CHAPTER 4

APPROACH TO DRAWING UP ROAD MAINTENANCE SCENARIOS

CHAPTER 4 APPROACH TO DRAWING UP ROAD MAINTENANCE SCENARIOS

To realize an effective road maintenance system, it is first necessary to determine the gap between the needs and resources of road maintenance, and then second to implement the appropriate measures to deal with this "needs gap". To accomplish this, the Study Team constructed plausible road maintenance scenarios to assess the existence and size of the above-mentioned needs gap, and then drew up proposals that are both comprehensive and holistic in nature in order to integrate the relevant road maintenance components and thereby realize the most effective system possible to eliminate it. Below, the process for doing this is described.

4.1 Key Findings for Drawing Up Road Maintenance Scenarios

The Study Team was able to determine the current status of road maintenance in the previous chapter. Based on this, the Study produces output describing a suitable road maintenance system and strategic operation scenarios for Kenya's entire road network. As for the main findings for drawing up road maintenance scenarios, they are as listed below.

(1) Condition of Roads

- Lack of maintenance work has caused deterioration leading to the need for costly rehabilitation work.
- A significant percentage of the network is not in a maintainable condition and requires rehabilitation.
- The Roads 2000 Program, which calls for a new approach to rapidly bring the classified road network up to maintainable standard and place them under effective maintenance with optimum use of local resources, has not been implemented sufficiently.
- Current road condition data is not available.

(2) Legal and Institutional Setup for Road Maintenance

- Implementation of the KRB Act has been delayed by High Court action. The repercussions may delay full implementation.
- The issues identified by the "Interim Steering Group" need to be resolved as soon as possible. Especially, conflicts with previous legislation have to be resolved, which includes legal, finance/management, and technical issues.

(3) Road Maintenance Funding

- The fuel levy has been used for rehabilitation work reducing the amount available for maintenance. Funds for rehabilitation work should be kept separate from the fuel levy.
- Funds have not generally been allocated on a network priority basis.
- Funds are delayed, resulting in higher costs for work and materials and creating a lack of work continuity. This makes it a less attractive environment for the private sector.
- Funds have been used for purposes other than those designated.

(4) Management, Performance and Training

- The planning, supervision, and financial control of maintenance work needs to be improved.
- The accountability of the management, monitoring and evaluation system needs to be improved.
- Implementation plans have not always been carried out in accordance with work plans, and there are no standards for executing the contents of the work plans.
- There is a lack of skilled staff at the local level.
- Kenya has been relying on force-account method for road maintenance work.
- The majority of equipment is obsolete and is no longer economic to retain or maintain.
- Good training courses have been developed at Kisii, but the training has not been executed efficiently and effectively because of shortage of funds.
- A number of high quality manuals have been produced from previous studies. However, during our field survey, none were in use. A maintenance manuals that are user friendly, should be produced to ensure a consistent approach to maintenance under the KRB.

(5) Donors

- Donors have provided crucial support to the road sectors (e.g., RARP, MRP, Roads 2000). Donors have also provided funds for reviews of the institutional framework, as well as for the development and implementation of the KRB.
- Donors are likely to support road sector funding provided they see a functioning system that is capable of programming its work and that is transparent, accountable, provides proper technical/financial audits, and ensures that funds are spent on designated works.

4.2 Approach for Drawing Up Road Maintenance Scenarios

Scenarios are drawn up by the Study Team for both the classified and unclassified roads for the entire territory of the Republic of Kenya, and focus on such items as maintenance by road surface type, funding availability for road maintenance, maintenance by the different road administration agencies, force account versus contracting out, labor-based methods versus equipment-based methods, and the promotion of small-scale contractors in road maintenance works. The scenarios are for plausible future road maintenance, and propose a comprehensive and holistic program that focuses on the integration of all road maintenance components in order to realize the most effective road maintenance system possible. The Study Team's approach to drawing up road maintenance scenarios is as follows:

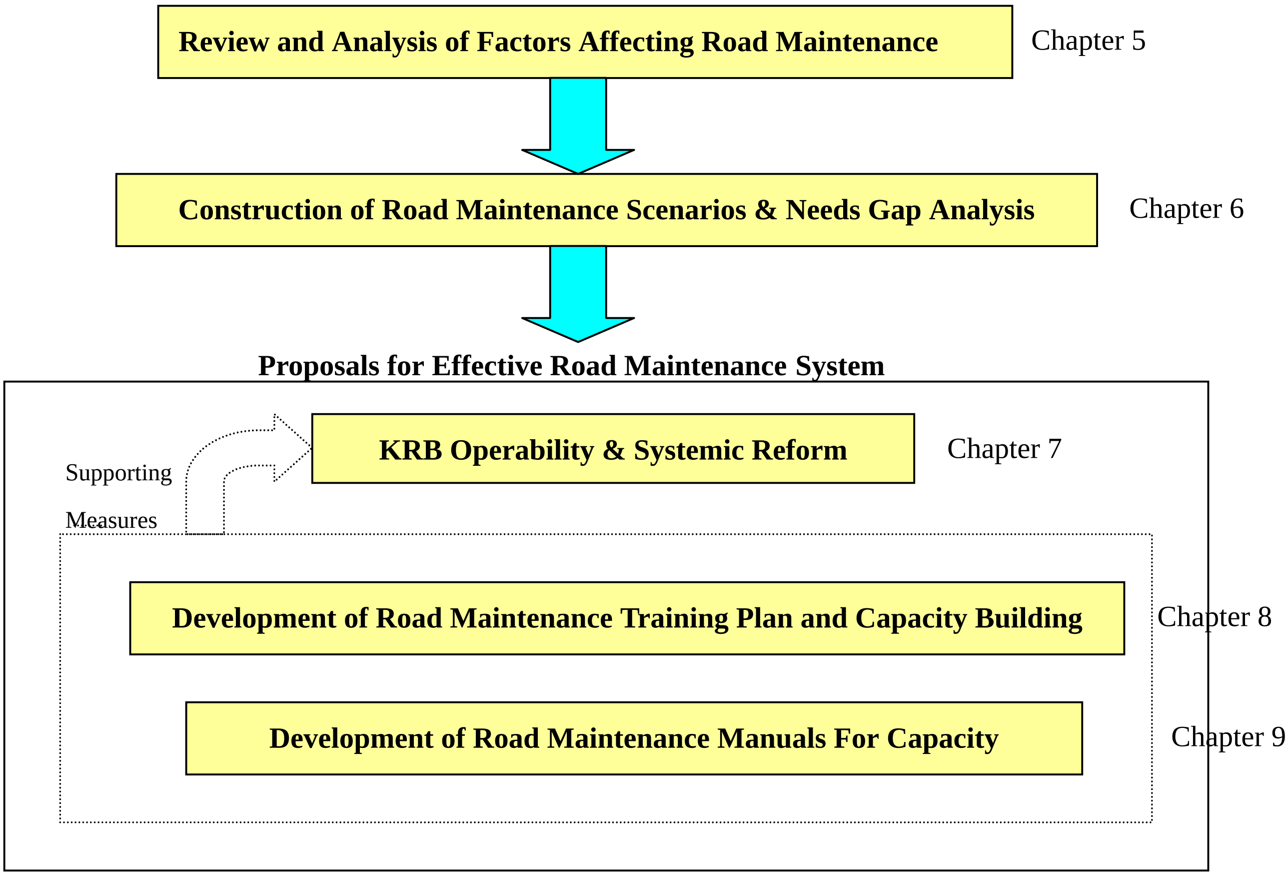

Figure 4.2.1 Approach for Drawing Up Proposals for an Effective Road Maintenance System

CHAPTER 5

REVIEW AND ANALYSIS OF FACTORS AFFECTING ROAD MAINTENANCE

CHAPTER 5 REVIEW AND ANALYSIS OF FACTORS AFFECTING ROAD MAINTENANCE

5.1 General

For the purposes of good, consistent management, the most useful way to classify maintenance activities is in terms of their frequency, which can be defined as follows:

- **Routine** maintenance: works that may need to be undertaken each year either continually through the year or at intervals during the year
- **Periodic** maintenance: works that are planned to be undertaken at intervals of several years
- **Emergency** maintenance: works whose frequency cannot be determined but require immediate action

Table 5.1.1 shows some typical examples of each type of maintenance work.

Table 5.1.1 Typical Maintenance Activities by Maintenance Type

Maintenance Type	Activity
Routine	Bush clearing
	Drain cleaning
	Road sign maintenance
	Pothole patching
	Grading
	Crack sealing
Periodic	Re-gravelling
	Resealing
	Road markings
	Overlays
Emergency	Removal of debris or obstacles

A number of physical factors affect the frequency and nature of road maintenance works. The key factors are:

- Road Surface Type
- Traffic Flows and Composition
- Road Surface Condition
- Climate
- Terrain

Combinations of the above factors can have a significant impact on road maintenance expenditure, e.g. earth roads in wet climate zones or any road surface type with a high heavy goods vehicle content. The design and the quality of construction of the original pavement will also play a major part in likely future maintenance works. Each of these factors is discussed in the following sections.

5.2 Road Surface Type

Table 5.2.1 shows the lengths of classified and unclassified roads for each road surface type:

Table 5.2.1 Road Length by Surface Type for Classified and Unclassified Roads

Province	Road Class	Premix	Surface Dressed	Gravel	Earth	Total (km)
All Provinces	Classified (km)	1,508.4	7,163.3	27,901.7	27,368.5	63,941.9
	(%)	2.4	11.2	43.6	42.8	100.0
All Provinces	Unclassified (km)	2,128.8		6,465.1	125,441.4	134,035.3
	(%)	1.6		4.8	93.6	100.0
Total	All Roads (km)	3,637.2	7,163.3	34,366.8	152,809.9	197,977.2
	(%)	1.8	3.6	17.4	77.2	100.0

Source: Schedule of Classified Roads in 1996; Annual Management Maintenance Needs of Local Authorities, May 1998; 1994 Local Authorities Road Inventory Survey

*Note: According to the Ministry of Roads and Public Works, the length of the unclassified road network is 94,161.1km, resulting in a total road network of only 158,103.0km.

As can be seen from the table, over 86% of the classified road network was unpaved in 1996 and over 98% of the unclassified road network was unpaved in 1994 (Local Authorities Road Inventory Project). This means that 95% of the entire road network in Kenya is unpaved.

Table 5.2.2 Road Condition by Surface Type for Classified Roads

Item	Paved Roads (km)				Unpaved Roads				Total Km
	Good	Fair	Critical	Failed	Good	Fair	Poor	Bad	
All Provinces	2,588.3	3,257.4	1,505.4	1,452.6	631.0	30,640.7	18,120.0	5,467.9	63,663.3
%	29.4	37.0	17.1	16.5	1.2	56.9	33.0	10.0	

Source: Strategic Plan for the Roads Sector, March 1997.

Note that the total km in Table 5.2.2 is 278.6km lower than that in Table 5.2.1. This is due to some corrections made to the data during the preparation of the 1997 report.

For the classified road network (Table 5.2.2), 66.4% of the paved roads were in a Good or Fair condition and 57.1% of the unpaved roads were in Good or Satisfactory/Fair condition in 1997. Note that 33.6% of the paved network was either in a critical condition or had already failed.

Table 5.2.3 Road Condition by Surface Type for Unclassified Roads

Province		Paved				Unpaved			Total (km)
		Good	Fair	Poor	Bad	Good	Fair/Poor	Bad	
All Provinces	Km	65.6	1,106.3	951.0	5.9	6,211.8	54,596.4	69,090.2	132,027.2
	%	3.1	52.0	44.6	0.3	4.8	42.0	53.2	

Source: Annual Management Maintenance Needs of Local Authorities, May 1998; 1994 Local Authorities Road Inventory Survey.

Note that the total km in Table 5.2.3 is 2008.1km less than that in Table 5.2.1. There is no explanation of the differences in the report.

For the unclassified roads (Table 5.2.3), 55.1% of the paved roads were in Good or Fair condition and 46.8% of the unpaved roads were in a Good or Fair/Poor condition from the 1994 survey.

Table 5.2.4 Roads in a Maintainable and Non-Maintainable Condition

Province	Road Class	Maintainable			Non-Maintainable		
		Paved	Unpaved	Total	Paved	Unpaved	Total
All Provinces	Classified (km)	7,351.1	49,391.7	56,742,8	1,452.6	5,467.9	6,920.5
	%	11.5	77.6	89.1	2.3	8.6	10.9
All Provinces	Unclassified (km)	2,122.9	60,808.2	62,931.1	5.9	69,090.2	69,096.1
	%	1.6	46.1	47.7	0.0	52.3	52.3
Total	All Roads (km)	9,474.0	110,199.9	119,673.9	1,458.5	74,558.1	76,016.6
	%	4.8	56.3	61.1	0.7	38.1	38.8

Table 5.2.4 shows the lengths and percentages of roads in maintainable and non-maintainable condition. For defining maintainable and non-maintainable, we have assumed that roads in a Bad or Failed condition are non-maintainable and need rehabilitation. For the classified roads, 56,742.8km (89.1%) and for the unclassified network, 62,931.1km (47.7%) are in a maintainable condition. On the basis of these assumptions, 119,673.9km (61.1%) of the entire network is in a maintainable condition. It must be remembered that this data is up to 7 years old and so the figures may be considerably different today. The road condition data requires to be updated urgently to enable sensible decisions on maintenance works to be made.

Unpaved roads need a program of regular and systematic attention.

Earth Roads

For grading works, the maintenance engineer must decide how many times during a year each unpaved road needs to be graded to provide the best level of service possible in the local conditions. In assessing this, he/she will have to take into account a range of factors including the road material, the traffic volume and type, local topography and climate. The objective should be to achieve year-round accessibility with the appropriate level of service on key selected roads in the network. The available funds may prevent the whole network being maintained in this way.

Research has been undertaken in Kenya by UK's Transport Research Laboratory (TRL) and grading frequency curves are available as an indicator to maintenance staff. The frequency will vary with the different factors mentioned above, particularly with regard to traffic and climate. Figure 5.2.1, which is taken from TRL Overseas Road Note 1, is shown as an example.

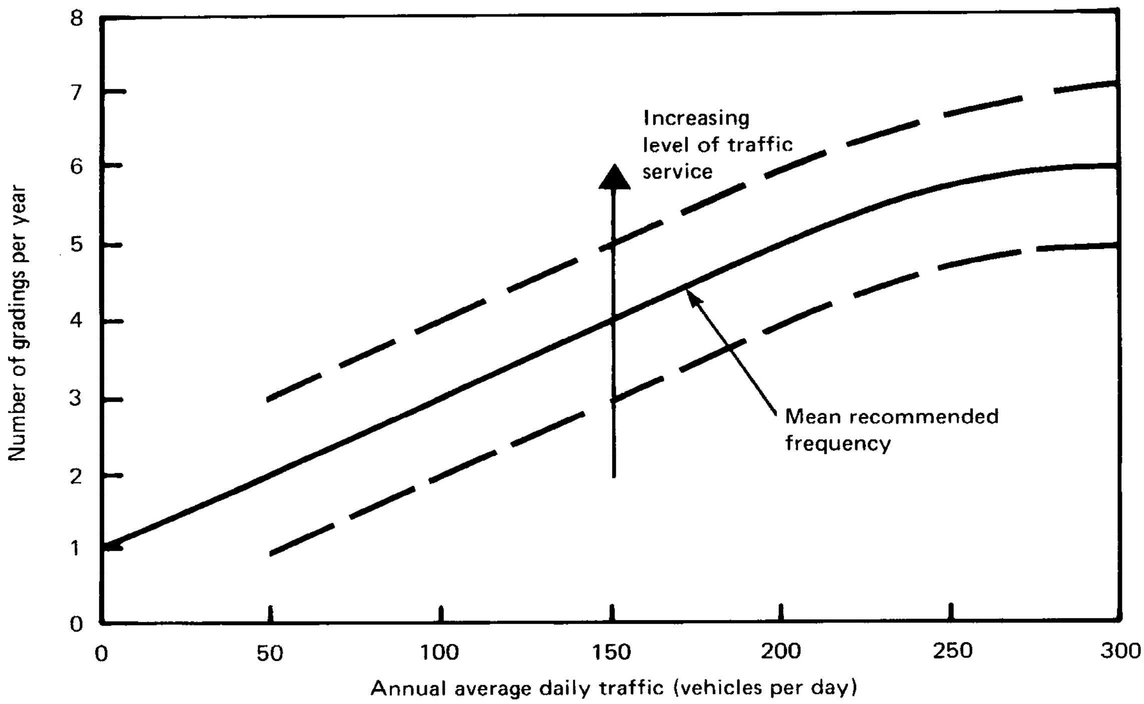

Figure 5.2.1 Grading Frequency Chart

By carrying out systematic monitoring of unpaved roads over a number of years, the local engineers should be able to determine the most appropriate frequency for grading works for the unpaved roads under their control. The frequencies will differ from province to province and may also differ from district to district within one province where a wide geographical area may have varied climate types.

Ideally, an appropriate frequency of grading should be identified for each individual road. However, it is more practical to determine optimum grading frequencies for groups of roads with similar traffic levels, similar material types and sizes, and sharing similar climatic conditions and other features. The more often a road is graded, the smoother its surface and the less deterioration there will be between successive grading works. The end result will be lower vehicle operating costs on the road. The aim is to choose a grading frequency that minimizes the sum of the maintenance costs and vehicle operating costs during a maintenance year.

Gravel Roads

Gravel roads, in addition to grading, require re-gravelling periodically when the gravel becomes unacceptably thin. The intervention level needs to be determined on a regional basis, but a typical example would be where the gravel layer has become less than 50mm thick for more than 20% of the section of road being inspected. Re-gravelling frequency will also be effected by the various factors listed above but again climate, traffic and terrain will be most influential.

It is very important to control and monitor gravel thickness during initial construction and re-gravelling works. This is important both for maximizing the life of the road and for making the correct payment to contractors, since it is very difficult to check the gravel depth later as there will always be reasons why the depth may be less than expected.

Paved Roads

For paved roads, the rate of pavement deterioration is a complex function of the pavement strength, material type, traffic volume and loading, climate and sub-grade type. Pavements deteriorate slowly at first and this can be almost imperceptible when pavements are well designed and constructed. Eventually, surface distress begins to appear, through the simultaneous actions of weathering and traffic loading, in the form of cracking, raveling, rutting, potholes and an increase in roughness.

The standards to which pavements are maintained affect their future performance and also the cost of maintenance works. In order to protect the money invested in a road network, it is important to detect defects as early as possible through regular visual inspections of the road surface. The road inspection process will be covered in the maintenance manuals that are to be produced later on in the study. The maintenance engineer must interpret the inspection results so as to decide when and where repairs are needed and what form of maintenance activity is required. Intervention levels should be set to identify the point at which the maintenance engineer should intervene and the action he should take to stop further deterioration.

It is also important to identify the cause of the defect and to put this right if possible rather than just to treat the symptom. For example, there is little point in continually filling in potholes if they keep occurring only because of poor drainage. Finding the real problem and focusing attention on its solution will produce more cost-effective use of maintenance resources.

5.3 Traffic Flows and Composition

Table 5.3.1 shows the median number of vehicles by road class for 1997. This data is based on traffic census data for 1,852 survey stations. Unfortunately, we are not able to convert this to national travel volumes, as there are no conversion factors and no reliable vehicle-kilometer parameters available for Kenya.

Table 5.3.1 The Median Number of Vehicles by Road Class for 1997

Road Class	Number of Survey Stations	Number of Vehicles (7am – 7pm) (Median)
A	254	1,721
B	208	1,205
C	630	290
D	423	68
E	337	33

Note: Kenyan Traffic Census Data for 1997.

It is recognized that Heavy Goods Vehicles (HGVs) cause the most damage to road pavement, so it is important to look at the HGVs on the roads in Kenya.

Table 5.3.2 shows the traffic mix for each road class. It can be seen that for Class A Roads the HGV percentage is 17.6%. For the other classes of road the percentages are 8.1% for Class B, 4.3% for Class C, 2.3% for Class D and 2.5% for Class E. The HGV percentage is very important, particularly for the design of the original pavement, as well as for determining a suitable maintenance profile for the road. HGVs will greatly influence the life of the pavement and the likely need for interventions, including patching, overlays and reconstruction. For unpaved roads, it will affect the frequency of grading and re-gravelling.

Table 5.3.2 % Vehicle Composition for Each Road Class

Road Class	Car	Light Goods	Matatu	Medium Goods	Medium Tanker	Heavy Goods	Heavy Tanker	Buses	HGV %	Total
A	28.7%	21.7%	22.2%	1.1%	8.6%	2.1%	11.4%	4.1%	17.6%	100.0%
B	29.3%	26.8%	27.0%	0.6%	8.1%	0.7%	3.7%	3.7%	8.1%	100.0%
C	30.3%	28.2%	28.8%	0.7%	7.6%	0.3%	1.9%	2.1%	4.3%	100.0%
D	24.7%	37.6%	25.8%	0.8%	8.9%	0.3%	0.8%	1.2%	2.3%	100.0%
E	23.0%	42.0%	22.9%	0.7%	8.9%	0.1%	1.5%	0.9%	2.5%	100.0%

Source: Analysis based on data from the Kenyan Traffic Statistics for 1997.
Note: A Matatu is a vehicle licensed to carry fare-paying passengers and is usually a minibus or small coach.

The availability of reliable and regular traffic data is of great importance to the Highway Engineer in both the design and maintenance of roads. The development of national average annual daily traffic figures, vehicle-kilometer parameters and HGV percentages are crucial totals in the overall control of the road network and in the design and planning of new roads and maintenance programs.

To help speed up the work of the Traffic Team in the Roads Department of the Ministry of Roads and Public Works, our Study Team has provided them with an EXCEL spreadsheet to simplify traffic data entry and to enable computer based analysis of the traffic data to be carried out for the first time.

5.4 Road Surface Condition

The road surface condition at the start of any maintenance evaluation period will affect the maintenance works to be done during that period. For a new road, off-road maintenance will remain the same but the surface works should be minimal. For a pavement 5 to 10 years old, the surface works will involve crack sealing, pothole patching, repairs to rutting and so on.

Maintenance evaluation models, such as Version 4 of Highway Development and Management model (HDM4), require the existing road condition to be inputted and then they use empirically derived deterioration curves to assess the likely maintenance works and costs.

Obtaining recent or historic road data for Kenya has been very difficult. Without such data, it is very hard to carry out any scientific or technically valid analysis. Historic maintenance data is essential to understand the deterioration of the roads in Kenya, to establish likely future maintenance cost profiles, and to determine the future life of the road and appropriate maintenance programs for the future.

It appears that the current Annual Maintenance Work Plans are left to the experience and discretion of the engineers in each district. Whereas many of these engineers are very experienced, none can be expected to have experienced all types of pavement defects, their causes and appropriate solutions. At present, road agencies, HQ staff and the KRB have no way of telling whether the correct road sections are included in these Work Plans. This also means that there is no way at present to check whether the road maintenance funds are being used in the most effective way.

A national system of guidance for the preparation of such Work Plans is required and an initial starting point is to have regular road condition survey data. There are a number of ways to establish the road condition, with some involving expensive high technology equipment not appropriate for Kenya at this stage of the development of its road sector. The following methods may be suitable for Kenya at this time.

Bump Integrator Method

The Bump Integrator (BI) is a well-tried and well-established technique for establishing the roughness of a road surface. The BI is used in Kenya by the Materials Branch of the MORPW and by the MOLG. If a BI survey was carried out over the whole network on a regular basis, then district engineers, HQ staff, road agencies and KRB would have a good indicator as to the sections of road in good, fair, and poor condition. Engineers could then quickly focus their maintenance Work Plan based on the BI survey and could also call for additional investigation on poor sections where there will be options for continuing routine maintenance, carrying out some periodic maintenance or allocating the section for rehabilitation or reconstruction. The choice is difficult to assess without a detailed investigation and lifecycle cost comparisons.

The Materials Branch of the Roads Department of MORPW has one BI in use and MOLG has purchased one BI under the KUTIP project and intends to use it for annual condition surveys. This work needs to be coordinated and one or two additional BIs and towing vehicles may need to be purchased. Annual surveys could then be carried out on behalf of KRB or the Road Agencies on an annual contracted basis. The Materials Branch and/or MOLG could also carry out an analysis of the BI surveys and undertake more detailed investigations where necessary in support of the Road Agencies.

There may be private sector consultants who would be willing to carry out such surveys and analysis if there was to be a guaranteed workload and reliable cash flow to recoup the cost of the equipment purchase and staff training required.

Drive-Through Method for Road Roughness

In Ghana, a drive-through method that relates vehicle speed to road roughness is in use. This is not so exact but is used when the lack of resources restrict the use of more sophisticated methods.

The method is based on vehicle travel speed, which they believe to be a good indicator of road condition. Figure 5.4.1, which is for unpaved roads, shows the conversion used in Ghana from vehicle speed to a Bump Integrator (BI) value or to an International Roughness Index (IRI), which are internationally accepted roughness parameters that can be used to determine maintenance priorities. They have been running this system for several years now and the correlation between vehicle speed and IRI is getting better as more data becomes available.

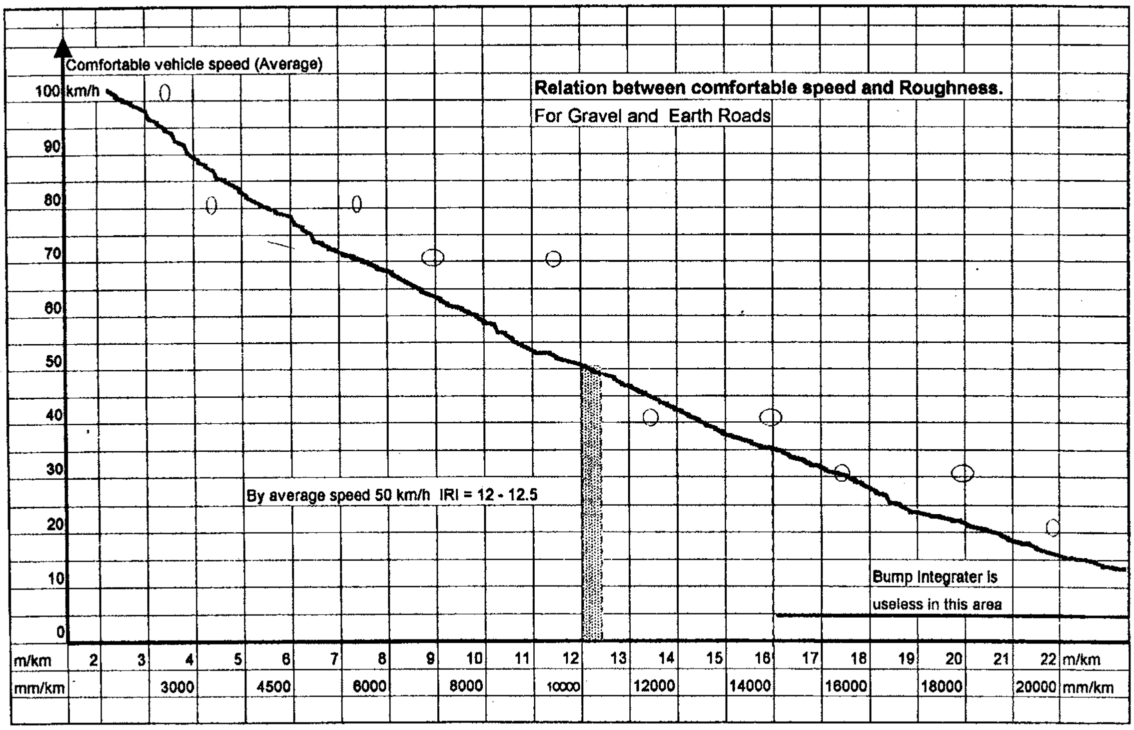

Figure 5.4.1 Relationship between Road Roughness & Vehicle Speed

This method needs calibration against more traditional methods to ensure the conversion curve from speed to IRI is reliable. However, the method, once calibrated, is simple, does not involve expensive equipment, and after a minimum amount of training can be carried out by staff in the District.

As with the BI survey, road agencies, HQ staff, and KRB would have an indicator as to the sections of road in good, fair, and poor condition and the Work Plans can be focused in accordance with the survey findings.

Present Serviceability Rating (PSR)

This is an alternative method proposed in the MORPW Road Design Manual, Part V, Section 4.1 (c). This involves a group of trained raters who ride in a vehicle over the pavement sections and observe the riding quality. The ratings are assessed from 0 (very poor) to 5 (very good). This method was developed as part of the AASHTO pavement evaluation program. This method requires good training of the raters and relies on human judgment and so will never be as uniform as a machine-based method.

Present Serviceability Index (PSI)

Again, this is an alternative method proposed in the MORPW Road Design Manual, Part V, Section 4.1(c). This method requires more detailed investigations of rutting, cracking and crazing, patching and potholes and so is more time consuming to arrive at a PSI Value.

Roads 2000 Road Condition Survey

This procedure includes both the pavement condition and that of the drainage and culverts, which are crucial in protecting the long-term life of pavement. The assessor can collect most of the data sitting in a vehicle but will need to alight to check culverts for silting or damage and to assess emergency or spot improvement needs. A standard form has been developed for the survey.

Recommendation

A priority for KRB must be to establish a system for national condition surveys to enable some measure of control over the effective allocation of road maintenance funds. This should be discussed with all the road agencies and should involve those with experience of such surveys and analysis.

The Bump Integrator Method is probably the most suitable for Kenya as it is already in use and the technology is well understood. Other more sophisticated methods are available and these should also be reviewed for future consideration, bearing in mind the cost implications. The Drive-Through Method appears to be simple but less accurate than other methods and requires calibration for Kenya. The Roads 2000 method has been used in Kenya and could be considered for expanded use, but since it relies on human judgment it perhaps should only be used on the gravel and earth road network with the BI method used for the paved road network. Whatever method or methods are adopted, the objective is to achieve a uniform ranking system over as much of the network as possible so that a national overview is possible for decision making.

In the future, maintenance records should be retained on a computer database to enable engineers to monitor the maintenance activities and costs for each road surface type. It is important to understand the variations for road surface types and the other physical factors. By studying past activities it is possible to build up typical maintenance activity profiles for the different road types and by applying agreed unit rates to these activities, a projected maintenance budget can be calculated.

By carrying out this exercise and comparing the budget to anticipated revenues available to KRB, it is possible to determine whether all of the network can be maintained to an agreed level of service or whether a core network should be identified as the main focus for the maintenance budget.

5.5 Climate

Figure 5.5.1 shows a moisture map of Kenya indicating the 4 climate zones:-

- Moist Sub-Humid
- Dry Sub-Humid
- Semi Arid
- Arid

The figures in the key on Figure 5.5.1 are moisture indices based on the Thornthwaite Formula. They indicate a moisture deficit, based on the amount of precipitation, the amount of evaporation and the moisture demand in the area. Details of the Thornthwaite formula can be found in the National Atlas of Kenya, Fourth Edition 1991, page 46. As can be seen, the vast majority of the country is in an Arid or Semi Arid moisture zone.

Figure 5.5.2 shows the rainfall map of Kenya. The western and central areas of Kenya have the heaviest annual rainfall.

Over many years of investigation throughout the world, it has been shown that water is the most common cause of pavement failures. This can be due to water penetrating pavement through surface cracks, water in pavement layers due to inadequate drainage, wash out and erosion of slopes due to inadequate drainage, etc. The common theme is water and so it is likely that there will be more pavement problems in the wetter areas of the country than the drier areas.

In these areas it is essential that the pavement and drainage design takes account of the climate condition and the maintenance regime should also pay particular attention to the sealing of cracks, repairing potholes and attention to drainage problems before these defects develop into much more expensive repair items.

Earth and gravel roads will be particularly prone to damage in the wet areas of the country during the wet season. The local engineers should be aware of the key roads in the network that have problems. Where these problems occur on a regular basis, consideration should be given to upgrading the road from earth to gravel or from gravel to paved where economic to do so. Although the upgrade cost is high, over the life of the pavement, the maintenance cost is reduced and such considerations should be made for key roads in the network.

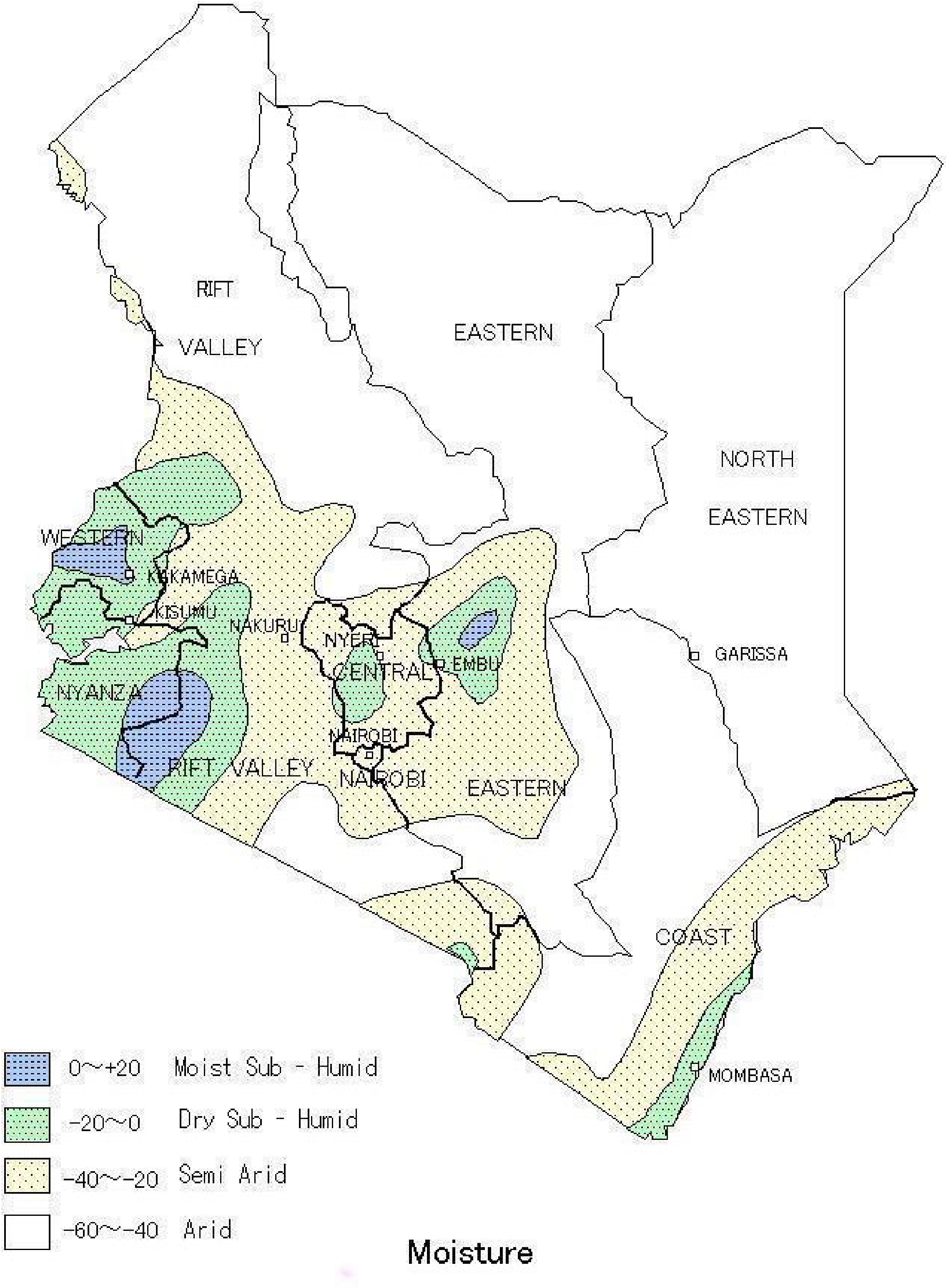

Figure 5.5.1 Moisture Map of Kenya

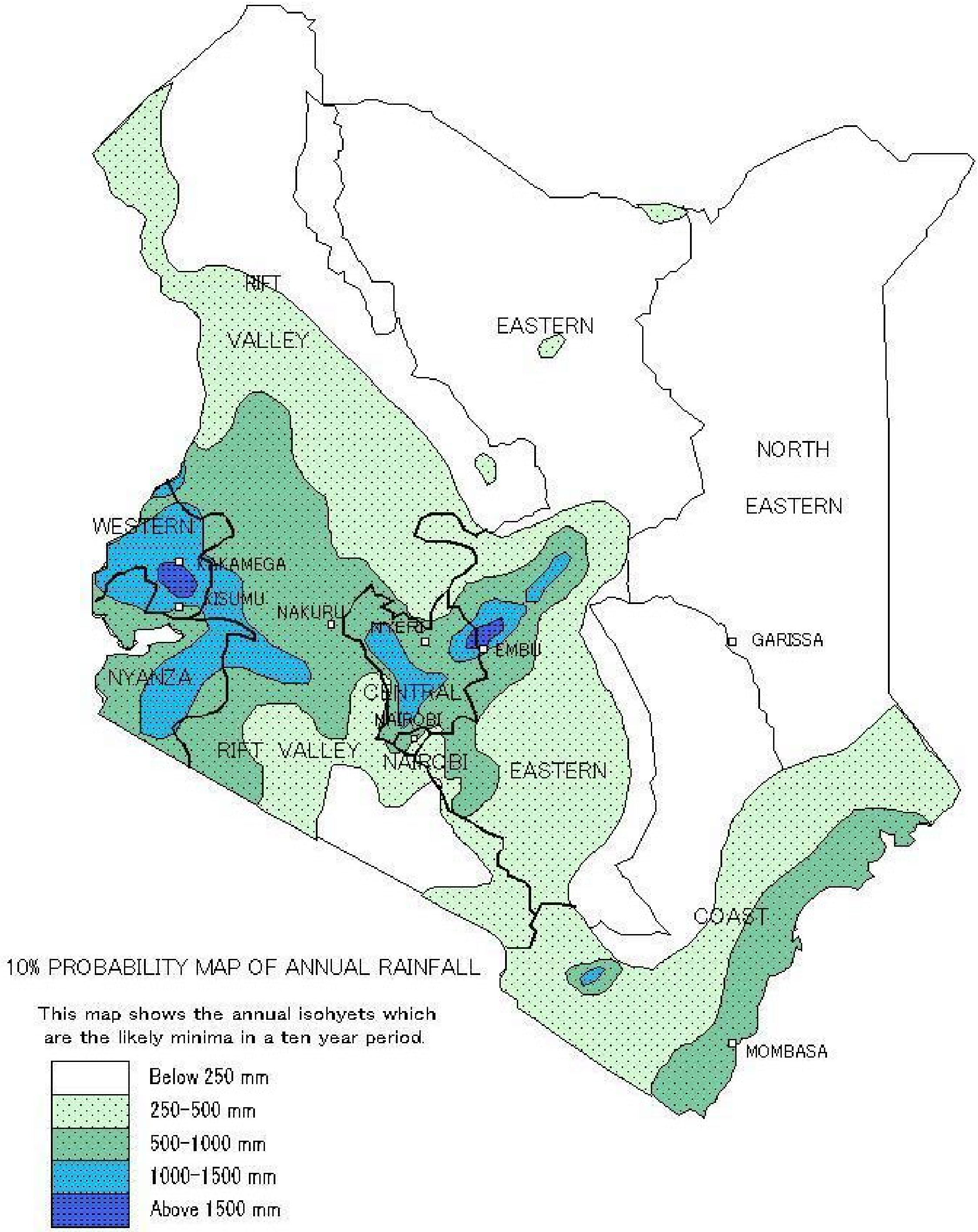

Figure 5.5.2 Rainfall Map of Kenya

5.6 Terrain

Terrain can have an impact on road maintenance. In hilly or mountainous areas, the drag effect on the road surface from a vehicle tire is much more significant particularly from Heavy Goods Vehicles (HGVs). The effect is much more noticeable on earth and gravel roads but sometimes even on paved roads where perhaps a soft bitumen has been used, rippling effects on the road surface can be observed.

The drainage in hilly and mountainous areas also needs special care. Water travels at higher speeds and so the scour and erosion effects will be more noticeable.

Varying geological conditions can also have an impact on maintenance works particularly in areas with difficult ground conditions, such as Black Cotton Clay, which can cause serious problems for roads. Proper account of such materials should be taken during the design of the roads pavement.

5.7 Summary of Key Factors Affecting Road Maintenance

Based on the above review and analysis, a summary of the most important key factors that affect road maintenance in Kenya can be broken down into physical and non-physical factors. These are described below and some recommendations made.

Physical Factors

The key physical factors having the largest effect on the maintenance of the Kenyan national road network are as follows:

- Over 86% of the classified road network is unpaved (as of 1996).
- Over 98% of the unclassified road network is unpaved (as of 1994).
- Approximately 95% of the entire road network in Kenya is unpaved.
- Approximately 33.6% of the classified paved network is either in critical condition or has already failed (as of 1997).
- Of the 197,977 km of roads in Kenya (refer to *note in Table 5.2.1 that quotes 158,103.0 km,), 119,673.9km (61.1%) were in a maintainable condition based on the data available, which is up to 7 years old.

Non-Physical Factors

Obtaining the relevant data for road maintenance in Kenya has proved very difficult. Road condition data is up to 7 years old and traffic data is 4 years old. We have been unable to obtain any historic maintenance data to establish maintenance work profiles. The analysis of the annual work plans showed such a large degree of variance that this data was considered to be too unreliable to be used in our study.

Current traffic and road condition data are essential to deciding on future maintenance works and the associated costs. Without such data, those allocating the funds have no way of telling whether the correct road sections are included in the Work Plans. This also means that there is no way at present to check whether the road maintenance funds are being used in the most effective way.

Historic maintenance data is essential to understand the deterioration of the roads in Kenya, to establish likely future maintenance cost profiles, to determine the future life of the road and appropriate maintenance programs and budgets for the future.

For HDM4, where no data was available or the data was considered unreliable, alternative sources were found or international experience was used and where possible adjustments made for local conditions in Kenya.

Recommendations

We strongly recommend that attention be paid to the following items in order to carry out reliable analyses, which are crucial for the effective management of the road system, as well as to ensure that value for money is obtained from road investments.

(1) **Road condition data requires to be updated urgently** to enable sensible decisions on maintenance to be made and to provide a basis for the justification for the allocation of funds.

(2) **In the future, maintenance records should be retained on a computer database** to enable engineers to monitor the maintenance activities and costs for each road surface type.

(3) **A national system of guidance for the preparation of Work Plans is required including a review of unit rates for maintenance works.**

(4) **The design and the quality of construction of the original pavement need to be strictly controlled** to ensure the maximum life from pavement in order to get value for money from road investments.

CHAPTER 6

DEFINING THE NEEDS OF THE ROAD MAINTENANCE SYSTEM

CHAPTER 6 DEFINING THE NEEDS OF THE ROAD MAINTENANCE SYSTEM

6.1 General

The purpose of this chapter is to define the (funding) needs of Kenya's road network, as well as the types of scenarios that may be necessary to satisfy those needs. This is carried out via the methodology described in Section 6.2 below. Based on this methodology, a model is constructed and applied to assess the future costs and benefits that arises from maintaining Kenya's road network at different levels of service, and various future funding and cost-reduction scenarios are examined with an eye towards the realization of these service levels.

6.2 Methodology for Analyzing Funding Needs & Scenario Implementation

The methodology applied to determine the funding needs of Kenya's road network and the possible scenarios to meet those needs is as shown in Figure 6.2.1 below.

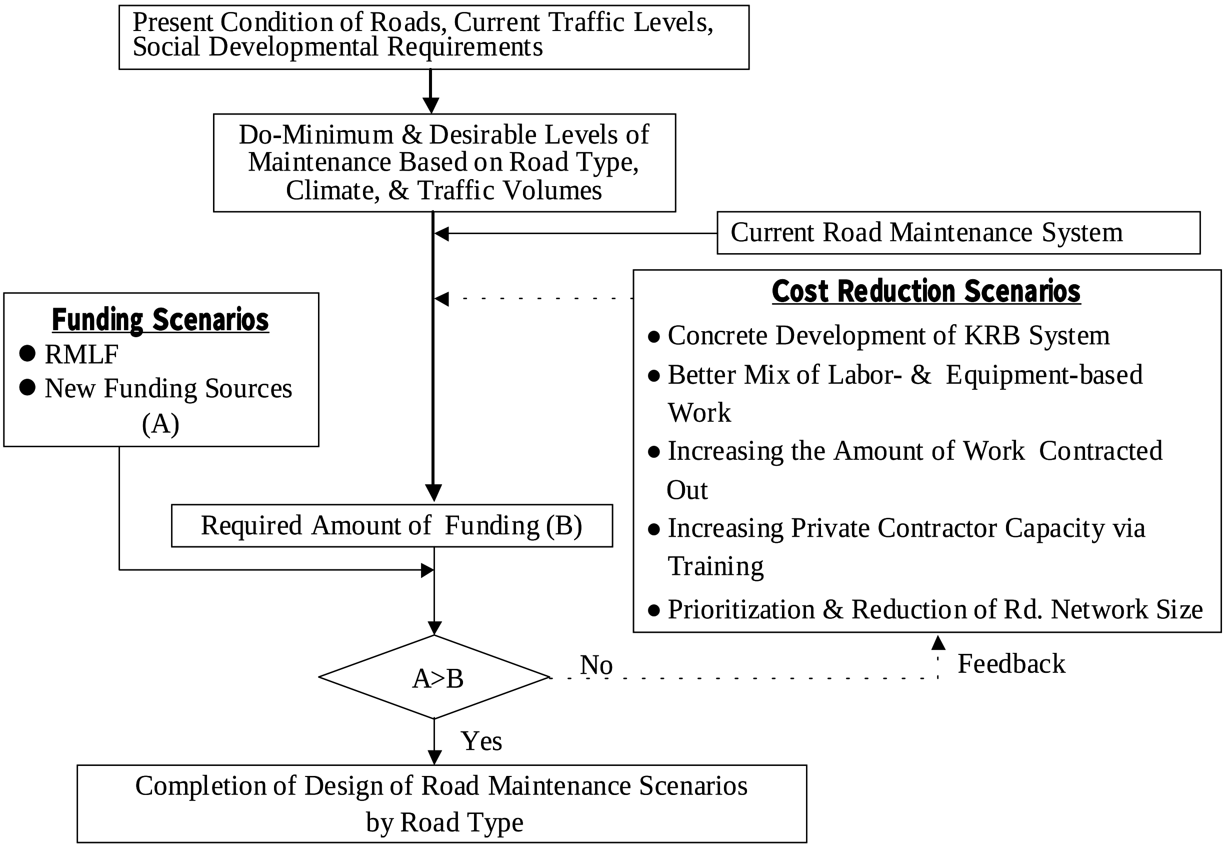

Figure 6.2.1 Workflow for Needs Gap Analysis

As the above figure indicates, the amount of funding required will be calculated for a Do-Minimum Case and a Desirable Case based on defined minimum and desirable standards of maintenance. Then, the costs for these two cases will be compared with present funding levels to assess any shortfall, which will be shown later to exist. Funding and cost-reduction scenarios are then examined with the purpose of eliminating this shortfall either by increasing revenue or decreasing costs. Finally, a funding structure for the Kenya Roads Board (KRB) will be recommended.

6.3 Calculation of Funding Needs

6.3.1 Introduction

In order to calculate the costs and benefits of road maintenance, which in turn determines funding needs, the Study Team has constructed models using the Highway Development and Management Model (version 4), or HDM-4.

The factors affecting the model's analysis were discussed in Chapter 5. These factors now have to be developed into appropriate model input parameters. The key factors in developing the models are:

- Road Maintenance Profiles
- Road Class, Surface Type and Condition
- Climate and Terrain
- Traffic Flows and Composition
- Socio-Economic Costs
- Unit Costs for Maintenance Works

The development of these parameters is explained in Section 6.3.2 below.

6.3.2 Modeling of Costs and Benefits for Road Maintenance Profiles

Road Maintenance Profiles

In order to determine road maintenance interventions, or the frequency at which maintenance works are executed, it is necessary to determine the serviceability levels of a road via for example a roughness index. This may be achieved by using the Overseas Road Note 5 published by the UK's TRL, which gives a table of road roughness values for different serviceability levels (see Table 6.2.1). The table gives a range of IRI (international roughness index) and BI (bump integrator) values for serviceability descriptions for both paved and unpaved roads.

Based on this table of descriptions and experience in Kenya, it is possible to set intervention levels as a guide for road engineers.

Table 6.3.1 Road Roughness Values for Different Road Serviceability Levels

Paved roads			Unpaved roads		
Serviceability description	M/km IRI	Mm/km BI	Serviceability description	M/km IRI	Mm/km BI
Ride comfortable over 120km/h. Undulation barely perceptible at 80 km/h in range 1.3 to 1.8. No depressions, potholes, or corrugations are noticeable: depressions <2mm/3m. Typical high quality asphalt 1.4 to 2.3. High quality surface treatment 2.0 to 3.0.	1.5-2.5	1000-2000	Recently bladed surface of fine gravel, or soil surface with excellent longitudinal and transverse profile (usually found only in short lengths)	1.5-2.5	1000-2000
Ride comfortable up to 100-120 km/h. At 80km/h, moderately perceptible movements or large undulation may be felt. Defective surface: occasional depressions, patches or potholes (e.g., 5-15mm/3m or 10-20mm/5m with frequency 1-2 per 50m) or many shallow potholes (e.g., on surface treatment showing extensive ravelling). Surface without defects: moderate corrugations or large undulations.	4.0-5.5	3000-4000	Ride comfortable up to 80-100km/h. Aware of gentle undulations or swaying. Negligible depressions (e.g., < 5mm/3m) and no potholes.	3.5 –4.5	2500-3500
Ride comfortable up to 70-90 km/h, strongly perceptible movements and swaying. Usually associated with defects: frequent moderate and uneven depressions or patches (e.g., 15-20mm/3m or 20-40mm/5m with frequency 5-3 per 50m). Occasionally potholes (e.g., 1-3 per 50m). Surface without defects: strong undulations or corrugations	7.0-8.0	5500-6500	Ride comfortable up to 70-80 km/h but aware of sharp movements and some wheel bounce. Frequent shallow to moderate depressions or shallow pot-holes (e.g., 6-30mm/3m with frequency 5-10 per 50m). Moderate corrugations (e.g., 6-20/0.7-1.5m)	7.5-9.0	6000-7000
Ride comfortable up to 70-90 km/h, strongly perceptible movements and swaying. Usually associated with defects: frequent moderate and uneven depressions or patches (e.g., 15-20mm/3m or 20-40mm/5m with frequency 5-3 per 50m). Occasionally potholes (e.g., 1-3 per 50m). Surface without defects: strong undulations or corrugations	9.0-10.0	7000-8000	Ride comfortable up to 50 km/h (or 40-70 km/h on specific sections). Frequent moderate transverse depressions (e.g., 20-40mm/3-5m at frequency 10-20 per 50m) or occasional deep depressions or potholes (e.g., 40-80 mmm/3m with frequency less than 5 per 50m). Strong corrugations (e.g., <20 mm/ 0.7-1.5m).	11.5-13.5	9500-11500
Necessary to reduce velocity below 50 km/h. Many deep depressions potholes and severe disintegration (e.g., 40-80 mm deep with frequency 8-16 per 50m).	11.0-12.0	9000-10000	Ride comfortable at 30km-40km/h. Frequent deep transverse depression and/or potholes (e.g., 40- 80mm/1-5m with frequency less than 5 per 50m) with other shallow depression .Not possible to avoid all the depressions expect the worst.	16.0-17.5	14000-15000
			Ride comfortable at 20-30km/h. Speed higher than 40-50 km/h would cause extreme discomfort and possible damage to the car. On the good general profile: frequent deep depression and/or pot-holes (e.g., 40-80 mm/1-5m and occasionally very deep depressions (e.g., <80mm/ 0.6-2m) On a poor general profile: frequent moderate defects and depression (e.g., poor earth surface).	20.0-22.0	18000-20000

In the MORPW's "Road Design Manual Part V Pavement Rehabilitation and Overlay Design", in sections 5.1 and 5.2 of Chapter 5, intervention levels are included that are based on the UK's TRL findings regarding surface condition criteria and surface roughness criteria.

The intervention levels on roughness in the MORPW Design Manual are shown below.

Roads require resurfacing when surface irregularity measured by a bump integrator exceeds the following values:

- Trunk Roads 2,800 mm/km (IRI = 4)

Roads require overlay or reconstruction when the surface irregularity exceeds the following values:

- Trunk Roads 3,400 mm/km (IRI = 5)
- Other roads 3,750 mm/km (IRI = 5)

Equivalent IRI numbers shown in the brackets above are derived using a conversion formula from the TRL's Overseas Road Note 5 (A Guide to Road Project Appraisal) and is as follows:

- m/km IRI = $0.0032^{0.89}$ (mm/km BI)

The above values require some review as if these are set too low, this could result in unnecessary intervention and considerable extra cost. Furthermore, experience in Kenya should be used to identify appropriate intervention levels.

Both the TRL table and the MORPW Design Manual would require IRI or BI values to be available to the road engineer, or for the engineer to be able to relate the physical condition of a road to an IRI or BI value. Overseas Road Note 1 (ORN1) gives tables of recommended interventions for paved and unpaved roads and also for structures and road furniture. These tables are shown below (Tables 6.3.2, 6.3.3, and 6.3.4). For unpaved roads, the grading frequency chart in Section 5.2 of Chapter 5 can be used as a guide to road engineers. However, actual experiences across Kenya should be collected and retained to provide better guidance for the local engineers.

Table 6.3.2 Maintenance Intervention Levels: Unpaved Roads

Defect	Level	Extent (% of sub-section length)	Action	Program	Notes
Gravel thickness	<50 mm	>20 %	Re-gravel	Periodic	
Camber Roughness Rutting Corrugation Potholes	(Various criteria: see ORN1)	-	Grade-drag	Routine	Planned on a programmed basis

Table 6.3.3 Maintenance Intervention Levels: Paved Roads

Defect	Level	Extent (% of sub-section length)	Climate/traffic category	Defect	Extent(%of sub-section length)	Action	Program	Notes
Stripping or fretting	Any	<10	All	_		Local sealing	Routine	A fog spray of emulsion may be sufficient to renew the surface
		>20	All	_		Surface dress		
Fatting –up or bleeding	_	_	All	_		No action	_	Local sealing or surface dressing may be required if the lack of skid resistance is a problem. In this case, the excess binder must be burned off first. Sanding is appropriate when live (shiny) bitumen is on the surface.
Pot-holes	Any	_	All	_		Patch	Routine	Extensive potholing may result from lack of effective maintenance or rapid deterioration of the road structure or surfacing. The cause must be determined and appropriate action taken
Edge damage	Erosion from original edge >150mm	>20	All	_		Patch road edge and repair shoulder	Routine	If the failure is severe or persists, reconstruct the shoulder
Edge step	>50mm	>50	All	_		Reconstruct shoulder	Period	
Wheeltrack rutting (surface dressing on granular base)	<10mm	_	Rainfall > 1500mm/yr or Traffic <1000 vpd	Wheeltrack Cracking	<5	Seal cracks	Routine	
					>5	Surface dress	Periodic	Single seals are often insufficient for wide cracks.
				Non-wheeltrack cracking	<10	Seal cracks	Routine	
					>10	Surface dress	Periodic	See note above
			Rainfall< 1500mm/yr AND Traffic< 1000vpd	Wheeltrack Cracking	<10	Seal cracks	Routine	
					>10	Surface dress	Periodic	See note above
				Non-wheeltrack cracking	<20			
					>20			
	10-15mm	>10	All	Any cracking	_	Treat cracks depending on extent as above	Routine/ periodic	If rate of change of rut depth is slow
						Further investigation	_	If rate of change of rut depth is fast
	>15mm	<10	All	Cracking only associated with local ruts	_	Patch	Routine	
				Other cracking	_	Patch excess rutting and treat cracks depending on extent as above	Routine/ periodic	
		>10	All	Any cracking	_	Further investigation	_	
				Other cracking	_	Patch excess rutting and treat cracks depending on extent as above	Routine/ Periodic	
		>5	All	Any cracking	_	Treat cracks depending on the extent as above	Routine/ Periodic	If rate of change of rut depth is slow
						Further investigation	_	If rate of change of rut depth is fast

Table 6.3.3 (Cont'd)

Defect	Level	Extent (% of sub-section length)	Climate/traffic category	Defect	Extent(%of sub-section length)	Action	Program	Notes
Wheeltrack rutting (asphaltic concrete on granular base)	<10mm	-	Rainfall >mm/yr or Traffic>1000 vpd	Any cracking	<5	Seal cracks	Routine	
					5-10	Surface dress	Periodic	Single seal are often insufficient for wide cracks.
					>10	Further investigation	_	
			Rainfall <mm/yr and Traffic<1000 vpd	Any cracking	<10	Seal cracks	Routine	
					10-20	Surface dress	Periodic	See note above
					>20	Further investigation	_	
	>10mm	<5	All	Cracking only associated with local ruts	_	Patch	Routine	
				Other cracking	_	Patch excess rutting and treat cracks depending on extent as above	Routine/ Periodic	
		>5	All	Any cracking	_	Treat cracks depending on the extent as above	Routine/ Periodic	If rate of change of rut depth is slow
						Further investigation	_	If rate of change of rut depth is fast
Wheeltrack rutting (asphaltic concrete or surface dressing on stablised road base)	<5mm	_	Rainfall>1500mm/yr or Traffc>1000 vpd	Any cracking	<10	Seal cracks	Routine	Includes reflection
					>10	Seal crack and surface dress	Periodic	
			Rainfall< 1500mm/yr or Traffc<1000 vpd	Any cracking	<20	Seal cracks	Routine	
					>20	Seal crack and surface dress	Periodic	
	5-10mm	>10	All	Any cracking	_	Treats cracks depending on extent as above	Routine/ Periodic	If rate of change of rut depth is slow
						Further investigation	_	If rate of change of rut depth is fast
	>10mm	<5	All	Cracking only associated with local ruts	_	Patch	Recurrent	
				Other cracking	_	Patch excess rutting and treat cracks depending on extent as above	Routine/ Periodic	
		>5	All	Any cracking	_	Further investigation	_	

Note that in Tables 6.3.2 to 6.3.4, we have converted the term Recurrent Maintenance used by TRL to Routine Maintenance.

Table 6.3.4 Maintenance Intervention Levels: Structures and Road Furniture

Elements	Defects	Level	Extent (% of sub-section length	Action	Program	Notes
Safety	Debris on road	Any	_	Remove	Urgent	This includes mud, stones and rocks trees, dead animals etc. Debris should be removed, where possible, by the inspection team. Where the volume of material requires additional labor or equipment, this should be reported.
	Broken down vehicles	Any		Inform traffic police	Urgent	These are especially dangerous at night. Temporary reflective warnings signs should be placed around the vehicle.
Side drains and turnouts	Silted/too shallow	Ditch depth reduced to less than 1 meter	Any	Clean out	Routine	Drainage faults should be corrected before the wet season starts. Long length of roads will need to be part of a special program.
	Scoured	Erosion channels in ditch	Any	1.Build check dams 2.Fill	Routine	In tropical countries, scour usually develops rapidly and can cause severe damage to roads. It must be repaired as soon as possible.
	Standing water after rain	Any	-	Realign to correct gradient	Routine	
Bridges and culvert	Silted or blocked	Visual assessment	_	Clean out	Routine	Drainage faults should be corrected before the wet season starts.
	Outfalls scoured	Any	_	1.Build scour control works 2.Fill	Routine	In tropical countries, scour usually develops rapidly and can cause severe damage to structures. It must be repaired as soon as possible.
	Structural damage	Any	_	Repair	Routine	
Road Furniture	Dirty	Any	_	Clean	Routine	Includes warning signs, informatory signs, kilometre posts, bridge and culvert markers, bridge handrails, guardrails, etc.
	Damaged or corroded	Any	_	Repair, repaint or replace	Routine	
	Missing	Any	-	Replace	Routine	
Shoulders and side-slopes	Deformation	Visual assessment	>20	Fill/patch	Routine	
			>50	Reconstruct	Periodic	
	Scour	Visual assessment	>20	Fill/patch	Routine	
			>50	Reconstruct	Periodic	
	High vegetation growth	Interferes with line of sight	Any	Cut	Routine	

There is a wide range of intervention criteria available, with some being included in manuals in Kenya. For the future, these criteria need to be examined in the light of past experience around the country and refined to suit achievable performance targets. Over time, these can be revised and maintenance profiles and costs can be established as a good guide for future budgeting. The maintenance profiles established for this study are as shown in Table 6.3.5 to 6.3.8, and consist of a minimum and desirable maintenance profile for the different road surfaces. Due to an absence of historical maintenance data in Kenya, the maintenance profiles were determined after discussions with staff from MORPW and local consultants with experience in maintenance work and in the use of the HDM-4 model in Kenya.

Table 6.3.5 Maintenance Profiles for Earth Roads

Maintenance Profile	Average Traffic < 200 veh/day			
	Dry		Wet	
	Minimum	Desirable	Minimum	Desirable
Grading	1/year	2/year	1/year	3/year

Table 6.3.6 Maintenance Profiles for Gravel Roads

Maintenance Profile	All Traffic Groups			
	Dry		Wet	
	Minimum	Desirable	Minimum	Desirable
Grading	1/year	2/year	1/year	2/year
Gravelling	1/7 years	1/4 years	1/5 years	1/3 years
Spot Gravelling	Determined by HDM model			

Table 6.3.7 Maintenance Profiles for Paved Roads

Maintenance Profile	All Traffic Groups			
	Dry		Wet	
	Minimum	Desirable	Minimum	Desirable
Overlay	1/12 years	1/10years	1/12years	1/10 years
Patching	Determined by HDM model			
Resealing	1/7 years	1/5 years	1/7 years	1/5 years

Note: An overlay assumes a 50mm overlay for a carriageway with an average width of 6.0m.

Table 6.3.8 Off-Road Maintenance Profiles for All Roads

Maintenance Profile	Dry		Wet	
	Minimum	Desirable	Minimum	Desirable
Bush Clearing	1/year	1/year	2/year	3/year
Ditch Clearing	1/year	2/year	2/year	3/year
Culvert Cleaning	1/year	2/year	2/year	3/year

Note: Bush clearing assumes a 3m band on each side of a road.
Ditch clearing assumes an open ditch on each side of a road 0.5m deep, v-shaped, and 1m across the top ($0.25m^2$).
Culverts: Dry areas assume 1 culvert every 2km on average. Wet areas assume 2 culverts per km on average.
Average culvert length is assumed to be 10m.

HDM-4 Models

Two strategic models, which break the road network down into representative sections, were constructed to calculate the costs and benefits for road maintenance profiles: a Kenyan National Model and a Kajiado District Model. The purpose of the former model, which is based mostly on desk studies because full national data is not available, is to grasp the budgetary needs and restraints on road maintenance for Kenya as a whole, as well as the potential benefits of a better-maintained national network overall. As for the latter model, which is contained in Annex 9, the purpose was to check the needs of road maintenance at the district level based on actual data gathered from field surveys carried out by the JICA Study Team in Kajiado District.

The models, which assume a 15-year lifecycle for roads, start in the year 2001 and end in the year 2015. Both the Kenyan National Model and the Kajiado District Model take into account a "Do-Minimum Case" and a "Desirable Case". The Do-Minimum Case and Desirable Case assume that the purpose of maintenance is to keep roads in fair and good condition over the lifecycle, respectively. Fair and good are measured by applying the international roughness index concept (see Table A9.5 in Annex 9) for paved roads, varying between 5 and 7 for fair and 3 and 5 for good, depending whether the road was a trunk, primary, or secondary & minor road. As for unpaved gravel roads, fair was assumed to be a surface with 100 mm of gravel and good a surface with 150 mm of gravel, while for unpaved earth roads fair meant grading two times a year and good three times a year. The inputs for the construction of the models, as well as the assumptions that are made, are described below in detail.

Model Inputs

Including the key factors mentioned in Section 5.1 of Chapter 5, models to estimate the costs and benefits of road maintenance profiles were constructed for representative road sections of the road network applying the following inputs:

- Road class
- Road surface type
- Road surface condition
- Climate
- Terrain
- Traffic flow and composition
- Social Costs (vehicle operating costs)
- Maintenance frequency and unit costs

Based on the above inputs, 486 representative road sections (i.e., 3 road classes × 3 road surface types ×3 road conditions × 2 climate types × 3 terrain types × 3 levels of traffic flow) comprising the entire Kenyan road network were derived.

Road Class, Surface Type, Length, & Condition

The data inputted into the HDM-4 model for the surface type and condition of roads by road class and length are as shown in Table 6.3.9.

Table 6.3.9 Road Class, Surface Type, Length & Condition Data for Kenya

Road Class	Surface Type	Road Length km (excl. failed roads)	Road Length km (incl. failed roads)	Road Condition (%)		
				Good	Fair	Poor
Trunk	Paved	3,324.2	3,957.4	30	55	15
	Gravel	1,496.8	1,559.2	69	31	00
	Earth	642.8	765.2	68	23	09
Primary	Paved	2,080.4	2,476.7	17	57	26
	Gravel	3,423.3	3,565.9	13	71	16
	Earth	1,678.3	1,998.0	82	18	00
Secondary & Minor	Paved	3,935.4	4,684.9	18	69	13
	Gravel	47,382.3	49,356.6	15	62	23
	Earth	75,380.8	89,739.1	42	50	08
Total Road Length		139,344.3	158,103.0			

Note: Trunk roads consist of Class A & B roads.
Primary roads consist of Class C roads
Secondary roads consist of Class D roads and Minor roads consist of Class E roads and 94,161.1 km of unclassified road.

Data on the length and surface type of the classified road network was obtained from MORPW's 1996 "Schedule of Classified Roads". As for road condition data for the classified road network, this was obtained from MORPW's 1997 "Strategic Plan for the Road Sector".

As for the unclassified road network, the figure of 94,161.1 km was used in the construction of the HDM 4 models and is based on the consultant bmb's "Road Sector Institutional Study" for MORPW, April 1999. On the other hand, according to recent information from MOLG, the unclassified network is supposedly 134,035.3 km (see Table 5.2.1). This results in the size of the total road network used in the HDM-4 model being 158,103 as compared to MOLG's total of 197,977.2 km. It is important that the Kenyan authorities eventually determine which is correct.

Here, after conferring with the MORPW, this Study's counterpart organization, it was decided to use MORPW data. Unfortunately, since the MORPW does not possess data on the surface type and condition of unclassified roads, it was assumed that they were similar to that of Class D roads. Finally, 'failed' and 'bad' roads were not included in the models, since they are considered to be non-maintainable, meaning the size of the network examined by the HDM-4 models was eventually determined to be 139,344.3 km (see above table), as compared to the total maintainable network of 119,673.9 km (see Table 5.2.4) cited by the MOLG. In the final analysis, whether MORPW or MOLG data is used does not make a large difference in the total size of the maintainable network.

Climate & Terrain

Climate for Kenya was assumed to consist of two zones in the HDM-4 model: wet and dry. These were defined based on the Thornthwaite formula as described in Section 5.5. Wet zones were defined as moist and dry sub-humid and dry zones as semi-arid and arid (see Figure 5.5.1). Annual precipitation for the former is in the range of 800 to 1600 mm, while for the latter it is anything less than 800 mm.

As for terrain, this was broken up into three categories: flat, hilly, and mountainous. The road geometry parameters for these three categories are based on the default values contained in the HDM-4 model and are as shown in Table 6.3.10.

Table 6.3.10 Terrain Categories & Road Geometry Parameters

Terrain	Rise + Fall (m/km)	Number of Rises & Falls per km	Horizontal Curvature (deg/km)	Superelevation (%)
Flat	1.00 – 3.00	1.00 – 2.00	3.00 – 50.00	2.00 – 2.50
Hilly	10.00 – 15.00	2.00	15.00 – 75.00	2.50 – 3.00
Mountainous	20.00 – 25.00	3.00	150.00 – 300.00	5.00

Traffic Flows & Composition

The traffic flows applied in the HDM-4 models consisted of three traffic bands: high, medium, and low. Average traffic volumes for these bands, together with traffic composition, were derived for the different road classes and surface types using data from the MORPW's traffic census (see details in Annex 8***).*** This information, in addition to annual traffic growth derived from trend data for the 1990s, is contained in Table 6.3.11. Finally, the appropriateness of these figures was checked with MORPW and a few adjustments made.

Table 6.3.11 Traffic Flows and Growth by Road Class & Surface Type

Road Class	Surface Type	Traffic Composition						Traffic Volume			Annual Traffic Growth
		Car	Pickup	Bus	Matatu	Med Truck	Heavy Truck	High	Medium	Low	
Trunk	Paved	0.29	0.23	0.04	0.24	0.09	0.11	5800	3400	2100	5.00%
	Gravel							700	550	325	
	Earth							290	200	70	
Primary	Paved	0.30	0.28	0.02	0.29	0.09	0.02	2550	1360	900	2.00%
	Gravel							550	325	190	
	Earth							100	60	25	
Secondary & Minor	Paved	0.24	0.39	0.01	0.25	0.10	0.01	2200	960	740	1.00%
	Gravel							230	130	80	
	Earth							40	20	10	

Note: A Matatu is a vehicle licensed to carry fare-paying passengers and is usually a minibuses or small coach.

Socio-economic Costs

The main purpose of this part of the study is to calculate the financial needs of the road agencies (i.e., the budget required) in order for them to carry out pre-determined levels of maintenance. Therefore, social costs, although important in other contexts, are not given great weight here. In addition, in most developing countries, the greatest social cost (conversely benefit) in regards to road maintenance is vehicle-operating cost. Vehicle-operating cost is directly related to the condition of a road's surface and will therefore vary with the different maintenance alternatives. The parameters and their values used to calculate vehicle-operating cost for each vehicle type are shown in Table 6.3.12.

Table 6.3.12 Parameters for Calculating Vehicle-Operating Costs

Vehicle Type	Bicycle	Motor cycle	Car	Pick-up	Minibus/ Matatu	Large Bus	Light Truck	Med truck	Heavy truck	Artic. truck
Representative Make	Hero 25	Honda 110cc	Corolla	Toyota Hilux	Isuzu NPR	Isuzu Coach	Toyota Dyna	Tata	Merc	Merc
Basic Characteristics										
Gross vehicle weight (t)	0.02	0.20	1.60	2.70	3.20	12.60	4.00	12.30	40.00	50.00
ESAL factor per veh. (E4)	0.00	0.00	0.00	0.00	0.03	2.40	1.00	4.30	4.60	13.00
Number of axles	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	4.00	5.00
Number of tyres	2.00	2.00	4.00	4.00	4.00	6.00	4.00	6.00	12.00	22.00
Number of passengers	1.00	1.00	1.90	1.70	11.80	52.80	3.00	0.00	0.00	0.00
Calibration										
Payload (tones)	0.06	0.10	0.40	1.00	2.00	8.00	2.00	8.00	16.00	32.00
Aerodynamic drag coefficient		0.70	0.40	0.50	0.60	0.70	0.70	0.80	0.90	1.00
Projected frontal area		0.80	2.00	3.00	4.00	7.00	6.00	6.00	7.00	8.00
Driving power (metric HP)		16.00	80.00	80.00	80.00	120.00	100.00	120.00	140.00	200.00
Braking power (metric HP)		7.00	25.00	30.00	30.00	180.00	120.00	230.00	270.00	500.00
Paved desired speed (km/hr)	21.00	80.00	90.00	90.00	80.00	80.00	85.00	45.00	45.00	45.00

Table 6.3.12 (Cont'd)

Vehicle Type	Bicycle	Motor cycle	Car	Pick-up	Minibus/ Matatu	Large Bus	Light Truck	Med truck	Heavy truck	Artic. truck
Representative Make	Hero 25	Honda 110cc	Corolla	Toyota Hilux	Isuzu NPR	Isuzu Coach	Toyota Dyna	Tata	Merc	Merc
Calibration										
Unpaved desired speed, kph	18.00	75.00	85.00	75.00	75.00	70.00	75.00	75.00	70.00	60.00
Energy efficiency factor	1.00	0.95	0.85	0.95	0.95	0.95	0.80	0.95	0.95	0.80
Calibrated engine speed, rpm		800.00	3,500.0	3,500.00	3,300.00	2,900.0	3,000.0	2,700.0	2,200.0	2,200.0
Fuel adjustment factor		1.16	1.16	1.16	1.16	1.15	1.16	1.15	1.15	1.15
Recap ratio, %		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Tyre rubber volume, dm3				7.60	7.60	7.60	6.85	7.30	7.60	8.39
No. retreads						2.39	2.39	2.39	2.39	3.57
Tread wear, dm3						0.16	0.16	0.16	0.16	0.16
Tread wear scale						12.78	12.78	12.78	12.78	12.78
Spare parts COSPI	16.00	16.00	16.00	16.00	16.00	6.50	6.50	6.50	6.50	9.00
Spare parts, COSQPI						2.00	110.00	110.00	12.50	6.00
Labour Hours, COSPI	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	500.00	900.00
Hourly utilization ratio			0.20	0.80	0.80	0.70		0.80	0.85	0.85
Vehicle Utilization Data										
Service life (years)	10	10	9	8	8	10	10	8	8	8
Hours driven per year	150	400	400	600	3,000	3,000	1,200	2,500	2,500	2,500
Km driven per year	2,500	10,000	20,000	50,000	100,000	100,000	40,000	80,000	60,000	60,000
Depreciation code	2	2	2	1	1	1	2	2	2	2
Utilisation code	1	1	1	3	3	3	3	3	3	3
Annual interest rate (%)	12	12	12	12	12	12	12	12	12	12
Economic Unit Costs, Ksh										
New vehicle price (Ksh)	3,868	88,975	1,761,700	1,493,228	2,204,253	7,062,274	2,204,253	4,084,328	6,209,664	10,885,867
New tyre price (Ksh)	232	619	4,178	7,118	5,648	17,253	5,648	14,468	18,104	20,658
Maintenance labour (Ksh/hr)	170	170	364	364	364	472	364	472	472	472
Crew cost (Ksh/crew-hr)					85	162	162	162	162	162
Annual overheads	23	23	23	23	46	85	70	77	101	108
Passenger time (Ksh/pa-hr)	8	8	31	31	15	15	15			
Cargo time (Ksh/veh-hr)								23	54	70
Gas/petrol price (Ksh/lt)	23	23	23	23						
Diesel price (Ksh/lt)					23	23	23	23	23	23
Lubricants price (Ksh/lt)	132	132	132	132	132	132	132	132	132	132

Source: Lanet-Nakuru-Timboroa Road Rehabilitation Project, World Bank, 1999-2000.

Maintenance Frequency and Unit Costs

To calculate road maintenance costs, information on maintenance frequency and unit costs is necessary. As for the former, this was defined by the maintenance profiles in Section 6.3.2 of this chapter. As for unit costs, work plans were provided by the MORPW for 7 of the 8 Provinces of Kenya for fiscal year 2000. These work plans provided a good spread across the country and take into account regional, climatic and other variations. The data from these work plans was put into an EXCEL spreadsheet and analysed to provide average unit rates for each maintenance activity.

A number of points should be made regarding these work plans. Each was in a different format, which made quick comparisons and data entry difficult. Item descriptions also were not consistent; for example, up to three different types of units were used for the same activity for a single province. Moreover, there was a wide range of unit rates in use across the country and again even sometimes within a single province.

Table 6.3.13 shows the summary of the analysis of the fiscal year 2000 work plans. The table shows the total quantity of work and total value of work included in the work plans for major maintenance activities. From these totals, a national average unit rate was calculated. This is the unit rate shown under the 'All Provinces' column in the table. Also shown are the average unit rates for each province.

As can be seen, for some activities, there is some degree of consistency, but for others there are huge variations that are difficult to explain. We would expect to see some variation across the country as materials and labor costs will vary. However, with rates up to 100 times the lowest rate, it is difficult to provide any sensible explanation for such variations.

It may be that some of these rates are for contracted works, which would include overhead, profit and all associated costs, and some for force-account works. If this is the case, it should be clearly stated in the work plan so that the payments can be properly made. That is, what is to prevent a work plan stating a contract rate and then making payments as a force-account job in order to secure more funding?

Some of these extreme values should be checked and amended in the future. They not only prevent any realistic evaluation of unit rates, but may lead to excessive funding being allocated to some regions.

Table 6.3.13 Unit Rates Based on Fiscal Year 2000 MORPW Work Plans

	UNIT	ALL PROVINCES SUMMARY Qtty	Amount KSh	Unit Rate KSh	EASTERN Unit Rate KSh	NAIROBI Unit Rate KSh	NYANZA Unit Rate KSh	N EASTERN Unit Rate KSh	CENTRAL Unit Rate KSh	WESTERN Unit Rate KSh	RIFT VALLEY Unit Rate KSh	COAST Unit Rate KSh
Unpaved												
Bush Clearing	km	22,320	3,560,200	**160**	**160**	-	-	-	-	-	-	-
Bush Clearing	M/Days	519,297	95,590,710	**184**	**389**	-	**168**	**200**	**160**	-	-	-
Bush Clearing	m^2	23,060,984	67,064,830	**3**	**254**	-	-	-	-	**3**	**3**	-
Drainage	km	472,737	76,512,000	**162**	**265**	-	-	-	-	**159**	-	-
Drainage	M/Days	636,520	132,602,140	**208**	**222**	-	**173**	**200**	**160**	-	**299**	-
Drainage	m^3	59,734	8,543,940	**143**	**143**	-	-	-	-	-	-	-
Grading	km	68,208	410,615,550	**6,020**	**8,378**	**25,000**	**1,585**	**7,933**	**8,000**	**24,763**	**25,208**	-
Spot Patching	km	8,680	65,265,000	**7,519**	**423**	**1,500,000**	**521,236**	-	-	-	-	-
Spot Patching	M/Days	12,500	1,999,950	**160**	**160**	-	-	-	-	-	-	-
Spot Patching 2	m^3	1,520,059	1,684,061,790	**1,108**	**2,148**	-	**1,139**	**700**	**10,650**	**1,227**	**1,000**	-
Culverts	m	31,892	139,666,500	**4,379**	-	-	**4,370**	-	**5,000**	-	-	-
Gravelling	m^2	9,980	11,976,000	**1,200**	-	-	**1,200**	-	-	-	-	-
Shoulder patching	m^3	5,912	5,367,200	**908**	-	-	-	**700**	**4,638**	-	-	-
Spot gravelling	m^3	298,899	1,009,381,385	**3,377**	-	-	-	**3,612**	**1,448**	-	-	-
Shoulder grading	km	151	1,094,200	**7,242**	-	-	-	-	**7,242**	-	-	-
Pothole Patching	m^3	1,000	4,000,000	**4,000**	-	-	-	-	**4,000**	-	-	-
Paved												
Bush Clearing	km	1,100	176,000	**160**	**160**	-	-	-	-	-	-	-
Bush Clearing	M/Days	44,820	7,765,200	**173**	**739**	-	**160**	-	-	-	-	-
Bush Clearing	m^2	19,186,004	42,639,544	**2**	**207**	**4**	-	-	-	**3**	**2**	-
Drainage	km	1,231	195,131	**159**	**160**	-	-	-	-	**90**	**201**	-
Drainage	M/Days	48,565	17,945,360	**370**	**270**	-	**407**	-	-	-	-	-
Drainage	m^3	81,571	9,138,140	**112**	**140**	**105**	-	-	-	-	-	-
Pothole Patching	km	50	410,000	**8,200**	**8,200**	-	-	-	-	-	-	-
Pothole Patching	m^3	112,351	170,191,900	**1,515**	**1,177**	**5,000**	**1,126**	-	-	**2,731**	-	-
Protection works	No unit	250	225,000	**900**	**900**	-	-	-	-	-	-	-
Protection works (Gabions)	No.	80	360,000	**4,500**	**4,500**	-	-	-	-	-	-	-
Shoulder Rehabilitation	km	159	1,342,400	**8,443**	**8,443**	-	-	-	-	-	-	-
Shoulder Rehabilitation	M/Days	1,500	1,125,000	**750**	**750**	-	-	-	-	-	-	-
Shoulder Rehabilitation	m^3	159,743	111,709,300	**699**	**129**	**1,200**	**965**	-	-	**608**	**1,026**	-
Shoulder Rehabilitation	No unit	60	480,000	**8,000**	**8,000**	-	-	-	-	-	-	-
Culverts	m	10,934	35,699,460	**3,265**	-	-	**488**	**8,843**	-	-	-	-
Resealing	m^2	60,000	4,800,000	**80**	-	-	**80**	-	-	-	-	-
Spot Resealing	m^2	805,000	173,075,000	**215**	-	-	-	**215**	-	-	-	-
TOTALS			4,294,578,830									

KRB should instigate a standard work plan report in order to make comparisons and computer data entry easier. Annual analysis of the unit rates and costs should be carried out to identify any errors and any significant variations in unit rates, which can be investigated before work plans are approved and funds allocated, with contract work and force-account work being separated.

A printout of the work programme summary for a limited number of districts from the MORPW'S Highway Management System (HMS) was also received. We are not sure of the date of the data, but an examination indicates that this data too suffers from huge variances in unit rates. As an example, in Nairobi Province, the unit rate for Light Roadway Grading (Activity Code 1050002) is Ksh 67,500 and for Heavy Grading (Activity Code 1050001) it is Ksh 120,000. For Embu District the corresponding rates are Ksh 1,286 and Ksh 1,286, respectively, or 50 and 100 times lower than the rates of Nairobi. There are similar variations for other activities as well. Such variations, unless they are explainable, render this complex database to be of little use for analysis of the data.

As the unit rates from the 2000/2001 Work Plans and those from the HMS were not considered to be statistically reliable, we obtained unit rates from the District Works Officer in Kajiado for use in the Kajiado District Model. We have also obtained unit rates for all major maintenance activities developed by DANIDA for the Roads2000 project in Coast Province, those developed on a World Bank funded project on the A104 and rates in use under the World Bank funded KUTIP project. These rates were examined by our local sub-consultant and, based on their experience of maintenance works in Kenya, they arrived at a final set of unit rates for the national model. These rates are shown in Table 6.3.14.

We have received a copy of instructions for the preparation of annual works programs in the districts. This is aimed at standardizing the reporting from the DRCs. This should be reviewed together with the DREs after the first works programs have been submitted and checked by KRB. There needs to be similar guidance to the other road agencies in order to make any comparisons, analysis and computer data entry as easy as possible.

Table 6.3.14 Unit Costs for HDM-4 Analysis

Operation	Unit	Economic cost (KSh)	Financial cost (KSh)	Source
Paved Roads				
Routine Maintenance	km/yr	**14,336**	**20,480**	Danida
Drainage	km/yr	**5,764**	**8,233**	Danida
Edge repair	m^2	**768**	**1,096**	50% patching cost
Patching	m^2	**1,535**	**2,192**	A104
Crack sealing	m^2	**88**	**125**	KUTIP
Resealing	m^2	**280**	**400**	KUTIP
Overlay	m^2	**1,330**	**1,900**	A104
Reconstruction	km	**20,230,000**	**28,900,000**	A104
Unpaved Roads				
Routine Maintenance	km/yr	**14,336**	**20,480**	Danida
Drainage	km/yr	**5,764**	**8,233**	Danida
Grading	km	**18,669**	**26,670**	Danida, Medium grading
Spot re-gravelling	m^3	**287**	**410**	Danida
Gravel resurfacing	m^3	**1,100**	**1571**	Danida
Reconstruction	km	**2,450,000**	**3,500,000**	KUTIP
(Financial/Economic Conversion Factor = 70%)				

6.3.3 Calculation of Costs and Benefits for Road Maintenance Profiles

Applying the model inputs constructed in Section 6.3.2, the costs and benefits of road maintenance were calculated for the Kenyan road network for a lifecycle extending from 2001 to 2015 using the HDM-4 model. (As for the results for Kajiado District, see Annex 9.)

It should be mentioned that the model for Kenya, especially, due to problems with the reliability in unit rates for maintenance and inconsistencies in road inventory/condition data is indicative in nature. That is, by using the MORPW road inventory/condition data, which consists of a total maintainable network of 139,344.3 km, rough estimates on the overall costs and benefits of road maintenance are calculated.

Table 6.3.15 to 6.3.17 indicate the undiscounted costs for roads maintenance by road type, roads agency, and surface type, respectively, from 2001 to 2015. As Table 6.3.15 shows, secondary & minor roads account for the majority of the maintenance costs required for either the “Do-Minimum” or “Desirable” Cases. This is due to its network being much more extensive in length than either the trunk or primary road network. In terms of percentages, the trunk, primary, and secondary & minor roads account for 23%, 18%, and 59% of the maintenance costs for the Do-Minimum Case and 22%, 15%, and 63% for the Desirable Case.

Table 6.3.15 Summary of Undiscounted Costs by Road Type for 2001-2015 (Ksh millions)

Road Type	Do-Minimum Maintenance			Desirable Maintenance		
	Periodic	Routine	Total	Periodic	Routine	Total
Trunk Roads	64,154	5,825	69,979	81,631	5,763	87,395
Primary Roads	20,632	34,003	54,635	25,072	34,195	59,267
Secondary & Minor Roads	96,423	86,119	182,542	161,902	92,669	254,571
Total	181,208	125,947	307,156	268,605	132,627	401,232

Road maintenance costs by surface type, as shown in Table 6.3.16, indicate that the total for unpaved roads is approximately 2.3 times and 2.0 times that for paved roads, respectively, for the Do-Minimum and Desirable Cases. This is due to the unpaved road network being much more extensive (i.e., about 13.9 times that of the paved network). As for the cost per kilometer, on the other hand, it is much greater for paved roads then unpaved roads because of the materials and technical know-how involved. That is, it costs approximately Ksh 10.1 million per kilometer to maintain paved roads from the year 2001 to 2015, as compared to Ksh 1.6 million per kilometer to maintain unpaved roads for the Do-Minimum Case. For the Desirable Case, it costs approximately Ksh 14.2 million per kilometer to maintain paved roads and Ksh 2.1 million per kilometer to maintain unpaved roads, or an increase of 1.26 times for paved roads as compared to an increase of 1.41 times for unpaved roads.

Table 6.3.16 Summary of Undiscounted Costs by Surface Type for 2001-2015 (Ksh millions)

Road Surface Type	Do-Minimum Maintenance			Desirable Maintenance		
	Periodic	Routine	Total	Periodic	Routine	Total
Paved Roads	86,386	7,632	94,018	125,180	7,431	132,611
Unpaved Roads	94,822	118,315	213,137	143,425	125,196	268,622
Total	181,208	125,947	307,156	268,605	132,627	401,232

As for the maintenance costs of the roads agencies (i.e., the Roads Department and District Roads Committees (DRCs)), Table 6.3.17 indicates that the total maintenance costs from 2001 to 2015 for the DRCs (which are in charge of the secondary & minor roads) will be about Ksh 182,542 million and Ksh 254,571 million for the Do-Minimum and Desirable Cases, respectively. For the Roads Department, which is in charge of the trunk and primary roads, the maintenance costs for the same period for the Do-Minimum and Desirable Cases will be about Ksh 124,614 million and Ksh 146,662 million, respectively. Based on this, the percentage of the total amount of money required by the Roads Department and the DRCs, purely from an expenditure viewpoint, would be 41% and 59%, respectively, for the Do-Minimum Case, and 37% and 63%, respectively, for the Desirable Case. Under the KRB, it has been decided at present that the Roads Department should get 57% and the DRCs 40% of the Road Maintenance Levy Fund. These numbers, from a cost perspective only, might need to be re-considered. On the other hand, only taking costs into account can be misleading. It is important to take into account the benefits that the different types of roads produce.

As shown in Table 6.3.18, the Class A, B, and C roads of the Roads Department produce much greater benefits than those of the DRCs. That is, despite the maintainable trunk and primary road network being much smaller than the secondary & minor road network (about 10 times smaller), the total net present value (NPV) of the former is approximately 3.8 times greater for the Do-Minimum maintenance case. From the perspective of economic returns, it can be said that investment in the maintenance the roads of the Roads Department is a much better investment, which is due to the much greater traffic loads processed by the trunk and primary network. In fact, as Table 6.3.18 shows, investment in the secondary & minor road network should be kept to a certain minimum, since the NPV declines by more than 60% due to insufficient returns on investment for maintenance for the Desirable Case. On the other hand, in the case of the trunk and primary road network, the Desirable Case brings even greater returns on investment, with NPV being about 1.09 times greater than in the Do-Minimum Case.

Table 6.3.17 Summary of Undiscounted Costs by Road Agency for 2001-2015 (Ksh millions)

	Do-Minimum Maintenance			Desirable Maintenance		
	Periodic	Routine	Total	Periodic	Routine	Total
Roads Dept. (Trunk & Primary Roads)	84,786	39,828	124,614	106,703	39,959	146,662
DRCs (Secondary & Minor Roads)	96,423	86,119	182,542	161,902	92,669	254,571
Total	181,208	125,947	307,156	268,605	132,627	401,232

Table 6.3.18 Summary of NPV by Road Agency for 2001-2015 (Ksh millions)

	Do-Minimum Maintenance	Desirable Maintenance
Trunk & Primary Roads	163,585	179,048
Secondary & Minor Roads	42,858	15,865
Total	206,443	194,914

It should be said here that there are limitations to what cost-benefit analysis can do. The above analysis cannot take into account such important issues as providing basic access to rural areas and rural development. The importance of this should not be underestimated, since evidence from various World Bank studies have shown that poverty, lower educational levels, and poorer health is more pervasive in areas having no or unreliable access. For this, a different type of analysis capable of appraising benefits that cannot be easily measured in monetary terms should be applied, such as cost-effectiveness (see Section 6.5.2).

Finally, the importance of maintaining roads is graphically shown in Figure 6.3.1 below. As this figure indicates, roads not properly maintained will start to deteriorate and eventually fail. This is illustrated by what is called a “Base Alternative” in the model, which shows that roads that only receive Routine Maintenance, in an effort to cut road sector costs, results in roads reaching a point of becoming non-maintainable and requiring large investments for reconstruction/rehabilitation. On the other hand, the application of proper maintenance profiles that include Periodic Maintenance (in either the Do-Minimum or Desirable Case) result in roads that remain in better condition much longer and higher economic benefits to society.

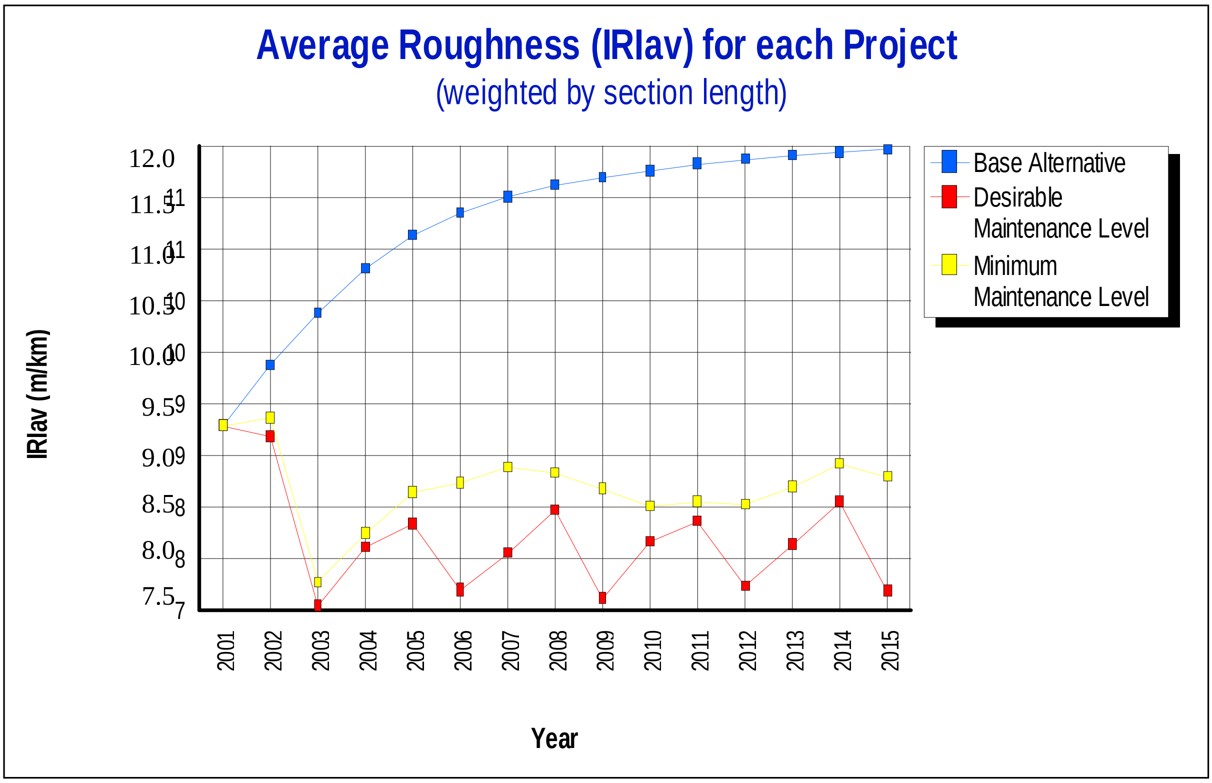

Figure 6.3.1 Trends in Average Roughness for All Roads in Kenya

(Note: It is assumed that the capital necessary to put roads into fair or good condition initially exists, which is not realistic but is acceptable for the purposes of this Study’s analysis.)

6.4 Comparison of Funding Needs & Existing Available Funding

6.4.1 Funding Needs

As shown in Section 6.3.3, to bring all of Kenya's roads up to the "Desirable" state of being in good condition for the maintenance lifecycle of 2001 to 2015, Ksh 401,232 million would be required, while to bring them up to the "Do-Minimum" state of being in fair condition would require Ksh 307,156 million. From the viewpoint of cost-effectiveness, it is better to maintain the trunk and primary roads in a "Desirable" state and the secondary & minor road network in a "Do-Minimum" state of service, since this would produce the highest net present value for the network as a whole. We can refer to this perhaps as the "Best Case", and the cost of maintaining roads in Kenya at this service level would require Ksh 329,204 million.

Below, funding for the period of 2001 to 2015 is determined to see what Cases for maintenance, if any, fund resources are capable of financing and the possibility of other potential funding sources to make up for any shortfall.

6.4.2 Existing Available Funding

Current Sources

The current sources of funding for road maintenance are as follows:

- Fuel levy
- Transit toll
- CESS
- Part of the LATF (Local Authority Transfer Fund)

Of the above-mentioned sources, the fuel levy and transit toll account for the majority of the funding for roads maintenance. Of the total of these two, the fuel levy accounts for approximately 96% and the transit toll for about 4%. The revenues over the past seven years that have been collected from these two sources, which make up the official roads fund for the Kenya Roads Board (KRB), are as shown in Table 6.4.1.

The fuel levy revenue is calculated every 10 days by oil companies based on the litres of fuel delivered to the local market. The levy is payable by check to the Commissioner for Customs. The checks are collected by the Customs Department of the Kenya Revenue Authority and consolidated into one check payable to the Ministry of Finance (MOF) to go into the Road Maintenance Levy Fund (RMLF) account. As for the transit toll, this is collected by Ministry of Roads and Public Works (MORPW) personnel at toll stations located throughout the country and then handed over to the MOF to go into the same RMLF account. Upon the KRB becoming fully operational, both of these monies would be transferred to its account, or preferably direct to its account rather than via the MOF.

As Table 6.4.1 shows, there have been strong increases in RMLF revenues, increasing on average by 1.29 times annually in current prices. The vast majority of this increase, however, is due to the fuel levy and not the transit toll. On the other hand, as the standard deviation shows, average variation from the mean of 1.29 is 0.26, indicating that the range for average annual increases can be a large 1.03 times to 1.55 times. Because the Kenyan Parliament can change the charge on fuel as it sees fit, or at the request of KRB, it is difficult to explain this variation completely. On the other hand, changes by Parliament should be made taking into consideration the overall state of the economy. Therefore, it is assumed that the economy is the prime attribute for explaining RMLF revenue. That is, less economic activity, for example, results on average in less travel and therefore in less fuel consumption and fewer toll payments.

Table 6.4.1 Revenue Flows for Fuel Levy and Transit Tolls (Ksh millions)

Fiscal Year	Fuel Levy Revenue	Toll Transit Revenue	Total Revenue Collected	Annual Increase in Total Revenue Collected (times)
1994	1371	134	1505	-
1995	2181	201	2382	1.58
1996	3101	196	3297	1.38
1997	3115	207	3322	1.01
1998	5086	183	5269	1.59
1999	-	-	7560	1.43
2000	-	-	8110	1.07
2001			8040	0.99
Average				1.29
Std. Dev.				0.26

Sources: Kenyan Ministry of Finance and Planning & BCEOM, “Review of the Road Maintenance Fuel Levy”, Nov. 2000.
Kenyan Roads Board Secretariat.

Another source of funding that is supposed to be used for the direct financing of road maintenance is the CESS, which is a 1% levy on a set unit of produce levied by the districts to pay for the maintenance of roads serving agricultural estates. The levy is collected by the various agricultural boards and then distributed to the District Development Committees of the local authorities to finance aforesaid road maintenance work.

The revenue from this levy over the past eight years is as shown in Table 6.4.2. As this table shows, the average annual increase is 1.13 times. However, via the application of the standard deviation, it can be seen that the average year-on-year increases can vary from less than one (i.e., 0.89 times or negative growth) to 1.37 times. Negative growth in the levy can perhaps be attributed to crop failures, poor weather, etc. Another thing to notice from the pattern of this data is that the CESS seems to have already have reached its upper limit regarding revenue collection. Given the data in Table 6.4.2, it is estimated that this limit is around Ksh 450 million per annum.

Table 6.4.2 Revenue Flows for CESS (Ksh millions)

Fiscal Year	Municipal Councils	Towns & County Councils	Total CESS	Annual Increase in Total Revenue Collected (times)
1992	86.08	99.33	185.41	-
1993	65.83	188.68	254.51	1.37
1994	90.72	213.28	304.00	1.19
1995	168.32	245.34	413.66	1.36
1996	168.15	196.54	434.69	1.05
1997	154.71	159.91	314.62	0.72
1998	134.75	147.47	282.22	0.90
1999	125.74	265.09	390.83	1.38
2000	141.93	274.11	416.04	1.06
Average				1.13
Std. Dev				0.24

Source: Based on information received from hearings with the Kenyan Ministry of Local Government.

The final current source of funding for road maintenance is the LATF, which began two years ago. The LATF is equivalent to 5% of the tax revenue collected by the Kenyan national government. Revenue from the LATF on a provincial basis is shown in Table 6.4.3, and is distributed by the central government to local authorities based on population, with the purpose of supplementing local financial resources. The LATF, unlike the other above-mentioned funding sources, is used for many purposes other than road maintenance (e.g., education, health, and sanitation). Data on how much of the LATF is used for road maintenance was not available. However, according to the 1999 Statistical Abstract of the Kenyan Central Bureau of Statistics, about 11% of the town, county, and urban council expenditures were on roads during the 1991 to 1998 period prior to the implementation of the LATF. It is assumed here, therefore, that the maximum amount of money that would be spent for roads using the LATF would therefore be 11% of the total.

Table 6.4.3 Revenue Flows for LATF (Ksh millions)

Province	Fiscal Year 2000	Fiscal Year 2001
Nairobi	485.32	456.821
Coast Province	217.86	306.26
Eastern Province	291.70	472.46
Central Province	253.29	325.56
Western Province	215.89	236.98
Rift Valley Province	459.25	614.09
Nyanza Province	306.36	396.10
North Eastern Province	60.96	80.83
Total	2,290.65	2,889.20

Source: Ministry of Local Government, Schedule of Disbursement published in Daily Nation, 5 September 2000 and 7 June 2001.

Based on the above, we can see that for the year 2001, assuming that the CESS increases by its annual average, that the total amount of money that would available for road maintenance is approximately Ksh 8,830 million. Of this, the RMLF accounted for 91.1%, the CESS 5.3%, and the LATF 3.6% of the total, respectively.

At present, only the RMLF is available to the KRB for maintaining roads, and an amendment by Parliament to the KRB Act would be necessary to include any other existing or new revenue sources. However, even if all of the above-mentioned funding sources were made available to the KRB, the difference between this amount for the year 2001 and the annual average required for the Do-Minimum and Desirable Cases for road maintenance would still be about Ksh 20,477 million and Ksh 26,749 million, respectively, or about 2.3 and 3.0 times more than the present revenue collected. For this reason, other potential sources of revenue should be considered as a countermeasure.

Revenue Forecast for Current Sources

As the above indicates, the most important source of existing available funding is the RMLF. Below, the revenue forecast for the RMLF is carried out.

To predict future RMLF revenues, it is important to consider the state of the Kenyan economy. As the figure below indicates, the state of the Kenyan economy has been experiencing continuous declining growth in its gross domestic product (GDP) over the past three decades, from a high of 6.6% per annum in the 1960s to 2.3% in the 1990s (see Figure 6.4.1) to negative growth in the year 2000. Given this, it will be very difficult to expect increases in the revenue of the RMLF to continue at its high pace in the initial years after its implementation. In fact, as Figure 6.4.2 indicates, there has been a noticeable slowing down in the increases in the amount of revenue collected from the RMLF over the past three years.

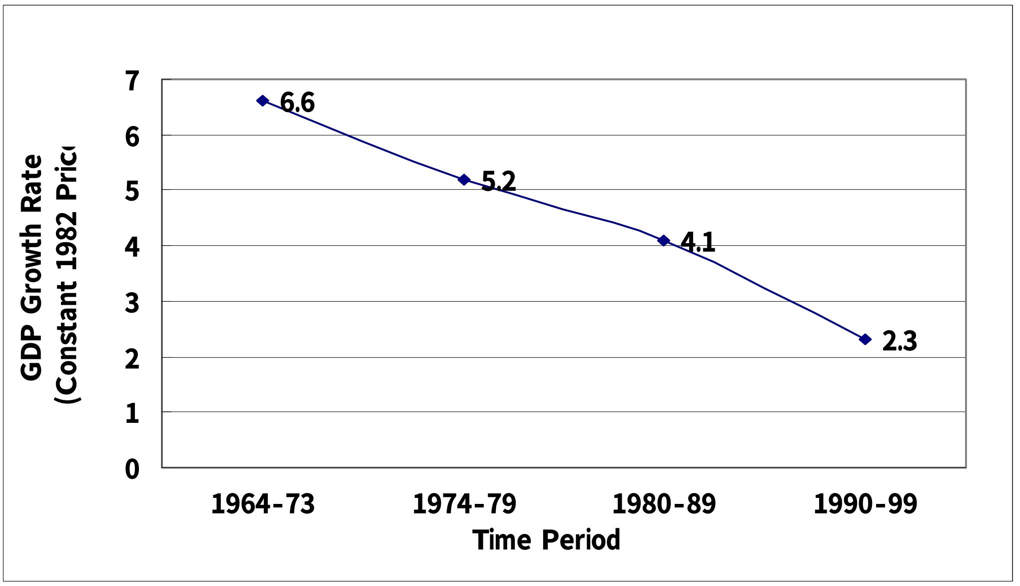

Figure 6.4.1 Trend in Kenyan GDP Growth Rate

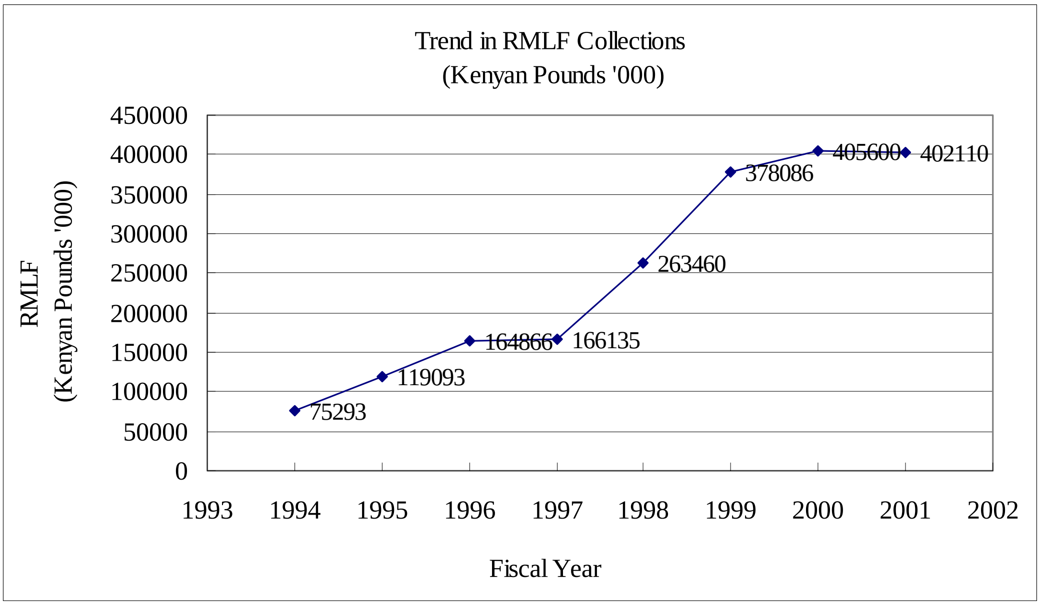

Figure 6.4.2 Trend in RMLF Collections

Based on Figure 6.4.2, the relationship between the growth in the RMLF and GDP is shown. As this figure shows, there is a strong and reliable relationship between the RMLF and GDP, as indicated by the value of 0.80 for the coefficient of determination.

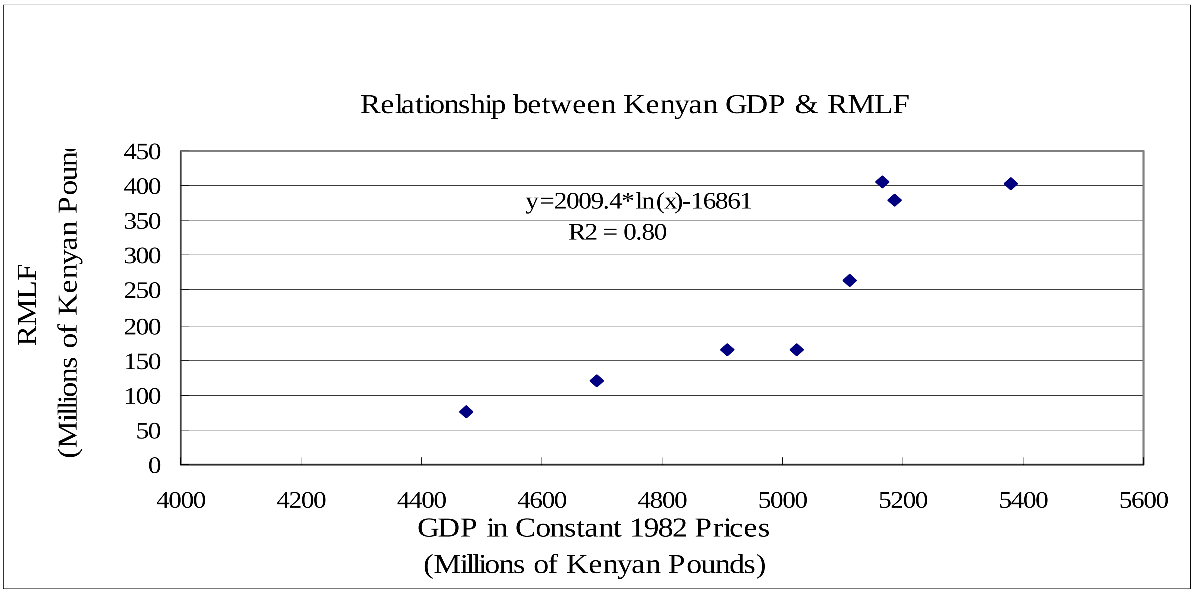

Figure 6.4.3 Relationship between Kenyan GDP & RMLF

Using the above relationship, and the assumption that GDP (in constant prices) will grow on average by 2.0% per year, the future revenue from the RMLF was calculated as shown in Table 6.4.4. As for the fuel levy rate, since it already is one of the highest among African countries operating under a roads board system, it was assumed that it would remain static. As this table indicates, the average annual growth in RMLF revenue would be about 5.6% per annum, resulting in the total money generated by the RMLF over the time period of 2001 to 2015 being Ksh 200,503 million.

Table 6.4.4 Forecast of RMLF Revenue (Ksh millions)

Fiscal Year	Revenue Collected by RMLF
2001	8,042
2002	8,841
2003	9,654
2004	10,451
2005	11,233
2006	11,999
2007	12,751
2008	13,489
2009	14,214
2010	14,926
2011	15,626
2012	16,314
2013	16,990
2014	17,655
2015	18,309
Total	200,503

As for the CESS and the LATF, the revenue per annum for the CESS is assumed to be on average Ksh 400 million based on the above analysis, while the LATF (which is directly related to national revenue) is assumed to grow at the same rate as GDP, or 2% Given this, the total revenue to be expected from the CESS is Ksh 6000 million and from the LATF Ksh 5500 million for a total of Ksh 11,500 million during the period 2001 to 2015.

6.4.3 Comparison of Funding Needs & Available Funding

Based on the above analysis, and the data from Section 6.3.3, there would be a shortfall in funding of Ksh 200,729 million and Ksh 106,653 million, respectively, for the maintenance needs of the Desirable Case and the Do-Minimum Case for all roads (see Figure 6.4.4). That is, there would have to be an average increase of Ksh 13,382 million and Ksh 7,110 million per annum, respectively, to achieve the funding levels necessary to realize these maintenance scenarios, which deal with the maintainable network only. In the Best Case, which assumes trunk and primary roads are kept in good condition and secondary & minor roads in fair condition, the shortfall would be Ksh 128,701 million. On the other hand, if we assume that the CESS and the LATF can be considered as part of the pool of funds for road maintenance, then the shortfall for the Desirable Case, Best Case, and Do-Minimum Case for all roads would be Ksh 189,229, Ksh 117,201 million, and Ksh 95,153 million, respectively.

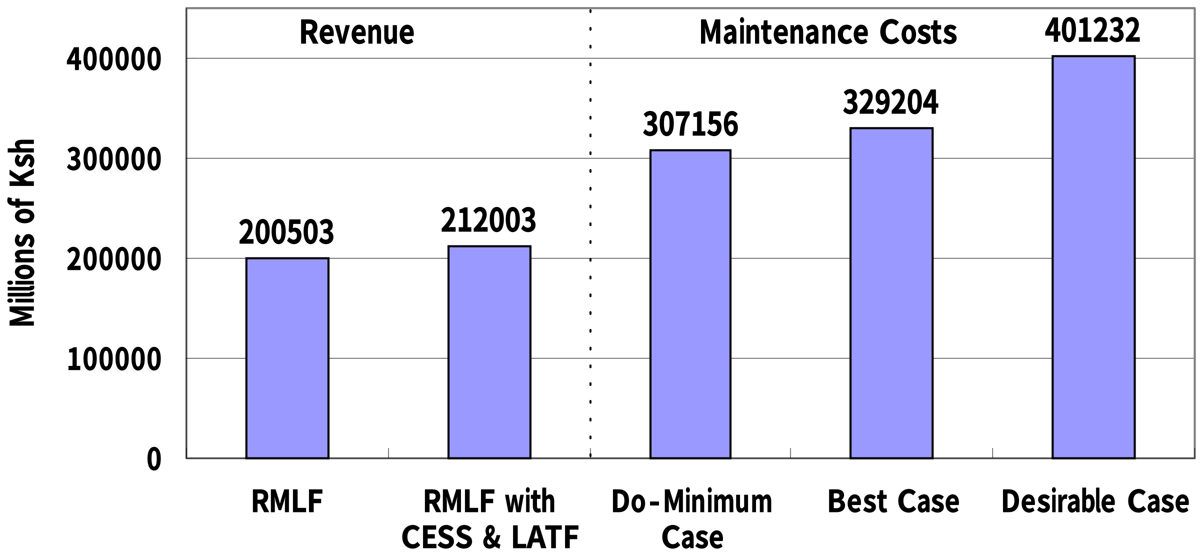

Figure 6.4.4 Revenue from Funding Sources and Funding Required by Maintenance Case

6.5 Potential Scenarios for Meeting Funding Needs Gap

As the above indicates, given the existing sources of road maintenance funding, there are insufficient monies to meet the road maintenance needs of Kenya. Below, potential scenarios are suggested to resolve this funding needs gap by looking at two types of scenarios: funding scenarios to increase revenue and cost-reduction scenarios to decrease expenditures. As for changes in the Kenyan tax structure itself, which could have an effect on either the revenues or costs for road maintenance, this was not considered since it would require major legislative action and is therefore almost impossible to forecast.

6.5.1 Funding Scenarios

Three potential sources that could be included in the KRB's pool of funds that seem most achievable are: (1) the tolling of highly traveled roads, (2) the license revenue and fees from the traffic act, and (3) axle load excess fines. As for tolling, according to a World Bank expert, there are about four highly traveled routes that could possibly be tolled under a concession, which would be required in order to rehabilitate the roads to a standard high enough to charge for money. However, due to the high returns that a concessionaire would need in this case, as well as to limitations on tolls due to other existing charges on transport (e.g., fuel levy, transit tolls, licensing), the revenues from this scheme would probably not be large.

As for the revenues from licensing and fees under the traffic act, these were in 1998 a substantial Ksh 869.80 million, which is approximately 10% of the total for the RMLF, CESS, and LATF. On the other hand, many of the fees collected under this act, such as vehicle registration and inspection fees, driving license fees, etc., should not theoretically be included in the RMLF, as these are service fees and are not charges for road use. It could be argued again though that these activities do contribute to road use indirectly and therefore should be used for road upkeep. Here, these monies are tentatively included as part of the funding for road maintenance. Annual average growth in revenue over the 2001 to 2015 period is assumed to be 4.4% based on recent data from the 1999 Kenyan Statistical Abstract, meaning that the total amount of revenue that could be expected from this source for this period is Ksh 19,577 million.

Finally, as for the monies collected from axle load excess fines, these should go to maintaining the road network because overloaded vehicles have a direct and significant impact on road conditions. At present, about Ksh. 1.4 million is collected monthly on overweight vehicles. As shown in the graph below, there has been a steady decline in excess loads due to more rigorous enforcement of axle load regulations. Therefore, it is assumed that the present average monthly revenue will remain static. Based on this, the total revenue that could be collected from this funding source for the 2001 to 2015 period is estimated at Ksh 252 million. In comparison to total funding needs this is an extremely small amount, and could be foregone if there is concern about the punitive nature of this source.

Based on the above, the amount of money that could be via likely funding scenarios is Ksh 19,829 million. Add this to the existing funding described in Section 6.4 above and the total revenue available for 2001 to 2015 is Ksh 231,832 million (see Figure 6.5.2).

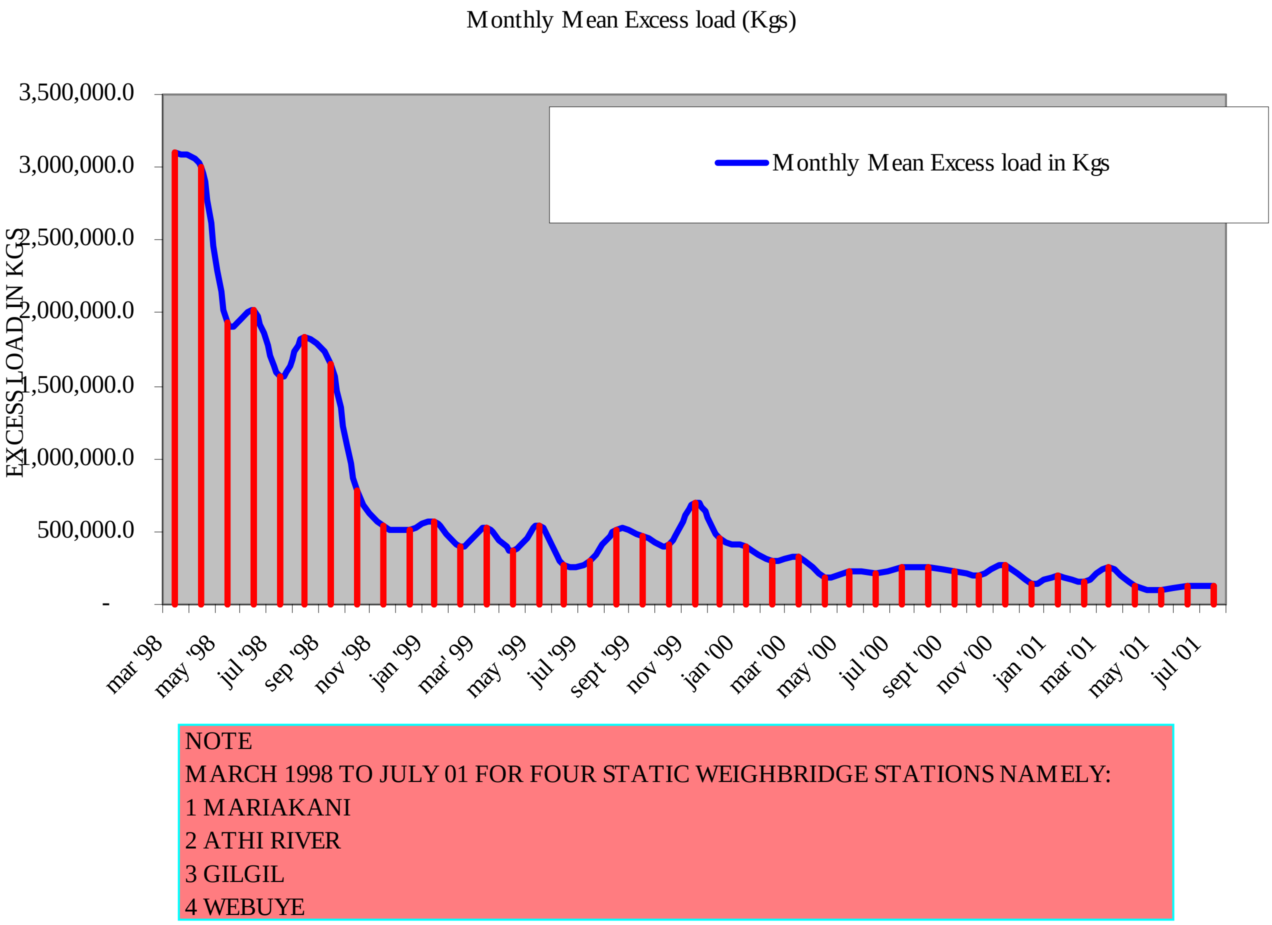

Figure 6.5.1 Monthly Mean Excess for Heavy Goods Vehicles

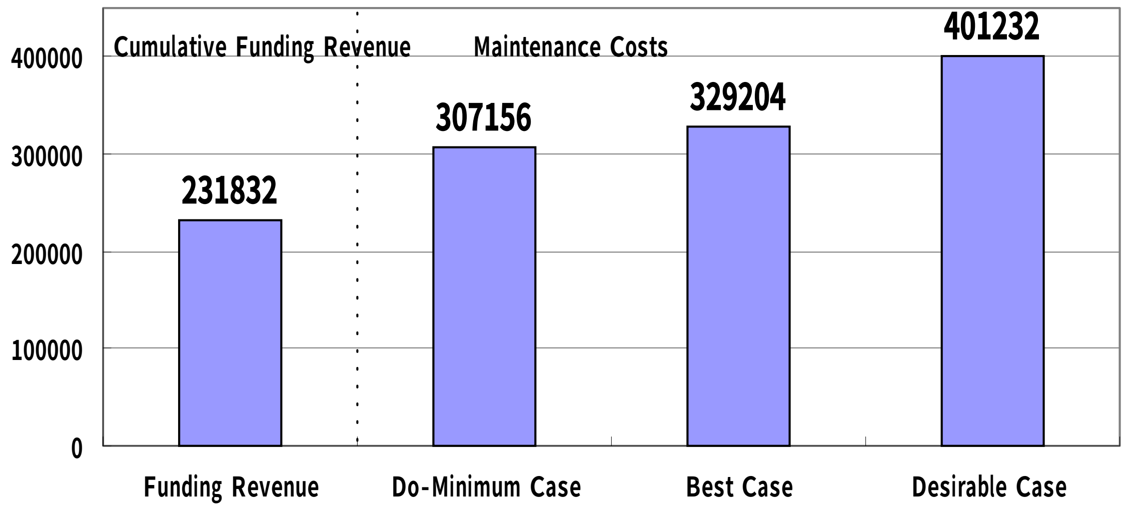

Figure 6.5.2 Revenue from Funding Sources and Funding Required by Maintenance Case

Note: Funding Revenue here is cumulative and includes, the RMLF, CESS, part of the LATF, fees from the Traffic Act, and fines from overweight heavy goods vehicles.

As the above discussion indicates, there are limits to how much money can be raised via existing or new sources, and this alone will not solve the problem of financing roads. Therefore, cost-reduction measures must also be considered.

6.5.2 Cost-Reduction Scenarios

The cost-reduction scenarios that seem most likely are as follows:

- Reduction in costs due to better management resulting from operation of KRB System
- Reduction in costs due to better mix of labor- & equipment-based work
- Reduction in costs due to more work being contracted out to private contractors
- Prioritization & reduction of road network size

Reduction in Costs due to Better Management

This is difficult to quantify at this stage, but in countries such as Ghana there has been a significant improvement in management and in reducing costs as a result of the implementation of an effective roads board system such as the Kenyan Roads Board. The desirable overall structure of a roads board for managing a roads fund effectively is as follows:

- Clearly defined legal executive powers and user-dominated
- Procurer of services rather than a service provider
- Includes persons and representatives of stakeholder interests and operated in accor-

dance with sound business principles

- Governance free from political interference
- Service providers are autonomous road agencies delivering on a performance-based regimen under clear budgetary constraints

Here, it is assumed that better management is basically a facilitator for realizing the other three items mentioned at the beginning of this section. That is, lower costs due to a better mix of labor- and equipment-based work, a more competitive environment as a result of contracting out and thereby a lowering in costs, and a reduction in overhead via a rational decrease in the size of the road network.

In any case, as Figure 6.5.3 shows, average maintenance cost per kilometer for Kenya is about 1.47 times higher than the average for other African countries. This is fine if value for money is obtained, but as Figure 6.5.4 indicates, Kenya pays on average much more per kilometer than other African countries to maintain a smaller proportion of its main road network in good shape. In other words, there is plenty of room for improvement in management.

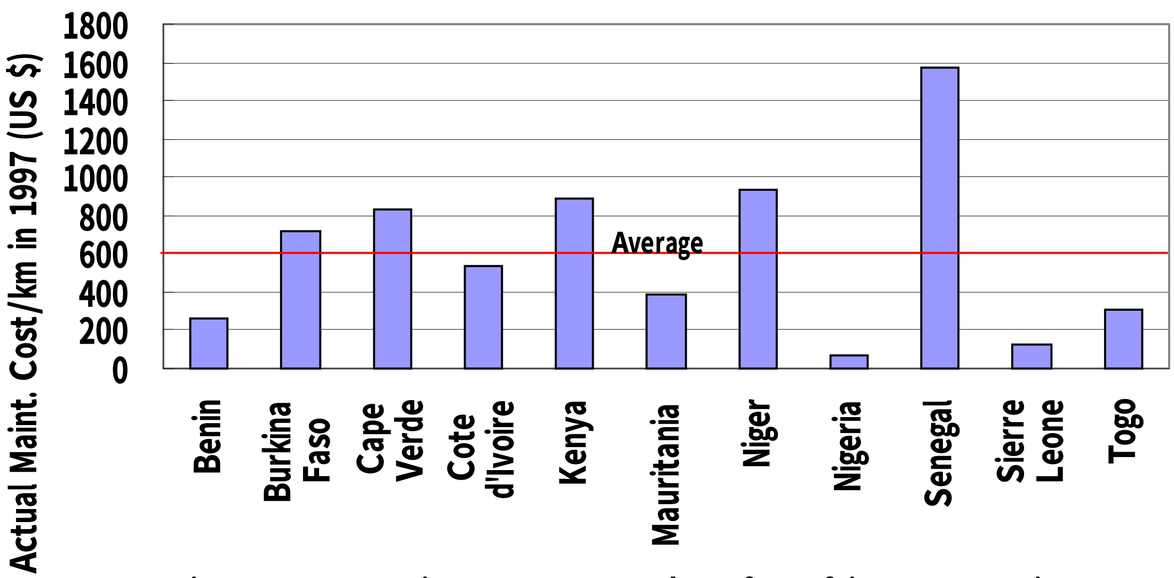

Figure 6.5.3 Maintenance Cost/Km for African Countries

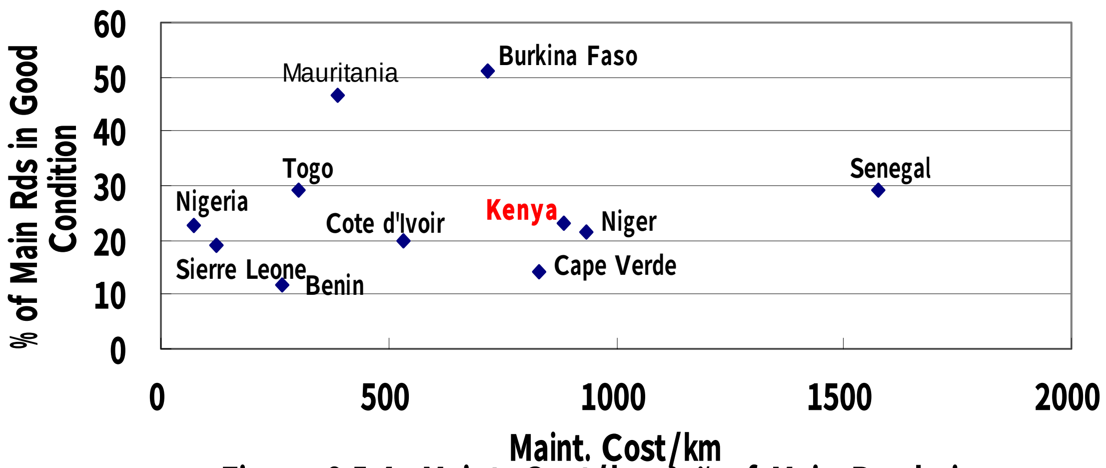

Figure 6.5.4 Maint. Cost/km & % of Main Roads in Good Condition in Africa (1997)

Better Mix of Labor- & Equipment-based Work

Studies by the International Labour Organization have shown that labor-based work can be 10% to 40% less expensive than equipment-based work. In Kenya, with initiatives such as the Roads 2000 program, together with the training program in Kisii (see Chapter 8), there has been some progress towards the effective utilization of labor-based work.

On the other hand, such initiatives have still not taken hold throughout the entire road sector. Therefore, it is assumed here that savings at a median of 20% is still possible in regards to routine maintenance. This would result in cost reductions of Ksh 25,189 million, Ksh 25,215 million, and Ksh 26,525 million for the Do-Minimum Case, Best Case, and Desirable Case, respectively. As for periodic maintenance, this is more equipment-based and no significant savings would be possible.

Encouragement of Contracting out to Private Contractors

Contracting out fosters a more competitive environment that results in lower cost per unit. For example, in the case of Ghana, there was a decline in maintenance costs by 40% after the system changed from being force-account oriented to contracting out. Again, based on the data in Table 6.5.1, the cost/km for maintenance work solely by force account is 12% higher than that done by private contractors.

Table 6.5.1 Percentage of Maintenance Work Contracted Out & Percentage of Main Roads in Good Condition in Africa (1995)

Name of Country	Percentage of Work Contracted Out		% of Main Roads in Good Condition
	Routine	Periodic	
1. Benin	0	0	11.58
2. Burkina Faso	74	100	50.37
3. Cape Verde	0	0	14.26
4. Cote d'Ivoire	0	0	20.00
5. Gambia	0	0	48.33
6. Ghana	90	90	29.92
7. Guinea	100	100	34.76
8. Kenya*	79		23.20
9. Liberia	0	0	16.00
10. Mali	20	100	15.60
11. Mauritania	0	0	40.00
12. Nigeria	70	70	22.68
13. Senegal	100	100	32.68
14. Sierra Leone	90	70	51.95
15. Togo	70	70	29.34

Source: Based on World Bank's RMI Database
Data is for 1997 (Strategic Plan for the Road Sector, Kenyan Ministry of .Roads & Public Works)

At present, the vast majority of routine maintenance work is via force account, while most period maintenance is carried out with private contractors. Based on the above, it is assumed that a further savings of 20% for routine maintenance is possible. Given this and the previous savings from more effective use of labor-based work, the costs for implementing the Do-Minimum Case, Best Case, and Desirable Case would be Ksh 256,776 million, Ksh 278,771, and Ksh 348,181, respectively. This means that the costs for implementing these cases are still 1.11, 1.20, and 1.50 times greater than potential funding (see Figure 6.5.5).

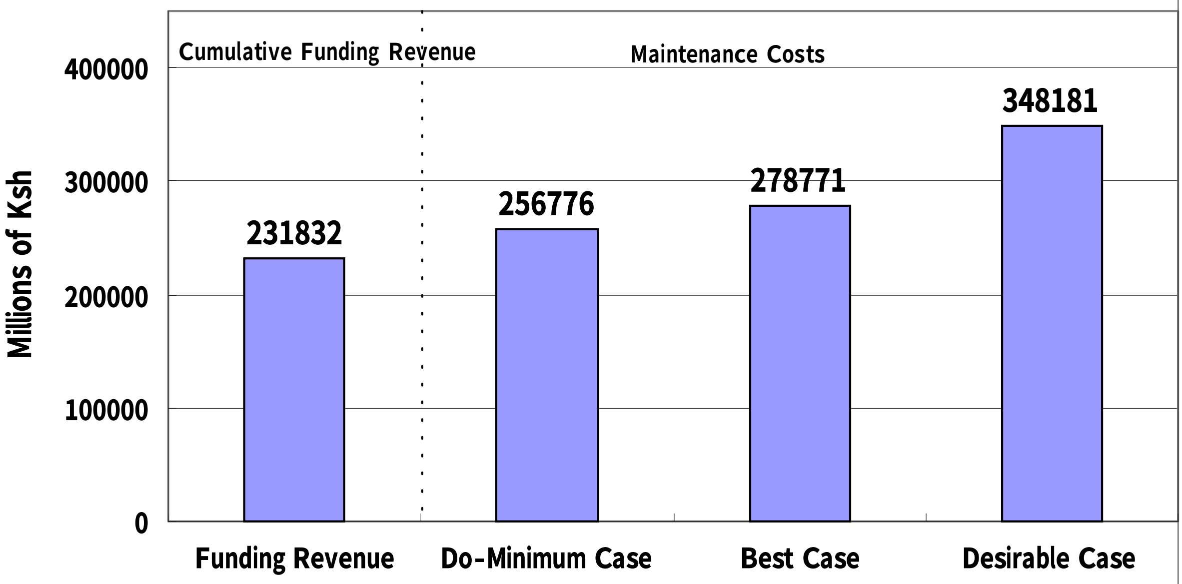

Figure 6.5.5 Costs for Maintenance Cases after Introduction of Cost-Reduction Scenarios

Prioritization & Reduction of Road Network Size

As a final measure to match funding with costs, the road network can be prioritized into a core and non-core road network. The former would be funded, while the latter would either have to be removed from the road network or funded with monies raised by local communities. The core network should be roads that have a significant effect on the national economy in moving people and goods around the country, roads involved with tourism that bring in foreign currency, and important agricultural access roads that have an impact on local and export markets. In the United States, for example, the core road network, which is referred to as the National Highway System, was defined to be as follows:

> *The National Highway System shall consist of interconnected urban and rural principal arterials and highways (including toll facilities) which serve major population centers, international border crossings, ports, airports, public transportation facilities, other inter-modal transportation facilities and other major travel destinations; meet defense requirements; and serve interstate and interregional travel. All routes on the Interstate System are part of the National Highway System. (Source: Federal Highway Administration Website at http:// www.fhwa.dot.gov/legsregs/)*

Based on the above, we can say that Kenya's Class A and B roads, which function as international and national trunk roads, should be designated as part of a Kenyan core road network. In addition, many of the Class C roads, which link major towns, district capitals, and border posts, should also be included. The cost for maintaining Kenya's core road network (i.e., Class A, B, and C roads), without any cost-reduction measures, for the Do-Minimum Case and Desirable Case is Ksh 124,614 million and Ksh 146,662 million, respectively, for the 2001 to 2015 period. The Best Case, since it assumes that trunk and primary roads are to be kept in good condition, is the same as the Desirable Case. As can be seen here, there is enough money to fund the core road network even without cost-reduction measures or, for that matter, new sources of revenue.

Assuming previous new sources of revenue and cost-reduction measures are implemented, there would be Ksh 123,149 and Ksh 101,154 million remaining after paying the maintenance costs for the 2001 to 2015 period for the Do-Minimum and Desirable Cases, respectively, for the non-core or secondary & minor road network. On the other hand, the amount of money required to finance the secondary & minor road network for the Do-Minimum and Desirable Cases is Ksh 148,093 million and Ksh 217, 502 million, respectively, assuming that the above cost-reduction measures are implemented. Since it is not cost-effective to maintain secondary & minor roads at the service level required by the Desirable Case, and cost effective to maintain the core road network at the Desirable Case level, the shortfall in funding for maintaining the secondary & minor road network is calculated to be equivalent to Ksh 46,939 million for the 2001 to 2015 period. There are three ways to make this difference up:

- Have local communities help pay for the costs of road maintenance
- Remove some of the roads from the road network
- A combination of the above two items

The shortfall of Ksh 46,939 million would be about Ksh 3,129 million per year, which is about 39% of the current total for the RMLF fund of Ksh 8,040 million. This is a rather large amount for local communities to bear themselves. Therefore, it seems inevitable that some portion of the secondary & minor road network will have to be retired from service. If local communities were unwilling or unable to bear this shortfall, approximately 29,000 km of road, or 23% of the secondary & minor road network, would have to be retired. Should this latter option be chosen, then a method to carry this out will be necessary. Since traffic volumes on the secondary & minor road network are low, conventional cost-benefit analysis should not be applied. Instead, some type of multi-criteria analysis or cost-effective analysis should be used. In addition the concept of basic access, which is crucial in rural areas, must be considered. The type of criteria that should be applied in deciding what roads to keep in the network should consider criteria such as the following:

- potential traffic and mobility levels,
- proximity to health and educational facilities,
- agricultural production,
- planned development projects,
- population served by road index,
- social facilities, and
- employment creation potential

6.5.3 Scenario Comparative Analysis

Scenario Comparison

Based on the above analysis, it can be said that there is sufficient funding for maintaining a core road network consisting of Class A, B, and C roads. This is true even if there are no new revenue sources or cost-reduction measures. It should be mentioned here, however, that this definition is tentative and that some portions of the secondary & minor road network may need to be included in a core network in the future. In any case, even with new revenue sources and cost-reduction measures, there is not enough funding for the entire road network that would include secondary & minor roads.

Although the funding gap can be reduced with the implementation of the funding and cost-reduction scenarios discussed above, there is no guarantee that all or even any of the above-mentioned funding and cost-reduction scenarios will be implemented. As shown in the table and graph below, the amount of secondary & minor road that would have to retired would vary from a high of about 80,000 km to a low of 29,000 km, or between 63% and 23% of the secondary & minor road network for the Best Case. Given this, the degree to which new funding sources and cost-reduction measures are successfully pursued is crucial.

Table 6.5.2 Comparison of Funding & Cost-Reduction Scenarios for the Best Case and the Amount of Road to be Retired

Funding and Cost-Reduction Scenarios	Funding Revenue (Ksh millions) (A)	Maintenance Costs (Ksh millions) (B)	A-B	Length of Secondary & Minor Rd to be Retired (km) *
Funding Scenario 1 (Base Case)	200,503	329,204	128,701	80,438 (63%)
Funding Scenario 2	212,003	329,204	117,201	73,251 (58%)
Funding Scenario 3	220,332	329,204	108,872	68,045 (54%)
Cost-Reduction Scenario 1	200,503	303,988	103,485	64,678 (51%)
Cost-Reduction Scenario 2	200,503	303,988	103,485	64,678 (51%)
All Funding Scenarios	231,832	329,204	97,372	60,858 (48%)
All Cost-Reduction Scenarios	200,503	278,771	78,268	48,918 (39%)
All Scenarios	231,832	278,771	46,939	29,337 (23%)

Note:
Funding Scenario 1: RMLF only.
Funding Scenario 2: RMLF, CESS, & LATF.
Funding Scenario 3: RMLF & New Funding Sources.
Cost-Reduction Scenario 1: Reduction in costs due to encouragement of labor-based work.
Cost-Reduction Scenario 2: Reduction in costs due to encouragement of contracting out.
*: Value in ( ) is percentage of maintainable secondary & minor road network.

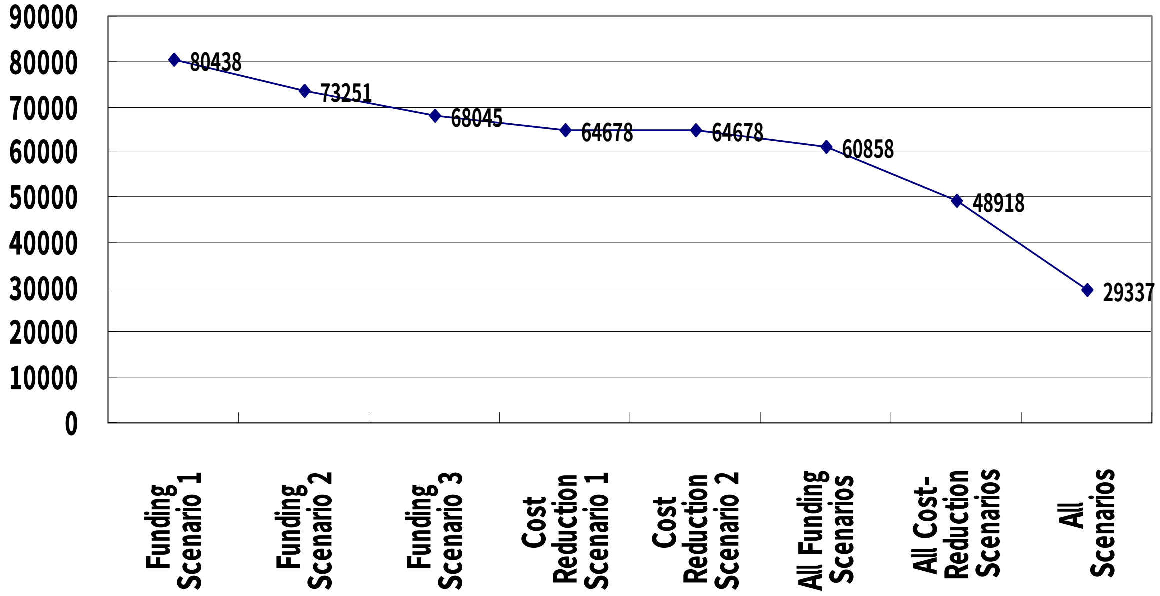

Figure 6.5.6 Length of Secondary & Minor Road to be Retired by Scenario

Recommendation

As the above analysis and discussion has shown, even with the achievement of all the funding and cost-reduction scenarios that were considered in this report, there would still be a significant shortfall in funding to maintain the entire road network. Therefore, it is important that the local authorities decide on what roads to retire and/or have local residents pay contributions to. However, in order to do this, it is recommended that a separate study be executed to determine those roads of the secondary & minor road network that should receive funding based on the analytical methods described in the previous section. This would, however, require that the following be carried out:

- Execution of a road inventory survey
- Execution of a road condition survey
- Definition of a core road network

Given the above lack of funds, **the RMLF should only be used for the maintainable road network and any road rehabilitation work should be financed by other sources including the donor community.** The JICA Study Team would like to note here that, if the Kenyan Government can draw up a plan detailing its core network and the possible scenarios for funding it and the non-core road network, together with better management via the full operation of the KRB system, **there should be no problems with obtaining outside funding to rehabilitate roads that the Government considers important.**