# Consultancy Services for Preparation of Design Manuals for Low Volume Roads in Tanzania
# **Manuals Review Report - Final**

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**This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.**

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

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**Report summary**

Roads agencies in Tanzania face a major challenge with the management of their rural road network of just over 50,000 km. This network is relatively lightly trafficked, almost completely unpaved, in mostly poor condition, and generally impassable during the rainy season. The agencies are now striving to find more appropriate, cost-effective solutions for maintaining their unpaved roads or upgrading them to a paved standard.

There is a concern that the current design manuals do not cater adequately for low volume roads. This has led to a need to develop a new design manual specifically for low volume roads–an initiative that is being supported by the UK Department for International Development (DFID) through its Africa Community Access Programme (AFCAP).

The purpose of the project is to prepare a design manual for low volume Roads in Tanzania as a basis for promoting rational, appropriate and affordable implementation of projects providing such roads in a manner that make appropriate use of local resources in a cost-effective and sustainable manner. It is expected that the new manual will be based on similar documents prepared previously under AFCAP in other countries such as South Sudan, though other relevant local and regional experience will also be incorporated.

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## List of Abbreviations

| | |
|---|---|
| AFCAP | African Community Access Programme |
| ARRB | Australian Road Research Board |
| Austroads | Assoc. of Australian and New Zealand Road Transport and Traffic Authorities |
| CI | Complementary Intervention |
| DCP | Dynamic Cone Penetrometer |
| DFID | Department for International Development |
| DN | Rate of DCP penetration in mm/blow |
| EOD | Environmentally Optimized design |
| HVR | High Volume Road |
| HV | Heavy Vehicle |
| ILO | International Labour Organization |
| IWP | Inner Wheel Path |
| IRAP | Integrated Rural Accessibility Planning |
| Km | Kilometre |
| LCC | Life Cycle Costing |
| LGA | Local Government Authority |
| LVR | Low Volume Road |
| LVSR | Low Volume Sealed Road |
| MESA | Million Equivalent Standard Axles |
| RFB | Road Fund Board |
| SADC | Southern African Development Community |
| ToR | Terms of Reference |
| TRL | Transport Research Laboratory |
| UK | United Kingdom |

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# 1. INTRODUCTION

## 1.1 Background

The provision and adequate maintenance of rural road infrastructure in Tanzania is central to the socio-economic growth and development of the country. Without physical access to jobs, health, education and other amenities, the quality of life suffers; without all-year physical access to resources and markets, growth stagnates, and poverty reduction cannot be sustained.

As indicated in Table 1, almost the entire length of the rural road network (district, feeder and urban roads which fall under the jurisdiction of the Prime Minister's Office-Regional Administration and Local Government (PMO-RALG)) is unpaved and occurs in areas where a high percentage of the population live and where agriculture is the predominant economic activity. Almost 60% of the Trunk and Regional road network, which falls under the jurisdiction of TANROADS, is also unpaved. Practically all the District, Feeder and Urban roads and a significant proportion of the Regional roads carry relatively low volumes of traffic, typically less than about 300 vehicles per day (vpd). These low volume roads (LVRs) fulfil a critical function in that they generally provide the only form of access to rural communities and provide for the mobility of people and movement of goods from the fields to the market place.

**Table 1-1: Approximate length of national classified road network**

| Road Class | Jurisdiction | Paved (Km) | Unpaved (Km) | Total (Km) | % paved |
|---|---|---|---|---|---|
| Trunk | TANROADS | 5,478 | 7,308 | 12,786 | 42.8 |
| Regional | TANROADS | 840 | 20,265 | 21,105 | 4.0 |
| District, Feeder, Urban | LGAs | 774 | 51,807 | 52,581 | 1.5 |
| **Total** | | **7,092** | **79,380** | **86,472** | **8.2** |

Source: TANROADS & PMO-RALG, 2010

Unfortunately, the task of maintaining a large network of unpaved roads has imposed a significant logistical, technical and financial burden on Tanzania's roads agencies. The result has been a network of rural roads that are generally in very poor condition (an estimated 90%), and often impassable during the rainy season. Moreover, in the medium to long term, the continuous use of gravel, a non-renewable resource, is unsustainable. This untenable situation has led to the need to find more appropriate, cost-effective solutions for upgrading gravel roads to a paved standard. However, **there is a concern that current design manuals in Tanzania do not cater adequately for LVRs.** This has led to a need to develop a new design manual for LVRs – an initiative that is being supported by the UK Department for International Development (DFID) through its Africa Community Access Programme (AFCAP).

## 1.2 Purpose and Scope of Project

The purpose of the project is to prepare a new design manual for LVRs in Tanzania as a basis for promoting rational, appropriate and affordable implementation of projects providing low volume roads that make appropriate use of local resources in a cost-effective and sustainable manner.

It is expected that the new manual will be based on design manuals for LVRs prepared recently under AFCAP in South Sudan, though other relevant local and regional experience will also be incorporated. Thus, the new manuals will build forward from what has already been produced and not require starting from the beginning. Therefore, the emphasis in terms of the content of the manual would be:

- Customizing the contents of the proposed LVR manual to the Tanzanian environment using the existing manuals in Tanzania, as well as those developed for South Sudan, and other countries as a basis;
- Identifying gaps that are particular to Tanzania and addressing them with information sourced from other relevant manuals and the experience of the project team.

In order to achieve the above objectives, one of the key tasks indicated in Phase 2 of the programme is to undertake a review of a number of existing LVR manuals for the reasons indicated above, and to prepare a summary report – **this report** - for presentation to stakeholders at an Inception Meeting.

# 2. REVIEW OF MANUALS

## 2.1 General Approach

The Terms of Reference indicate clearly that the new Tanzania LVR manual is to be based on the South Sudan LVR manuals plus incorporation of other local and regional experience as appropriate. However, it is worth noting that South Sudan LVR manuals complement and link to the latest versions of their other existing manuals - a sensible approach which gives priority to the documentation that already exists in the country. In similar vein, **it would seem appropriate to also use the existing documentation in Tanzania as a point of departure for developing the new LVR Design Manual and, wherever there are shortcomings, as regards their suitability for application to LVRs, to rectify them from relevant information contained in the South Sudan or other regional documentation.**

In view of the wealth of information that already exists on low volume roads technology as outputs from previous AFCAP and other similar projects, the aim should be **to provide Tanzania, within the resources made available for the project, with a comprehensive state-of-the art Design Manual for LVRs.**

Based on the above general approach, a key task is to firstly establish a common understanding as to the key characteristics of a LVR and, thereafter to develop an idealized framework for the provision of such roads in Tanzania. This framework can then be used as a yardstick for assessing the adequacy of the existing Tanzania, and other manuals, as a basis for developing the new Tanzania LVR manual.

## 2.2 Definition of a LVR

A common understanding of the definition of a LVR by all stakeholders is crucially important as such an understanding will dictate the manner in which the new manual will be developed, including its contents, in terms of the commonly perceived characteristics of such roads and the related criteria to be used in providing them at an appropriate level of service.

There is no internationally accepted definition of a LVR. In developed countries such as the USA, roads carrying about 400 vehicles per day (vpd) are defined as very low volume roads. In developing countries, the figure that is currently, typically, used is about 300 vpd PLUS a design traffic loading not exceeding about 1 million equivalent standard axles (MESA). However, neither of these definitions provide a complete picture of the characteristics of a LVR. The unique characteristics of such roads often challenge conventional engineering practice in terms of pavement and materials engineering, geometric design, road safety and maintenance. In this regard, the following attributes are becoming increasingly apparent:

- Almost exclusive reliance on the use of naturally occurring, often non-standard materials, many of which are quite moisture sensitive.
- The adoption of an “Environmentally Optimized Design” (EOD) approach in which the road is designed to suit a variety of task and environmental factors such as rainfall, available materials, construction capacity, terrain, flood risk, etc., in the most cost-effective and sustainable manner.
- The “relaxation” of geometric design standards within an “Extended Domain Design” context without undue increase in the risk of road users, including a significant amount of non-motorized traffic in urban/peri-urban areas, coupled with a focus on traffic safety measures in built up areas.

- An alignment which is not necessarily fully "engineered", especially at very low traffic levels, in the sense that some sections may follow the existing alignment and the full length may offer variable travelling speeds that will seldom exceed about 80 km/h, as dictated by the local topography.

- A recognition that pavement deterioration is driven primarily by environmental factors (particularly moisture), with traffic loading being a lesser influential factor in deterioration, and drainage being of paramount importance;

- An appreciation that conventional economic analysis often cannot justify the investment of public funds in the construction and maintenance of these roads in which relatively difficult to quantify benefits of a broad socio-economic nature are likely to occur.

Based on the above typical characteristics of LVRs, it should be readily apparent that certain types of roads that fulfil just some of the above attributes will not fall under the heading of LVRs as defined above for purposes of developing the new manual. For example:

- A trunk road carrying less than 300 vpd and less than 1 million MESA over its design life would not necessarily be classified a LVR, as the level of serviceability that it would be expected to provide would be dictated by its function which would be characterized by a relatively high design speed and matching geometrics, low risk of failure, etc.

- A haul road serving, for example, an industrial, mining or quarry area, in which heavy loads are transported for a few months of the year during the rainy season even though the design traffic loading may be less than 1 MESA.

A holistic appreciation of the attributes that characterize LVRs will guide designers in producing more appropriate designs with an emphasis on using a fit-for-purpose, context sensitive, environmentally optimized approach to design and construction. This will place an onus on the design engineer to provide a road that meets the expected level of service at least life-cycle cost based on a full understanding of the local environment and its demands, and to turn these to a design advantage.

## 2.3 Idealized Framework for Provision of LVRs

An idealized framework for providing LVRs in the Tanzania context is presented in Table 2-1 and includes all the activities that would typically be followed in a sequential manner in providing such roads in an integrated and holistic manner.

**Table 2-1: Idealized framework for provision of LVRs**

| Part | Chapter | Focus |
|---|---|---|
| A. Introduction | 1. General Introduction | Core |
| B. Planning | 2. Rural Accessibility Planning | Complementary |
| | 3. Complementary Interventions | Complementary |
| C. Investigations | 4. Site Investigations and Route Selection | Core |
| | 5. Geotechnical Investigations and Design | Core |
| | 6. Construction Materials | Core |
| D. Design | 7. Environment | Core |
| | 8. Traffic | Core |
| | 9. Geometric Design | Core |
| | 10. Road Safety | Core |
| | 11. Hydrology, Drainage and Erosion | Core |
| | 12. Drainage Structures | Core |
| | 13. Pavement Design | Core |
| | 14. Unpaved Roads | Core |
| | 15. Surfacing | Core |
| | 16. Comparison of Designs and Implementation | Core |
| E. Contracts | 17. Documentation, Tendering and Award | Complementary |
| F. Construction | 18. Construction and Quality Assurance | Core |
| | 19. Borrow Pit Management | Core |
| | 20. Technical Auditing | Complementary |
| G. Maintenance | 21. Management, Operations and Procedures | Complementary |

As indicated in Table 2-1, there are six distinct sets of activities (B to G) which are typically undertaken by different departments of an agency. These six sets of activities provide a basis for deriving the various chapters of a complete LVR manual. It must be stressed, however, that the idealized framework is presented for completeness only and **does not necessarily indicate the scope of the new Tanzania LVR manual which must be developed within the scope of the resources and time frame indicated in the Terms of Reference for the project.** Moreover, in the context of an LGA institutional environment, the focus of the chapters could range from those of a core nature to those of a complementary nature as suggested in Table 2-1.

## 2.4 Approach to Evaluation of Manuals

Based on the approach proposed in Section 2-1, the manner of undertaking the review of the various manuals is postulated conceptually in Table 2-2. In essence, Column 1 would contain all the topics considered appropriate for inclusion in the new Tanzania LVR Design Manuals. Columns 2, 3 and 4 would then indicate the extent to which the respective manuals meet the requirements of the new manual. In this manner, a systematic evaluation of all available existing manuals can be undertaken and, where appropriate, the sources of information required to supplement the existing Tanzania manuals, in line with the idealized framework, identified.

**Table 2-2: Conceptual approach for undertaking review of manuals**

| Scope of new Tanzania manuals | Extent to which existing manuals addresses requirements of new manual | | |
|---|---|---|---|
| | Existing Tanzania manuals | South Sudan manuals | Other manuals |
| Topic X | | | |
| Topic Y | | | |
| Topic Z | | | |
| | | | |
| Key | Substantially | Partially | Not at all |

## 2.5 Manuals Reviewed

### 2.5.1 Tanzania manuals

A paper presented by the Director of Roads, Ministry of Works, at the 8th Annual Meeting between PMO-RALG in Collaboration with the Road Fund Board (RFB) and Roads Stakeholders, July 2013, and entitled "*Improvement of Performance on Road Works Through Provision of Guidelines, Standard and Specifications: The Case of LGAs"*, provides a valuable insight into the various documents developed by the Ministry of Works in the past decade. These documents are listed below and served as a basis for the Consultant's review of existing documentation:

- Road Geometric Design Manual (2011)
- Stone Pavement Construction Manual (????)
- Materials and Pavement Design Manual (1999)
- Tanzania Standard specification for Road and Bridge works (1999)
- Tanzania Laboratory Testing Manual (2000)
- Tanzanian Field Testing Manual (2003)
- Tanzania Guideline on Technical Auditing of Road Projects (2011)
- Guide to Traffic Signing (2009)
- Environmental Code of Practice for Road Works (2009)
- Road Sector Environmental Assessment and Management Guidelines
- TANRAODS Maintenance Manual: Parts I, II and III (2009)
- Miscellaneous maintenance documents, including:
    - Road Maintenance Management Manual (GTZ) for Arusha and Kilimanjaro
    - Road maintenance Contracting manual (2013)
    - Labour Based Road Works Technical Manuals (ILO); Volume I – Rehabilitation; Volume II – Maintenance
    - Labour Based Document for Rehabilitation Works (UNCDF/ILO Assist)
    - Road Maintenance Management Manuals (RMMS)
    - Maintenance Specifications and BOQ
    - Maintenance Supervision Manual
    - Maintenance Activities Statements

Some of the significant points made in the paper which are relevant to the development of the new LVR manual include:

- There are a number of stand-alone manuals of a fairly detailed nature that do not deal with LVRs in a coherent and sequential manner as would be followed in the provision of such roads.
- There are a number of gaps in the documents that still need to be addressed. For example, there is no manual on Quality Control and Quality assurance
- The Labour Based Road Works Technical Manuals are believed to be appropriate for LVRs where labour is readily available.
- There is concern about the availability/access of the various manuals, standards and specifications and the extent of their utilization by LGAs.
- There is a need for further development/customization of the existing manuals so as to make them user friendly by simplifying them to produce short, brief and concise booklets to facilitate their use on site by professionals.

What is clear from the sentiments expressed in the paper is **a need for relatively simple, concise, user-friendly manual for use by LGAs – a sentiment that will be closely heeded by the Consultants during the development of the new manual with a strong focus on their applicability to LVRs**. This new manual can make a significant contribution to Tanzania's Local Government Transport Programme (LGTP) which has ambitious targets for the improvement and maintenance of the approximately 50,000 km local road network throughout the country. Almost all of these roads fall into the category of LVRs and would benefit from the proposed manual. Moreover, the manual would also be applicable to many of the Regional roads under the responsibility of the national roads agency, TANROADS, because a significant proportion of them exhibit the characteristics of LVRs as defined in Section 2.2.

### 2.5.2 Other manuals

An extensive list of manuals from the eastern and southern African region has also been reviewed as listed in Annex A of this report. These manuals include the South Sudan, Ethiopian and a number of other LVR manuals developed previously for such countries as Botswana, Malawi, South Africa, Zimbabwe and elsewhere internationally. The latter manuals include, in particular, those published by the Australian Road Research Board (ARRB) and the Association of Australian and New Zealand Road Transport and Traffic Authorities (Austroads) such as the following which are very relevant to the eastern and southern African regions:

- Sealed Local Roads Manual: Guidelines to good practice: design, construction, maintenance and rehabilitation of pavements (ARRB, July 2005).
- Pavement Design for Light Traffic: A supplement to the Austroads Pavement design Guide (Austroads, 2006).
- Unsealed Roads Manual: Guidelines to good practice (ARRB, March 2009).

The outcome of the review of the existing Tanzania LVR manuals and the other manuals referred to above is presented in the next section.

# 3. OUTCOME OF MANUALS REVIEW

## 3.1 General

Based on the idealized framework presented in Table 2-1, the chapter headings envisaged for a comprehensive LVR manual for Tanzania would comprise the headings presented in the right hand column of the table. Thus, some twenty one chapters, including an Introduction, are tentatively envisaged, as covering, to various depths (core or complementary), the scope of the Tanzania LVR manual. Based on the chapter headings, the outcome of the review of the various manuals against the idealized framework is summarized below.

## 3.2 Introduction

### 3.2.1 General

The introductory chapter to any manual on LVRs is an important scene-setting one in that there are a number of unique attributes of such roads that need to be clearly spelt out so as to sensitize the reader to the philosophy of their provision in a manner which is quite different to high volume roads (HVRs). For example, as indicated in Section 2.2, there is still no common definition of a LVR and such a definition needs to be clearly spelt out in the introduction to the new manual.

It is also important to highlight in the introduction to the LVR manual the range of factors that should be considered at various stages of the road provision process. In particular, the road design process should be fully responsive to the Tanzanian road environment and the scope of the manual should address all of the topics indicated in Figure 3-1.

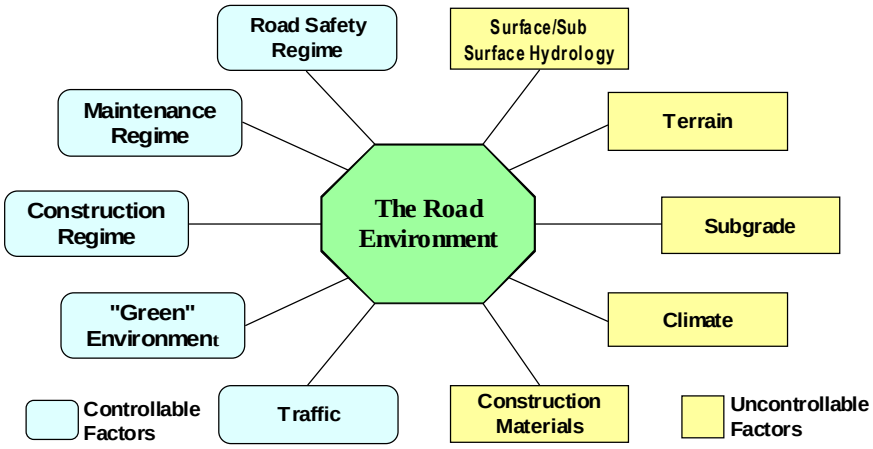


**Figure 3-1: Road environment factors**

### 3.2.2 Adequacy of existing Tanzanian LVR manuals

By virtue of the fact that the subject of LVRs is not specifically addressed in most Tanzanian manuals, the underlying characteristics of such roads and the philosophy governing their provision is not adequately addressed.

### 3.2.3 Adequacy of other manuals

The South Sudan, and other LVR manuals, such as the Ethiopian manual, all adequately address the underlying philosophy of LVR provision and provide valuable sources of information for inclusion in the Tanzania LVR manual.

## 3.3 Planning

### 3.3.1 General

Planning exerts a substantial level of influence on the downstream aspects of LVR provision in terms of its impact on the subsequent investigation, design, contract administration, construction and maintenance phases. The planning phase can rightly be viewed as the foundation on which the subsequent phases are based. It is an activity aimed at considering a wide range of options with the objective of providing optimal, sustainable solution, i.e. one which satisfies the multiple needs of stakeholders at minimum life-cycle costs. It should take full account of Government policies and strategies in the road transport sub-sector. Lack of planning data in the LGAs as a basis for inclusive network planning has been identified as a major shortcoming by PMO-RALG.

In light of the above, the chapter on planning should provide guidance to policy makers and planners in the Districts and elsewhere who are involved in making decisions or in planning the way in which LVRs are provided. In so doing, the chapter should address issues such as:

- The country and macro-economic setting and the policies and strategies that guide the planning of LVRs.
- The national and local planning frameworks and the various factors necessary for ensuring sustainability in the provision of LVRs.
- An overview of the LVR planning process with emphasis on integrated rural accessibility planning.
- Design, construction, maintenance, road safety & environmental aspects of LVR provision.

A tool that may be of interest to PMO-RALG is the Integrated Rural Accessibility Planning (IRAP) system which has been developed by the International Labour Organization (ILO) to reinforce local planning methods. This tool facilitates the development of comprehensive information on the location, condition and use of rural infrastructure and services, priorities, investments and identifies interventions. It further emphasises the building of local capacity and the use of local resources (material and human) in the implementation of locally initiated projects, including the adoption of appropriate technologies and use of labour-based methods. The use of IRAP assists communities in developing a set of well-defined and prioritized interventions that address the access needs of the rural population.

### 3.3.2 Adequacy of existing Tanzanian LVR manuals

The current documents on LVRs do not deal with the planning aspects of such roads in an integrated and holistic manner as described above. Although mentioned in a fragmented manner in some documents, the topic is neither addressed in a holistic manner nor given the prominent attention that it deserves in the planning aspects of LVRs.

### 3.3.3 Adequacy of other manuals

The planning aspects of LVRs are not adequately addressed in the South Sudan manuals. However, such information may be sourced from the Malawi Guidelines for Planning Rural Roads, Tracks and Paths as well as the ILO Guide to Integrated Rural Accessibility Planning.

## 3.4 Complementary Interventions

### 3.4.1 General

Complementary Interventions (CIs) are a relatively new concept that may be considered in the early stages of LVR planning. They include actions or initiatives that are implemented through a roads project which are targeted toward the communities that lie within the influence corridor of the road and are intended to optimize the benefits brought by the road to extend the positive and mitigate the negative impacts of the project.

In its simplest terms complementary Interventions take advantage of the presence of the road project to build in aspects that will enhance the social, environmental and safety situation of communities affected by the road. These are additional to the normal social, environmental and safety obligations of the contractor and do not replace or share the contractor's normal obligations.

Complementary Interventions can generally be grouped into three categories:

Cat. I Management Interventions – simple actions that enhance the road project itself and are well within the normal skills of the road contractor. These aim to improve the wider impacts of the project itself and build on or extend the normal socio-environmental and safety obligations of the contractor, for example, improving resident to a property.

Cat. II Opportunity Interventions – actions that are beyond the scope of traditional road projects but are within the technical and management skills of the road works contractor, for example, clearance of a market area.

Cat. III Enhancement Interventions – actions that utilise the provisions of the contract but extend beyond the normal skills and experience of road works contractor. These actions would normally be implemented by other parties with the necessary relevant skills, for example, provision of training to local service providers.

Complementary Interventions need to be considered early in the project development and be an integral part of project planning, from project identification to feasibility study. It is important that the client and key stakeholders (for example those who identify the need for the project and local authority representatives in the project area) work together to develop an outline plan for inclusion of Complementary Interventions in the road project/programme to a sufficient level of detail for their further development during the feasibility study and detailed design.

### 3.4.2 Adequacy of existing Tanzanian LVR manuals

The current Tanzanian documents on LVRs do not deal with the relatively new concept of Complementary Interventions which can be used to enhance access to employment opportunities for the wider community, where unemployment or under-employment are local issues.

### 3.4.3 Adequacy of other manuals

The issue of Complementary Interventions is adequately dealt with in both the South Sudan and Ethiopian LVR manuals and both documents provide sources of valuable information for possible inclusion in the Tanzania LVR manual.

## 3.5 Site Investigations and Route Selection

### 3.5.1 General

The choice of methods for site investigation is determined by the type of road project, the practical problems arising from site conditions, the terrain and climate. If an investigation is to be effective, it must be carried out in a systematic way, using techniques that are relevant, reliable and cost-effective. In many cases the project will be the upgrading of a track or old road to a new standard and major realignment will not be required. In such a case the site investigation should cover as many of the aspects required for the design of the road as possible to minimise the number of separate investigations that may be necessary. This will include information on the existing alignment, soils, materials, hydrology and drainage, existing traffic, environmental issues, etc.

For roads carrying high volumes of traffic each type of survey is usually described in separate manuals. The most frequently employed are described in the Tanzanian manuals for Field Testing, Laboratory Testing, and manuals on environmental issues, geotechnical investigations and hydrology. However,

for upgrading LVRs most of these could be combined into a single manual. Specialist manuals are usually very comprehensive and detailed and it is one of the main tasks of this review to identify the level of detail required for the LVR manual so that it is appropriate for use by the target audiences.

For LVRs, investigations should start using standard methods. For some field investigations specific labour-based methods that do not require a fully equipped laboratory are available. Sophisticated and expensive procedures should be employed only when problems are severe.

If the project is for an entirely new road it is likely that several stages of planning will be required, or at least a feasibility study which will include route selection. The level of detail of site investigations for this will be somewhat less than for the engineering design phase and will probably include considerably more liaison with and surveys of the local community. The route is essentially a blank canvas at inception. It is, therefore, vital to put the road in the best place to ensure it serves the needs of the communities for many decades into the future. Mistakes at this stage could be expensive to correct and unlikely to be carried out for many years.

### 3.5.2 Adequacy of Tanzanian LVR manuals

None of the existing Tanzania manuals deal with the issue of site investigations and route selection in a manner that is focussed specifically on LVRs. Some manuals, e.g. the Field Testing Manual (2003), do address the issue of ground investigations and alignment soil surveys, aspects of which are appropriate to LVRs. However, the topic of site investigations and route selection for LVRs is not dealt with in a coherent manner in any of the existing manuals.

### 3.5.3 Adequacy of other manuals

Several of the referenced manuals have dealt with this subject. The most recent is the Route Selection manual for Ethiopia. This comprises 160 pages and is not suitable as it stands for the new manual. It is also dealt with in the Ethiopian LVR manual and in the South Sudan manual but in somewhat less detail. For example, in the South Sudan manual geotechnical aspects of site investigations comprise 22 pages and other types of site investigations are dealt with in the context of the chapters on design. In both of these manuals full emphasis is given to all the preliminary stages of the project cycle including initial planning, pre-feasibility, feasibility and final engineering design. Such detail may not be appropriate for all classes of LVRs.

## 3.6 Geotechnical Investigations and Design

### 3.6.1 General

Geotechnical investigations are carried out to ensure that any structures (roads, bridges, cuts and fills, etc.) are designed so that the risk of collapse or failure is within acceptable limits. In principle, geotechnical investigations should be designed on a consistent basis for any type of structure.

The centre-line survey carried out to assess subgrade conditions beneath the proposed road would generally be included in the geotechnical investigation. This is relatively simple, but must be sufficiently comprehensive to identify the subgrade conditions and any problems and needs to be designed taking into cognizance the variability of the in situ conditions.

It is recognized that water crossing structures for LVRs will, in general, be relatively simple and low cost and the high costs of detailed geotechnical investigations will seldom be warranted. However, for example, even for a simple wooden water crossing facility, it is essential that the structure is founded on suitable materials, and at a suitable depth to avoid collapse or washing away of the structure during flooding. This requires investigations appropriate to the conditions and the envisaged structure.

Geotechnical investigations require careful design, management and interpretation and are best carried out by specialists in this area to minimize costs. However, it is considered that for low volume roads, simple investigations can be carried out by regional or district engineers. A simple process using

a decision tree technique with respect to identifying the need for specialist input is proposed to be incorporated into the manual.

Many LVRs roads have had significant problems with extended closures following slope instability of cuts (and to a lesser extent, fills) after heavy precipitation. The investigations and design of earthworks such as these can be done by LVR design engineers for small structures or in relatively stable areas. However, the trick is to know when to obtain specialist advice and guidelines in this direction will be included.

It is probably more important in this manual to discuss the needs and requirements of site investigations rather than the process, so that the LVR designer can develop the correct knowledge to know what he can do and when to procure specialist services.

### 3.6.2 Adequacy of existing Tanzanian LVR manuals

The current documents, such as the Materials and pavement Design manual (1999), deal with typical subgrade investigations but do not provide appropriate guidelines for geotechnical investigations. Both of these aspects can benefit from improved guidelines specifically for LVRs in order to optimize the costs.

Although some attention is paid to problem soils in the materials and Pavement Design Manual (1999) improved discussion on a wider range of problem soils and recent developments with regard to the mitigation of their potential problems should be included.

### 3.6.3 Adequacy of other manuals

Both the South Sudan and Ethiopian LVR manuals address the topic of Geotechnical Investigations and Design and provide sources of material that can be customized to the requirements of the Tanzanian LVR manual.

## 3.7 Construction materials

### 3.7.1 General

The selection of appropriate (mostly local) materials can have a far-reaching effect on the final cost of a LVR. It has been recognized that the cost of materials can comprise up to 70% of the cost of a road. In cost-benefit analyses, high cost and inappropriate construction materials increase the construction and maintenance costs, making the upgraded road option less economically viable. Recent developments in understanding the behaviour of local materials when used in the construction of LVRs have allowed the use of materials that were previously considered unsuitable for road construction.

This is especially true in areas such as Tanzania, where local sands and tropical soils not complying with conventional material specifications are widespread. The importation or chemical treatment of these materials increases their construction costs significantly.

In order to capitalize on the use of these local materials, a better understanding of their fundamental properties and behaviour is necessary and inclusion of this information in the LVR manual can be encapsulated in specifications that permit the use of a wider range of local materials.

### 3.7.2 Adequacy of existing Tanzanian LVR manuals

The current documents on LVRs, such as the Materials and pavement Design Manual (1999), discuss materials in some detail but do not cover many of the behavioural issues relevant to the use of local materials in LVRs. Background information in this respect is lacking.

### 3.7.3 Adequacy of other manuals

Both the South Sudan and Ethiopian LVR manuals address the topic of construction materials in a country specific manner. The recent knowledge in these regards has not been widely published yet but currently rests with the project team.

## 3.8 Environment

### 3.8.1 General

In its broadest sense, the term environment includes both the natural or "bio-physical" environment (flora, fauna and physical features) as well as the human environment (socio-economic and cultural factors) and the interaction between them. The four cornerstones of the environment that feature in the provision of LVRs include:

- Ecological
- Economic
- Social
- Physical

Each of the above includes a range of factors that should be considered at various stages of the LVR provision process.

### 3.8.2 Adequacy of existing Tanzanian LVR manuals

The current Materials and Pavement Design Manual (1999), discusses various aspects of the environment including the physical features of the country, climatic factors such as rainfall, the moisture regime and temperature, and environmental impact assessment issues. Much of this country-specific information can be retained for use in the new LVR manual.

### 3.8.3 Adequacy of other manuals

Both the South Sudan and Ethiopian LVR manuals address the topic of environment in a country specific manner. Thus, such information adds little of relevance for inclusion in the Tanzania LVR manual.

## 3.9 Traffic

### 3.9.1 General

Reliable information on traffic volume and loading is a critical input to geometric and pavement design as well as for road safety purposes. It is therefore essential that estimates of these parameters are obtained in a proper manner. This entails the undertaking of well-designed traffic surveys to produce reliable results that are influenced by a variety of factors such as seasonal variations of traffic movements, duration and frequency of the traffic count, day of the week, time of the year, etc. Moreover, the effects of upgrading a road will result in some traffic diversion and generation, in addition to normal traffic growth. There is also the issue of converting the traffic information in AADT terms to cumulative equivalent design axles for pavement design purposes which requires a knowledge of vehicle equivalence factors by vehicle class as determined from axle load surveys.

### 3.9.2 Adequacy of existing Tanzanian LVR manuals

The current Materials and Pavement Design Manual (1999) addresses most aspects of traffic estimation for design purposes in a manner that is appropriate to the design of LVRs. However, the manual does not address the issue of non-motorized traffic which is particularly important for geometric design and road safety purposes – a shortcoming which must be addressed in the new manual.

### 3.9.3 Adequacy of other manuals

The South Sudan, Ethiopian and other manuals, such as the Malawi DCP Design Manual, all deal with traffic estimation for design purposes in a manner which focuses specifically on its application for LVRs. Thus, these documents provide a valuable source of information for supplementing that contained in the current Tanzania Materials and Pavement Design Manual.

## 3.10 Geometric Design

### 3.10.1 General

Geometric design is the process whereby the layout of the road through the terrain is designed to meet the needs of all the road users. The geometric standards are intended to meet two important objectives namely **to provide acceptable levels of safety and comfort for road users and to minimise construction costs**. The level of service is not a quantity that can be calculated with much accuracy but it is universally accepted that it should increase as the traffic level increases hence higher standards (road classes) are specified for roads carrying higher levels of traffic and lower standards for lower volume roads. However, where the precise boundaries between classes occur is very debateable. As a result, the range of standards used worldwide for a particular level of traffic is wide. A recent study compared the standards worldwide and this study assisted in the revision of the Ethiopian standards and those incorporated in the South Sudan manual.

It is important to note that conditions on rural LVRs are changing slowly. Vehicles are improving and often getting bigger, more types of 'vehicle' are being used and, in particular, bicycles, motor cycles and different forms of motorcycle taxis are rapidly increasing in numbers. The public are now more aware of safety issues, especially concerning pedestrians and cyclists and are demanding better standards, engineers are more aware of the performance of road surfacings under different conditions and economists are better able to assess the consequences of road closures and impassability. Thus geometric standards developed or evolved in the past are unlikely to cater for the requirements that stem from these changes.

There are various ways in which geometric standards can be improved but there are no precise answers to all the issues hence consensus is required from the Tanzanian road community as part of this project.

### 3.10.2 Adequacy of Tanzanian Manual

Some of the issues described above have been considered in the current Tanzanian Geometric Design Manual (2011) but this review has identified others that could be included.

### 3.10.3 Adequacy of Other Manuals

The South Sudan and Ethiopian manuals include some improvements based on the above considerations but there are several decision points in the selection process for standards that need to be tailored to Tanzanian requirements.

## 3.11 Road Safety

### 3.11.1 General

Road traffic operations in the rural areas of Tanzania tend to be complex and often involve a mixture of motor vehicles, bicycles, motor cycles (boda-bodas), animal drawn vehicles and pedestrians. A large proportion of the traffic composition is dominated by relatively old, overloaded and slow-moving vehicles and there are often low levels of driver training and control of road users. In such an environment, traffic safety assumes paramount importance.

The challenge in the situation described above is to ensure that the speed of motorized traffic is restrained to relatively low levels, particularly within villages. This is not easily achieved because the roads serving these villages often serve two conflicting functions in that they cater for both inter- and intra-village traffic. As a result, specific speed reduction measures are required to minimize traffic accidents. Such measures may be achieved in a number of ways in the context of a "total village treatment" – a relatively new approach that has been developed specifically for LVRs which aims to instil in the driver a perception that the village is a low-speed environment in which driving speed should be reduced. This concept, which is increasingly being applied in a number of countries, would enhance and complement other road safety measures that are adopted in Tanzania.

### 3.11.2 Adequacy of Tanzanian Manual

None of the current Tanzania manuals address the issue of road safety for LVRs in a dedicated manner as described above.

### 3.11.3 Adequacy of Other Manuals

Both the South Sudan and Ethiopian manuals deal with the issue of road safety in a very limited way with a focus only on traffic calming, road markings, signage and lighting. However, the Malawi Design Manual for LVSRs includes detailed treatment of the "total village treatment" approach which would provide a valuable input to the Tanzania LVR manual.

## 3.12 Hydrology, Drainage and Erosion

### 3.12.1 General

Good drainage is vital to the operation of a LVR. Such drainage has four main functions:

- To convey water across the line of the road in a controlled fashion.
- To convey rainwater from the surface of the carriageway to outfalls.
- To control the level of the water table in the subgrade beneath the carriageway.
- To intercept ground and surface water flowing towards the road.

The above objectives may be attained through consideration of two topics that need to be treated separately, namely internal and external drainage.

*Internal Drainage*. The process of minimising the quantity of water that remains within a road pavement by maximising the ability of the road to lose water to an external drainage system. Sometimes this definition also includes minimising the quantity of water that gets into a road pavement in the first place.

*External drainage.* This consists of three components:

a) The process of determining the quantity of water that falls upon the road itself that needs to be channeled away from the road by the drainage system. This is water that falls upon the road as rain.
b) The process of determining the quantity of water that flows in the streams, rivers and natural drains that the road has to cross. This is water that falls as rainfall at locations away from the road.
c) Design of the individual engineering features of the drainage system to accommodate the flow of water.

There is nothing that is particularly new in these topics. Internal drainage is usually dealt with in pavement design manuals but external drainage is often the subject of a separate manual.

The detrimental effects of the action of the climate on roads is largely independent of the traffic that the road carries and therefore the engineering measures required to protect a LVR comprise a much higher percentage of their overall costs. Because of this, the level of risk that is used in the design of the drainage features of LVRs is usually higher than for HVRs. In view of the increasing severity of climatic events in some countries it may be prudent to review the risk factors and possibly revise them.

External drainage design has been the subject of many studies because of the difficulty of predicting rainfall, rainfall intensities, run-off, ground water retention, flow velocities, and storm durations amongst other things. As a result, there are numerous methods of predicting the amount of water that the various parts of the external drainage system must cope with, some of them very complex and all of them requiring data that are often unavailable in rural Africa. The range of methods available has resulted in a corresponding range of methods being used by highway authorities throughout the world but for LVRs the only practical methods must be relatively simple. The task for this project is to identify the best option.

Erosion of side slopes or longitudinal drains or at the inlet or outlet of drainage structures can severely impair the performance of LVRs, especially in high rainfall areas. The typical mitigation measures include well designed surface and sub-surface drainage features and appropriate slope angles for the soils and rocks present. Various protection systems can be used to control erosion on LVRs, including such measures as scour checks and lined drains, complemented by supplementary measures such as the use of mitre and interceptor drains.

### 3.12.2 Adequacy of Tanzanian Manual

For internal drainage the Tanzanian Materials and Pavement Design Manual (1999) provides some useful advice but recent research has provided more information and some quantification that was not available before. The principle is to use a combination of features to minimise the effects of the impact of internal drainage on the performance of LVR pavements.

As regards external drainage, there appear to be no manuals that deal with this subject in a simplified manner that is appropriate for application in a LVR environment.

The topic of erosion control for LVRs is not specifically addressed in any of the existing Tanzanian design manuals.

### 3.12.3 Adequacy of Other Manuals

The South Sudan and Ethiopian manuals provide more detailed advice on both internal and external drainage and are a valuable source of information that can be customised to the Tanzanian environment. The Malawi Design Manual for LVSRs also addresses the topic of drainage in manner that is well suited for application to LVRs in the Tanzania context.

## 3.13 Drainage Structures

Appropriately chosen, located and designed drainage structures are required to adequately deal with the drainage of LVRs as described in the previous section. Such structures typically comprise either culverts (corrugated metal, pre-fab or in-situ concrete pipes, etc.) or low level elements (drifts, causeways, low level, short–span bridges).

For LVRs the maximum use should be made of labour-based construction technology and methods of minimising the number of days in the year when a road is likely to be impassable.

The design of such structures should make use of the simplest methods and suitable risk factors applied to cope with the lack of good data on which to base the designs. If calculations are required then suitable nomogram-based or chart-based methods should be used for simplicity. Considerable use should be made of the knowledge of local people.

### 3.13.1 Adequacy of Tanzanian Manual

The Tanzanian design manuals, including the Materials and Pavement Design Manual (1999), do not address the topic of drainage structures

### 3.13.2 Adequacy of Other Manuals

The sections of the South Sudan and the Ethiopian LVR manuals dealing with drainage structures have a long history of continual development from a project in South East Asia some years ago. The authors have been involved in this field for nearly 40 years so it is possible that nothing better exists. Several organisations have been responsible for manuals on structures for LVRs using labour-based methods and details from these are also included in the South Sudan and Ethiopian manuals.

Simple methods of estimating water flows are described in both of these manuals and provide a valuable source of information for inclusion in the Tanzania LVR manual.

Erosion control measures are addressed in the Malawi Design Manual for LVSRs which also provides a valuable source of information for inclusion in the Tanzania LVR manual.

## 3.14 Pavement Design (New Roads)

### 3.14.1 General

Many different techniques have been developed for the structural design of roads over the years. The majority of these have been based on conventional road design procedures and have been "downsized" or adapted for low volume roads. Experience has shown that this has not proved to be effective or successful with many low volume roads being severely overdesigned and thus excessively costly. Recent developments combining the concepts of "environmentally optimized design" with the use of in situ environmental and material conditions have shown the direct benefits in terms of optimum pavement design as well as cost savings.

It is important, however, that the engineer understands the fundamental principles and assumptions that this technique depends on for instance good in situ testing, an effective and well-maintained drainage system and good construction practices.

It is useful, however, to compare the designs developed with those from other procedures such as the South African or TRL catalogue methods (based on CBR) in order to get a "feel" for the differences and the possible implications should the design assumptions not be met.

### 3.14.2 Adequacy of existing Tanzanian LVR manuals

The current documents on LVRs essentially use conventional design techniques and although the "environmentally optimized design" concept is incorporated in certain aspects of the design (e.g. the use of unsoaked CBR designs in dry areas) the current manuals do not gain the maximum benefit of recent developments in this field of engineering.

The DCP DN design for instance can easily be carried out by a relatively inexperienced engineer, albeit one with a good theoretical understanding of the fundamentals of pavement engineering.

### 3.14.3 Adequacy of other manuals

Currently only the Malawi (and various South African publications) makes full use of the DCP design method. Other design methods are well covered in most traditional design manuals, although as stated earlier, they are not considered to be the most appropriate techniques for low volume roads.

## 3.15 Pavement Design (Upgrading)

### 3.15.1 General

There are two key feature of upgrading a LVR of a lower class to one of higher class. The first is to make full use of the existing pavement layers and the consolidation of the materials in the lower pavement and subgrade that has taken place over the years. Some existing methods do not do this and the resulting construction can be considerably more expensive than necessary.

The second is to investigate the performance of the existing road to determine the cause or causes of any local or general failures. This may be relatively easy if the road has performed well and local failures are caused by failures of the drainage, but if the causes are not obvious an analysis will be required to ensure that the best remedial method is used.

The subsequent rehabilitation design can be based on several different methods that invariably give different results but the method most suitable for LVRs is based on direct comparison with the design charts for new pavements, calculation of the deficiency and application of treatment and/or an additional layer to correct that deficiency. The most suitable methods will use DCP measurements of pavement layer strengths because a DCP method will provide pavement strength data at very frequent intervals and eradicate most of the risk of under design caused by an inadequate statistical data base.

### 3.15.2 Adequacy of Tanzanian Manual

The Tanzanian Pavement Design Manual includes a relatively comprehensive chapter on rehabilitation design but is concerned with HVRs. There are basically three general methods of overlay design:

1. An empirical pavement strength/thickness approach using the concept of Structural Number or an equivalent empirically-based pavement design method.
2. An analytical approach based on reducing calculated critical stresses to safe levels.
3. A load spreading approach based on elastic deflections.

The first two methods are essentially the same as methods for designing new roads and depend on knowledge of the strength of the subgrade, the strength of the pavement layers, their thicknesses and so on. The additional element for rehabilitation design is simply the method for determining the 'residual strength' of the existing pavement which is needed in order to determine the extra strength required. However, a considerable amount of additional information is available for designing rehabilitation that is not available when designing a new road. This comprises the elastic deflections of the existing road and knowledge of the performance of the road to date.

The problem is that the three methods rarely result in the same design solutions. This is not surprising because empirically-based design methods depend on measurements of the strength of pavement layers whereas deflection-based methods depend on the elastic properties of the layers. Unfortunately the elastic properties of pavement materials are very poorly correlated with strength properties.

The analytical methods, despite their apparent attraction, do not solve the problem. Analytical methods need to be calibrated against empirical evidence before they can be used reliably, hence they need to be calibrated against one or other of the two empirical alternatives. Furthermore, in all analytical methods in regular use today, the elastic modulus of the subgrade, and usually other pavement layers as well, is assumed to relate linearly to the strength of the layer, usually as measured by CBR. Thus the fundamental problem that the elastic and strength properties are poorly correlated is not addressed.

Quite clearly, effective rehabilitation design requires knowledge of both the elastic (or load spreading) properties and the strength properties of the materials. The Tanzanian method attempts to address these issues and does so well enough given the constraints, but such sophistication is not required for LVRs and the recommended method is simpler and empirically based.

### 3.15.3 Adequacy of Other Manuals

The Ethiopian manual on rehabilitation addresses the problems mentioned in the previous paragraph for HVRs but not for LVRs.

The Malawi Manual for Low Volume Sealed Roads deals with this thoroughly based on a DCP-DN method. A similar DCP-CBR method is advocated in the TRL DCP manual. These methods will be recommended for Tanzania.

## 3.16 Unpaved Roads

### 3.16.1 General

Unpaved roads are the basis of all LVRs and nearly all access roads start initially as unpaved roads. These include earth, gravel, engineered gravel and treated gravel roads, the latter becoming more sought after in order to conserve gravels and reduce maintenance and dust. There have been a lot of developments in the study of unpaved roads in the last decade with interesting results. Significant improvement in the performance as well as maintainability of unpaved roads have resulted in cost savings, the need for less plant, improved riding quality and a generally more satisfied road user.

Earth roads are normally required to provide access, which may or may not be all-weather, although in many cases the occasional loss of passability is usually related to water crossings more than the actual road surface.

As the majority of low volume roads in most countries (including developed countries) consist of unpaved roads, these are of critical importance in ensuring rural access and cannot afford to be neglected.

The final step before reaching paved low volume roads (Figure below) is the treatment of local natural gravels using various chemicals stabilizers in order to improve their quality or performance. This is not covered in most manuals but the science has developed to the stage that it is now a viable alternative in some cases.

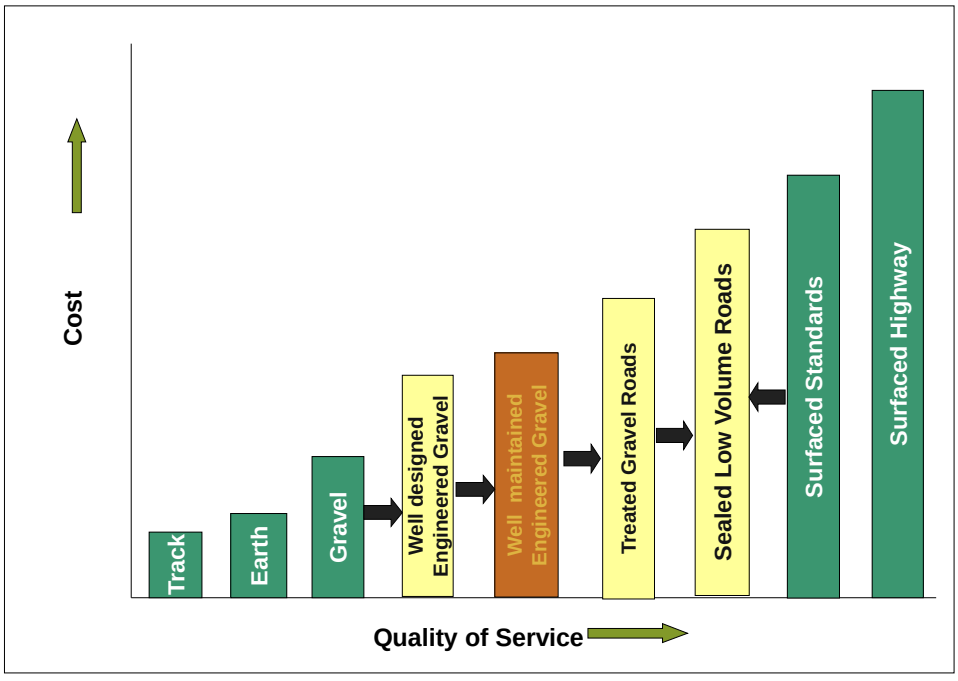


**Figure 3-2: Range of LVRs between tracks and conventional surfaced standard**

### 3.16.2 Adequacy of existing Tanzanian LVR manuals

The section on unpaved roads in the current Tanzanian design manual is based on the South African work published in 1990, which has been slightly modified to take into account the different test methods. However, only the shrinkage product has been corrected and not the grading coefficient. Additional work is required in this area.

### 3.16.3 Adequacy of other manuals

A number of recent African manuals have included the South African specification for unpaved roads in modified or unmodified form. However, the original TRH 20 (1990) on which these were based has recently been upgraded and some of the new findings should be incorporated into the Tanzanian manual. Work on gravel loss prediction in Tanzania is currently ongoing and some of the findings of this could also be incorporated where relevant.

## 3.17 Surfacing

Surfacings for LVRs may be either earth/gravel or paved, with the latter being either bituminous or non-bituminous. In each case, the provision of an adequate surfacing is crucial to the performance of a LVR.

1. Earth: The surfacing of an earth road would typically consist of the in situ surface material (unformed roads) or drain-excavated in-situ material (formed roads) over which there is little choice. The performance of this type of surface, in terms of whether it provides all-weather passability or not, would depend on the quality/properties of the material, and the drainage, camber and maintenance provided.
2. Gravel: The surfacing (wearing course) of a gravel road would depend, amongst other factors (terrain, rainfall, traffic, etc.) on the quality of the materials used. To this end, the properties of the gravel, in terms of such factors as its grading and plasticity, will critically affect its performance. Performance-related specifications have been developed which provide guidance on the desirable properties of the gravel wearing course.
3. Paved: There are a large number of bituminous and non-bituminous surfacing options available for use on a LVR pavement. These surfacings fulfill a variety of functions which, collectively, preserve the integrity of the underlying pavement layers and improve the functionality of the road in service. The basic local materials of gravel, stone, fired clay brick can be used with or without a range of binders/sealers to offer a range of attributes which need to be matched to such factors as expected traffic levels and loading, locally available materials and skills, construction and maintenance regimes and the local environment.

Typical surfacing types that should be considered for use in Tanzania, many of which have already been trialled on District Roads (e.g., the Lawate-Kibongoto road in Siha District and the Bago-Talawanda road in Bagomoyo District) include:

- Stone paving: Hand packed stone/ Cobble stone
- Bituminous: Sand seal/Slurry seal/Chip seal/Cape seal/Otta seal/Cold mix asphalt
- Concrete: Reinforced/unreinforced/Ultra-thin reinforced/Hyson cells

The design of the above types of surfacings all require special consideration if satisfactory performance is to be achieved.

### 3.17.1 Adequacy of existing Tanzanian LVR manuals

The Tanzania Materials and Pavement Design Manual (1999) considers most, but not all (e.g. Cold Mix Asphalt), of the bituminous surfacings that could be used on LVRs in the country. The manual does not consider non-bituminous surfacings. However, another manual–the Stone Pavement Construction Manual (still under preparation) does include valuable information on the design of cobblestone pavements.

### 3.17.2 Adequacy of other manuals

The South Sudan and Ethiopian manuals adequately cover a wide range of bituminous and non-bituminous surfacings which could be considered for use in Tanzania. Neither of these manuals deal in detail with the design of the surfacings.

## 3.18 Comparison of Designs and Implementation

### 3.18.1 General

There are always a number of potential alternatives available to the designer in the design of new, or the upgrading of existing unpaved, LVRs, each capable of providing the required performance. For example, as illustrated in Figure 3-3, for a given analysis period, one alternative might entail the use of a relatively thin, inexpensive pavement which requires multiple strengthening interventions (Alternative A) whilst another alternative might entail the use of a thicker, more costly pavement with less interventions (Alternative B).

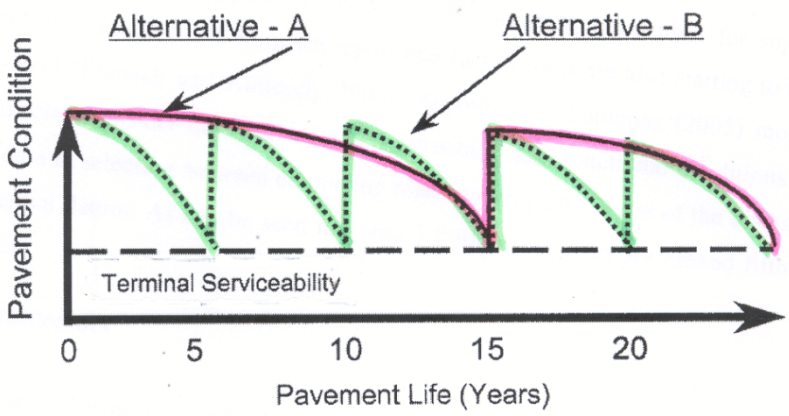


**Figure 3-3: Alternative pavement standards**

In order to make the most effective use of the available resources, the designer would be required to find which alternative will serve the needs of road users for a given level of service at the lowest cost over time. Such a task can be achieved through the use of a life-cycle economic evaluation, often referred to as “life-cycle” or “whole-of-life” costing.

Various procedures may be followed in undertaking a life-cycle cost (LCC) analysis to compare alternative pavement designs over their design lives in order to arrive at the most cost-effective solution. The designer should be aware of such procedures so that he is in a position, either directly or indirectly, to quantify the basis on which his preferred design options are based.

### 3.18.2 Adequacy of existing Tanzanian LVR manuals

The Tanzania Materials and Pavement Design Manual (1999) does not consider the topic of life-cycle costing.

### 3.18.3 Adequacy of other manuals

The South Sudan and Ethiopian manuals both address the topic of life-cycle costing and provide a useful source of information for inclusion in the Tanzania LVR manual.

## 3.19 Contracts

### 3.19.1 General

Contract documentation, tendering and award are collectively an integral component of the LVR provision cycle. When the design is complete and is approved by all interested and affected parties, the process can proceed to the procurement of the Works needed to construct the road. The processes typically associated are illustrated in Figure 3-4.

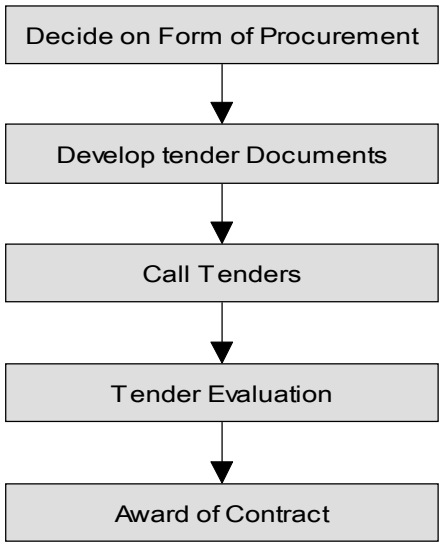


**Figure 3-4: Procurement of Works**

The purpose of procurement and tendering is to obtain priced offers from competent contractors to carry out the works. Offers from different tenderers are compared in a fair and transparent manner, and the work is awarded to the most favourable offer. It is also important in the Tanzania context to ensure that the procurement process assists in developing the local construction industry, so that the pool of resources available to carry out the work expands and remains competitive. In addition, it is also essential to ensure that the procurement process makes all the client needs and related risks known to potential tenderers, so that they respond appropriately and price the work based on a good understanding of what is required.

The procurement of Works for LVRs that will typically be undertaken by local contractors in a LGA environment, often with a significant labour-based component, will be quite different to that required for larger scale works undertaken by international competitive bidding. For this reason, the bidding documents for relatively small-scale works, are usually relatively simple and geared to the requirements of the local contracting industry in a number of respects. Moreover, these documents usually reflect the policies of the Client organization and the laws of the land. Thus, such documents are typically quite country and organization specific and often require modification of contract conditions, tender evaluation procedures, and administration and financing procedures normally used for high volume roads. .

### 3.19.2 Adequacy of existing Tanzanian LVR manuals

The roads agencies in Tanzania have developed their own procurement procedures based on their standard bidding documents. The extent to which such documents are appropriate for LVRs can only be ascertained after detailed discussions with PMO-RALG and TANROADS, on which basis any modifications can be entertained.

### 3.19.3 Adequacy of other manuals

The South Sudan manuals do not address the issue of procurement of Works. However, this topic is specifically addressed in the Ethiopian manuals for which specific standard bidding documents have been developed after extensive consultations with stakeholders. However, as indicated above, such documents reflect the policies and requirements of the roads agencies in Ethiopia and, as a result, would not be directly transferable to Tanzania.

## 3.20 Construction and Quality Assurance

### 3.20.1 General

Construction is a practical manifestation of the planning and design phases of the provision of LVRs in which the constructor faces the challenge of adopting a construction strategy that is appropriate to the prevailing social, economic, cultural and other needs of a particular country. In Tanzania, such a strategy should be aimed at optimising the use of funds by making maximum use of the relatively abundant resource of labour, local materials and construction skills.

One of the secondary objectives and consequences of adopting an appropriate construction strategy is that it should reduce the demand for foreign goods and services. This can often be achieved by reducing the need for plant-intensive operations, where feasible, and incorporating more labour-based operations into the contract. This is appropriate to the construction of the generally low traffic volume roads in Tanzania and often requires modification of conventional construction management techniques, contract conditions, tender evaluation procedures, and the administration and financing procedures normally used for construction of major, high-volume roads.

Irrespective of the construction strategy adopted, the quality of the construction process, including drainage aspects, is critical as this can have a significant impact on the subsequent costs of maintaining the road.

In view of the above, the Client organization should be fully aware of the various issues that need to be considered during the construction phase of LVRs, including the quality assurance procedures that should be followed. Such guidance should be provided in the Tanzania LVR manual.

### 3.20.2 Adequacy of existing Tanzanian LVR manuals

The issue of Construction Strategy is not addressed in the Tanzania manuals. However, that of Construction Control is addressed in the Field Testing Manual (2003) which considers the quality control aspects of the following:

- Earthworks and unbound layers
- Cemented layers
- Bituminous layers
- Surface treatments
- Concrete

However, in addition to the above, there are numerous other aspects of the actual construction process which site supervisors should be aware of. They include issues such as:

- Construction equipment
  - Choice of appropriate equipment
  - Selection of compaction plant
- Utilizing soils and natural gravels
  - Winning, stockpiling of natural gravels
  - Compaction of natural gravels, including “working with nature”

  - Materials management
  - Borrow pits and the community (see Section 3.19)
- Construction aspects
  - Clearing, grubbing and topsoil removal
  - Construction of earthworks and pavement layers
- Dealing with variability
- Shoulder construction

### 3.20.3 Adequacy of other manuals

Neither the South Sudan nor the Ethiopian LVR manuals deal with the issue of construction and quality control in the manner described above. However, in addition to the Tanzania Field Testing manual, this topic is also addressed in the Draft Botswana Road Design Manual Volume 2: Materials and Pavement Design.

## 3.21 Materials and Borrow Pit Management

### 3.21.1 General

Proper management of material sources is essential to ensure that the best qualities of available material are used in the top layers of the pavement structure. The efforts made to locate the best quality locally available, and often scarce, materials for road base are of little use if this material is wastefully used in earthworks layers. Good management of materials is therefore a critical operation in LVR construction.

An awareness of the potential damaging effects (negative impacts) that borrow pits and quarries may have on the local environment is also required so that mitigating measures may be incorporated in the tender documents for enforcement during the construction of the works.

Unfortunately, the topic of materials and borrow pit management is seldom addressed in LVR manuals, as a result of which the winning of such materials is often not effectively undertaken.

### 3.21.2 Adequacy of existing Tanzanian LVR manuals

The existing Tanzania manuals, such the Environmental Code of Practice for Road Works (2009), do address a number of environmental issues pertaining to the construction of roads. However, the topic of materials and borrow management is not addressed in the manner described above.

### 3.21.3 Adequacy of other manuals

Neither the South Sudan nor the Ethiopian LVR manuals deal at all with the issue of materials and borrow pit management. However, this topic is addressed very comprehensively in the Roughton International *Guidelines on Materials and Borrow Pit Management for Low Volume Roads* (2000) and partially in the TRL *Environmental Damage from Extraction of Road Building Materials: Results and Recommendations from Studies in Southern Africa* (1999).

## 3.22 Technical Auditing

### 3.22.1 General

A technical audit may be defined as *a formal, systematic procedure for undertaking an independent, objective, assessment of a project to determine the extent to which it has complied with various prescribed procedures, standards and specifications set down in the project documents.*

Technical auditing of road projects is now routinely carried out by both TANROADS and the Road Fund Board in their endeavour to demonstrate that Government is getting “value for money”, as well as to

engender greater accountability in the expenditure of public funds. This has been prompted by instances of problems arising mostly during the implementation stage of the project cycle due to the following:

- Human errors
- Incompetence
- Corruption
- Poor quality control during works execution
- Poor professional ethics by consultants and contractors

### 3.22.2 Adequacy of existing Tanzanian LVR manuals

The Tanzania Guideline on Technical Auditing of Road Works (2009) does deal quite comprehensively with the issue of technical auditing of roads. However, there may be scope for customizing the approach to deal specifically with LVRs.

### 3.22.3 Adequacy of other manuals

Neither the South Sudan nor the Ethiopian LVR manuals deal at all with the issue of technical auditing of road projects.

## 3.23 Maintenance

### 3.23.1 General

Road maintenance is an integral component of the road provision process, the type and cost of which are influenced significantly by decisions made during the preceding planning, design and construction phases. In essence, proper maintenance contributes to the preservation of the road asset and to prolonging the road's life to its intended service duration.

LVRs present a more demanding challenge than the more heavily trafficked HVRs roads for their proper maintenance. Their characteristics, particularly their greater sensitivity to the vagaries of the natural environment, often mean that, in order to avoid rapid deterioration, maintenance must be scheduled and carried out more frequently and expeditiously than HVRs. Thus, without adequate maintenance, LVRs deteriorate rapidly, become dangerous and costly to use and, ultimately, the costs to the national economy are substantial.

Maintenance of LVRs is also a multi-dimensional challenge that requires a sound appreciation of a number of inter-related factors including:

- Maintenance management
- Maintenance standards
- Maintenance operations and procedures
- Maintenance specifications

Not surprisingly, due to the comprehensive nature of the subject, road maintenance is normally dealt with in stand-alone manuals rather that as sections of a manual.

### 3.23.2 Adequacy of existing Tanzanian LVR manuals

As indicated in Section 2.6.1 of this report, there are numerous documents dealing with road maintenance in Tanzania that have been developed during the past 10 – 15 years. These documents all vary in terms of their scope and applicability to LVRs as they have been developed by a various donors involved in providing support to the various regions in Tanzania, for example, the GTZ *Road Maintenance Management Manual for Arusha and Kilimanjaro.*

The major concern in Tanzania is that, for whatever reason, which needs to be ascertained, the current manuals are not properly used, especially by LGAs. Thus, Tanzania is not short of maintenance manuals, but the incentive for using them seems to be greatly lacking. This fundamental issue needs to be addressed before consideration is given, even if warranted, to the production of yet more maintenance manuals.

### 3.23.3 Adequacy of other manuals

The South Sudan LVR manual is a stand-alone document that focuses on the operational aspects of road maintenance. It does not deal with maintenance standards and specifications and, in that respect, is probably deficient for application to the Tanzanian environment. However, the Botswana Road Maintenance Manual does deal with these aspects and will provide a valuable source of information for possible inclusion in the Tanzania LVR manual.

## 3.24 Summary

### 3.24.1 Findings

The outcome of the evaluation of the existing Tanzania manuals against the idealized framework for the provision of LVRs, as discussed in Section 2.3, may be summarized as follows:

1. There is no single existing document in Tanzania that caters specifically for all the requirements of LVRs. However, a number of existing manuals do address aspects of LVR provision that are appropriate for inclusion in the new manual.
2. Most of the Tanzania manuals cater primarily for HVRs although aspects of their make-up are applicable to LVRs.
3. There a few gaps in the coverage of the existing Tanzanian, and other regional manuals that need to be filled. They include, for example, Materials and Borrow Pit Management and Construction and Quality Control.
4. Almost all the information required to be included in the development of the new LVR manual for Tanzania can be sourced from the extensive range of documents available to the Consultants (See Annex B).

### 3.24.2 Conclusions

1. There is a need to develop a new manual for Tanzania that caters specifically for the requirements of LVRs.
2. The new LVR manual should be developed in close consultation with stakeholders so as to capture their specific requirements. There is no existing document in Tanzania that caters specifically for all the requirements of LVRs.

# 4. WAY FORWARD

## 4.1 General

There are a number of aspects of the development of the new LVR manual for Tanzania that will require careful consideration by stakeholders, as discussed below.

### 4.1.1 Layout of manual

There are various options for laying out design manuals. They range from the more traditional single column layout (e.g. that adopted in the South Sudan LVR manual) to the 2-column layout (e.g. that adopted in the Botswana and some South Africa and Australian manuals).

### 4.1.2 Structure of manual

The structure of design manuals varies in respect of the manner in which the various topics are addressed. Some manuals are divided into separate parts which collectively address the various topics considered necessary for inclusion in the document (e.g. the ARRB Local Sealed Roads Manual). Others are a single document which contains chapters dealing with the various topics (e.g. the Malawi LVR Design Manual). Yet others comprise separate self-standing documents (e.g. the South Sudan LVR manuals which comprises three separate volumes dealing with Road Design, Cross Drainage and Structures and Maintenance).

### 4.1.3 Contents of manual

The contents of design manuals also vary with respect to the approach adopted to address the topic. At one extreme, they can be very simple and qualitative in approach and provide guidance only on the various aspects of LVR provision (e.g. the Zimbabwe Pocket Guide to Road design). At the other extreme, they can be quite detailed and quantitative in approach (e.g. Volume 2 of the South Sudan LVR manual that deals very comprehensively with all aspects of Cross Drainage and Structures.

There is no “right” or “wrong” approach regarding the contents of a design manual. An appropriate balance needs to be struck between a simplified/brief approach versus a more complex/detailed approach. That balance needs to be decided by the end users of the manual and the institutional environment in which they operate.

## 4.2 Next steps

In accordance with the ToR, the next step will be to present the findings of the Manuals Review Report (this report) at a stakeholders’ workshop where the issues raised above will be carefully considered and the way forward to the development of the LVR manual agreed.

# Appendices

## APPENDIX A: EVALUATION OF LVR MANUAL REQUIREMENTS AGAINST EXISTING MANUALS

| Document | Planning | Environment | Site investigation and route selection | Geotechnical surveys and design | Geometric Design | Hydrology, Drainage and Erosion | Drainage Structures | Construction Materials | New Pavement Structural Design | Pavement Upgrading Design | Surfacings | Unpaved Roads | Comparison of Designs and Implementation | Construction and Quality | Borrow Pit Management | Maintenance | Road safety | Complementary Interventions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **General All-inclusive Manuals** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10a** | **10b** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| Tanzanian Pavement and Materials Design Manual | | | | | | | | | | | | | | | | | | |
| S Sudan Vol 1 Road Design (220) | | | | Vol 2 | | Vol 2 | Vol 2 | | | | | | | | | | | |
| Ethiopian Design Manual for Low Volume Roads Part B and D | | | | | | | Vol E | | | | | | | | | | | Vol C |
| Malawi Manuals on Planning, Design, Construction and Maintenance of Rural Roads (2004). | | | | | | | | | | | | | | | | | | |
| Low Volume Rural Road Surfacing and Pavements – A Guide to Good Practice (AFCAP 2013) | | | | | | | | | | | | | | | | | | |
| Malawi Design Manual for LVSRs Sealed Roads Using the DCP Design Method (2012) | | | | | | | | | | | | | | | | | | |
| SADC Guideline on Low-Volume Sealed Roads | | | | | | | | | | | | | | | | | | |
| Botswana RDM Vol 1: Road Types and Geometric Design (2013). | | | | | | | | | | | | | | | | | | |
| SATCC Code of Practice for the Design of Road Pavements | | | | | | | | | | | | | | | | | | |
| South Africa SAPEM documents | | | | | | | | | | | | | | | | | | |
| TRH 20 (2009) | | | | | | | | | | | | | | | | | | |
| TRH 9, 10 and 19 | | | | | | | | | | | | | | | | | | |

# APPENDIX B: LIST OF DOCUMENTS REVIEWED

| No | Specialist Documents |
|---|---|
| 1 | Tanzanian Geometric Design Manual |
| 2 | Tanzanian Stone Pavement Construction Manual |
| 3 | Tanzanian Standard Specification for Road and Bridge works |
| 4 | Tanzania Laboratory Testing Manual |
| 5 | Tanzanian Environmental Code of Practice for Road Works |
| 6 | Tanzanian Field Testing Manual |
| 7 | Tanzania Guideline on Technical Auditing of Road Projects |
| 8 | Tanzanian Guide to Traffic Signing |
| 9 | Tanzanian Road Sector Environmental Assessment and Management Guidelines |
| 10 | Tanzania Road Maintenance Contracting Manual |
| 11 | Tanzania Improved Maintenance Systems |
| 12 | Tanzania Stone pavement Manual |
| 13 | S Sudan Vol 2 Cross Drainage and Design of Small Structures (137) |
| 14 | S Sudan Vol 3 Maintenance (144) |
| 15 | Ethiopian Design Manual for Low Volume Roads Part C |
| 16 | Ethiopian Design Manual for Low Volume Roads Part E |

| | |
|---|---|
| 17 | Ethiopia Best Practice Manual for Thin Surfacings |
| 18 | Ethiopian Site Investigation and Route Selection Manual |
| 19 | Ethiopian Rehabilitation Design Manual 2013 |
| 20 | Botswana Road Maintenance Manual (2010). |
| 21 | Botswana Guideline on the Use of Marginal Surfacing Aggregates (2008). |
| 22 | Zimbabwe Guideline on Quality Control Testing on Labour-based Gravel roads – for ILO in Zimbabwe. |
| 23 | Zimbabwe: Min. of Works: Pocket Guideline on the Design of Low Volume Roads |
| 24 | Guidelines on Materials and Borrow Pit Management for Low Cost Roads (2000). Roughton. |
| 25 | SATCC Code of Practice for the Rehabilitation of Road Pavements |
| 26 | ARRB Sealed Local Roads Manual |
| 27 | ARRB Unsealed Roads manual |
| 28 | S. Africa-Western cape Provincial Admin., Dept. of Public Works: materials Manual (2004/2005. |
| 29 | S. Africa. TRH4 1966-Structural Design of Flexible Pavements for Inter-Urban and Rural Roads. |
| 30 | Southern Africa Transport and Communications Commission (SATCC): Guideline for Low Volume Sealed Roads (2003) |

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