected in the surrounding area of Nairobi, in which a high level of food self-sufficiency becomes necessary, because of population pressure both at present and in the future. It is undoubted that connecting the missing part between C70 and C64 would contribute greatly to agricultural development in this region.

-Likoni Bridge

Mombasa City is the second largest city in Kenya, which is connected to neighboring areas by three major roads. However, a part of the A 14 route near Mombasa City, which would connect to the small bay, is missing. Although ferry service is available at present, some serious accidents have occurred recently. Construction of the Likoni bridge on the A14 route would smooth traffic movement in this area.
(refer to project kind No. 5 in the project list, Appendix 4)

3) By Pass around Large Cities

Although this Road Network Development Master Plan Study mainly focuses on inter city traffic demand, necessity of bypass roads around large cities are one of rather important issues in the future road network. Properly speaking, it is essential



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 6.2.1
Missing Links

to investigate intra-urban traffic movement and to analyze and assess urban bypasses. Bypasses are to be basically provided on important cities designated as regional centers and sub regional centers, except for those having some special features such as too low a traffic volume.

An appropriate analytical, however, gives some guidance on this point. This is using the relationship between peripheral average traffic volume and population of cities. Figure 6.2.2 shows this relationship and categorization.

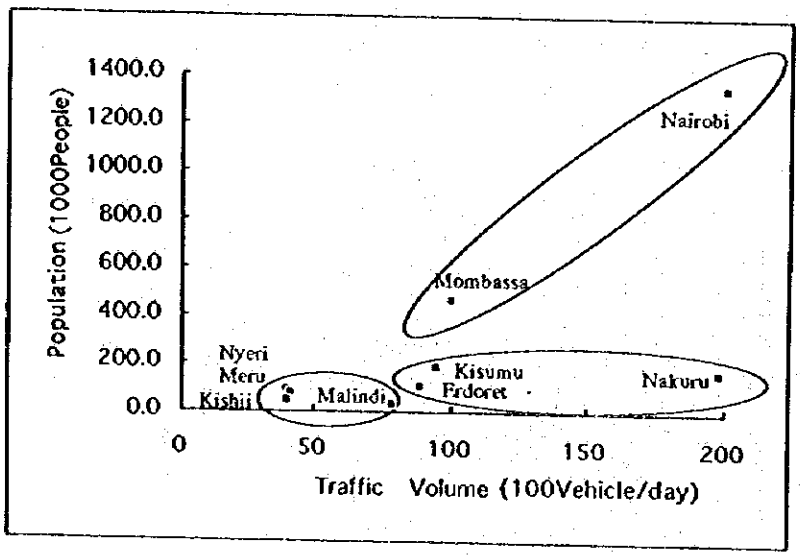


Figure 6.2.2 Bypass Analysis Chart

According to the results of this analysis, the following can be stated.

a Mombasa and Nairobi

It might be necessary to have bypasses in Mombasa and Nairobi even in the early stage. Some proceeding can be observed about planning a bypass in Nairobi several years ago by a Japanese technical assistance cooperation. On the other hand, the idea of having a Mombasa bypass has been considered. From a viewpoint of regional development in the Mombasa area, a rather large bypass seems to be desirable to deploy regional development to the hinterland area. This

is due to the fact that the central area in Mombasa has a rather small space for future development and also due to current topographical constraints.

b Nakuru

Although the population in Nakuru is as low as 162,000 people, the traffic volume around Nakuru is rather high. Nakuru is expected a play a role of relay point for commodity transportation movement and other long trip movement, since it is located on the most active major arterial road A104, at the middle of the Nairobi and Kisumu territory. For these reasons, early provision of a bypass road seems to be desirable.

c Kisumu and Eldoret

Kisumu and Eldoret can be placed in almost same group. However, Kisumu might have a comparatively high priority for a bypass, because Kisumu is designated as regional center of this territory. It can be clearly mentioned that both cities have to plan bypass roads in future.

d Others

Such four cities as Malindi, Nyeri, Meru and Kisii are grouped in the same group. Immediate actions to provide bypasses seem unnecessary at this stage, though, the necessity will grow in future.

e Bypass to be Considered in Network

Considering that this study focuses on inter city arterial roads, only three bypasses of Mombasa, Nairobi and Nakuru are taken into account for traffic assignment in the future road network.
(refer to project kind No. 3 in Project List 2, Appendix 4)

(3) Support to Industrial Promotion

1) Super Highway for Mombasa-Nairobi-Uganda Corridor

Route No. A 104 and A 109 connecting Mombasa with the Uganda border are the most important and vital roads in Kenya, from a viewpoint of promoting all industries, including the agricultural sector, manufacturing industry sector,

tourism industry sector and others. From these points, it is strongly recommendable to establish a "super highway" road through Mombasa and Uganda via Nairobi, which enables cars and trucks to run at high speed, under best safety circumstances and with suitable incidental service facilities.

Detailed items and facilities to be provided for the super highway can be considered as follows :

Facilities for Super Highway

1	Operating speed	100 km and more operating speed
2	Access control	Full access control at cross points with class A, B and C road
3	Incidental Facility	Lightening Parking and service area for drivers
4	Others	Rescue and telecommunication system in the event of accidents Tourism information facility

(refer to project kind No. 6 in Project List 2, Appendix 4)

2) Connection to Neighboring Countries

a Existing Plan

According to the 7th national development plan for the period 1994 to 1996, the following road plans and construction situation on international connections are described.

-Lodwar-Lokichogio section of Kenya - Sudan road (completed)
-Thika-Garissa-Liboi of Kenya - Somalia road (incomplete)
-Isiolo-Morale section (incomplete)
(This road is a section of Gabarone-Cairo Trans Africa Highway and still requires upgrading to Bitumen standard)

b Plan in this Study

When considering manufacturing industrial promotion, intensive attention should be paid on the matter of markets from a point of competitive power against

surrounding countries. Although the industrial sector is expected to be promoted to keep sustainable economic growth in Kenya, markets seems to be constrained, due to existing comparatively high quality products made in India, European countries and others. Considering these facts, it can be envisaged that PTA is most likely a market for Kenyan exporting products. This indicates that the provision and improvement of international arterial trunk roads connecting to these neighboring countries becomes essential and a key issues to promote manufacturing industry. (refer to project kind No. 4 in Project List 2, Appendix 4)

3) Arterial Road Network System

This road network system indicates formulation of well integrated road network as a whole and as a system. With reference to the agricultural aspect, the main roles of arterial roads are defined in the following points :

- Enlargement of cultivated area
- Collecting and distributing products from and to market centers
- Transport of products to regional centers.

All these items are related to the improvement and construction of arterial roads. Major arterial roads contribute to the transportation of products from farms to regional centers and minor roads do the same to market centers. In addition to this, low class roads might be important for enlargement of cultivated area. From this point, improvement of the existing arterial roads in the following districts becomes essential.

-Surrounding districts of Nairobi

Meru, Tharaka Nithi, Embu, Machacos, Makueni
Nyeri, Nyandarua, Muranga , Kiambu, Eastern Part of Nakuru

-Narok district

With respect to the manufacturing industry, more focus has to be placed on providing major arterial roads connecting sub regional centers with each.
(refer to project kind No. 7 in Project List 2, Appendix 4)

4) Enhancement of Access for Tourism Resources

The future road network has to be formulated, considering the following points :

- Improvement of arterial roads having deteriorated sections at present to access to such tourism resources as National Parks and Reserves (see Figure 6.2.3).

- Enhancement of circulating and alternative routes to tourism resources

  Lamu-Nairobi (C112, B8, A3)
  Narok-Masai Mara (B3, C11, 12, 13)
  Nakuru-Kerio Valley-Sigor (B4)
  Access to Amboseli (C103, between Voi and Namanga)
  and circulating route (A23, Voi and Taveta)

(refer to project kind No. 10 in Project List 2, Appendix 4)

(4) Access to Important Facilities

Maintaining good access of roads to such important facilities as international airports and ports is one of the roles of the road network. As regards access to international airports, the bottle neck of the C 110 route, which connects with the Mombasa International Airport, has to be widened to keep smooth traffic movement. Furthermore, the section between Kendu Bay and Homa Bay on the C19 route has to be upgraded to bitumen in order to keep steady transport from/to Homa Bay.

(5) Future Road Network

Figures 6.2.4 and 6.2.5 show the configuration of the future road network arrived at through the aforementioned examination.

1) Necessity of Strategic Approach

As is described in the 7th National Development Plan in Kenya, the idea of "Resource Mobilization for Sustainable Development" is a key word in considering the future road network in the country. In this context, the points have to be focused on both, an intensive development and effective development approach, considering the fact that scarcity budget for public investment will continue, even in the future. From this point of view, it becomes important to

decide which cities and areas should be emphasized for regional development to induce effective national development in the whole country. Such regional centers as Mombasa, Nairobi and Kisumu and also sub centers as Malindi, Lamu, Nyeri, Meru, Eldoret and Kisii are selected as regional pivotal growth centers in this study through a city ordering system analysis. This also indicates that attention has to be paid on formulating a integrated well functioned road network to connect those cities with each other.(see Figure 6.2.6)

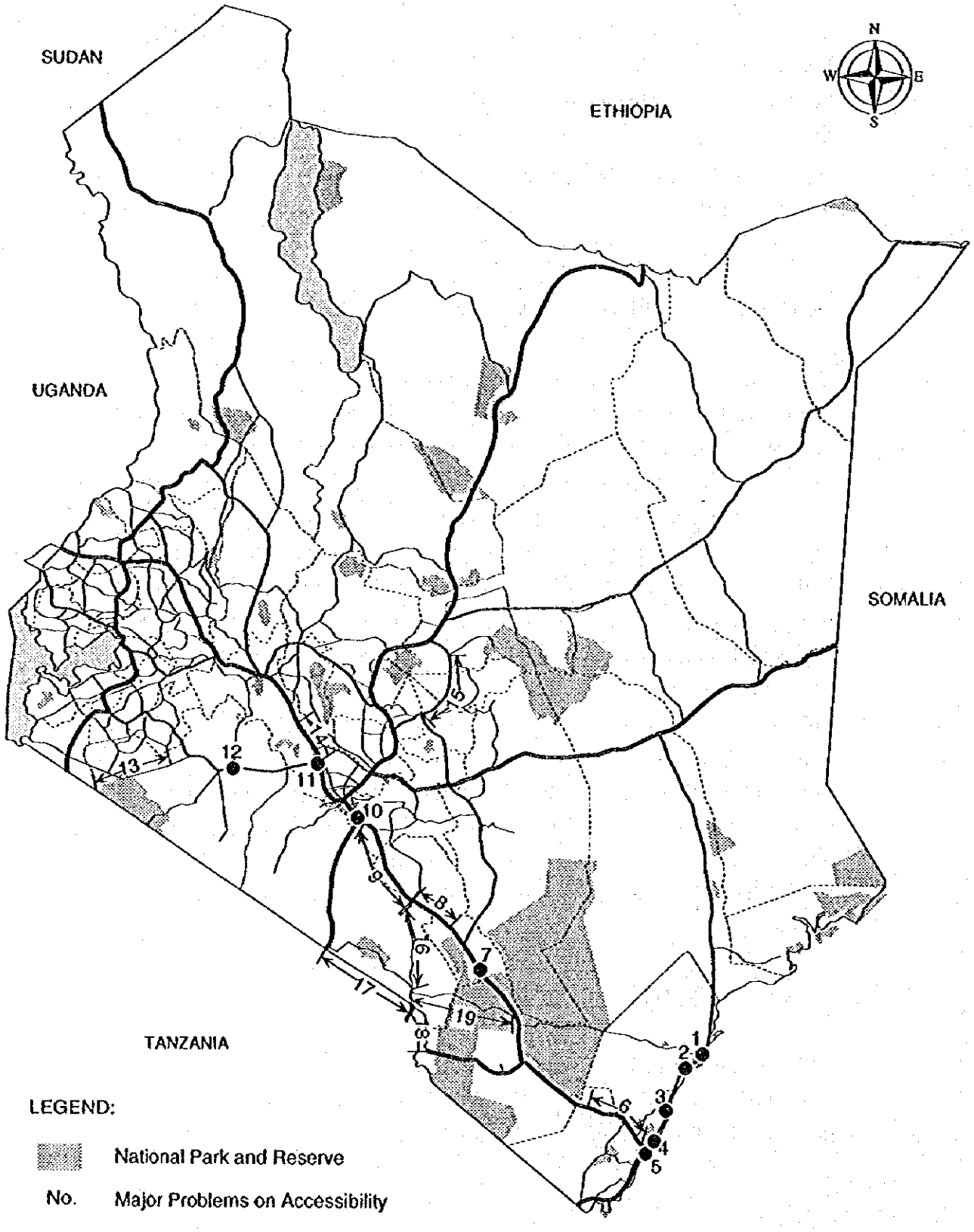
2) Necessity of Establishment of Road Network

The major reasons to introduce the road network in Kenya are explained by mainly such two items as the traffic demand aspect and support to industrial promotion. Although each item has a close relationship with the establishment of the future road network, it seems that the strategy has to be focused on manufacturing industry promotion view point. This is, because the industrial sector will take a leading position in keeping a sustainable economic growth path in the future. It also means that the agricultural sector may not be in a position to occupy a dominant position in the national economic development. It is, however, expected that much emphasis will have to be placed on this sector in the future.

This leads to the idea of establishing a super highway, which link Mombasa -Nairobi-Kisumu/Eldoret -Uganda border. This would safeguard the most important backbone route in the country for safe and smooth traffic operations. It would also promote drastically industrial activities by improving basic transport infrastructure. It also promises job creation and increase of national income in the future. The necessity of other arterial roads is explained by the items shown in Figure 6.2.7.

3) Cross Section and Others

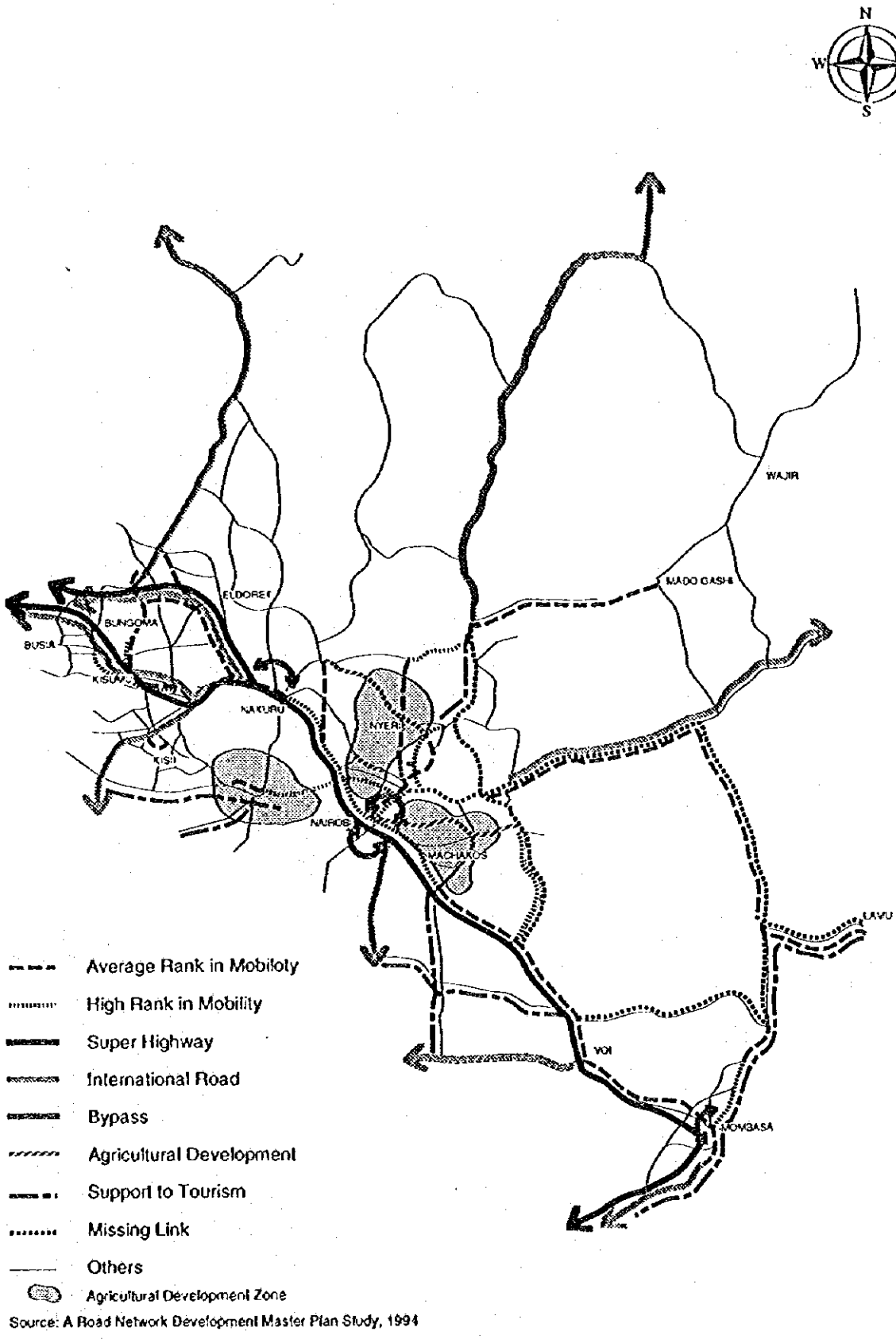
Every road has to be improved to meet the design standard manual. However, the super highway proposed in this study has to be improved with some special incidental facilities. (refer to Chapter 6.2.1(3)).



Source : JICA Study Team

Road Network Development Master Plan in Kenya

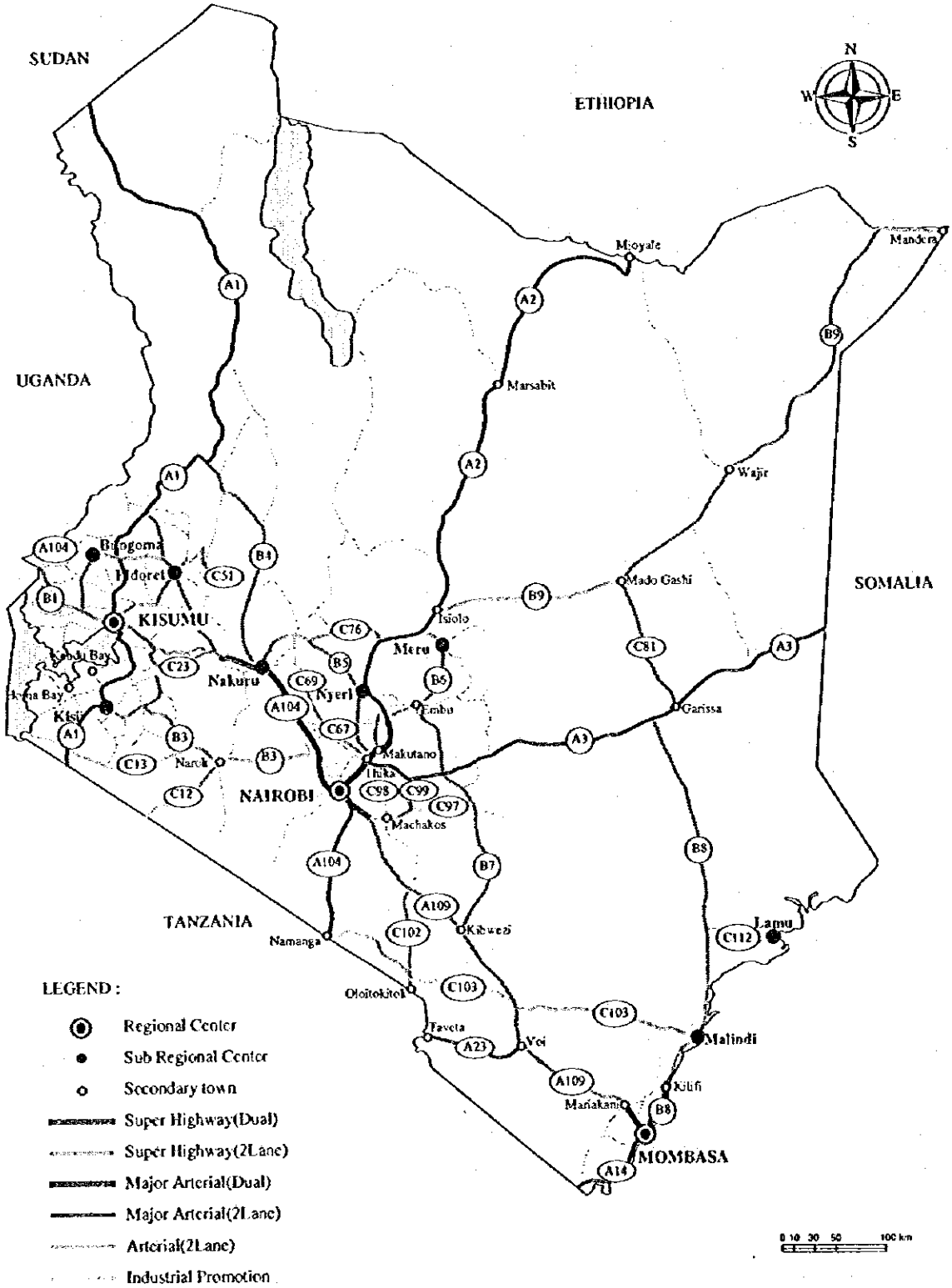
Figure 6.2.3
Major Problems on Tourism Access



Source: A Road Network Development Master Plan Study, 1994

Road Network Development Master Plan In Kenya

Figure 6.2.4
Significance Future Road Network Plan



Road Network Development Master Plan in Kenya

Figure 6.2.5
Integrated Future Network Plan

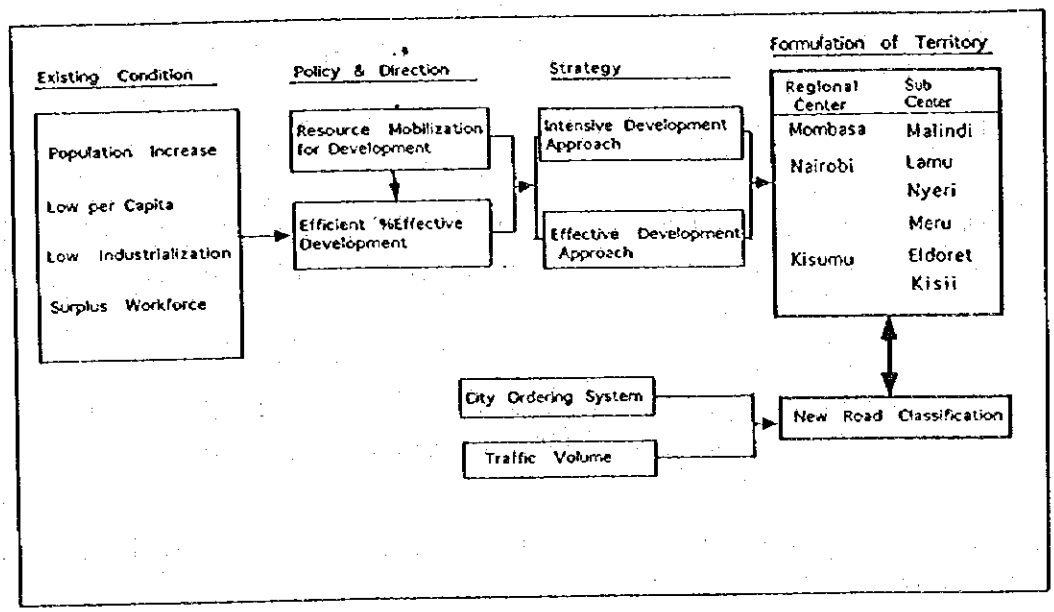


Figure 6.2.6 Necessity of Strategic Approach

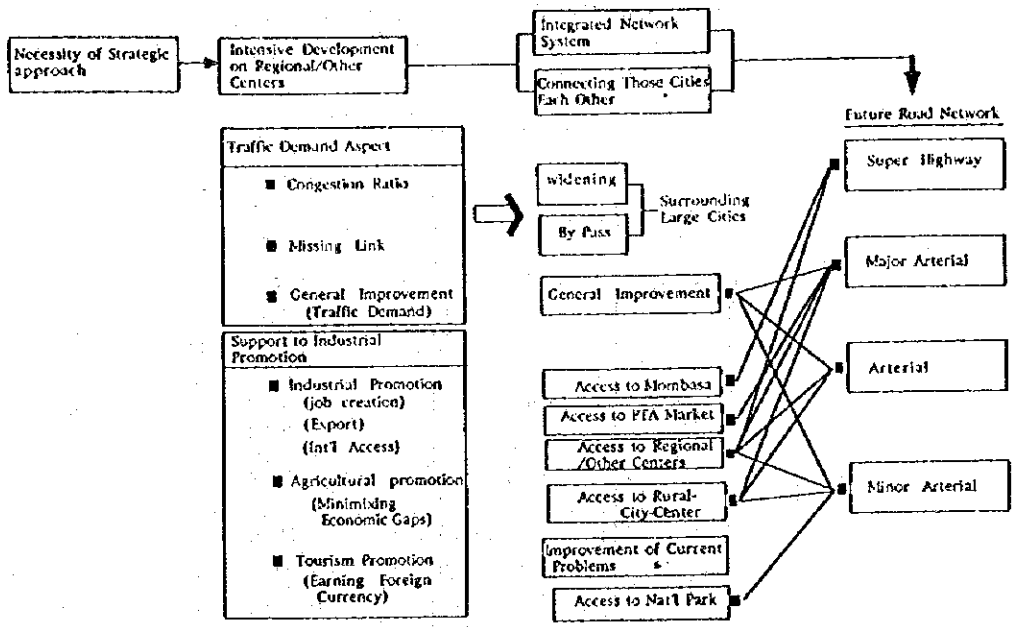


Figure 6.2.7 Necessity of Establishment of Road Network

6.2.2 Implication of Future Road Network

The future road network will save the travel time to regional centers.

(1) Travel Time to Regional Centers

The number of population, which fall in selected time bands of travel from the zone centroid, is counted and compared between the following two cases of traffic assignments. They are :

-Traffic assignment of 2013 OD to the 1994 road network (case 3)
-Traffic assignment of 2013 OD to the 2013 road network (case 4)

The analytical result of the above comparison are presented in Table 6.2.1 and Figure 6.2.8.

However, the super highway proposed in this study has to be improved with some special incidental facilities.

Table 6.2.1 Time Band and Covered Population

Time Band	Acc.Pop (person)	
(hrs)	Case3	Case4
<1.0	13600	18600
1.0-1.5	69100	161800
1.5-2.0	94500	318900
2.0-2.5	219800	361300
2.5-3.0	345500	400800
3.0-4.0	445500	607000
4.0-5.0	724400	829300
5.0-6.0	724400	889000
6.0-7.0	740500	917200
7.0-8.0	751700	964500
8.0-9.0	751700	990000
9.0-10.0	763400	1017200
10.0-15.0	809200	1129300
15.0-30.0	952600	1173300
30.0<	1173300	

Note:Case3(2013OD,1994net)
Case4(2013OD,2013Net)

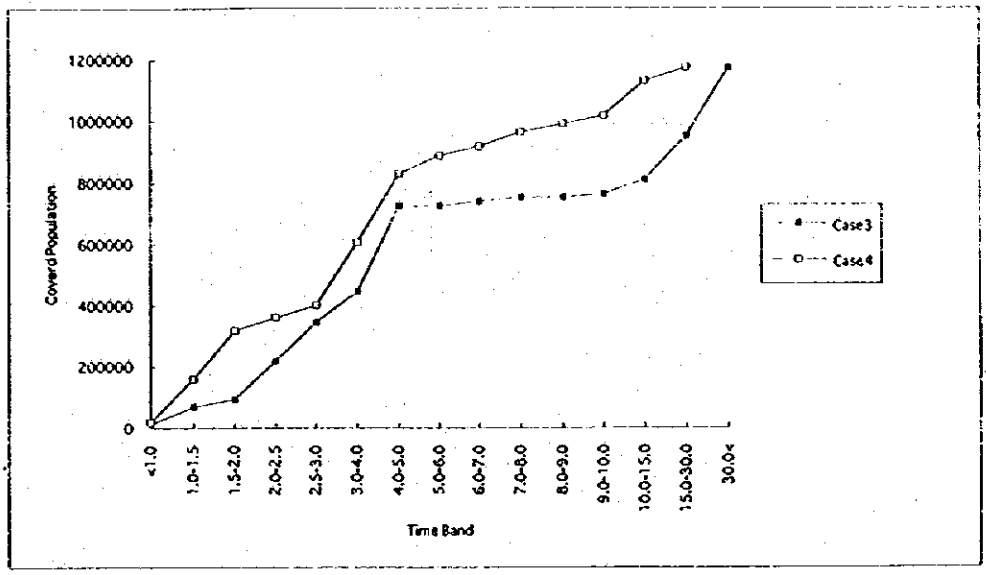


Figure 6.2.8 Accumulated Population

According to the comparative result, the accumulated population covered within 2.0 hours of traveling time is largely expanded when 1994 and 2013 networks are compared. The travel time of 2.0 hours has usually a significant meaning from view points of commuting, marketing, shopping and other daily activities. Widely speaking, a time-banded population derived from the 2013 network is higher by 20-25% ,comparing to the respective time-banded population derived from the 1994 network. This proves the effectiveness or saving of travel time achieved by the future road network in 2013.

(2) Traveling Time to Mombasa

Another comparison was made on traveling time to Mombasa from other central cities of the districts. As shown in Table 6.2.2 and Figure 6.2.9, within a traveling time up to 10 hours, the accumulated population derived from the 1994 network is not distinct from that derived from the 2013 network. However, all the population in Kenya is covered within 25 hours in the 2013 network, but is barely covered by more than 50 hours in the 1994 network.

Table 6.2.2 Covered Population to Mombasa by Time Band

Time Band (hrs)	Case 3 Acc Pop (person)	Case 4 Acc Pop (person)
0-1.0	0	0
1.0-2.0	8200	8200
2.0-5.0	55100	55100
5.0-7.5	57300	83300
7.5-10.0	83300	235300
10.0-15.0	1581300	1843900
15.0-20.0	1777299	2154700
20.0-25.0	1864100	2508400
25.0-30.0	2041700	
30.0-40.0	2313800	
40.0-50.0	2497500	
50.0-	2508500	

Note:Case3(2013OD,1994net)
Case4(2013OD,2013Net)

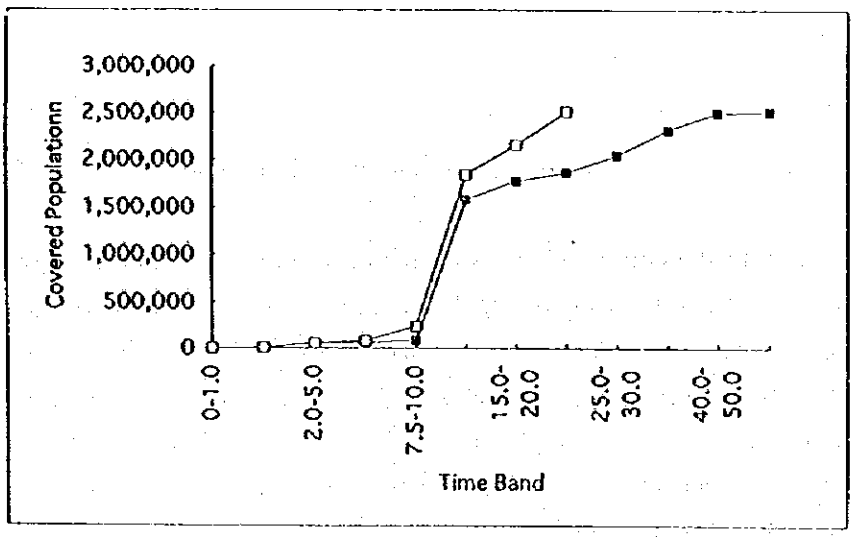


Figure 6.2.9 Covered Population to Mombasa

6.2.3 Environmental Consideration in Road Planning

(1) The Government's Environmental Policy

The overall theme for the Seventh National Development Plan (1994 to 1996) is "Resources Mobilization for Sustainable Development". This title expresses the Government's commitment to ensure sustainable economic, social, and ecological development. The environmental issue is one of the main concerns of the Government.

It is mentioned in the Plan that success in achieving ecological sustainability development will largely depend on the extent to which environmental considerations are integrated in all major economic and sectoral policies, plans and decision-making in the public and private sectors.

To implement the policy, the concerned authorities are now preparing the "National Environment Action Plan (NBAP)", which should be published in 1994.

(2) Environmental Machinery

To realize the environmental policies mentioned above, environmental matters are dealt with by the following governmental bodies :

-Office of the President
-Ministry of Agriculture and Livestock Development
-Ministry of Education, Science and Technology
-Ministry of Environment and Natural Resources
-Ministry of Health
-Office of the Vice-President and Ministry of Home Affairs
-Ministry of Energy and Regional Development
-Ministry of Transport and Communication
-Ministry of Tourism and Wildlife
-Ministry of Planning and National Development
-Ministry of Labor
-Ministry of Water Development
-Ministry of Works, Housing and Physical Planning
-Kenya African National Union (KANU)

Of the above mentioned governmental bodies, the organizations mainly responsible for providing environmental considerations for road planning are :

a Ministry of Environment and Natural Resources

This Ministry has three departments : the Forest Department, the Mines and Geology Department and the National Environmental Secretariat (NES). The Forestry Department is responsible for the management and conservation of the

gazetted forests. The NES coordinates environmental matters in the country, and provides advice and information on national environmental issues.

b Ministry of Tourism and Wildlife

This Ministry is in charge of wildlife conservation and management and the management of fisheries. The Kenya Wildlife Service (KWS), a parastatal under the Ministry, is directly responsible for the conservation of Kenya's wildlife.

c Ministry of Water Development

This Ministry is responsible for water development and the supply of clean water. It is also concerned with the conservation of water catchment areas, water quality and pollution control.

In addition to the above mentioned governmental bodies, several non-governmental organizations (NGOs), some of which are shown below, are involved in environmental matters in Kenya.

-Environment Liaison Center (ELC)
-African Wildlife Foundation (AWF)
-International Council for Research in Agro-Forestry (ICRAF)
-Kenya Energy Non-Governmental Organization (KENGO)
-Kenya Freedom from Hunger Council
-Mazingira Institute
-Men of Trees (K)

(3) Outline of the Environmental Legislation

Under the Laws of Kenya, there is no single composite or specific legislation covering environment (i.e. an environmental law). In near future, however, the law would be set up according to the National Environment Action Plan, which will be published soon.

At present, different Acts of Parliament touch on environmental issues. The most important legislation dealing with environment in Kenya are :

1) Conservation Legislation

The Water Act - Chapter 372 of the Law of Kenya
The Agriculture Act - Cap 318
The Forest Act - Cap 385
The Land Planning Act - Cap 303
The Fish Industry Act - Cap 378
The Plant Protection Act - Cap 324
The Local Government Act - Cap 265
The Town Planning Act - Cap 134
The Lakes and Rivers Act - Cap 409
The Government Fisheries Protection Act - Cap 379
The Kerio Valley Development Authority Act - Cap 441
The Lake Basin Development Authority Act -Cap 442
The Tana and Athi Rivers Development Authority Act - Cap 443'
The Wildlife Conservation and Management Act - Cap 376
The Grass Fires Act - Cap327

2) Pollution Control Legislation

The Water Act - Cap 372'
The Public Health Act - Cap 242
The Factories Act - Cap 514
The Food, Drugs and Chemical Substances Act - Cap 254
The Pharmacy and Poisons Act - Cap 244
The Use of Poisonous Substances - Cap 247
The Cattle Cleansing Act - Cap 319
The Fertilizers and Animal Foodstuffs Act - Cap 345
The Agricultural Produce (Export) Act - Cap 319
The Pest Control Products Act No. 4 of 1982 - Cap 346
The Radiation Act (The Radiation Protection Bill 1982)- Cap 245
The Traffic Act - Cap 403
The Penal Code - Cap 63
The Merchant Shipping Act - Cap 389
The Kenya Bureau of Standards Act - Cap 496

Each of the above-mentioned legislation deals with and operates for the specific purposes for which it was enacted, either for conservation, pollution control

and/or establishment of limits of emissions of harmful substances. In road planning, attention should be paid to the following :

a The Water Act - Cap 372

This Act makes provisions for the conservation, control, apportionment and use of water resources in Kenya. Besides addressing itself to issues of conservation, the Act also prohibits water pollution and gives control devises by giving such conditions in the permit that will ensure that pollutant substances are not left in any water supply.

b Agriculture Act - Cap 318

This Act is for promoting agriculture development. It stresses the need for the conservation of soil and its fertility and for the development of agriculture land in accordance with sound practices of good land management and good husbandry. In other words, the Act emphasizes the prevention of soil erosion and in such a way it prevents land degradation and, indirectly, the deterioration of the quality of surface waters.

c The Forest Act - Cap 385

This Act provides for the establishment, control and regulation of central forests, other forests and forest areas in the Nairobi area and on unalienated Government land. The main objective is to encourage conservation and the maintenance of vegetative cover in all lands.

d The Wildlife Conservation and Management Act - Cap 376

This Act makes provisions for the preservation and control of wild animal life and wild vegetation so that they will be able to flourish in their natural habitat.

e The Lakes and Rivers Act - Cap 409

This Act controls the process of dredging of lakes and rivers.

There are no Acts regarding the Environmental Impact Assessment (EIA). However, the Ministry of Environment and Natural Resources has prepared three

types of EIA forms for development project concerning the industrial, agriculture, and dams and reservoirs sectors.Ther is, however, none for the road sector. Currently, the government is preparing EIA guidelines regarding all kinds of development project.

Although there are no EIA forms for road projects at the present, the Environmental Impact Assessment should be conducted in the F/S stage in road projects.

(4) Environmental Consideration in Road Planning

For the environmental constraints shown in section 3.2.6 and 4.3.4, the main issues to be taken into environmental consideration in road planning are pointed out below. In the event environmental issues, other than those mentioned below, appear in an environmental consideration process for a project, they should be studied in the particular project.

-Soil erosion
-Deforestation
-Wildlife conservation
-Water pollution
-Air pollution, and
-Issues concerning local communities.

Environmental considerations related to these issues are explained herewith :

a Soil Erosion

Soil erosion generally occurs in the ASALs and in areas having intensive rainfall and steep slopes with sandy soil. In road planning, causes of soil erosion by road construction are: 1) exposure of topsoil caused by land reclamation or removal of vegetation for road construction; and 2) rainfall and flooding during construction. Measures for avoiding soil erosion are :

1. protection against soil erosion, e.g., vegetation cover, slope protection,
2. alternate route selection, and
3. examination of construction method and schedule.

The discharge of accumulated water from a road surface into agriculture land also causes soil erosion. A measure for minimizing this problem is to construct water reservoirs along the road. The water in the reservoirs, if not polluted, could serve for reducing the impact of water depletion and drought.

b . Deforestation

Causes of deforestation by road construction are : 1) removal of vegetation due to the construction of roads and related facilities; and 2) generation of exhaust gas from vehicles. Measures for minimizing these problems include careful route selection and replantation along the road side and in the medial strip.

The Minister of Environment & Natural Resources may, by notice in the Gazette, declare any unalienated Government land to be a forest area. Natural reserves in the gazetted forest are established for the purpose of preserving the natural amenities, so that such activities as cutting, grazing, removal of forest products or the disturbance of the flora and fauna are not authorized.

The area of the Gazetted Forests and the Natural Reserves and its list are shown in Figure 6.2.9 and in Table 6.2.3, respectively.

In road route selection, forest areas, especially the natural reserves, should be avoided. If a route passes through or near these areas, a careful environmental consideration will be required.

c Wildlife Conservation

The causes of impacts on wildlife by road construction are : 1) removal of vegetation and extinction of wildlife habitats due to the construction of the road and related facilities; 2) generation of exhaust gas and noise from running vehicles and 3) disruption of migratory routes and habitats by the existence of roads and related facilities.

Some measures for minimizing the impacts are : a careful route selection; relocation of valuable wildlife; careful construction designing; and protection measures for wildlife habitation.

In Kenya, approximately 8% of the total land area is set aside for National Parks and Reserves (see Figure 6.2.10 and Table 6.2.4). For road planning near/in these area, considerations should be given to the affects on wildlife and its habitats.

Attention should be paid to the corridors used by animals to migrate between their habitats. Much of the wildlife from inside National Parks or Reserves moves to surrounding areas part of the year. Maintaining the present size and diversity of the wildlife population depends on their having continued access to traditional seasonal dispersal areas.

Unfortunately, research concerning the corridor is not well advanced at present. Data pertaining to the corridor and wildlife migration should be corrected and organized through continuous future studies.

Regarding wildlife conservation, a detailed study will be required at the F/S stage because a long term ecological study is needed to understand wildlife behavior. If a planned road affects the migration route, protection measures should be taken to keep the route open.

d Water Pollution

At the construction stage, water pollution could occur because of the disturbance of sediment by the construction of piers, when the route passes over lakes, streams and rivers. Especially in coastal areas, silt-laden water from rivers affect mangroves and coral communities.

As an impact in the operation stage, recent studies have shown that lead particles deposited on roads from vehicle combustion are usually washed off and end up in the rivers.

Careful road designing, and construction planning and management is needed to avoid this problem.

e Air Pollution

Causes of air pollution by road construction are : 1) exhaust gas from construction equipment and vehicles, and dust generated by earthwork; and 2) exhaust gas from vehicles.

Although the present air pollution situation is not so crucial, there is the possibility of this problem becoming serious in the future when a higher vehicle concentration is generated in the big cities, such as Nairobi and Mombasa. Road planning to avoid the concentration of vehicles in an urban area should be considered.

There were complaints from local residents about the dust and fumes from construction equipment as elaborated on in Chapter 4.3.4. Prevention measure for this problem should be devised in the construction stage.

f Issues Concerning Local Communities

Resettlement and the splitting of communities are issues to be considered prudently in the road planning stage. In Limuru - Kebeta (A 104 road), the existence of a wall in the center of the road, prevents local people from crossing the road and causes a spilt of communities.

If the problems should occur, some measures should be taken, i.e., sufficient compensation, careful resettlement site selection and its arrangement, and the securing of alternative routes to prevent the split of communities. The participation of local people in the planning stage would serve to avoid these kinds of problems.

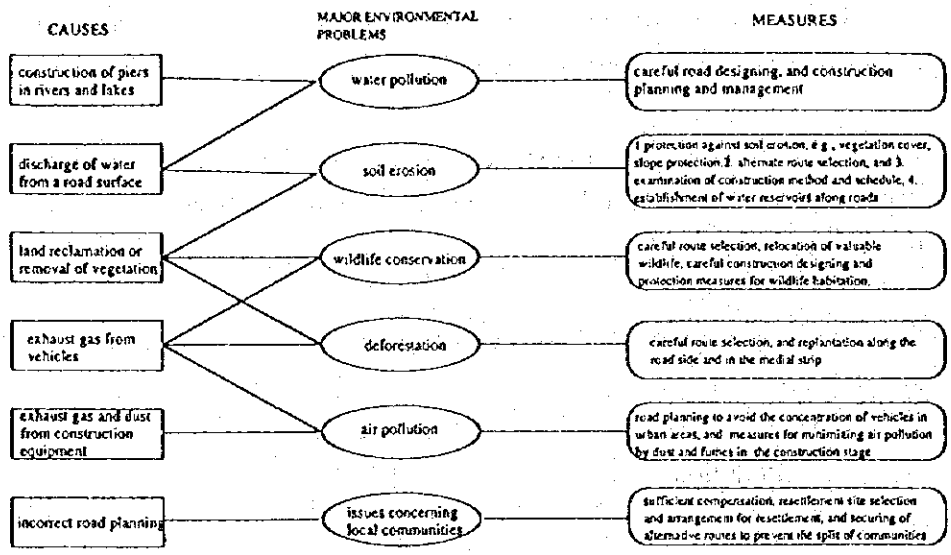
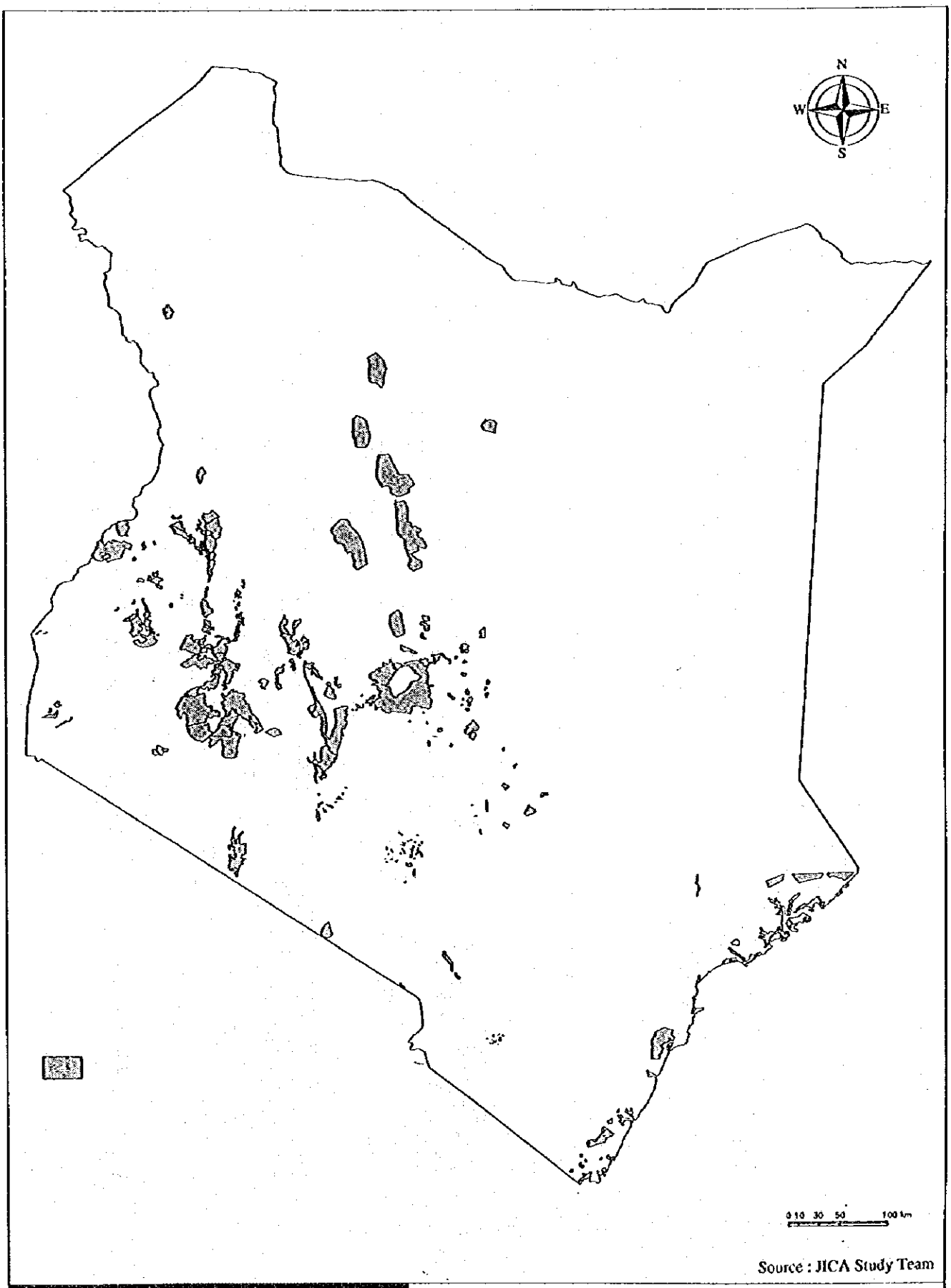


Figure 6.2.12 Causes of Major Environmental Constraints and Measures



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 6.2.10
Areas of Gazetted Forest

Table 6.2.3 List of Gazetted Forests (1)

Code	Forest	Status	District	Province	Area (Ha)
1	ABERDARES		NYANDARUA	CENTRAL	10,219
2	ABERDARES		NYANDARUA	CENTRAL	81,688
3	ABERDARES		NYERI	CENTRAL	11,409
4	ARABUKO SOKOKE		KILIFI	COAST	41,676
5	BAHATI		NAKURU	RIFT VALLEY	10,101
6	BAOMO EAST	NR	TANA RIVER	COAST	6
7	BAOMO EAST	NR	TANA RIVER	COAST	2
8	BAOMO EAST	NR	TANA RIVER	COAST	7
9	BAOMO SOUTH	NR	TANA RIVER	COAST	14
10	BAOMO SOUTH	NR	TANA RIVER	COAST	192
11	BONI		LAMU	COAST	11,537
12	BUDA		KWALE	COAST	670
13	BUNYALA		KAKAMEGA	WESTERN	808
14	BUYANGU		KAKAMEGA	WESTERN	3,857
15	CHEBARTIGON		BARINGO	RIFT VALLEY	102
16	CHEBOIT		ELGEYO MARAKWET	RIFT VALLEY	2,527
17	CHEMOROGOK		BARINGO	RIFT VALLEY	1,338
18	CHEMUROKOI		ELGEYO MARAKWET	RIFT VALLEY	3,979
19	CHEPALUNGU		KERICHO	RIFT VALLEY	4,670
20	CHEPALUNGU		KERICHO	RIFT VALLEY	4,895
21	CHEPKUCHUMO		BARINGO	RIFT VALLEY	327
22	CHERIAL		BARINGO	RIFT VALLEY	40
23	CHYULU RANGE	NP	TAITA TAVETA	COAST	1,559
24	CHYULU RANGE	NP	KAJIADO	RIFT VALLEY	6,385
25	CONGOLANI	NR	TANA RIVER	COAST	56
26	DAGORETTI		KIAMBU	CENTRAL	774
27	EAST NGAMBA (GVT)		KITUI	EASTERN	1,205
28	EASTERN MAU		NAKURU	RIFT VALLEY	66,067
29	EBURU		NAKURU	RIFT VALLEY	8,736
30	ELDORET		UASIN GISHU	RIFT VALLEY	39
31	ELDORET		UASIN GISHU	RIFT VALLEY	113
32	ELDORET PROPOSED EXCISION		UASIN GISHU	RIFT VALLEY	9
33	EMBAKASI		KAJIADO	RIFT VALLEY	591
34	EMBOBUT		ELGEYO MARAKWET	RIFT VALLEY	21,689
35	ENDAU		KITUI	EASTERN	6,915
36	EXCISED ?		BARINGO	RIFT VALLEY	17
37	EXCISION		WEST POKOT	RIFT VALLEY	913
38	FIGI	N	TAITA TAVETA	COAST	1
39	FURURU	N	TAITA TAVETA	COAST	17
40	GAIKUYU		KITUI	EASTERN	3,258
41	GEMBE HILLS		SOUTH NYANZA	NYANZA	2,716
42	GONJA		KWALE	COAST	861
43	GOYE	N	TAITA TAVETA	COAST	10
44	GURU EAST	NR	TANA RIVER	COAST	6
45	GURU NORTH	NR	TANA RIVER	COAST	42
46	GURU SOUTH	NR	TANA RIVER	COAST	5
47	GURU SOUTH	NR	TANA RIVER	COAST	4
48	GURU SOUTH	NR	TANA RIVER	COAST	48
49	GURU SOUTH	NR	TANA RIVER	COAST	9
50	GWASI		SOUTH NYANZA	NYANZA	4,958
51	IKILISA		MACHAKOS	EASTERN	80
52	IMBA-CHAKUYU		KITUI	EASTERN	750
53	JOMBO		KWALE	COAST	887
54	KABARAK		BARINGO	RIFT VALLEY	1,395
55	KABIOK		BARINGO	RIFT VALLEY	14
56	KABONGE	N	KITUI	EASTERN	29
57	KACHORUA BLOCK IV		ELGEYO MARAKWET	RIFT VALLEY	141
58	KAISUNGOR		ELGEYO MARAKWET	RIFT VALLEY	1,089
59	KAKAMEGA		KAKAMEGA	WESTERN	17,838
60	KALIMANI		MACHAKOS	EASTERN	192

NR = Nature Reserve, N = Not Gazetted, Blank = Gazetted Forest Reserve

Table 6.2.3 List of Gazetted Forests (2)

61	KAMATIRA		WEST POKOT	RIFT VALLEY	1,944
62	KAMITI		KIAMBU	CENTRAL	171
63	KAPASRET		UASIN GISHU	RIFT VALLEY	1,008
64	KAPCHEMUTWA		ELGEYO MARAKWET	RIFT VALLEY	8,874
65	KAPCHORUA BLOCK I		UASIN GISHU	RIFT VALLEY	111
66	KAPKANYAR		WEST POKOT	RIFT VALLEY	5,764
67	KAPOLET		TRANS NZOIA	RIFT VALLEY	1,625
68	KAPTAGAT		UASIN GISHU	RIFT VALLEY	12,985
69	KAPTAROI		NANDI	RIFT VALLEY	318
70	KAPTIMOM		BARINGO	RIFT VALLEY	96
71	KARURA		NAIROBI	NAIROBI	715
72	KARURA		NAIROBI	NAIROBI	76
73	KARURA		NAIROBI	NAIROBI	2
74	KARURA		NAIROBI	NAIROBI	252
75	KATENDE		MACHAKOS	EASTERN	933
76	KATIMOK		BARINGO	RIFT VALLEY	2,019
77	KENZE		MACHAKOS	EASTERN	189
78	KERRER		ELGEYO MARAKWET	RIFT VALLEY	2,241
79	KESSOP		ELGEYO MARAKWET	RIFT VALLEY	1,971
80	KETNWAN		BARINGO	RIFT VALLEY	44
81	KIAGU		MERU	EASTERN	1,361
82	KIAMBERE	N	EMBU	EASTERN	693
83	KIAMBU		KIAMBU	CENTRAL	149
84	KIANGOMBE	N	EMBU	EASTERN	1,427
85	KIANJIRU HILLS	N	EMBU	EASTERN	1,025
86	KIBITHEWA		MERU	EASTERN	239
87	KIEIGA		MERU	EASTERN	573
88	KIERERA		MERU	EASTERN	777
89	KIGANJO		NYERI	CENTRAL	172
90	KIJABE HILL		NAKURU	RIFT VALLEY	740
91	KIJEGE		MERU	EASTERN	3,303
92	KIKINGO		MERU	EASTERN	1,203
93	KIKUYU ESCARPMENT		KIAMBU	CENTRAL	1,995
94	KIKUYU ESCARPMENT		KIAMBU	CENTRAL	35,554
95	KIKUYU ESCARPMENT		KIAMBU	CENTRAL	70
96	KILALA		MACHAKOS	EASTERN	161
97	KILOMBE HILL		BARINGO	RIFT VALLEY	1,534
98	KILULUNYI	N	TAITA TAVETA	COAST	1
99	KILUNGU		MACHAKOS	EASTERN	145
100	KIMOJOCH		BARINGO	RIFT VALLEY	762
101	KINGATUA		KIAMBU	CENTRAL	62
102	KINYESHA MVUA	N	TAITA TAVETA	COAST	57
103	KINYO		BARINGO	RIFT VALLEY	339
104	KIONGWANI		MACHAKOS	EASTERN	37
105	KIOO		MACHAKOS	EASTERN	44
106	KIPIPIRI		NYANDARUA	CENTRAL	5,077
107	KIPKABUS		UASIN GISHU	RIFT VALLEY	6,760
108	KIPKUNURR		ELGEYO MARAKWET	RIFT VALLEY	15,892
109	KIPTABERR		ELGEYO MARAKWET	RIFT VALLEY	12,801
110	KIRIMA	N	NYANDARUA	CENTRAL	512
111	KIRIMIRI	N	EMBU	EASTERN	174
112	KISERE	N	KAKAMEGA	WESTERN	457
113	KITALALE		TRANS NZOIA	RIFT VALLEY	2,070
114	KITALE TOWNSHIP		TRANS NZOIA	RIFT VALLEY	114
115	KITALE TOWNSHIP		TRANS NZOIA	RIFT VALLEY	135
116	KITALE TOWNSHIP		TRANS NZOIA	RIFT VALLEY	94
117	KITERE		TANA RIVER	COAST	11
118	KITETA		MACHAKOS	EASTERN	4
119	KITETA		MACHAKOS	EASTERN	24
120	KITHENDU		MACHAKOS	EASTERN	248
121	KITONDU		MACHAKOS	EASTERN	1,093

NR = Nature Reserve, N = Not Gazetted, Blank = Gazetted Forest Reserve

Table 6.2.3 List of Gazetted Forests (3)

122	XITOO		MACHAKOS	EASTERN	37
123	XITUMBUUNI		MACHAKOS	EASTERN	74
124	XIU (NGUNGU)		MACHAKOS	EASTERN	83
125	XOTIM RANGE	N	SIOLO	EASTERN	3,332
126	XULUNDU	N	TAITA TAVETA	COAST	0
127	XYAI		MACHAKOS	EASTERN	109
128	XYAWEA	N	KITUI	EASTERN	62
129	XYEMUNDU		MACHAKOS	EASTERN	147
130	LAMBWE	N	SOUTH NYANZA	NYANZA	2,455
131	LAMU MANGROVES		LAMU	COAST	975
132	LAMU MANGROVES		LAMU	COAST	1,093
133	LARIAK		LAIKIPIA	RIFT VALLEY	4,988
134	LELAN		WEST POKOT	RIFT VALLEY	1,262
135	LELAN		WEST POKOT	RIFT VALLEY	1,075
136	LELAN		WEST POKOT	RIFT VALLEY	12,179
137	LEMBUS		BARINGO	RIFT VALLEY	16,308
138	LEMBUS		UASIN GISHU	RIFT VALLEY	620
139	LEROGHI		SAMBURU	RIFT VALLEY	91,794
140	LOIMA HILLS		TURKANA	RIFT VALLEY	9,520
141	LOITA		NAROK	RIFT VALLEY	41,480
142	LOITOKITOK		KAJIADO	RIFT VALLEY	690
143	LONDIANI		KERICHO	RIFT VALLEY	106
144	LOWER IMENTI		MERU	EASTERN	2,477
145	LUGARI		BUNGOMA	WESTERN	2,193
146	LUNGI		LAMU	COAST	33,001
147	LUSOI		LAIKIPIA	RIFT VALLEY	268
148	MAASAI MAU	N	NAROK	RIFT VALLEY	46,373
149	MAATHA		MERU	EASTERN	632
150	MACHA	N	TAITA TAVETA	COAST	18
151	MAGUMO NORTH		NYANDARUA	CENTRAL	240
152	MAGUMO SOUTH		NYANDARUA	CENTRAL	364
153	MAI	N	KITUI	EASTERN	494
154	MAJI MAZURI		BARINGO	RIFT VALLEY	7,809
155	MAKERE WEST	NR	TANA RIVER	COAST	18
156	MAKONGO		MACHAKOS	EASTERN	169
157	MAKONGO		KITUI	EASTERN	2,447
158	MAKULI NGUUTA		MACHAKOS	EASTERN	1,676
159	MALUGANJI		KWALE	COAST	1,685
160	MARANGA	N	EMBU	EASTERN	238
161	MARENJI		KWALE	COAST	1,519
162	MARMANET		LAIKIPIA	RIFT VALLEY	22,648
163	MARONI EAST	NR	TANA RIVER	COAST	108
164	MARONI EAST	NR	TANA RIVER	COAST	95
165	MAROP		BARINGO	RIFT VALLEY	211
166	MARSABIT		MARSABIT	EASTERN	15,778
167	MATAA		MACHAKOS	EASTERN	48
168	MATHEWS RANGE		SAMBURU	RIFT VALLEY	97,392
169	MAU NAROK		NAKURU	RIFT VALLEY	810
170	MBILI	N	TAITA TAVETA	COAST	12
171	MBOONI NORTH		MACHAKOS	EASTERN	40
172	MBOONI SOUTH		MACHAKOS	EASTERN	207
173	MCHELELO EAST	NR	TANA RIVER	COAST	31
174	MCHELELO WEST	NR	TANA RIVER	COAST	12
175	MCHUNGUNYI	N	TAITA TAVETA	COAST	8
176	MDENGU	N	TAITA TAVETA	COAST	1
177	MENENGAI		NAKURU	RIFT VALLEY	5,737
178	METKEI		ELGEYO MARAKWET	RIFT VALLEY	1,958
179	MKONGANI NORTH		KWALE	COAST	1,165
180	MKONGANI WEST		KWALE	COAST	1,408
181	MLABA		BUNGOMA	WESTERN	721
182	MNAZINI		TANA RIVER	COAST	115

NR = Nature Reserve, N = Not Gazetted, Blank = Gazetted Forest Reserve

Table 6.2.3 List of Gazetted Forests (4)

183	MNJONYI	N	TAITA TAVETA	COAST	131
184	MODAGACHE	N	TAITA TAVETA	COAST	4
185	MOLO		NAKURU	RIFT VALLEY	915
186	MOMANDU		MACHAKOS	EASTERN	141
187	MOSEGEM		BARINGO	RIFT VALLEY	205
188	MOTUNYI HILL	N	ISIOLO	EASTERN	1,973
189	MOUNT ELGON		TRANS NZOIA	RIFT VALLEY	15,901
190	MOUNT ELGON		BUNGOMA	WESTERN	57,188
191	MOUNT KENYA		NYERI	CENTRAL	199,538
192	MOUNT KULAL	N	MARSABIT	EASTERN	45,942
193	MOUNT LONDIANI		BARINGO	RIFT VALLEY	30,152
194	MOUNT NYIRO		SAMBURU	RIFT VALLEY	45,496
195	MRIMA		KWALE	COAST	390
196	MTARAKWA		BARINGO	RIFT VALLEY	110
197	MTEGE	N	TAITA TAVETA	COAST	1
198	MUGUGU	N	KIAMBU	CENTRAL	225
199	MUKOBE		BARINGO	RIFT VALLEY	747
200	MUKOGODO		LAIKIPIA	RIFT VALLEY	29,931
201	MUNGUNI		MERU	EASTERN	189
202	MURINGATO NURSERY		NYERI	CENTRAL	24
203	MURUAI	N	NYANDARUA	CENTRAL	235
204	MURUAI	N	NYANDARUA	CENTRAL	398
205	MURUAI	N	NYANDARUA	CENTRAL	84
206	MUSEVE	N	KITUI	EASTERN	54
207	MUTEJWA		MERU	EASTERN	1,318
208	MUTHARANGA		MERU	EASTERN	293
209	MUTILUNI	N	KITUI	EASTERN	567
210	MUTITO		KITUI	EASTERN	1,975
211	MUTULA		MACHAKOS	EASTERN	578
212	MUUMONI	N	KITUI	EASTERN	11,031
213	MWACHI		KWALE	COAST	381
214	MWACHORA	N	TAITA TAVETA	COAST	6
215	MWAGANINI	N	TAITA TAVETA	COAST	35
216	MWAKAMU A	N	TAITA TAVETA	COAST	1
217	MWAKAMU B	N	TAITA TAVETA	COAST	1
218	MWANDONGO	N	TAITA TAVETA	COAST	705
219	NABKOI		UASIN GISHU	RIFT VALLEY	3,033
220	NAIROBI ARBORETUM		NAIROBI	NAIROBI	30
221	NAKURU		NAKURU	RIFT VALLEY	631
222	NAMANGA HILL		KAJIADO	RIFT VALLEY	11,904
223	NAMULUKU		BUSIA	WESTERN	10
224	NANYUNGU		BUSIA	WESTERN	22
225	NDARE		MERU	EASTERN	5,627
226	NDATAI		MACHAKOS	EASTERN	15
227	NDIWENYI	N	TAITA TAVETA	COAST	5
228	NDOTOS RANGE		SAMBURU	RIFT VALLEY	93,205
229	NDULUNI KALANI		MACHAKOS	EASTERN	106
230	NGAIA		MERU	EASTERN	4,314
231	NGAMBA (TRUST)		KITUI	EASTERN	1,141
232	NGANGAO	N	TAITA TAVETA	COAST	149
233	NGOMENI	N	TAITA TAVETA	COAST	0
234	NGONG HILLS		KAJIADO	RIFT VALLEY	3,081
235	NGONG ROAD		NAIROBI	NAIROBI	1,106
236	NGONG ROAD		NAIROBI	NAIROBI	10
237	NJUGUNI		MERU	EASTERN	1,987
238	NJUKIINI EAST	N	EMBU	EASTERN	110
239	NJUKIINI WEST	N	KIRINYAGA	CENTRAL	195
240	NORTH COAST MANGROVES		TANA RIVER	COAST	10,914
241	NORTH COAST MANGROVES		KILIFI	COAST	1,886
242	NORTH NANDI		NANDI	RIFT VALLEY	11,345
243	NORTHERN TINDERET		UASIN GISHU	RIFT VALLEY	26,285

NR = Nature Reserve, N = Not Gazetted, Blank = Gazetted Forest Reserve

Table 6.2.3 List of Gazetted Forests (5)

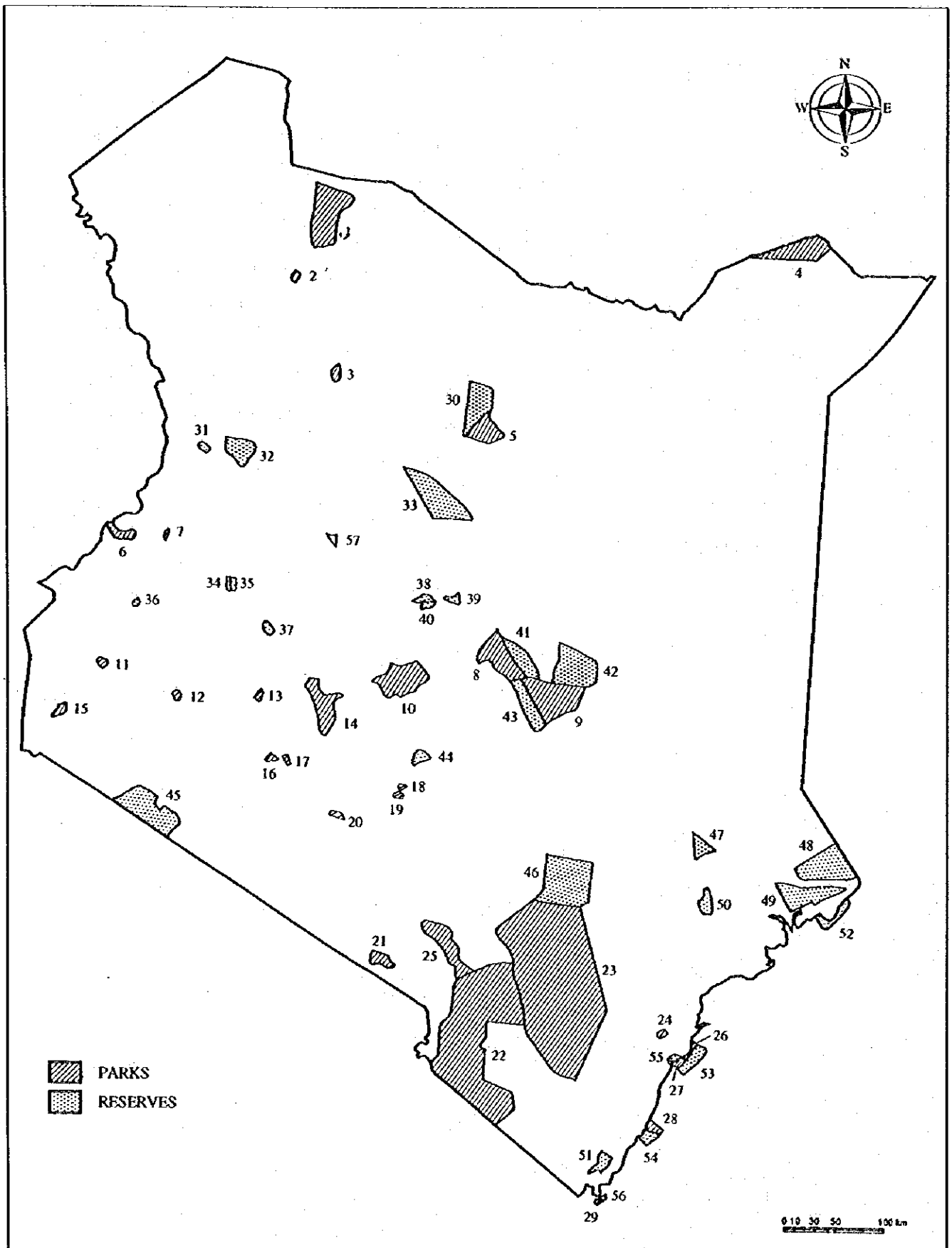
244	NTHANGU		MACHAKOS	EASTERN	845
245	NTUGI		MERU	EASTERN	1,356
246	NUU		KITUI	EASTERN	2,532
247	NYAMBENI		MERU	EASTERN	4,793
248	NYAMBENI		MERU	EASTERN	711
249	NYAMWERU		KIAMBU	CENTRAL	803
250	NYERI		NYERI	CENTRAL	1,214
251	NYERI HILL		NYERI	CENTRAL	200
252	NYERI MUNICIPAL		NYERI	CENTRAL	12
253	NZAUI		MACHAKOS	EASTERN	1,001
254	OL ARABEL		LAIKIPIA	RIFT VALLEY	9,738
255	OL BOLOSSAT		NYANDARUA	CENTRAL	3,269
256	OL LENGISHU	N	SIOLO	EASTERN	4,674
257	OL PUSIMORU		NAROK	RIFT VALLEY	17,258
258	OL PUSIMORU EXCISION		NAROK	RIFT VALLEY	20,411
259	OLOLUA		KAJIADO	RIFT VALLEY	639
260	PEMWAI		BARINGO	RIFT VALLEY	132
261	PERKERRA CATCHMENT		BARINGO	RIFT VALLEY	4,414
262	PROPOSED EXCISION		NANDI	RIFT VALLEY	99
263	PROPOSED EXCISION		NANDI	RIFT VALLEY	25
264	PROPOSED EXCISION		BARINGO	RIFT VALLEY	5
265	PROPOSED EXCISION		BARINGO	RIFT VALLEY	17
266	PROPOSED EXCISION		BARINGO	RIFT VALLEY	1
267	PROPOSED EXCISION		BARINGO	RIFT VALLEY	13
268	PROPOSED EXCISION		BARINGO	RIFT VALLEY	11
269	PROPOSED EXCISION		BARINGO	RIFT VALLEY	10
270	PROPOSED EXCISION		BARINGO	RIFT VALLEY	3
271	PROPOSED EXCISION		KAJIADO	RIFT VALLEY	49
272	PROPOSED EXCISION		NANDI	RIFT VALLEY	99
273	RANGWE (KAKSINGRI)	N	SOUTH NYANZA	NYANZA	1,011
274	RONGE	N	TAITA TAVETA	COAST	315
275	RUMURUTI		LAIKIPIA	RIFT VALLEY	6,551
276	SAIMO		BARINGO	RIFT VALLEY	727
277	SANAO		BARINGO	RIFT VALLEY	292
278	SEKENWO		BARINGO	RIFT VALLEY	863
279	SEKERR	N	WEST POKOT	RIFT VALLEY	7,890
280	SEKHENDU		TRANS NZOIA	RIFT VALLEY	804
281	SHIMBA HILLS		KWALE	COAST	18,968
282	SHIMBA LEASE		KWALE	COAST	27
283	SHIMBA NATIONAL RESERVE		KWALE	COAST	125
284	SIFA EAST	NR	TANA RIVER	COAST	229
285	SIFA WEST	NR	TANA RIVER	COAST	10
286	SOGOTIO		ELGEYO MARAKWET	RIFT VALLEY	3,555
287	SOKTA		BARINGO	RIFT VALLEY	170
288	SOUTH COAST MANGROVES		KWALE	COAST	1,279
289	SOUTH LAIKIPIA		NYERI	CENTRAL	792
290	SOUTH LAIKIPIA		NYERI	CENTRAL	2,708
291	SOUTH NANDI		NANDI	RIFT VALLEY	19,568
292	SOUTH WEST MAU		KERICHO	RIFT VALLEY	84,129
293	SOUTHERN MAU		NAROK	RIFT VALLEY	128
294	SUSU	N	TAITA TAVETA	COAST	2
295	TARAMBAS		BARINGO	RIFT VALLEY	475
296	TARESSIA		NANDI	RIFT VALLEY	375
297	THUNGURU HILL		MERU	EASTERN	554
298	THUURI		MERU	EASTERN	732
299	TIMBOROA		UASIN GISHU	RIFT VALLEY	5,813
300	TINDERET		KERICHO	RIFT VALLEY	28,167
301	TINGWA HILL		ELGEYO MARAKWET	RIFT VALLEY	905
302	TOROPKET		ELGEYO MARAKWET	RIFT VALLEY	120
303	TRANSMARA		NAROK	RIFT VALLEY	34,457
304	TULIMANI		MACHAKOS	EASTERN	328

NR = Nature Reserve, N = Not Gazetted, Blank = Gazetted Forest Reserve

Table 6.2.3 List of Gazetted Forests (6)

305	TUMEYA		ELGEYO MARAKWET	RIFT VALLEY	577
306	TURBO		KAKAMEGA	WESTERN	1,578
307	TURBO		KAKAMEGA	WESTERN	9,236
308	TUTWOIN		BARINGO	RIFT VALLEY	11
309	UASO NAROK		LAIKIPIA	RIFT VALLEY	1,996
310	UPPER IMENTI		MERU	EASTERN	10,402
311	URURU		NANDI	RIFT VALLEY	438
312	UTANGWA		MACHAKOS	EASTERN	56
313	UTUNENE		MACHAKOS	EASTERN	174
314	WAIYA		MACHAKOS	EASTERN	300
315	WANGA		BUSIA	WESTERN	95
316	WENI MBOGO	N	TAITA TAVETA	COAST	3
317	WENI MWANA	N	TAITA TAVETA	COAST	6
318	WENJE EAST (CENTRAL)	NR	TANA RIVER	COAST	180
319	WENJE EAST (NORTH)	NR	TANA RIVER	COAST	191
320	WENJE EAST (SOUTH)	NR	TANA RIVER	COAST	53
321	WEST MOLO		NAKURU	RIFT VALLEY	277
322	WESTERN MAU		KERICHO	RIFT VALLEY	22,748
323	WITU		LAMU	COAST	4,002
324	YALE	N	TAITA TAVETA	COAST	22

Source: KFCON, Forestry Department



Source : JICA Study Team

Road Network Development Master Plan in Kenya

Figure 6.2.11
Areas of National parks and Reserves

Table 6.2.4 List of National Parks and Reserves

	NATIONAL PARKS		NATIONAL RESERVES
1	SIBIL OI	30	MARSABIT
2	CENTRAL ISLAND	31	NASOLOT
3	SOUTH ISLAND	32	SOUTH TURKANA
4	MALKA MARI	33	LOSAI
5	MARSABIT	34	KERIO VALLEY
6	MOUNT ELGON	35	KAMNAROK
7	SAIWA SWAMP	36	KAKAMEGA
8	MERU	37	LAKE BOGORIA
9	KORA	38	SAMBURU
10	MT. KENYA	39	SHABA
11	MDERE ISLAND	40	BUFFALO SPRINGS
12	MAU	41	BISANADI
13	LAKE NAKURU	42	RAHOLE
14	ABERDARE	43	NORTH KITUI
15	RUMA	44	MWEA
16	HELL'S GATE	45	MASAI MARA
17	LONGONOT	46	SOUTH KITUI
18	FOURTEEN FALLS	47	ARAWALE
19	OL DONYO SABUX	48	BONI
20	NAIROBI	49	DODORI
21	AMBOSELI	50	TANA RIVER PRIMATE
22	TSAVO WEST	51	SHIMBA HILLS
23	TSAVO EAST		MARINE RESERVES
24	ARABUKO SOKOKE	52	KIUNSA
25	CHYULU	53	MALINDI
	MARINE PARKS	54	MOMBASA
26	MALINDI	55	WATAMU
27	WATAMU	56	MPUNGUTI
28	MOMBASA		NATIONAL SANCTUARY
29	KISITE	57	MARALAL

Source: KWS (1990) A Policy Framework and DevelopmentProgramme 1991-1996

6.3 Maintenance Requirements

6.3.1 Present Situation of Road Maintenance

(1) Existing Road Maintenance Systems

1) General

Road maintenance is the most important work item in road management in Kenya. It's execution is shared by MOPWH and several other organizations of central and local government organizations.

MOPWH is the main organization responsible for road maintenance of classified roads classes A, B, C, D, and E.

For the roads covered by this Master Plan Study, that is class A to C roads, the maintenance system has been established, based on the type of works, type of contract, type of equipment and type of funding resources.

Detailed studies for such systems, including organization, were conducted in the 1980's and 1990's. The detailed findings and recommendations are in those reports. A summarized description of them and the JICA Study Team's findings are presented in this report.

2) Classification of Work Items

In highway engineering, road maintenance works are basically categorized in two categories :

a Category-1: Routine Maintenance (road surface)

- RM-1 Bush clearing and ditch cleaning
- RM-2 Patching of surface debot
- RM-3 Grading of rut, corrugated surface etc.
- RM-4 Sealing cracks of A/C road.

The above maintenance works will be implemented in short intervals, that is once or several times a year as routine maintenance, in order to keep good and passable surface conditions.

b Category-2: Periodical Maintenance

Periodical maintenance will be implemented within longer intervals, based on the progress of the deterioration of the road surface. Intervals are usually longer than one year. It is desirable to implement periodical maintenance by using appropriate monitoring and inventory systems.

- PM-1 Regravelling on gravel roads,
- PM-2 Resealing/Overlay on Bituminous surface dressing roads (S/D) and A/C pavement roads,
- PM-3 Rehabilitation of S/D roads or A/C roads including sub-base structure.

Re-construction of pavement structures, Gravel, S/D and A/C roads, are out of the categories of maintenance.

Only RM-1 is implemented by the District Office and funded from the Recurrent Budget. The other RM-works and PM-works are implemented by the project office as periodical maintenance. They are funded from the Development Budget and foreign aid.
Road maintenance works are grouped into four groups by using level of equipment use as a main parameter.

c 1st Group (Labour Based Method)

This applies to basic routine maintenance, like bush clearing and ditch cleaning, which is implemented in short intervals, shorter than one year, and supervised by district office of MOPWH.
Funds are prepared by GOK from the recurrent budget and payment is done on a Force Account Basis.

d 2nd Group (Light Equipment Based Method)

This refers to a part of routine maintenance and periodical maintenance, like patching and re-gravelling on gravel roads, which is implemented by MOPWH in medium intervals, shorter or longer than one year, and supervised by the District Office or project office, MOPWH.

In this case, there are two funding sources, one is the original fund of GOK and the other is foreign aid.

In case of GOK funding, the District Office of MOPWH supervises the project. In case of foreign aid funding, the project office supervises the project.
The two major projects of MRP and RARP are categorized in this group, and they are implemented by using a labor intensive method with light tractors.

e 3rd Group (Medium Equipment Based Method)

The road maintenance works categorized in this group are implemented on force account basis or contract basis, using light vehicles other and medium equipment (small heating of bituminous materials for patching, tamping rammer etc.). Major work items are as follows :

- Patching of gravel/bituminous road with compaction
- Repairing of road facilities, like drainage structure, sign board, railing, road mark, guard rail and so on.

f 4th Group (Heavy Equipment Based Method)

The road maintenance works categorized in this 4th Group will be implemented using heavy equipment and vehicles on contract basis.
This work category includes up-grading and re-construction or renovation as follows :

- Upgrading

(i) Surface condition

- From Earth to Gravel or Bituminous
- From Gravel to Bituminous

(ii) Drainage

- Installation of pipe culvert or box culvert
- Construction of bridge

- Re-Construction/Renovation

(i) Surface Condition

- Regravelling
- Overlay
- Re-Sealing

(ii) Drainage

Reconstruction (re-installation) of deteriorated pipe culvert, box culvert and bridge.

- Other road facilities

Renovation of miscellaneous road facilities, like steel railing, road marking, traffic sign board and so on.

(2) Organizations

The organization, including functions of MOPWH and the Road Department are presented in Section 6.4.7, including organization charts.
The two road maintenance branches have functional cooperation with other related divisions such as the Construction Branch, the Provincial District Office, the Mechanical and Transportation Departments, and the Material Department.

1) Routine Maintenance

a Basic Routine Maintenance

The District Office manages this work, bush clearing and ditch cleaning, on a Force Account Basis or by their own manpower resources with funds from the Recurrent Budget.

However, few periodical monitoring activities are conducted by the District Offices and some information requirement for maintenance are actually provided by residents in rural areas.

b Light Equipped Routine Maintenance

This work is implemented by the District Office or Project Office, based on fund resources.

District Office -------- recurrent budget
Project Office -------- foreign aid.

2) Periodical Maintenance

It is recognized that some work items, which should basically be categorized in routine maintenance, are categorized as periodical maintenance and implemented with funding from the development budget. This may be because of its longer interval of implementation due to a lack of funds, like patching on gravel road and/or paved road, grading and/or re-gravelling on shoulder and so on.

At present, maintenance works, excluding bush clearing and ditch cleaning, are implemented as periodical maintenance using development budget and foreign aid funding.

(3) On-Going Projects

The related projects ,which are being implementing at present, are as follows :

1) MRP (Minor Road Program) & RARP (Rural Access Roads Program)

- Type of Works : Re-gravelling on Minor Roads
- Type of Contract : Force Account Basis
- Type of Equipment : Labor and Tractor Based
- Type of Fund : Development Budget and Foreign Aid
- Covered Area : 28 Districts in Provinces (high agricultural potential area)
- Implementation Period : 1974 to 1986 RARP
  1986 to present MRP.

<Note>

1974 to 1986	RARP planned road length 14,000 km
1986 to Present	The name was changed from RARP to MRP and supplementary included the selected Minor Roads, and by this time approx. 8,000 km of rural access roads with gravel In 1992 about 10,000 km of roads were maintained.

2) GBC (Gravelling, Bridges and Culverts Program)

- Type of Works: Regravelling, Maintenance and Rehabilitation of Bridges and Culverts
- Type of Contract: Force Account & Contract Account
- Type of Equipment: Equipment Based
- Type of Fund: Force Account & Contract Basis
- Covered Area: Not available
- Implementation Period: Ongoing.

3) Others

The following three projects are under implementation at present.

- KMDP (Kenya Market Development Program)
- KDRP (Kenya Drought Recovery Program)
- ROADS 2000 Program

The organizational set-up of MOPWH including the Road Department are presented in the Section 6.4.7 and the number of personnel and road length of specified classes, class A to C, to be maintained by the Road Department are presented in Table 6.3.1 on a district basis.

The existing condition of the workshop of MTD (Mechanical and Transportation Department), MOPWH, by District Office and the number of registered private contractors by Province are also shown in the same table.

(4) Budget Allocations and Disbursements

As has been indicated above already,, fund for basic routine maintenance works, such as bush clearing and ditch cleaning, are allocated in recurrent budget and funds for other maintenance works are allocated in development budget.
The allocated recurrent budgets in (1994/95) and (1993/94) are as follows :

Table 6.3.2 Recurrent Budget

Unit: Million KL

	Gross 1994/95	Gross 1993/94
Total Recurrent Estimates (Expenditure)	6,856	6,558
Total of MOPWH	204	137
Total of Roads	128	-
	(53)	(74)
Sub-Total of Major Roads	19.6	-
(Maintenance of Trunk Roads)	(4.6)	(4.6)
Sub-Total of Other Roads	78.2	41.1
(Primary, Secondary, Minor, Service, Rural Access and Special Purpose Roads)	(18.2)	(41.1)

Table 6.3.1(1) Road Length of the Road Network Development Programme

CODE NO.	DISTRICT	ROAD LENGTH MANAGED BY DISTRICT OFFICE (Km)													TOTAL ROAD LENGTH (A-E+) Km	NO. OF PERSO-NNEL (R.D.)	MTD WORK-SHOP	REMARKS
		CLASS-A				CLASS-B				CLASS-C				GROSS TOTAL				
		B	G	E	TOTAL	B	G	E	TOTAL	B	G	E	TOTAL					
110	NAIROBI (Nairobi)	90.5	0.0	0.0	90.5	8.3	0.0	0.0	8.3	119.1	1.5	1.5	122.1	220.9	384	49	I	121
200	CENTRAL PROVINCE (Nyeri)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	112	-	1
210	KIAMBU	153.8	0.0	0.0	153.8	20.0	0.0	0.0	20.0	223.2	15.4	0.0	238.6	412.4	1847	250	I	
220	KIRINYAGA	37.7	0.0	0.0	37.7	42.1	0.0	0.0	42.1	46.8	0.0	0.0	46.8	126.6	1061	160	I	
230	MURANGA	39.5	0.0	0.0	39.5	0.0	0.0	0.0	0.0	130.3	38.4	0.0	168.7	208.2	1893	180	T	
240	NYANDARUA	4.3	0.0	0.0	4.3	27.8	0.0	0.0	27.8	90.7	150.5	8.0	249.3	281.4	1244	166	M*	
250	NYERI	74.2	0.1	0.0	74.3	64.3	0.0	0.0	64.3	36.2	0.0	0.0	36.2	174.8	1747	288	T	
300	COAST PROV. (Mombasa)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	111	-	1
310	KILIFI	48.1	0.0	0.0	48.1	103.5	52.1	0.0	155.6	38.2	134.1	53.2	225.5	429.2	1688	239	I	
320	KWALE	151.7	0.0	0.0	151.7	0.0	0.0	0.0	0.0	18.0	81.0	105.7	204.7	356.4	1546	183	I	
330	LAMU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.4	93.4	93.4	483	70	M*	
340	MOMBASA	40.1	0.0	0.0	40.1	17.6	0.0	0.0	17.6	18.8	3.8	0.0	22.6	80.3	128	151	M	
350	TAITA-TAVETA	130.2	88.8	0.0	219.0	0.0	0.0	0.0	0.0	22.0	0.6	0.0	22.6	241.6	942	155	M*	
360	TANA RIVER	25.5	0.0	89.0	114.5	24.5	43.4	187.7	255.6	29.0	0.0	0.0	29.0	399.1	1071	107	I	

Table 6.3.1(2) Road Length of the Road Network Development Programme

CODE NO.	DISTRICT	ROAD LENGTH MANAGED BY DISTRICT OFFICE (Km)													TOTAL ROAD LENGTH (A-E+) Km	NO. OF PERSO-NNEL (R.D.)	MTD WORK-SHOP	REMARKS
		CLASS-A				CLASS-B				CLASS-C				GROSS TOTAL				
		B	G	E	TOTAL	B	G	E	TOTAL	B	G	E	TOTAL					
400	EASTERN PROV. (Embu)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	141	-	1
410	EMBU	0.0	0.0	0.0	0.0	81.1	0.0	0.0	81.1	0.0	45.1	8.3	53.4	134.5	1283	203	M*	
420	ISIOLO	9.0	36.0	0.0	45.0	0.0	118.0	9.0	127.0	0.0	0.0	0.0	0.0	172.0	1128	129	M*	
430	KITUI	52.7	116.9	0.0	169.6	6.5	0.0	157.2	163.7	25.5	145.7	39.3	210.5	543.8	3049	372	T	
440	MACHAKOS	108.6	0.0	0.0	108.6	35.5	0.0	0.0	35.5	151.9	82.7	0.0	234.6	378.7	1563	330	I	
450	MARSABIT	9.5	370.0	0.0	379.5	0.0	0.0	0.0	0.0	0.0	0.0	492.1	492.1	871.6	2216	117	N	
460	MERU	73.0	0.0	0.0	73.0	88.9	0.0	66.0	154.9	50.7	68.0	0.0	118.7	346.6	2158	170	T	
470	MAKUENI	220.4	0.0	0.0	220.4	3.0	24.8	0.0	27.8	0.0	151.0	0.0	151.0	399.2	1593	1		
480	THARAKA-NITHI	0.0	0.0	0.0	0.0	32.9	0.0	0.0	32.9	50.7	35.0	0.0	85.7	118.6	616	1		
500	N/EASTERN PROV. (Garissa)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71	-	1
510	GARISSA	3.0	79.0	122.0	204.0	0.0	37.1	15.0	52.1	0.0	35.0	141.5	176.5	432.6	1836	165	M*	
520	MANDERA	0.0	0.0	0.0	0.0	136.4	122.4	14.0	272.8	0.0	0.0	0.0	0.0	272.8	1321	117	T	
530	WAJIR	0.0	0.0	0.0	0.0	0.0	220.0	46.0	266.0	0.0	12.0	336.0	348.0	614.0	1696	89	M*	
600	NYANZA PROV. (Kisumu)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87	-	2
610	KISII	31.0	0.0	0.0	31.0	30.2	0.0	0.0	30.2	42.0	43.0	0.0	85.0	146.2	1072	239	T	
620	KISUMU	68.1	0.0	0.0	68.1	55.2	0.0	0.0	55.2	162.7	7.9	0.0	170.6	293.9	1639	286	T	

Table 6.3.1(3) Road Length of the Road Network Development Programme

CODE NO.	DISTRICT	ROAD LENGTH MANAGED BY DISTRICT OFFICE (Km)													TOTAL ROAD LENGTH (A-E+) Km	NO. OF PERSO-NNEL (R.D.)	MTD WORK-SHOP	REMARKS
		CLASS-A				CLASS-B				CLASS-C				GROSS TOTAL				
		B	G	E	TOTAL	B	G	E	TOTAL	B	G	E	TOTAL					
630	SIAYA	0.0	0.0	0.0	0.0	49.5	0.0	0.0	49.5	93.4	135.3	0.0	228.7	278.2	1333	155	T	
640	HOMA BAY	42.0	0.0	0.0	42.0	0.0	0.0	0.0	0.0	40.2	173.7	0.0	213.9	255.9	1304	287	M*	
650	NYAMIRA	0.0	0.0	0.0	0.0	18.0	0.0	0.0	18.0	0.0	88.7	0.0	88.7	106.7	621	4		
660	MIGORI	69.0	0.0	0.0	69.0	0.0	0.0	0.0	0.0	16.5	72.1	0.0	88.6	157.6	1257	80		
700	RIFT VALLEY PROV. (Nakuru)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	238	-	1
710	KAJIADO	131.5	0.0	0.0	131.5	0.0	0.0	0.0	0.0	114.5	281.4	0.0	395.9	527.4	1765	150	M*	
720	KERICHO	0.0	0.0	0.0	0.0	90.4	0.0	0.0	90.4	73.9	75.4	0.0	149.3	239.7	1123	307	T	
730	LAIKIPIA	3.8	0.0	0.0	3.8	38.3	0.0	0.0	38.3	82.3	149.3	15.5	247.1	289.2	1069	177	M*	
740	NAKURU	152.7	0.0	0.0	152.7	107.6	0.0	0.0	107.6	190.9	11.0	0.0	201.9	462.2	1850	481	T	
750	NAROK	0.0	0.0	0.0	0.0	98.9	41.0	0.0	139.9	47.1	301.6	74.8	423.5	563.4	2066	177	T	
760	TRANS NZOIA (Kitale)	61.8	0.0	0.0	61.8	18.6	0.0	0.0	18.6	21.2	100.6	16.5	138.3	218.7	1138	163	T	
770	UASIN GISHU (Eldoret)	123.4	0.0	0.0	123.4	35.2	0.0	0.0	35.2	103.2	92.1	0.0	195.3	353.9	1228	220	M*	
780	BOMET	0.0	0.0	0.0	0.0	62.0	0.0	0.0	62.0	48.0	86.6	0.0	134.6	196.6	1039			
810	BARINGO	0.0	0.0	0.0	0.0	88.4	118.0	0.0	206.4	125.7	30.0	39.0	194.7	401.1	1622	337	I	
820	ELGEYO MARAKWET	0.0	0.0	0.0	0.0	0.0	0.0	18.3	18.3	87.0	81.6	106.7	275.3	293.6	887	143	T	

Table 6.3.1(4) Road Length of the Road Network Development Programme

CODE NO.	DISTRICT	ROAD LENGTH MANAGED BY DISTRICT OFFICE (Km)													TOTAL ROAD LENGTH (A-E+) Km	NO. OF PERSO-NNEL (R.D.)	MTD WORK-SHOP	REMARKS
		CLASS-A				CLASS-B				CLASS-C				GROSS TOTAL				
		B	G	E	TOTAL	B	G	E	TOTAL	B	G	E	TOTAL					
830	NANDI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	121.0	52.0	0.0	173.0	173.0	1290	340	I	
840	SAMBURU	0.0	93.0	0.0	93.0	0.0	0.0	0.0	0.0	0.0	254.7	50.7	305.4	398.4	1406	91	I	
850	TURKANA	381.0	0.0	30.0	411.0	0.0	0.0	0.0	0.0	18.2	0.0	397.8	416.0	827.0	2505	128	I	
860	WEST POKOT (Kapenguria)	102.3	0.0	0.0	102.3	0.0	43.8	0.0	43.8	0.0	0.0	45.0	45.0	191.0	1215	126	I	
900	WESTERN PROV. (Kakamega)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	107	-	
910	BUNGOMA	82.1	0.0	0.0	82.1	0.0	0.0	0.0	0.0	26.3	121.5	5.0	152.8	234.9	1392	197	I	
920	BUSIA	15.1	0.0	0.0	15.1	27.0	0.0	0.0	27.0	0.0	106.9	58.5	165.4	207.5	794	139	T	
930	KAKAMEGA	95.5	0.0	0.0	95.5	12.0	0.0	0.0	12.0	47.2	51.9	49.8	148.9	256.4	1462	305	M*	
940	VIHIGA	20.0	0.0	0.0	20.0	12.5	0.0	0.0	12.5	49.2	22.1	0.0	71.3	103.8	401		T	
TOTALS		2567	783	241	3591	1403	831	524	2748	2501	3304	2148	7953	14402	63324	12057	-	

The number in REMARKS is number of local offices

ABBREVIATION:

[Surface Condition]
B: Bitumen, road surface type
G: Gravel, " " "
E: Earth, " " "

[Workshop]
M: Modern Workshop (M*: financed by (World Bank)
I: In-House Workshop
T: Temporary Workshop (Garage)
N: Non-Existent Facility

6.3.2 Current Problems and Issues

The following subject were studied in the Administrative Plan :

- Policy Reform and Institutional Reform
- Funds and Budget
- Implementation System (Contract System/Payment System)
- Organization and Manpower, including training
- Equipment and vehicles.

According to the results of these studies, the present problems in road maintenance are as follows :

a Insufficient funds, even for routine maintenance

b Inadequate allocation of personnel

- Overstaffing compared to allocated funds and planned activities,
- Shortage of well trained manpower, including skilled personnel and operator,
- Not well assessed organizations and personnel for trend of "Privatization",
- Lack of equipment and tools for road maintenance,
- Lack of adequate contractors for road maintenance works in rural areas.

These problems are summarized in the following items.

(1) Situation of Road Maintenance

Presently, road maintenance is not well implemented and many roads have deteriorated on surface conditions as follows :

a A/C Paved Roads

- Deteriorated/Less-weared bituminous surface,
- Damaged sub-base structure,
- Un-repaired pot-holes,
- Damaged edge of A/C pavement,
- Eroded shoulders (hard, soft).

b S/D Paved Roads

- Deteriorated surface,
- Damaged sub-base structure,
- Damaged edge of S/D pavement,
- Erosed shoulders.

c Gravel Roads

- Deteriorated gravel surface,
- Missing surface materials (Gravel),
- Erosed shoulders.

d Earth Roads

- Loss of shape and camber for normal traffic and drainage,
- Obstacles for traffic due to ruts, pot-holes, corrugations, erosion gullies and blocked ditches.

(2) Funds and Budget

Fund resources for road maintenance, routine and periodical maintenance, presently consist of the following two kinds of funds :

- Original funds of GOK, based on tax revenue and fuel levy,
- Foreign Aid.

The Government budget for road maintenance consists of two kinds of budget :

- Recurrent Budget

It is basically used for routine maintenance.

- Development Budget

It is mainly allocated for periodical maintenance, combined with foreign aids and used on a project basis.

As described above, funds of foreign aid are mainly allocated for periodical maintenance and some other objectives, such as training and so on.

The existing problems in funding and budgets are as follows :

- Insufficient funds even for routine maintenance and diversion of the development budget, for routine maintenance purposes,

- Delayed and/or canceled disbursement due to shortage of government fund resources,

- Not so smooth disbursement of development budget due to shortage of government fund resources and diversion of development budget and recurrent budget.

(3) Personnel

Considering present situation of funding sources and the performance of MOPWH in road maintenance, it is recognized that overstaffing is one of the major problems to be resolved together with the lack of sufficient funds.
The data, collected by the Master Plan Study Team, JICA, show the following figures (Table 6.3.3 refers) :

Table 6.3.3 Expenditures and Budget

	1989/90	1994/95
Total number of personnel of MOPWH	15,982	12,057
	Million K£	Million K£
Total amount of Expenditure (for Road)	130	253
Recurrent Exp.	**23**	**127**
Domestic Net Budget	23	52
Aid Appropriate	0	75
Development Exp.	**107**	**126**
Domestic Net Budget	62	76
Aid Appropriate	45	50

The trend of "Privatization" in public works, especially road in maintenance and construction, would be an asset for the reform efforts of the Government. Maintenance works on contract basis should have a much higher share than maintenance work carried out directly by employees of MOPWH.

On the other hand it is also true that quick release of government employees will create new problems by increasing unemployment, and it may be a quite serious problem in rural areas, where less job opportunities exist.

(4) Organization

It is required that MOPWH reform and streamline its organization in line with the requirements of good efficiency, sufficient performance, improvement of budget allocation and the reduction of expenditures for personal emoluments and related expenditures.

The Program for the Civil Service Reform has already been established by the Government of Kenya and implementation has started.

(5) Equipment and Vehicles

In the provision of adequate and sufficient equipment and vehicles for road maintenance, the government mechanism has not worked well for the following reasons and even after the establishment of the Equipment Management System (RMS) :

- Lack of fund to purchase required parts and tools for proper maintenance and repairing,
- Lack of facilities and equipment of MOPWH workshops,
- Shortage of well trained staff of MOPWH.

(6) Periodical Maintenance

Work item and period of periodical maintenance are decided mainly based on surface type, surface condition (IRI; International Roughness Index), and traffic conditions.

6.3.3 Policy and Institutional Reform

Reforms for the Government Service system, including road management, have been studied by the GOK since late 1980's and some programs like seminars and meetings have been implemented. It is understood that one of the major objectives is to promote privatization, even in routine maintenance activities.

The major objective is to improve the efficiency of existing organizations, inter alia through streamlining, that is decreasing the total number of government employees, to the targeted number of about 60,000. One of the major subjects of policy reform is to develop privatization in government services, including in public works.

During independence, only few local private firms were available to undertake Government service work on a contract basis. The Government had to implement most of public works with their own direct employees in that time.
And up to the present, this system has been adopted, because of the unavailability of adequate private contractor in rural areas.

Based on the above situation, the following changes in public works, especially in road maintenance works will be realized :

- Increasing employment of private contractors for road maintenance works on a contract basis,
- Decreasing direct implementation of road maintenance works with government employee and equipment.

6.3.4 Plan for Road Maintenance

(1) Maintenance Program

The existing road maintenance program by maintenance types, equipment types, contract types and budgeting are presented in Table 6.3.4.

From the point of view of road engineering, it can be said that many sections of existing roads are deteriorated. They can no longer provide a good serviceability level to public traffic, because of lack of proper maintenance, routine maintenance and periodical maintenance, including rehabilitation and re-construction.

Delayed implementation or neglecting of proper maintenance interval increases both, maintenance cost and deterioration of road structure, pavement, drainage, slope and so on.

The following introduces elements of an applicable maintenance plan, the standards of which are slightly relaxed as compared to those in developed countries.

Table 6.3.4 (1) Road Maintenance Programme

WORK ITEM CODE NO.	WORK ITEM	MAINTENANCE TYPE		EQUIPMENT TYPE		CONTRACT TYPE		BUDGETING		REMARKS
M.1	ROAD BODY ST.									
M.1.1	EMBANKMENT/CUTTING FOR WIDENING	-	P/M	-	E/B	-	C/B	-	D/B	
M.1.2	EMBANKMENT FOR ELEVATION UP	-		-	E/B	-	C/B	-	D/B	
M.2	PAVEMENT STR. (1) (GRAVEL/EARTH ROAD)									
M.2.1	SURFACE									
M.2.1.1	GRADING	<----	--P/M	L/B	-	F/B	-	<--	-D/B	
M.2.1.2	PATCHING	<----	--P/M	L/B	-	F/B	-	<--	-D/B	
M.2.1.3	RE-GRAVELLING	-	P/M	-	E/B	-	C/B	-	D/B	
M.2.2	SHOULDERS									
M.2.2.1	GRADING	<----	--P/M	L/B	-	F/B	-	<--	-D/B	
M.2.2.2	RE-GRAVELLING	-	P/M	L/B	-	-	C/B	-	D/B	
M.3	PAVEMENT STR. (2) (BITUMINOUS ROAD)									
M.3.1	SURFACE									
M.3.1.1	PATCHING	<----	--P/M	-	E/B	-	C/B	<--	-D/B	
M.3.1.2	OVERLAYING	-	P/M	-	E/B	-	C/B	-	D/B	
M.3.1.3	RE-SEALING	-	P/M	-	E/B	-	C/B	-	D/B	
M.3.2	SHOULDERS									
M.3.2.1	SOFT SHOULDERS									
	(1) GRADING	<----	--P/M	L/B	-	L/B	-	<--	-D/B	
	(2) RE-GRAVELLING	-	P/M	L/B	-	-	-	-	D/B	
M.3.2.2	HARD SHOULDERS									
	(1) PATCHING	<----	--P/M	-	E/B	-	E/B	<--	-D/B	
	(2) OVERLAYING	-	P/M	-	E/B	-	E/B	-	D/B	
	(3) RE-SEALING	-	P/M	-	E/B	-	E/B	-	D/B	

Table 6.3.4 (2) Road Maintenance Programme

WORK ITEM CODE NO.	WORK ITEM	MAINTENANCE INTERVAL		EQUIPMENT TYPE		CONTRACT TYPE		BUDGETING		REMARKS
M.4	DRAINAGE STRUCTURES									
M.4.1	SIDE DITCH									
M.4.1.1	CLEANING	R/M	-	L/B	-	F/B	-	-		
M.4.1.2	RE-SHAPING	-	P/M	L/B	-	F/B	-	D/B		
M.4.2	BOX CULVERT/PIPE CULVERT									
M.4.2.1	CLEANING	R/M	-	L/B	-	F/B	-	-		
M.4.2.2	REPAIRING	-	P/M	-	E/B	-	C/B	D/B		
M.4.2.3	RE-CONSTRUCTION	-	-	-	E/B	-	C/B	-		
M.4.3	BRIDGE	R/M	-	L/B	-	F/B	-	-		
M.4.3.1	CLEANING	-	P/M	-	E/B	-	C/B	D/B		
M.4.3.2	REPAIRING	-	-	-	E/B	-	-	-		
M.4.3.3	RE-CONSTRUCTION									
M.5	SLOPE PROTECTION STR.									
M.5.1	SLOPE PROTECTION STRUCTURES									
M.5.1.1	SLOPE									
	(1) RE-SHAPING OF SOIL SLOPE	-	P/M	L/B	-	F/B	-	-		
	(2) GRASS CUTTING, BUSH CLEARING AND TREE TRIMMING ON VEGETATED SLOPE	R/M	-	L/B	-	F/B	-	-		
	(3) SPOT REVEGETATION	-	P/M	L/B	-	F/B	-	D/B		
	(4) RE-VEGETATION	-	P/M	L/B	-	-	C/B	D/B		
M.5.1.2	CONCRETE STRUCTURE									
	(1) SURFACE CLEARING	R/M	-	L/B	-	F/B	-	-		
	(2) SPOT REPAIRING	-	P/M	-	E/B	-	C/B	D/B		
	(3) RE-CONSTRUCTION	-	-	-	-	-	-	-		

Table 6.3.4 (3) Road Maintenance Programme

WORK ITEM CODE NO.	WORK ITEM	MAINTENANCE INTERVAL		EQUIPMENT TYPE		CONTRACT TYPE		BUDGETING		REMARKS
M.6	MISCELLANEOUS ROAD FACILITIES									
M.6.1	SEPARATOR AND RAILINGS									
M.6.1.1	SEPARATOR/CURB									
	(1) PATCHING BY MORTAR	R/M	-	-	E/B	-	C/B	-	D/B	
	(2) RE-CONSTRUCTION	-	P/M	-	E/B	-	C/B	-	D/B	
M.6.1.2	RAILING									
	(1) STEEL RAILING ON ROAD AND DRAINAGE STRUCTURE									
	1) RE-PAINTING	-	P/M	L/B	-	-	C/B	-	D/B	
	2) REPAIRING OF DAMAGED (COLLIDED) RAILING									
	- POST	-	P/M	-	E/B	-	C/B	-	D/B	
	- RAILING	-	P/M	-	E/B	-	C/B	-	D/B	
	(2) CONCRETE RAILING									
	1) PATCHING BY MORTAR	-	P/M	-	E/B	-	C/B	-	D/B	
	2) RE-CONSTRUCTION	-	P/M	-	E/B	-	C/B	-	D/B	
M.6.2	LIGHTING									
M.6.2.1	POLE									
	(1) RE-PAINTING	-	P/M	L/B	-	-		-	D/B	
	(2) REPAIRING OF LIGHTLY COLLIDED POLE	-	P/M	L/B	-	-	C/B	-	D/B	
	(3) REPLACEMENT OF DAMAGED POLE	-	P/M	-	E/B	-	C/B	-	D/B	
M.6.2.2	LAMP & COVER									
	(1) EXCHANGE OF LAMP	R/M	-	L/B	-	-	C/B	-	D/B	
	(2) RE-INSTALLATION OF COVER	R/M	-	-	E/B	-	C/B	-	D/B	
M.6.2.3	CABLE (WIRE), SWITCH BOX ETC.									
	(1) REPAIRING	-	P/M	-	E/B	-	C/B	-	D/B	
	(2) RE-INSTALLATION	-	P/M	-	E/B	-	C/B	-	D/B	

Table 6.3.4 (4) Road Maintenance Programme

WORK ITEM CODE NO.	WORK ITEM	MAINTENANCE INTERVAL		EQUIPMENT TYPE		CONTRACT TYPE		BUDGETING		REMARKS
M.6.3	SIGN BOARD ON ROAD SIDE									
M.6.3.1	POST									
	(1) RE-PAINTING	-	P/M	L/B	-	-	C/B	-	D/B	
	(2) REPAIRING OF LIGHTLY COLLIDED POST	-	P/M	L/B	-	-	C/B	-	D/B	
	(3) RE-CONSTRUCTION	-	P/M	-	E/B	-	C/B	-	D/B	
M.6.3.2	BOARD									
	(1) REPAINTING	-	P/M	L/B	-	-	C/B	-	D/B	
	(2) RE-INSTALLATION OF BOARD	-	P/M	-	E/B	-	C/B	-	D/B	
M.6.4	ROAD SIGN ON BITUMINOUS PAVEMENT									
M.6.4.1	ROAD SIGN									
	(1) RE-WRITING	-	P/M	L/B	-	-	C/B	-	D/B	

Abbreviation:

R/M: Routine Maintenance
P/M: Periodical Maintenance

L/B: Labour Based
E/B: Equipment Based

F/B: Force Account Basis
C/B: contract Basis

R/B: Recurrent Budget
D/B: Development Budget

<------ P/M: Be recommended to include in R/M in future.

<------ D/B: Be recommended to change to R/B.

(2) Appropriate Road Surface Types

A road inventory survey was conducted in February and March 1994 along all roads of class A, B and C, totaling about 14,000 km, in order to evaluate appropriate road surface types and to establish an applicable road maintenance plan.

Related standards and manuals of MOPWH and some other organizations, like UN/ECFA, on road maintenance were consulted. In addition, discussions were held with MOPWH on the present situation and activities of the ministry in road maintenance.

The established Evaluation Criteria for road surface type are based on traffic volume (PCU-1994) and are as follows:-

Traffic Volume (PCU-1994)	PCU < 150	Earth Road (E/R)
	150 < PCU < 500	Gravel Road (G/R)
	500 < PCU < 2000	Surface Dressed Road (S/D)
	2000 < PCU	Asphaltic Concrete Paved Road (A/C)

(3) Recommended Maintenance by Pavement Type

In order to resolve the current troubled surface conditions, it is recommended to implement adequate periodical maintenance based on pavement type and on surface roughness.

The recommended plan for periodical maintenance is as follows :

a A/C Paved Roads

Type and time of periodical maintenance works will be determined by IRI or an equivalent index as follows :

IRI < 2.0 - No periodical maintenance but only routine maintenance,

IRI = 6.0 - Overlay will be implemented when IRI value increases to 6.0,

IRI = 8.0 - Rehabilitation will be implemented when IRI value increases to 8.0, including sub-base structure (if necessary),

10.0 < IRI - Re-construction of pavement structures will be implemented and minor improvement for insufficient width of carriage way pavement, shoulders and for inadequate loading capacity of

pavement structures, and A/C pavement and sub-base will be implemented.

b S/D Paved Roads

Type and time of periodical maintenance works will be determined by IRI as follows :

IRI < 6.0 - No periodical maintenance,
IRI = 6.0 - Resealing for only surface dressing,
IRI = 8.0 - Rehabilitation of surface dressing structure, including sub-base, if necessary,
IRI = 10.0 - Re-construction of surface dressing structures, including sub-base etc., will be implemented and minor improvement for insufficient width of carriage way and shoulders will be implemented, if necessary.

c Gravel Roads

In case of Gravel Road, periodical maintenance will be implemented based on calendar year :

Two times a year (Grading, beginning of each dry season)
Five year interval (Re-gravelling including shaping of carriage way and shoulders)

d Earth Roads

In this case, only grading will be implemented for periodical maintenance, based on calendar year;

Two times a year (Grading, beginning of each dry season)

e Special Consideration on Low Traffic Roads

According to the results of traffic surveys conducted by MOPWH and the JICA Master Plan Study Team, respectively, several over graded roads on pavement type are reported :

- A/C paved road (deteriorated) Low traffic volume (PCU: less than 2000)
- S/D paved road (deteriorated) Low traffic volume (PCU: less than 500)
- A/C paved road with low traffic volume (PCU < 2000).

Even if the existing surface type is A/C pavement (deteriorated), considering the low traffic volume and effective budget expenditures, the application of the following periodical maintenance of S/D Paved Road is recommended :

IRI < 6.0	No periodical maintenance,
IRI = 6.0	Resealing for only surface dressing,
IRI = 8.0	Rehabilitation of surface dressing structure, including sub-base, if necessary,
IRI = 10.0	Re-construction of surface dressing structures, including sub-base etc., will be implemented and minor improvement for insufficient width of carriage way and shoulders will be implemented, if necessary.

- S/D paved roads with low traffic volume (PCU < 500)

Even existing surface type is S/D pavement (deteriorated), considering the low traffic volume and effective budget expenditure, the application of the following periodical maintenance of Gravel Road Type is recommended :

Two times a year (Gravel patching)
Five year interval (Re-gravelling, if seriously deteriorated S/D pavement).

(4) Stream of Privatization

Privatization should be considered in road maintenance, construction equipment and vehicles for road works.

However, it is not so easy to find adequate private firms for operation and maintenance/repairing of equipment/vehicles in rural areas, and they may be found only in some limited provincial capitals, like Kisumu.

The serviceable area of the said private firms are not so wide from their based workshops, because of small scale of their business activities and lack of transportation facilities.

A combination of several types of employment schemes of pure private firms and special kind of organizations should be considered province by province.
The planned special kind of organization will have the following conditions :

- The organization will be established as a private firm but the government can have a part of shares.

- Existing government employee will have an advantaged to be transferred to the new organization.

- Existing facilities and equipment of MOPWH workshops will be transferred to new firm at reasonable costs and this may be the share of MOPWH.

- New organizations will be favored to get contracts for road maintenance works in specified areas, on a province or district basis.

- New organizations will be time-limited organizations, ten to twenty years according to the situation/forecast of construction business in that area.

(5) Establishment of New Organization

It is recommended to consider the establishment of new organizations for road maintenance in rural areas and to give them some advantage to get contracts, including routine maintenance.
Employees of the Road Department, MOPWH and other related organizations will be advantaged to be transferred as employees of the new organizations.

When the new organizations will perform their duties well, the remaining government organizations will have more strategic duties, limited to management and disaster prevention, like planning of maintenance program, monitoring of road inventory and management of disaster prevention.