



Guideline

Low-volume Sealed Roads

July 2003

Southern African Development Community (SADC)
SADC House
Private Bag 0095
Gaborone
BOTSWANA

Tel: + 267 3951 863
Fax: + 267 3972 848
E-Mail: registry@sadc.int

JULY 2003

ISBN 99912-0-456-3

Any material from this Guideline may be reproduced without permission provided the source is acknowledged.

Although the Guideline is believed to be correct at the time of printing, SATCC does not accept responsibility for any consequences arising from the use of the information contained in it.

Foreword



The SADC road network of just over one million kilometres provides the dominant mode of freight and passenger transport and thus plays a vital role in the economy of the region. Unsurfaced low-volume roads constitute a substantial proportion of that network and impact on the lives of the majority of the region's population who live and work in rural areas. Many of these roads are being upgraded to a sealed standard following strategies that focus on poverty alleviation in pursuit of the region's broader goals of socio-economic growth and development.

The main purpose of the Guideline is to provide stakeholders with a synthesis of best regional and international practice in all aspects of low-volume sealed roads. In so doing, it will correct a shortcoming of other available guidelines and manuals that tend to be more narrowly focused on the technical aspects of relatively more heavily trafficked roads and, as a result, have limited applicability to low-volume sealed roads.

Funding for this Guideline has been provided by the UK Department for International Development (DFID), the Norwegian Agency for Development Co-operation (NORAD) and the Swedish International Development Agency (SIDA). These co-operating partners continue to provide development assistance to the region in the transport sector aimed, in part, at improving the sustainability of low-volume sealed roads, coupled with direct poverty alleviation.

By promoting the adoption of a more holistic approach to the provision of low-volume sealed roads and the use of innovative best practice from the region, the Guideline will undoubtedly lead to a more efficient use of available road funding. This will result in direct benefits to all SADC countries and facilitate socio-economic growth and development, leading to a reduction in poverty.

I wish to thank our cooperating partners for co-funding this project as well as the UK Transport Research Laboratory (TRL) and the Norwegian Public Roads Administration (NPRA) for managing it. I also wish to thank all those who contributed their knowledge and experience to enable this Guideline to be produced; in particular, the Lead Authors, representatives from member states who were closely involved in its development and the international panel of experts who reviewed the document. I am convinced that all stakeholders will find the Guideline to be a valuable source of information for the more efficient and effective provision of low-volume sealed roads in the SADC region.

Sakhe Silo
Director - SATCC Technical Unit
Maputo, Mozambique

Dedication

This guideline is dedicated to the memory of the late Eric Msolomba, former director of the SATCC Technical Unit, whose vision provided the motivation for this project, and whose dedication and leadership made this document possible.

Acknowledgements

The Project Team gratefully acknowledges the contributions and comments received from a large number of professionals representing a wide range of disciplines, in organisations from both the public and private sectors, who participated in the workshops held in connection with the compilation of the Guideline. These organisations included Government ministries (including Roads Departments and Traffic Safety Units), National Roads Authorities, consultants, contractors and materials suppliers. Particular thanks are due to the SATCC Technical Unit, the CSIR and the authors for their contributions and to the Peer Reviewers for their comments on the drafts. Thanks are also due to the workshop facilitators and presenters who also made valuable contributions to the project.

SADC Road Sector Organisations

The high level of support and guidance provided by the road sector organisations in the SADC member states in the development of the Guideline and in the hosting of country workshops is gratefully acknowledged. The following organisations are expected to be the main agencies involved in the implementation of the Guideline:

Angola	Angolan Road Agency (INEA), Ministry of Public Works, Luanda
Botswana	Roads Department, Ministry of Works and Transport, Gaborone
DRC	Office des Routes, Kinshasa/Gombe
Lesotho	Roads Department, Ministry of Public Works and Transport, Maseru
Malawi	National Roads Authority, Lilongwe
Mauritius	Road Development Authority, Ministry of Public Infrastructure, Phoenix
Mozambique	National Roads Administration (ANE), Maputo
Namibia	National Roads Authority, Windhoek
Seychelles	Land Transport Division, Ministry of Transport and Tourism, Mahé
South Africa	South African National Roads Agency (SANRA), Pretoria
Swaziland	Roads Department, Ministry of Public Works and Transport, Mbabane
Tanzania	Tanzania National Roads Agency (TANROADS), Dar es Salaam
Zambia	Roads Department, Ministry of Works and Supply, Lusaka
Zimbabwe	Roads Department, Ministry of Transport, Harare

Project Management Team

Project Manager	Mr P A K Greening, Transport Research Laboratory, UK
Deputy Project Manager	Mr C Overby, Norwegian Public Roads Administration, Norway
Team Members	Mr M I Pinard, InfraAfrica Consultants, Botswana Mr M E Gumbie, Civil Consult (Pvt) Ltd., Zimbabwe Mr D R Rossmann, National Roads Agency, South Africa
Quality Assurance	Dr J Rolt, Transport Research Laboratory, UK

Authors

M I Pinard (Lead)	InfraAfrica Consultants, Botswana
S D Ellis (Main)	World Bank (formerly Transport Research Laboratory, UK)
C-H Eriksson (Main)	Transport Consultants AB, Sweden
R Johansen (Main)	ViaNova Consultants, Norway
T Toole (Main)	ARRB, Australia (formerly Transport Research Laboratory, UK)
R Beger (Contributing)	RB Project Management, South Africa
M E Gumbie (Contributing)	Civil Consult (Pvt) Ltd., Zimbabwe
H J S Lotter (Contributing)	Council for Scientific and Industrial Research, South Africa
A R Quimby (Contributing)	Transport Research Laboratory, UK

National workshop facilitators: A A Awadh (Tanzania), C S Gourley (Transport Research Laboratory, UK), T E Mutowembwa (Zimbabwe), G Sibanda (ILO ASIST, Zimbabwe)

Peer Review Team

Mr J N Bulman, OBE	Consultant, UK (formerly Head of TRL Overseas Unit)
Prof J D G F Howe	Consultant, UK (formerly Professor, IHE Delft, Netherlands)
Prof H G R Kerali	University of Birmingham, UK
Prof J B Metcalf	Louisiana State University, USA
Dr F Netterberg	Construction Materials and Geotechnical Specialist, South Africa
Prof N A Parker	City University of New York, USA
Prof A T Visser	University of Pretoria, South Africa

Publishing Services

Layout	M I Pinard, InfraAfrica Consultants, Botswana
Cover design/DTP	J Edvardsen, Interconsult, Oslo, Norway
Printing	Goldfields Press (Pty) Ltd, Johannesburg, South Africa



A new approach

The successful provision of a low-volume sealed road requires ingenuity, imagination and innovation. It entails “working with nature” and using locally available, non-standard materials and other resources in an optimal and environmentally sustainable manner.

It will rely on planning, design, construction and maintenance techniques that maximize the involvement of local communities and contractors.

When properly engineered, a LVSR will reduce transport costs and, through its impact on rural production and on trade between regions, facilitate socio-economic growth and development and reduce poverty in the SADC region.

The criteria for defining a “Low-volume road” varies significantly in various parts of the world. In the SADC region, such roads may be primary, secondary or tertiary/access roads. They typically carry less than 200 vehicles per day, including up to 20% commercial vehicles, and often include non-motorised traffic, particularly near populated areas.



Extensive research has been undertaken in the SADC region over the past 20 - 30 years. This has enabled local, “non-standard” materials to be successfully incorporated in appropriate pavement design for LVSRs.

Provision of Low-volume sealed roads: Time for a re-think by decision-makers!



Low-volume roads, economic development and poverty alleviation

- ◆ The majority of rural roads and a significant proportion of the main roads in the SADC region are currently unsurfaced and are relatively lightly trafficked. These low-volume roads are important in that they:
 - impact significantly on the livelihoods of the majority of the population of many countries in the region, who live and work in rural areas where poverty levels are generally very high
 - are central to sustained socio-economic growth and development of the region and are a key component of development programmes targeted by donors and governments in which poverty reduction strategies feature
- ◆ Unfortunately, the poor condition of these roads, which can be largely attributed to the way in which they have customarily been provided and maintained, has acted as a brake on economic development and hindered poverty alleviation efforts.
- ◆ New, more appropriate, approaches to the provision of low-volume sealed roads (LVSRs) are now required if the region is to improve road transport efficiency and attain its broader goals of socio-economic growth, development and poverty alleviation.

The inappropriateness of traditional methods

- ◆ Traditional approaches to the provision of low-volume sealed roads have stemmed from technology and research carried out in Europe and the USA over 40 years ago in very different environments.
- ◆ Locally prevailing circumstances are usually very different in terms of climate, traffic, materials and road users. It is therefore not surprising that many of the imported approaches, designs and technologies are inappropriate for application in the region.
- ◆ Technology, research and knowledge about LVSRs have advanced significantly in the region and not only question much of the accepted wisdom on LVSR provision but also show quite clearly the need to revise conventional approaches.
- ◆ Unfortunately, there has been little effective dissemination and uptake of the results of research carried out in the region. This has triggered the need for this *SADC Guideline on Low-volume Sealed Roads*.



Unpaved roads generate dust in dry weather causing health hazard, damage to crops, vehicles and natural habitats and adversely affecting the safety of pedestrians and vehicles. Is a sealed surface an affordable option? **Yes! It certainly can be.**



A substantial amount of gravel is extracted annually from borrow pits in all countries of the SADC region. Is this sustainable? **No! It is not.**

Achieving sustainability in all aspects of LVSR provision is absolutely critical, if the SADC region's long term goals of sustained economic growth and poverty alleviation are to be attained. In the past, attempts to achieve such sustainability have failed because one or more of the seven key dimensions has been missing or inadequate. The result has been that LVSRs have fallen into disrepair and, consequently, have not only failed to serve the needs of the poor but, also, have often adversely affected the environment.

Why sealed roads?

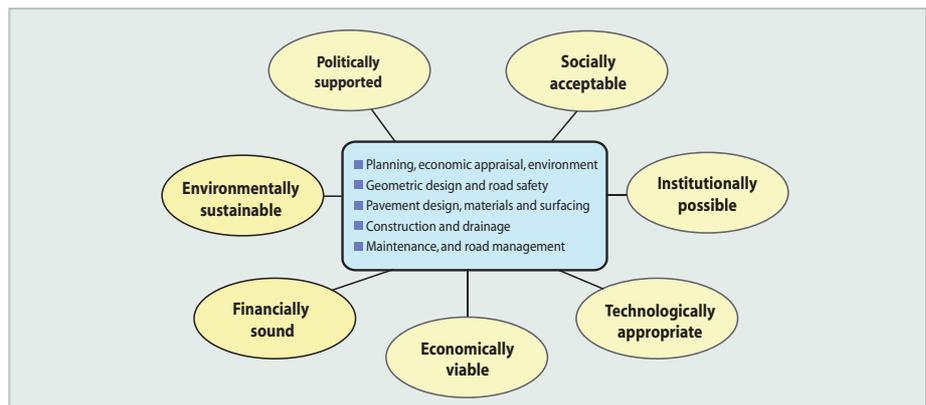
- ◆ The substantial length of unsurfaced, particularly gravel, roads in the region is becoming increasingly difficult to sustain in that such roads:
 - impose a logistical, technical and financial burden on most road agencies due to constraints on physical, human, financial and natural resources
 - require the continuous use of a non-renewable resource (gravel) which is being seriously depleted in many countries and, in the process, is causing serious environmental problems
- ◆ Implementation of the results of regional research (for example, that reduce construction costs through the increased use of natural gravels), enable the sealing of gravel roads to be economically justified at less than 100 vehicles per day (vpd). This figure is in contrast to the previously recommended threshold values for Sub-Saharan Africa, which were in excess of 200 vpd and is a figure that still persists in the minds of many practitioners.
- ◆ Failure to observe the optimal timing for sealing gravel roads can be very costly to national economies, not only in terms of incurring excess transport costs but, also, in the continuing excessive maintenance burden and adverse socio-environmental effects. This provides a strong impetus for policy change and the adoption of alternative, cost-effective, surfacing strategies promoted in this Guideline.

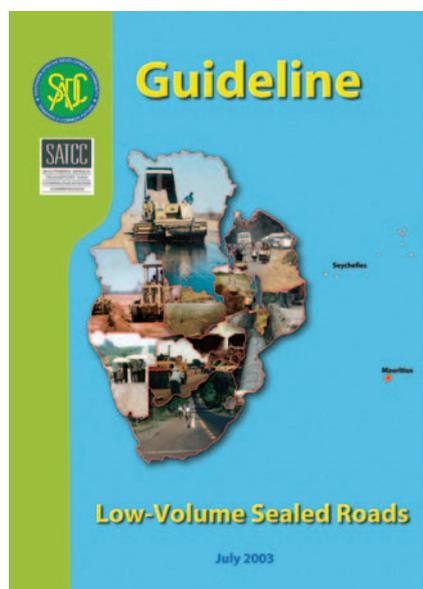
The benefits of sealed roads

- ◆ The whole-life benefits of sealed roads include:
 - lower transport (construction, maintenance and vehicle operating) costs
 - increased social benefits (more reliable access to schools, clinics, etc)
 - reduced adverse environmental impacts and health and safety problems
- ◆ Based on a conservative rate of upgrading gravel roads to a sealed standard of 100 km/year, the annual benefits of adopting the recommendations of this Guideline will be of the order of US \$35 million.
- ◆ The above benefits hinge critically on the ability of the responsible authority to maintain the sealed roads to the level of service for which they were designed. This requires provision of adequate, sustainable and timely funding for the sub-sector which, increasingly, is being provided by road users on a “fee-for-service” basis.

Key dimensions of sustainability

- ◆ There has been a tendency to focus predominantly on the technical and economic aspects of LVSR provision and inadequate attention has been given to other aspects of sustainability. The result has often been a lack of responsiveness to various other requirements and a reduced likelihood of achieving sustainable solutions, even when substantial funding is made available.
- ◆ The seven key dimensions of a sustainable system, which should always be observed in the provision of LVSRs, are shown below.





Promotion of labour-based methods where feasible, is a key factor in creating productive employment and reducing poverty.

The new idea either finds a champion or dies.....No ordinary involvement with a new idea provides the energy required to cope with the indifference and resistance that major technological change provokes... Champions of new ideas must display persistence and courage of heroic quality.

- ◆ Sustainability in all aspects of LVSR provision should now become the basis of a more demanding policy of SADC governments. This will require that practitioners adopt a more broadly based approach than hitherto that pays full attention to all seven dimensions of sustainability.

Meeting new challenges – the SADC Guideline on LVSRs

- ◆ The main objective of the Guideline is to capture best regional and international practice in all aspects of LVSR provision. It is not a prescriptive document but, rather, provides guidance to users so as to ensure that well-considered decisions are made. The development of the Guideline has benefited from the close involvement of practitioners in the region.
- ◆ The Guideline presents a major departure from traditional practice in all aspects of LVSR provision by examining procedures, practices and methods used in:
 - planning, appraisal and environment
 - geometric design and road safety
 - pavement design, materials and surfacing
 - construction and drainage
 - maintenance
- ◆ The Guideline promotes the use of a holistic approach to LVSR's, which recognizes that criteria need to be satisfied in the different and often interacting dimensions of road provision.

The benefits of using the Guideline

- ◆ There are a number of benefits to be derived from adopting the approaches advocated in the Guideline. These include providing LVSRs that:
 - are less expensive in economic terms to build and to maintain through the adoption of more appropriate, locally-derived technology and design/construction techniques that are better suited to local conditions
 - minimize adverse environmental impacts, particularly as regards the use of non-renewable resources (gravel)
 - increase employment opportunities through the use of more appropriate technology, including the use of labour-based methods, where feasible
 - improve road safety in all aspects of road provision
 - take better account of the needs of all stakeholders, particularly the local communities served by these roads
 - foster local road building and maintenance capacity through the greater use of small-scale, local contractors
 - ultimately, facilitate the longer-term goal of socio-economic growth, development and poverty alleviation in the region
- ◆ In addition to the above, the Guideline will also generate awareness and disseminate the knowledge required if these benefits are to be enjoyed more widely in the region.

Moving from vision to practice

- ◆ The full benefits of the Guideline will be realised only if the approaches recommended are implemented in practice. However, there are a number of barriers which will tend to frustrate this process. These include:
 - an inevitable and natural tendency to resist change and the conservative nature of public-sector organisations which tend to institutionalize this resistance
 - The fact that many of the recommendations contained in the Guideline may be in conflict with existing, often out-dated, country manuals and standards

- ◆ Ultimately, the successful move from vision to practice will require endorsement at political level, as well as the full support of all stakeholders. In addition, it will require considerable technology transfer effort including:
 - support and technical assistance to facilitate the implementation of the Guideline
 - updating country documents to suit specific local conditions
 - technical staff training to address potential internal resistance to change
 - careful monitoring of acceptance, adoption, refinement and satisfaction amongst users of the Guideline

Contents

Foreword	iii
Acknowledgments	v
Preview	vii
Abbreviations	xiii

1. INTRODUCTION

1.1	Background.....	1 – 1
1.2	Purpose and Scope.....	1 – 2
1.3	Focus.....	1 – 3
1.4	Development of Guideline.....	1 – 4
1.5	Structure and Content	1 – 5
1.6	Updating	1 – 6
1.7	Sources of Information	1 – 6
1.8	References and Bibliography.....	1 – 7

2. REGIONAL SETTING

2.1	Introduction	2 – 1
2.2	The SADC Region.....	2 – 2
2.3	Regional Road Network	2 – 5
2.4	Road Network Details	2 – 7
2.5	Low-volume Sealed Roads.....	2 – 9
2.6	Summary.....	2 – 14
2.7	References and Bibliography.....	2 – 15

3. PLANNING, APPRAISAL AND ENVIRONMENTAL ISSUES

3.1	Introduction	3 – 1
3.2	Planning	3 – 3
3.3	Appraisal.....	3 – 14
3.4	Environmental Issues.....	3 – 25
3.5	Summary	3 – 33
3.6	References and Bibliography.....	3 – 34

4. GEOMETRIC DESIGN AND ROAD SAFETY

4.1	Introduction	4 – 1
4.2	Design Philosophy, Standards and Approach	4 – 4
4.3	Design Framework and Process	4 – 7
4.4	Design, Controls and Elements	4 – 17
4.5	Roadside Safety, Education and Enforcement.....	4 – 28
4.6	Summary.....	4 – 33
4.7	References and Bibliography.....	4 – 34

5. PAVEMENT DESIGN, MATERIALS & SURFACING

5.1	Introduction.....	5 - 1
5.2	Pavements, Materials and Surfacing Terminology	5 - 4
5.3	Materials	5 - 10
5.4	Pavement Design.....	5 - 27
5.5	Surfacing	5 - 43
5.6	Summary	5 - 57
5.7	References and Bibliography	5 - 58

6. CONSTRUCTION AND DRAINAGE

6.1	Introduction.....	6 - 1
6.2	Construction Issues.....	6 - 3
6.3	Construction Equipment.....	6 - 10
6.4	Utilising Soils and Natural Gravels.....	6 - 14
6.5	Construction of Seals	6 - 23
6.6	Quality Assurance and Control	6 - 26
6.7	Drainage.....	6 - 29
6.8	Summary	6 - 37
6.9	References and Bibliography	6 - 38

7. MAINTENANCE AND ROAD MANAGEMENT

7.1	Introduction.....	7 - 1
7.2	Maintenance Issues.....	7 - 3
7.3	Maintenance Management	7 - 11
7.4	Maintenance Operations.....	7 - 24
7.5	Summary	7 - 28
7.6	References and Bibliography	7 - 29

8. VISION TO PRACTICE

8.1	Motivation	8 - 1
8.2	Pathway to Implementation	8 - 2
8.3	Vision to Practice.....	8 - 6
8.4	References and Bibliography	8 - 7

APPENDICES

	Appendix A - List of Figures and Tables.....	A - 1
	Appendix B - List of Useful Organisations	B - 1

Abbreviations

Organisations

AID	Agency for International Development
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ARRB	Australian Road Research Board
ASIST	Advisory Support Information Services And Training (For Employment-Intensive Infrastructure)
ASTM	American Society for Testing and Materials
CAPSA	Conference on Asphalt Pavements for Southern Africa
CEBTP	Centre Experimental de Recherches et D'études du Batiment et des Travaux Publics
CSIR	Council for Scientific and Industrial Research
CSRA	Committee of State Road Officials
DFID	Department for International Development
DLO	Direct Labour Organisations
DoR	Department of Roads
ILO	International Labour Organisation
IRF	International Road Federation
MOW	Ministry of Works
NAASRA	National Association of Australian State Road Authorities
NIRR	National Institute for Road Research
NITRR	National Institute for Transport and Road Research
NORAD	Norwegian Agency for International Development
NPRA	Norwegian Public Roads Administration
NRRL	Norwegian Road Research Laboratory
NSW	New South Wales (Australia)
ODA	Overseas Development Administration
PIARC	Permanent International Association of Road Congresses (World Road Association)
RA Board	Roads Agency Board
RF Board	Road Fund Board
SABITA	Southern Africa Bitumen and Tar Association
SADC	Southern Africa Development Community
SADCC	Southern African Development Coordination Conference
SAICE	South African Institution of Civil Engineering
ATC	Annual Transportation Conference
SANRA	South African National Roads Agency
SATCC	Southern Africa Transport and Communications Commission
SIDA	Swedish International Development Agency
TANROADS	Tanzania National Roads Agency
TRB	Transportation Research Board
TRL	Transport Research Laboratory
TRRL	Transport and Road Research Laboratory
UK	United Kingdom
UN	United Nations
UNESCO	United Nations Educational Scientific & Cultural Organisation
USA	United States of America
WA	Western Australia

Abbreviations

Technical

AADT	Annual Average Daily Traffic
AIV	Aggregate Impact Value
AC	Asphalt Concrete
ACV	Aggregate Crushing Value
ADT	Annual Daily Traffic
BCR	Benefit Cost Ratio
BOQ	Bill of Quantities
BS	British Standards
CBA	Cost-benefit analysis
CaSE	Cost and Safety Efficient Design
CBR	California Bearing Ratio
CEO	Chief Executive Officer
DMI	Durability Mill Index
elv	Equivalent Light Vehicles
DCP	Dynamic Cone Penetrometer
E_c	Elastic Stiffness
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ESA	Equivalent Standards Axle (based on 80 kN standard)
FACT	Fines Aggregate Crushing Test
FMC	Field Moisture Content
FWD	Falling Weight Deflectometer
GDP	Gross Domestic Product
HDM-4	Highway Development and Management Model-4
HIV/AIDS	Human Immune Deficiency Virus/Acquired Immune Deficiency Syndrome
HVR	High-volume road
HVS	Heavy Vehicle Simulator
HVSR	High-volume Sealed Roads
IQL	Information Quality Level
IRAP	Integrated Rural Accessibility Planning
IRI	International Roughness Index
IRR	Internal Rate of Return
KPI's	Key Performance Indicators
LAA	Los Angeles Abrasion
LBM	Labour Based Methods
LVR	Low-volume Road
LVSR	Low-volume Sealed Road
MC	Moisture Content
MDD	Maximum Dry Density
NMT	Non Motorised Traffic
NPV	Net Present Value
OMC	Optimum Moisture Content
ORN	Overseas Road Note (TRL series of publications)
PI	Plasticity Index
PSD	Passing Site Distance
PSV	Polished Stone value
R & W	Riedel and Weber
RED	Road Economic Decision model

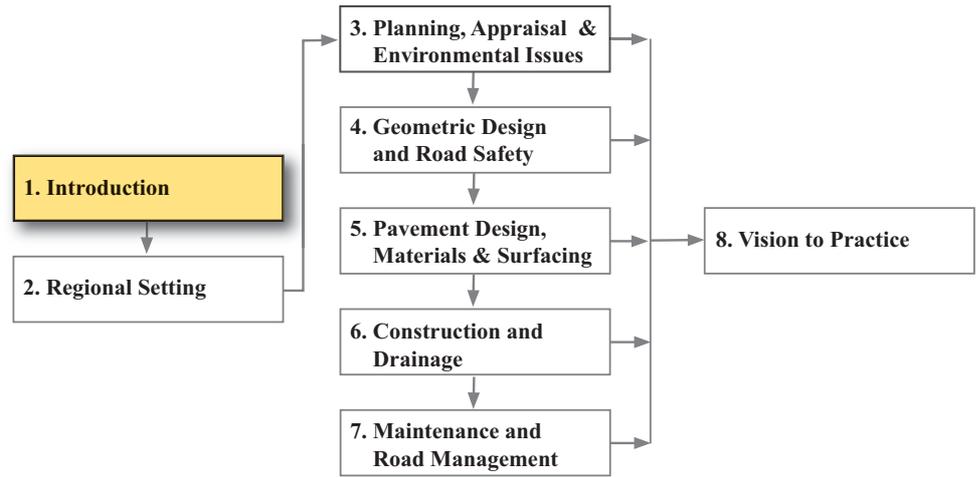
RM	Routine Maintenance
RMI	Road Maintenance Initiative
RMS	Road Management Systems
RTIM	Road Transport Investment Model
RTRN	Regional Trunk Road Network
SAMDM	South African Mechanistic Design Method
SFRDP	Secondary Feeder Road Development Programme
SSATP	Sub-Saharan Africa Transport Program
SSD	Stopping Sight Distance
TBM	Texas Ball Mill
TMH	Technical Methods for Highways
TRH	Technical Recommendations for Highways
TTC	Travel Time Cost
VCI	Visual Condition Index
VOC	Vehicle Operating Costs
vpd	Vehicles per day

Abbreviations

Units

Hr	Hour
Kg	Kilogram
Km, m, cm, mm	Kilometre, metre, centimetre, millimetre
kPa	Kilo-Pascal
kN	Kilo-Newton
Km/h	Kilometre per hour
m ² , m ³	Square metre, cubic metre
Veh-km	Vehicle kilometre
Yr	Year

Chapter 1



Contents

Introduction

1

1.1	Background	1 - 1
1.2	Purpose and Scope.....	1 - 2
1.3	Focus	1 - 3
1.4	Development of Guideline.....	1 - 4
1.5	Structure and Content.....	1 - 5
1.6	Updating	1 - 6
1.7	Sources of Information	1 - 6
1.8	References and Bibliography	1 - 7

Introduction

1

“The body of highway engineering knowledge remains empiric rather than rigorously scientific. So, the knowledge taught in our [UK, USA] universities is generally derived from a synthesis of local experience. No wonder it is often irrelevant and sometimes downright misleading in other parts of the world”.

Ray Millard, Highways Advisor, World Bank.
2nd Int. Conf. on Low-volume Roads, 1979¹.

1.1 Background

Many aspects of the documentation on low-volume road provision in the SADC region have stemmed from technology and research carried out in Europe and the USA some 30 - 40 years ago in vastly different environments. Although some of this documentation has been modified to some extent in the intervening years, the basic philosophy of road provision has remained essentially the same. Whilst these standard approaches may still be appropriate for the more heavily trafficked SADC trunk road network, they are clearly inappropriate for use on low-volume roads which make up a large proportion of national road networks. This has prompted a number of international research organizations, as well as government departments and local agencies, to undertake research into various aspects of low-volume sealed roads.

Box 1.1 - Road research in the SADC region

Research carried out in the SADC region by a number of international, regional and local organisations, which is conservatively estimated to have cost US \$20 - 30 million, has questioned many of the accepted assumptions about the planning, design, construction and maintenance of low-volume sealed roads. This research has quite clearly shown:

- the importance of adopting a more holistic, sustainable approach to the provision of low-volume roads
- the need to revise conventional approaches to planning, economic appraisal and the environment
- the shortcomings of conventional specifications and, to some extent, of test methods, in assessing the adequacy of local materials for use in low-volume roads
- the advantages of adopting more appropriate geometric and pavement design standards
- the economic success of innovative construction methods
- the importance of paying greater attention to the environmental aspects of road provision



Research carried out in the SADC region has catalysed the re-thinking of the whole approach to low-volume sealed roads^{2,3,4}.

*“Probably the most important and critical issue (in technology transfer) is **information dissemination**. Presenting all available and relevant information to practitioners is essential to implementing improved procedures and new techniques. Given the amount of research and development that is still being undertaken, the ability to disseminate this information quickly is the key to advancing the low-volume road situation”.*

Transport Research Circular No. 446, May 1995⁵.

Unfortunately, because of a lack of funding, there has been very little effective dissemination of the research carried out in the region. This has led to:

- a lack of awareness of the results of research
- a lack of understanding of the often satisfactory performance of innovative solutions
- an aversion to the use of “non-standard” designs, particularly by foreign consultants and contractors who are often unfamiliar with local conditions
- poor technology transfer
- little implementation of innovative technology

In recognition of the need for raising awareness of recent developments in low-volume sealed road technology in the region, the Southern African Transport and Communications Commission (SATCC) commissioned the preparation of this *Guideline on Low-volume Sealed Roads (LVSRs)* which was funded by DFID, NORAD and SIDA.

1.2 Purpose and Scope

The main purpose of the Guideline is to provide a synthesis of practical, state-of-the-art approaches to LVSR provision, based largely on regional knowledge and experience, while taking into account international best practice. In so doing, the primary goal is to reduce the cost of constructing and maintaining LVSRs leading to:

- increased public and commercial transport through lower road user costs
- improved access to schools, clinics, jobs, urban centres and neighbouring rural areas
- improved environmental, health and social conditions
- reduced depletion of finite materials resources - regravelling is an inherently unsustainable activity
- enhanced socio-economic growth, development and poverty alleviation

The means of achieving the above hinges on cost-effective provision of sealed roads in rural and peri-urban areas by the transfer of technology developed through research. The Guideline therefore seeks to:

- act as a vehicle for the dissemination and implementation of appropriate innovative LVSR technology in the SADC region
- promote the use of a holistic approach to LVSR provision
- encourage optimal utilization of local resources and “non-standard”, but appropriate, designs for all aspects of LVSR provision
- promote greater local public and private sector involvement and participation in road projects
- ultimately, act as the standard consultative document for LVSRs

Adoption of the above is expected to lead to an increase in sealed roads constructed at an affordable cost and to an appropriate standard by applying proven, sometimes unconventional, methods and innovative technology.

Contrasting examples of low-volume roads in the SADC region



Earth/gravel road (Tanzania).



Old "strip" road (Zimbabwe).



Old "narrow-mat" road (Zimbabwe).



New low-volume sealed road (Botswana).

The Guideline is aimed at a wide range of stakeholders, from politicians to practitioners, including consultants, contractors, materials suppliers, donors, road users and the general public who, in various ways, are all involved in different but complementary aspects of low-volume road provision.

Because the SADC region is a diverse one, it would be impractical and inappropriate to provide recipe solutions for specific situations. Instead, emphasis has been placed on guiding the practitioner towards evaluating alternative options and considering their pros and cons as a basis for decision making and application to country-specific situations. This is achieved by collating together in one document key background knowledge and experience in the application and performance of tried and tested, new and innovative solutions in all aspects of LVSR provision.

The Guideline provides a compendium of recent approaches to the following aspects of low-volume sealed road provision:

- Planning, appraisal and environment.
- Geometric design and road safety.
- Pavement design, materials and surfacing.
- Construction and drainage.
- Maintenance.

The Guideline does not deal in detail with slope stability, geotechnical and hydrological issues or standard drainage details. However, it provides a source of comprehensive references which provide additional details and more fully documented examples of local and international experience.

Although the Guideline has been produced specifically for the SADC environment, there are many aspects of it which, with sound engineering judgement, could apply in similar environments elsewhere.

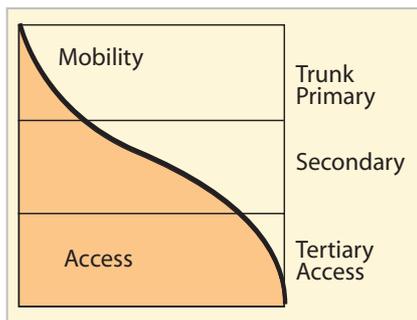
1.3 Focus

The focus of the Guideline is on *Low-volume Sealed Roads* (LVSRs) - a term for which there is no standard definition. Typical criteria for defining such roads include traffic volume, road function, administrative classification as well as management and financing arrangements. The concept of a low-volume road (LVR) also varies from country to country, simply because this type of road serves different functions and operates in different socio-economic environments. In the context of this Guideline, LVSRs are characterized by the following features that pertain to the SADC region:

Table 1.1 - LVSR Characteristics

● Ownership	Mostly local governments/communities but also provincial/ central governments.
● Classification and function	Mostly secondary or tertiary/access roads but can also be main/ primary roads. Serve predominantly rural populations of most countries – typically more than 75% of the population.
● Management and financing	Local government for tertiary/access roads, central government for primary/ secondary roads.
● Function	Economic/social/administrative/political.
● Physical features	Majority are unsealed, partly engineered, single or 2-lane, earth/sand or gravel roads with elevated running surfaces, side drains and cross-drainage structures, including low or high level water crossings.
● Traffic	Relatively "low-volume", typically up to about 200 vpd, carrying both motorised and non-motorised traffic.

The multi-functional nature



LVRs are multi-faceted. At one extreme, they serve as a mobility link in the road transport chain from the main highway network to the local market. At another extreme, they serve as an access link in a road transport chain with one end in the agricultural fields or villages and the other in the town market.

Low-volume roads in the region cut across a wide range of environments. In practice, there will be many overlaps in classification and function and clear distinctions will not always be apparent on functional terms alone. Nonetheless, the focus will be secondary/tertiary/access roads in rural and peri-urban areas.

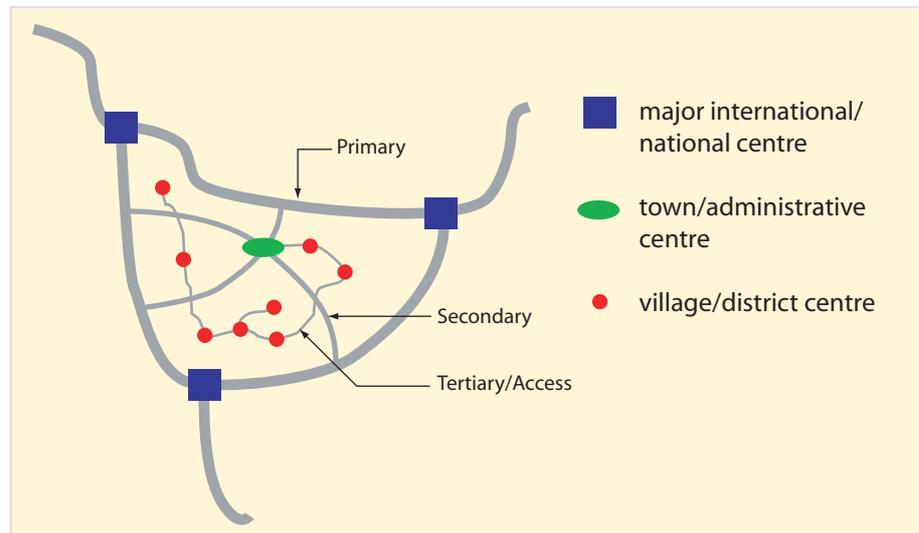


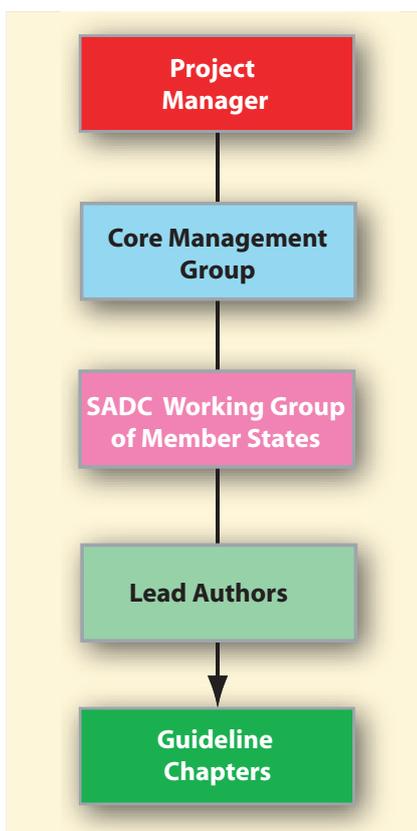
Figure 1.1 - Road hierarchy and function

1.4 Development of Guideline

The Guideline draws on the accumulated knowledge and practical experience of international research organizations, consultants and others who have long experience of working in the region. It was produced by a team comprising key specialists in each technical field, together with experts from SADC countries.

The Guideline is unique in the following important aspects:

1. It was developed with a high level of “local” participation. As a result, it has been possible to capture and incorporate a significant amount of local knowledge in the document. The benefits of this approach include a document that:
 - reflects the needs of the region
 - has an emphasis on local ownership
 - facilitates wider application
 - improves prospects for sustainable implementation
2. It draws extensively on the output of a 4-year SADC regional programme of research in highway engineering materials².
3. It focuses on the multi-dimensional nature of LVSR provision, giving balanced attention to aspects of LVR provision that are often neglected in most other guidelines, such as the political, social, institutional and funding aspects.



Organisational chart for management and development of the Guideline.

1.5 Structure and Content

The Guideline is divided into eight chapters which collectively address various aspects of LVSR provision as presented below.

1 Introduction

Comprises the introduction to the Guideline, including an overview of the focus of the document and the approach advocated in contrast to previous approaches to road provision. Against this background, the purpose, scope, development and structure of the Guideline are highlighted.

2 Regional Setting

Provides the geographic setting for the SADC region. Gives an overview of the regional road network and its various details. Highlights the challenge faced in providing LVSRs in a sustainable manner and the developments taking place in road sector reform. Outlines the main components of LVSR provision.

3 Planning, Appraisal and Environmental Issues

Provides a holistic framework for planning and appraising LVSRs and highlights the key external factors that affect their provision. Covers the process of life-cycle costing and the appropriateness of the available appraisal tools for doing so. Presents various environmental issues including the importance of the EIA process in the planning process.

4 Geometric Design and Road Safety

Presents factors relevant to the selection of appropriate standards for LVSRs and the steps involved in selecting suitable solutions. Summarises both conventional techniques and low-cost 'design-by-eye' methods, and the cost, environmental and safety implications of each. Highlights measures for improving road safety on LVSRs.

5 Pavement Design, Materials and Surfacing

Provides a systems approach to the design of LVSR pavements and surfacings derived from regional research work and practice. Highlights the importance of using local materials selected on the basis of appropriate specifications. Emphasises the importance of catering for both internal and external drainage of pavements to enhance performance.

6 Construction and Drainage

Provides guidance on the choice of methods available for the construction of LVSRs, with a focus on labour-based methods. Includes examples aimed at optimising the use of local labour and equipment technologies within a conducive contracting environment aimed at maximizing the use of small-scale local contractors.

7 Maintenance and Road Management

Highlights the importance of maintenance and the challenges faced in carrying it out effectively and efficiently. Presents the particular characteristics of LVSRs, including their deterioration characteristics. Outlines typical maintenance management functions and considers the contractual aspects of undertaking maintenance works. Outlines the role, function and selection criteria for Road Management Systems.

8 From Vision to Practice

Summarises the motivation for producing the Guideline and the benefits of adopting the approaches proposed. Outlines the pathway to implementation of the Guideline, the barriers that need to be overcome in the course of doing and the need to take account of many non-technical factors that often influence the manner in which LVSRs are provided.

1.6 Updating

As highway engineering technology and improved methods of low-volume road provision are continually being researched and changed, it will be necessary to update the Guideline periodically to reflect improvements in practice.

The Guideline has been produced in a loose-leaf format to allow notes and pages to be inserted as and when necessary. In addition, it has been produced in electronic CD format and has also been posted on the SATCC website www.sadc.int. The Guideline is produced in all three official SADC languages - English, French and Portuguese.

1.7 Sources of Information

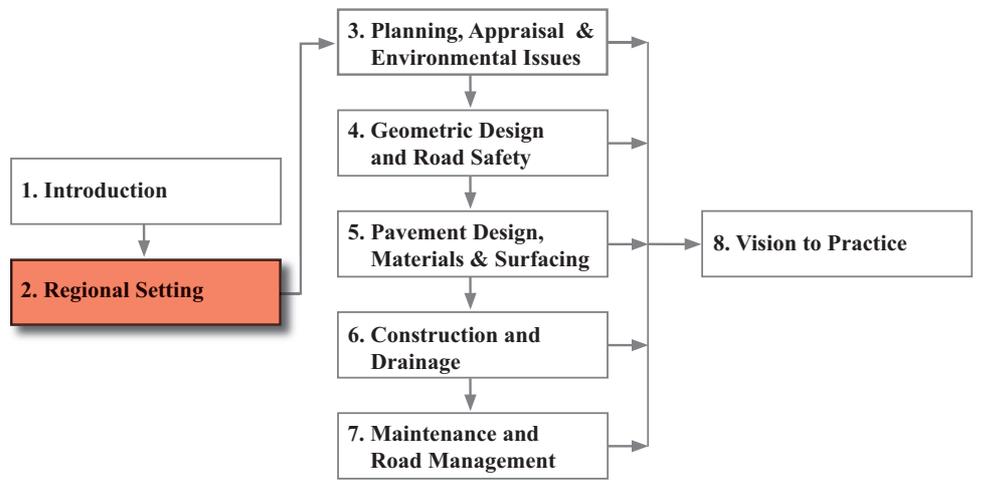
In addition to the references cited in the text of each chapter, an extensive bibliography has also been provided for those readers who wish to obtain additional information about any of the topics included. A list of the main organizations producing relevant publications is also provided, including their contact details.

1.8 References and Bibliography

References

1. Transportation Research Board (1979). *Low-volume Roads: Second International Conference*. Transportation Research Record 702. National Academy of Sciences, Washington, D.C. August, 1979.
2. Gourley C S and P A K Greening (1999). *Performance of Low-volume Sealed Roads: Results and Recommendations from Studies in Southern Africa*. Project Report PR/OSC/167/99. TRL. November, 1999.
3. Norwegian Public Roads Administration (1999). *A Guide to the Use of Otta Seals*. Road Technology Department (NRRL), Publication No. 93, Oslo. August, 1999.
4. Netterberg F and P Paige-Green (1998). *Pavement Materials for Low-volume Roads in Southern Africa: A Review*. Annual Transport Convention, S.443, Vol. 2D, Pretoria. July, 1988.
5. Transport Research Board/National Research Council (1995). *Assessing Worldwide Low-volume Roads: Problems, Needs and Impacts*. Transport Research Circular No. 446. Washington. May, 1995.

Chapter 2



Regional Setting

2

2.1	Introduction	2 - 1
2.1.1	Background	2 - 1
2.1.2	Purpose and Scope of Chapter	2 - 1
2.2	The SADC Region	2 - 2
2.2.1	Geographic Setting	2 - 2
2.2.2	Road Sector Reform	2 - 2
2.3	Regional Road Network	2 - 5
2.3.1	The Road Network	2 - 5
2.3.2	Roads and Economic Development	2 - 6
2.4	Road Network Details	2 - 7
2.4.1	Classification and Traffic Flows	2 - 7
2.4.2	Design Standards.....	2 - 7
2.4.3	Road Conditions.....	2 - 7
2.4.4	Road Safety	2 - 8
2.5	Low-volume Sealed Roads	2 - 9
2.5.1	The Challenge	2 - 9
2.5.2	Gravel Road Issues	2 - 9
2.5.3	Need for Sustainable Strategies	2 - 10
2.5.4	Main Components of LVSR Provision	2 - 12
2.6	Summary	2 - 14
2.7	References and Bibliography	2 - 15

Regional Setting

2

2.1 Introduction

2.1.1 Background

Road transport is essential for the operation of the SADC economy and for the development of national and regional markets. With a total fleet of over 10 million vehicles in 2002, it provides the dominant mode of freight and passenger transport and carries about 80% of the region's total trade in goods and services. It also accounts for about 20% of the region's cross-border trade.

In common with many other developing countries, a large percentage of the population in the SADC region lives in rural areas, where agriculture is the dominant economic activity. In this context, low-volume roads fulfil a critical function in that they generally provide the only form of access to these communities and provide for the mobility of people and movement of goods from the fields to the market place. A good rural road network is therefore essential for improving rural livelihoods and socio-economic growth and development.

Unfortunately, despite the substantial investments made in road transport infrastructure, the cost of road transport services is still inordinately high, especially in rural areas where inadequate transport infrastructure and lack of mobility still impose major constraints on development. There are many reasons for this unsatisfactory situation, some of which are attributable to the questionable nature of various approaches adopted in the provision of LVSRs, many of which have proved to be unsustainable.

2.1.2 Purpose and Scope of Chapter

The main purpose of this chapter is to set the background to the SADC region against which the characteristics of the regional road network are presented. Issues relating to the sustainability of the gravel road network and the challenges of alternative approaches for the delivery of low-volume sealed roads are described. A new, more sustainable, multi-dimensional approach is proposed that is set in the context of the reforms taking place in the road sector in the SADC region. These initiatives are designed primarily to improve the management and financing of roads but will also facilitate the implementation of the approaches recommended in this Guideline.



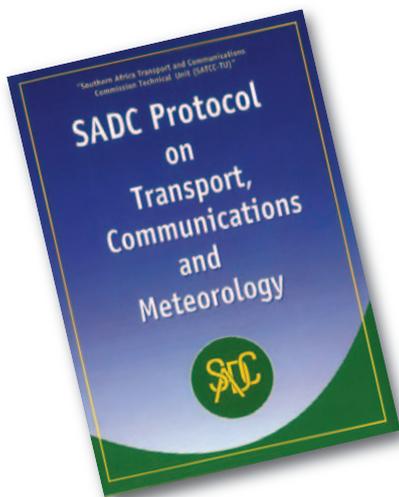
Agriculture is the predominant activity in the rural areas of most SADC countries.

The vision of SADC is to transform the fourteen countries of southern Africa from operating as individual fragmented markets into a single integrated vibrant and globally competitive market characterised by free movement of goods, services and labour. Transport, particularly road transport, is an integral component of this vision.

One of the first institutional priorities identified by SADC was the creation of the **Southern African Transport and Communications Commission (SATCC)** to coordinate the use of existing systems and the planning and financing of additional regional transport facilities. Transport is, therefore, the major initial focus for regional action.



The bulk of the SADC rural road network is still unsurfaced and in relatively poor condition.



2.2 The SADC Region

2.2.1 Geographic Setting

The Southern Africa Development Community (SADC) is an economic grouping of fourteen countries located in the Southern African region with a collective land area of about 10 million square kilometers and a population of nearly 200 million people in 2002. Six of the fourteen countries are land-locked and two are island states as shown in Figure 2.1.



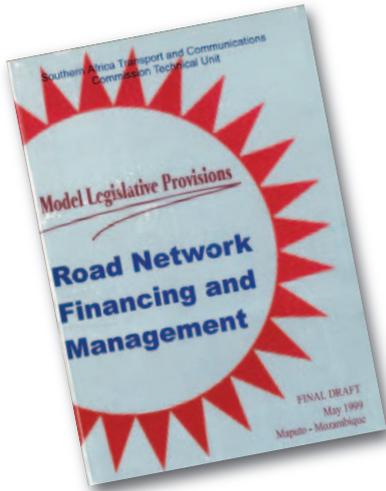
Figure 2.1 - The Southern African Development Community

The SADC region is diverse with climates varying from true deserts through savannah to rainforests. Although the natural resource base is varied, the economies of the various countries are mostly agrarian, with approximately 80% of the population living and working in the rural areas. In such a setting, rural roads play a critical role in support of socio-economic growth and development and, ultimately, poverty alleviation - an over-arching goal of all SADC governments.

2.2.2 Road Sector Reform

Since the late 1990s, the SADC region has experienced a “wind of change” in its approach to road management and financing. It has become increasingly apparent that traditional approaches, which have relied on managing roads through a government department and financing them through general budget allocations, have generally not worked satisfactorily. This has led to the development of the SADC Protocol on Transport, Communications and Meteorology¹.

The SADC Protocol promotes perhaps the most far-reaching set of changes ever contemplated in the roads sector in Sub-Saharan Africa. Its strategic vision is to provide a “safe, sustainable, efficient and effective road transport system” in support of regional socio-economic growth and development. Since its ratification by all member states, the SADC Protocol has been implemented to varying extents and with varying degrees of success. All member states are required to fully comply with the requirements of the protocol by 2010.



Box 2.1 - The main features of the SADC Protocol on Transport, Communications and Meteorology

The SADC Protocol commits member states to the development of a harmonised regional road sector policy with the following main features:

- Clear *demarkating* and *allocating* of authority and responsibilities for *road funding and road management*.
- Establishing *accountable* and *autonomous* roads authorities with public and private sector participation in key decision-making and the ability to source expertise outside civil service restrictions.
- Adopting *commercial management practices* to foster institutional, economic and technical efficiency, amongst others, by introducing competition in undertaking any road-related activity and adopting a preference for the contracting out of all types of road construction and maintenance activities.
- Adopting *appropriate financing principles* and practices to secure adequate and sustainable sources of funding through incremental expansion of road user charging.
- *Dedicating revenues* from roads to their provision, operation and maintenance.
- Identifying *sustainable funding sources* to ensure a regular flow of funds.

SADC Institutional Framework

The agreed SADC institutional framework clearly and unambiguously differentiates between the separate and discrete roles played by key road sector stakeholders in terms of policy formulation, policy delivery and works execution as illustrated in Figure 2.2.

The restructuring of road management and financing in the SADC region, within a more commercialised institutional framework, is meant to ensure that institutional capacity exists to support improvements in technical capability, such as maintenance operations and management.

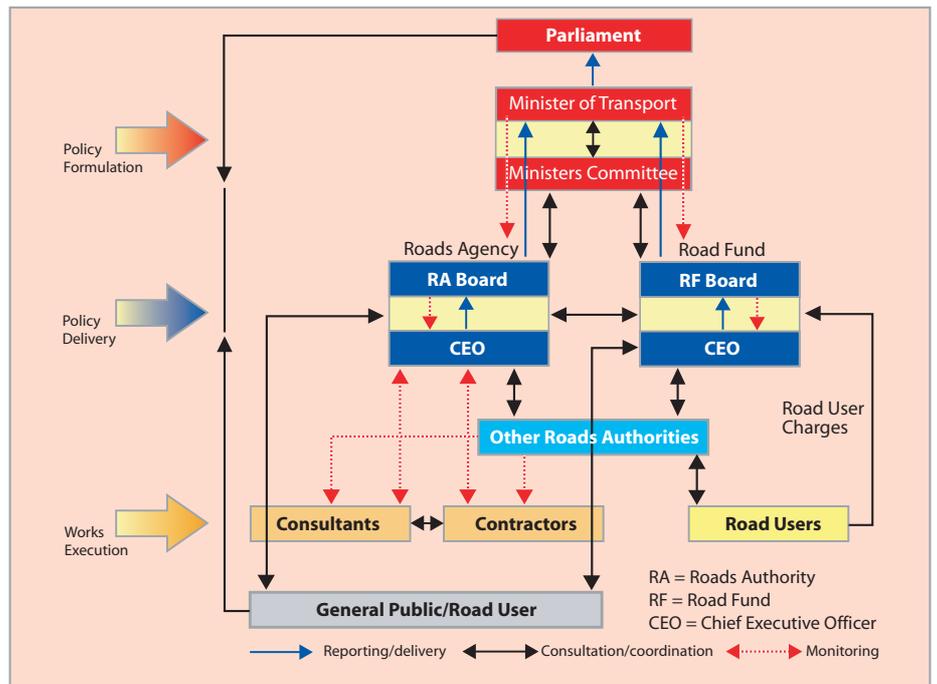


Figure 2.2 - SADC institutional framework for management and financing of roads²

Within the new SADC institutional framework, policy, management, financing and operations are treated as follows:

Policy formulation: The overall legal authority for the road network is vested in a *single Ministry* with responsibility for all regulatory, policy, standards and legislative matters. The Ministry has authority over the Transport/Traffic Agency. The authority over the National Roads Board is limited to approving the level of road user charges recommended by the Board to finance road maintenance and improvement works, and to monitoring the Board's compliance with the terms set out in the legislation under which it was established.

A Ministers' Committee fulfils the function of a policy co-ordination forum in respect of national, regional and local road authorities. The committee also plays an important role in promoting transparency and accountability and democratizing decision-making with regard to roads.

Management: An "arms-length" autonomous or semi-autonomous *Roads Agency* has replaced (or commercialised) the former Roads Department in the Ministry of Transport. Its functions are basically the same as those of the previous Roads Department in terms of strategic management and planning of the development, maintenance and rehabilitation of the national road network, except that they are carried out in a commercial manner. The Agency is overseen by a majority private sector Board and managed on a day-to-day basis by a Chief Executive Officer (CEO).

Financing: An "arms-length" autonomous or semi-autonomous *Road Fund* operates as a commercial agency with responsibility for road financing. In so doing, it:

- acts as a channel for the receipt of all revenues destined for roads
- disburses funds to roads agencies based on simple, transparent procedures
- audits compliance with well defined financial auditing principles

Sustainable funding for road maintenance is based on the "*user pays*" principle and is secured through the levying of a *Road User Charge*. Such a charge reflects the usage of roads and typically consists of a fuel levy on petrol, diesel, vehicle license fees including supplementary heavy vehicle license fees, fines imposed on overloaded vehicles, and any other user charges that may be prescribed by Parliament from time to time.

The funds available from road user charges should not necessarily be spent directly according to traffic level. Low-volume "social" roads will probably need to be subsidised to some extent from the revenues from high-volume "economic" roads.

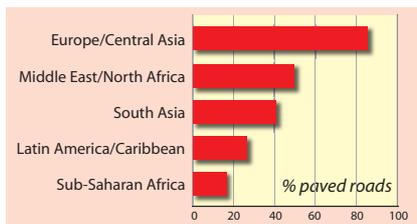
Operations: All types of road construction and maintenance works should be contracted to the private sector through competitive bidding processes rather than undertaken in-house by Force Account or Direct Labour operations. The procurement of works through performance-specified term contracts and the use of Petty Contractors is increasingly being viewed as the preferred method of contracting out maintenance works, in contrast to the traditional type of contract which, typically, is based on rather prescriptive input specifications and utilises large, foreign contractors.

2.3 Regional Road Network

2.3.1 The Road Network

The total length of the SADC classified road network (Figure 2.3) is just over 930,000 km of which approximately 20 per cent is paved. More than half of the region’s total network (511,000 km) is in South Africa. There is also a large network of rural roads in the SADC region, approximately 430,000 km, which consists mainly of 2-lane, all-weather gravel roads and seasonal earth tracks. Most of these roads were constructed in the post independence era of the 1960s and 1970s and are one of the region’s biggest assets with current replacement costs in excess of US \$50 billion.

The SADC Regional Trunk Road Network (RTRN) comprises approximately 50,000 kms of strategic, intra-regional routes linking capital cities, major regional ports and other areas of economic importance. In addition to the unpaved rural road network, a significant proportion of the RTRN (approximately 30 per cent) also carries relatively low levels of traffic and, hence, these roads are also classified as “low-volume roads”.



Sub-Saharan Africa, including the SADC region, lags considerably behind Asia and Latin America in terms of road coverage and density³.

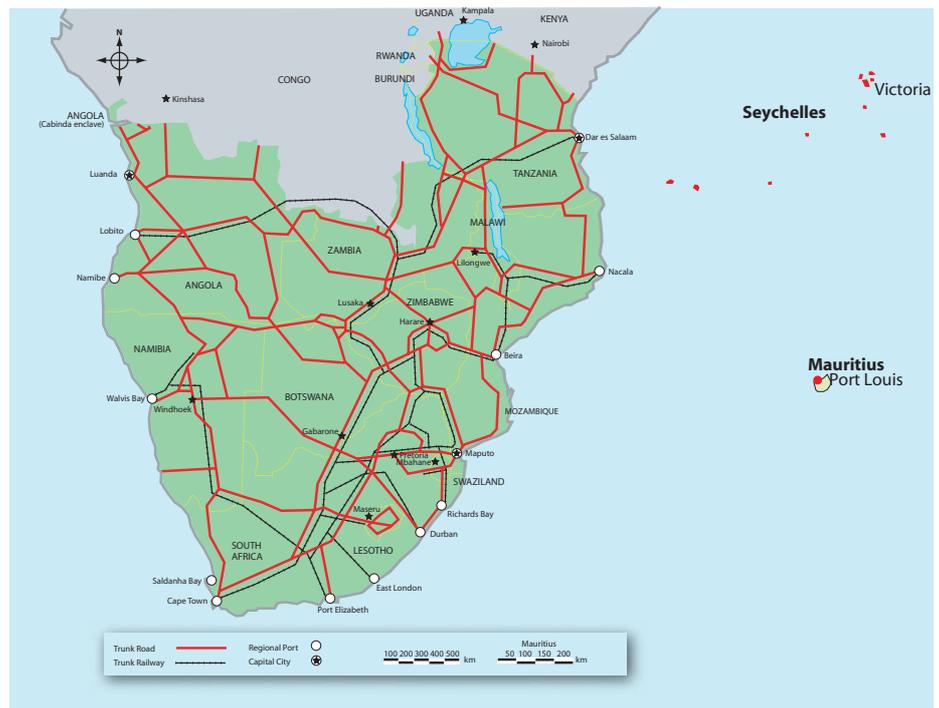


Figure 2.3 - The SADC Regional Trunk Road Network (2001) (excludes the Democratic Republic of the Congo)

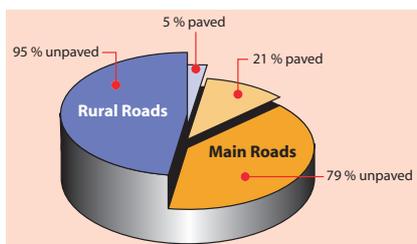
The current main road length averages about 5.6 kilometres for every 100 square kilometers, which is low by comparison with to other developing regions such as Latin America (12 km/100 sq. km) and Asia (18 km/sq. km).

Table 2.1 - Inventory of SADC Regional Road Network

Main Roads			Rural Roads			Total Network		
Paved (km)	Unpaved (km)	Total (km)	Paved (km)	Unpaved (km)	Total (km)	Paved (km)	Unpaved (km)	Total (km)
105,122	395,900	501,022	21,559	409,626	431,185	126,681	805,526	932,207
21.0%	79.0%	100.0%	5.0%	95.0%	100.0%	13.6%	86.4%	100.0%

Source: Report by SAGP consultants; Updates from SADC member states (2001)⁴. (Note: Classification is inconsistent. Main roads can include trunk, regional, main, primary and secondary roads.)

* Excludes the Democratic Republic of the Congo



A substantial proportion of both the main and rural road networks in the SADC region is unpaved.

Road transport investment should be viewed as part of an integrated approach considering the economic and social context where improvements take place, and including additional policies on other fronts (e.g. marketing, education, stimulus to demand) that would lead to higher social returns from investment.

Road network density in developed countries is generally much higher than in developing countries. However, the cost of building roads is not proportional to the wealth of a nation in terms, for example, of the GDP per inhabitant. Thus, with the GDP per inhabitant being 10 to 20 times lower in developing countries, the cost of road provision is two to three times higher than in developed countries. It is therefore critically important that paved road construction costs are minimized through the selection of appropriate standards and implementation strategies.

2.3.2 Roads and Economic Development

The precise role that roads play in economic development is complex but the fact that there is a link is widely accepted and most economists agree that investment in transport infrastructure makes a positive contribution. However, the provision of road transport infrastructure alone is not enough to reap all the possible benefits from interventions. Indeed, recent research⁵ highlights two major aspects that should be considered by policy makers: *the access to transport means, and the market organisation for goods and transport services. Thus, SADC governments should also address the need for credit, low-cost vehicles, and intermediate means of transport, and also be prepared to intervene in markets to ensure that benefits become widespread.*

The benefits from road investment vary greatly depending upon the type of interventions, and the social and economic context where they take place. For example, in those rural areas in southern Africa where infrastructure is so basic that vehicle use is difficult or near impossible, facilitating the change to motorised transport would result in major benefits.

In terms of the relationship between km of paved roads/million persons and GDP per capita, the SADC region occupies a relatively low position (Figure 2.4). Thus, improving the efficiency of LVSR provision by providing them at lower and more affordable costs than hitherto, has the *potential* (together with other complementary interventions) for providing considerable benefits to the region's economy and, in so doing, for reducing poverty.

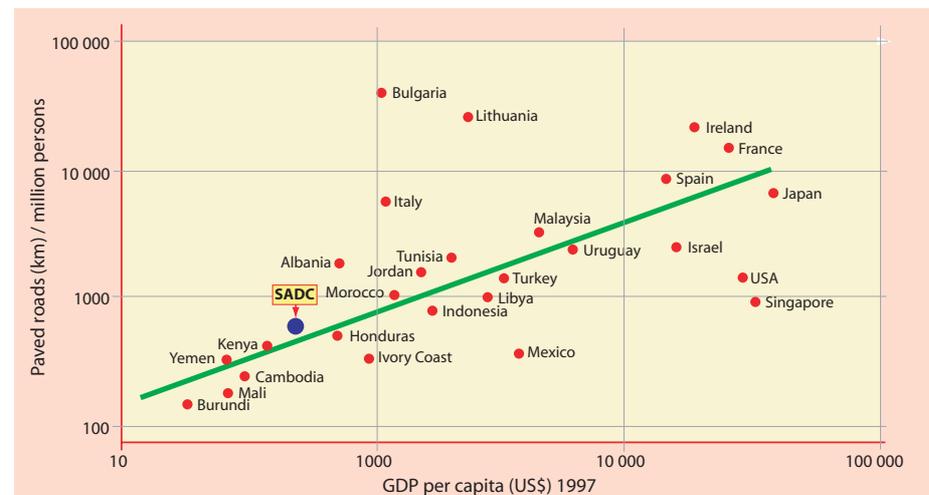


Figure 2.4 - International comparison of paved road density and GDP per capita

2.4 Road Network Details

2.4.1 Classification and Traffic Flows

Roads in the SADC region are typically classified according to function as shown in Table 2.2 and illustrated in Figure 1.1.

Table 2.2 - Typical road functions and classification

Road Function				Design Class	Traffic Flow (AADT)	Typical Surface Type
Tr	P	S	Te			
				A	> 2000	Paved
				B	500 - 2000	Paved
				C	200 - 500	Paved/Unpaved
				D	50 - 200	Unpaved
				E	< 50	Unpaved

Key Tr = Trunk P = Primary S = Secondary Te =Tertiary/access



Pedestrians and non-motorised traffic often constitute a significant proportion of traffic near villages.

With the exception of South Africa, and apart from a few heavily trafficked international routes, most of the main roads carry modest volumes of traffic, with little more than about 10 per cent carrying over 2000 vpd, approximately 25 per cent of which consists of heavy, often over-loaded, commercial vehicles. On rural roads, traffic volumes are relatively very low and much of this network carries traffic in the range of 50 - 200 vpd. Near village centres non-motorised traffic, including bicycles, often comprises a significant proportion of the total traffic.

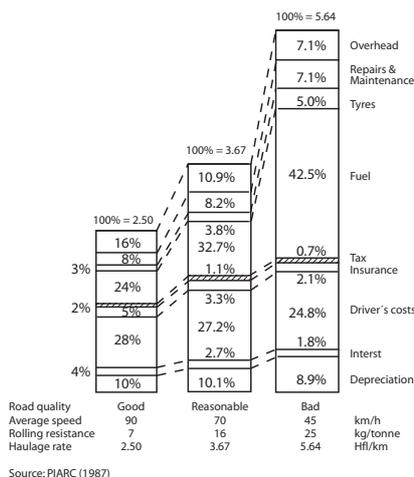
The “low-traffic” characteristics of much of the rural road networks in the SADC region have implications for geometric design, pavement and drainage structures, road furniture and maintenance practice and, indeed, the manner in which investment appraisals are carried out.

2.4.2 Design Standards

Road design standards in the SADC region vary considerably, reflecting neither the practice of the developed countries with which member states have had previous ties, or the preferences of international consultants, usually donor funded, who have worked in the country. Thus, British, American, Portuguese, French, German and other standards have left their mark on the road infrastructure. In many instances, these standards have been inappropriate for cost-effective application in the SADC region where the physiographic, socio-economic and environmental conditions vary tremendously from those prevailing in the countries of origin of the standards.

2.4.3 Road Conditions

About 50% of the paved main road network is currently (2001) in good condition, with the remainder classified as only fair or poor, as shown in Table 2.3. The unpaved main road network is considerably worse than the paved road network, with less than 40% being in good condition. The net result is that transport costs are very high with estimates of four to five times of those in developed countries and, for some landlocked countries, as high as 30 - 40 per cent of the price of goods⁶.



The influence of road conditions on haulage costs - both the operating and maintenance costs of vehicles escalate with increasing rapidity as the surface condition worsens (PIARC, 1987).

Can any country afford roads in this condition?



“My country was never so rich that it could afford poor roads”

(William the Conqueror, Doomsday Survey, 1066).

Table 2.3 - Condition of main roads in the SADC region

Main Roads	Road Condition (Weighted Average)		
	Good	Fair	Poor
Paved	49	36	15
Unpaved	38	31	31

Sources: Report by SAGP consultants to SATCC⁴; Updates from member states (2001).

Notes:

Good: Substantially free of defects and requiring only routine maintenance. Unpaved roads need only routine grading and spot repairs.

Fair: Having significant defects and requiring resurfacing or strengthening. Unpaved roads need reshaping or re-gravelling and spot repair of drainage.

Poor: Having extensive defects and requiring immediate rehabilitation or reconstruction. Unpaved roads need reconstruction and major drainage works.

Rural poverty in the SADC region is exacerbated by the prevailing poor road conditions which adversely affect accessibility and, as a result, limit the facilitating role of transport in both production and consumption activities. Improvements in the quality and reliability of the rural road network are therefore critical for development and poverty eradication, the over-arching goal of all SADC governments.

For these reasons, most of the current investment in the roads sub-sector involves upgrading these predominantly low-volume, rural secondary and feeder roads to an improved standard at minimum life-cycle cost - which is the main focus of this Guideline.

2.4.4 Road Safety

There is a serious road safety problem in all countries of the SADC region. This is characterised by a high rate of road accidents involving pedestrians and other vulnerable road users, particularly on rural roads where vehicle speeds tend to be relatively high. Fatality rates, in relation to vehicle fleets, are estimated to be 30 - 40 times higher than those of industrialised countries and cost the region between one and three per cent of its annual GDP⁷.

Fortunately, there is now a widespread recognition that much more can be done to improve the poor road safety situation. This includes improvements in road design and the more widespread use of road safety audits. These issues, amongst others, are dealt with in Chapter 4 of the Guideline.



The high accident rate in the SADC region is a source of loss and damage to trade and one of the major causes of injury and death.

2.5 Low-volume Sealed Roads

2.5.1 The Challenge

A number of factors combine to pose a major challenge to road authorities in the provision of LVSRs. In this regard:

- They generally constitute a high proportion (typically 80%) of the road network for which available resources are severely limited.
- Limited funding tends to be allocated in favour of HVRs which are perceived as fulfilling an important economic role even though LVRs fulfill at least equally important social and development functions.
- Social and developmental benefits are often dealt with inadequately in traditional investment appraisal methodology.
- There has been a tendency to focus predominantly on the technical aspects of LVSRs, with inadequate attention being paid to the other environments within which they operate and which influence their long-term sustainability.
- Traditional highway engineering, planning and standards that are applied to roads with higher volumes of traffic are often not appropriate for LVSRs and, when used, result in unnecessarily expensive solutions.
- Although traffic volumes may be relatively low, vehicle loads are often high, with significant overloading. This makes the relatively light pavement structures, that would otherwise be appropriate, vulnerable to overloading.
- The allocation of limited research funding tends to be prioritized in favour of high-volume roads which are perceived to offer higher rates of return.

In addition to the challenges faced by road agencies in providing LVSRs, transport agencies also face a major challenge of providing affordable transport services to rural communities. However, although closely related, this topic is outside the scope of this Guideline.

2.5.2 Gravel Road Issues

A substantial proportion of the rural road networks, and to a lesser extent, of the main road networks in the SADC region, are currently unpaved. These roads need to be continuously regravelled utilizing naturally occurring gravels, a finite, often scarce, non-renewable resource.

In practice, many countries do not have the necessary financial resources to sustain their gravel road networks. As illustrated in Figure 2.5, this quickly leads to the total loss of the investment as well as to all-weather access for the communities that these roads serve.

In the past, geometric design standards were not specifically addressed in the SADC region. Both road planners and designers were faced with either using “national” imported standards that were developed for a higher classification of roads or reducing these higher classification standards to meet economic constraints, usually without a logical basis for doing so.



*Based on a typical regravelling cycle of 3 - 4 years and a replacement gravel thickness of 100 mm over a 6.5 m carriageway, the annual consumption of gravel in the region is of the order of 150 million cubic metres. Is this process sustainable in the medium to long term? **NO!***

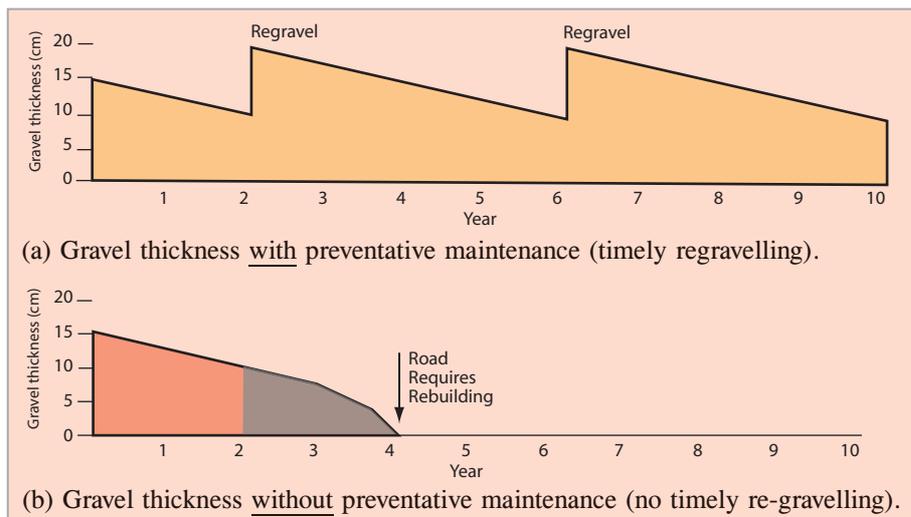


Figure 2.5 - Periodic maintenance (regravelling) of unsurfaced roads¹⁰

Sustainability considerations

There are a number of very serious concerns to national governments, development agencies and rural communities regarding the use of gravel road surfaces. These are summarized in Table 2.4.

Table 2.4 - Gravel road sustainability considerations

Issue	Sustainability Factor
<ul style="list-style-type: none"> ● Financial and economic 	<ul style="list-style-type: none"> ○ Gravel is a sacrificial layer and replacement is at a high cost: <ul style="list-style-type: none"> - 30 to 150 mm can be lost per annum - regravelling operations cost US \$5,000 to 30,000 per/km/year - periodic maintenance costs US \$2,000 to \$3,000/km/year - continuous regravelling is a significant recurrent financial burden
<ul style="list-style-type: none"> ● Institutional and management 	<ul style="list-style-type: none"> ○ Unpaved roads: <ul style="list-style-type: none"> - typically constitute 70 to 90% of the main road network and most of the undesignated network - generate a continuous cycle of deterioration and backlog maintenance ○ Roads agencies: <ul style="list-style-type: none"> - suffer logistical, technical and financial constraints - often have limited physical, human and natural resources - have little capacity to intervene in maintenance activities as required
<ul style="list-style-type: none"> ● Standards and technology 	<ul style="list-style-type: none"> ○ Wastage of finite resources (selective gravelling difficult in practice). ○ Expensive mechanised approaches required for regravelling result in: <ul style="list-style-type: none"> - operational, support and technical problems - local financing burden ○ Potential longer term sustainability of labour-based methods
<ul style="list-style-type: none"> ● Social 	<ul style="list-style-type: none"> ○ Land take and rehabilitation of borrow pits. Wet weather access problems for communities continue. ○ Generation of dust in dry weather with adverse impacts including: <ul style="list-style-type: none"> - health hazard - pedestrian and vehicle safety - crop, natural habitat and vehicle damage
<ul style="list-style-type: none"> ● Environmental 	<ul style="list-style-type: none"> ○ Continuous demand for use of non-renewable natural resources which are being seriously depleted. ○ Haul distances and costs continually increase. ○ Land take continues. ○ Roads susceptible to erosion (silting of drains and water courses). ○ Chemical treatment options can be hazardous.



Due to loss of fines, gravel roads often become very rough which make driving conditions hazardous and, in addition to severe driver discomfort, impose very high vehicle operating costs.



Generation of dust is a constant hazard to over-taking motorists as well as to inhabitants living nearby and their crops.

For the above reasons, it is now abundantly clear that the time has come to provide more sustainable solutions to low-volume roads in many SADC countries by sealing them, where viable, at an affordable cost. Meeting this challenge is the main focus of this Guideline.

2.5.3 Need for Sustainable Strategies

Traditional approaches to LVSR provision have tended to focus somewhat narrowly on the technical environment with inadequate consideration of the other inter-related environments shown in Figure 2.6. The result has often been a lack of responsiveness to the needs of various stakeholders and a reduced likelihood of achieving sustainable solutions^{8,9}.

Lessons learned from the region indicate that if LVSRs are to be provided in a more sustainable manner than hitherto, new approaches are required that focus in a more holistic way on a number of factors operating within multi-dimensional, inter-acting environments.

By their nature, LVSRs fulfil a variety of economic and social functions and their provision is influenced by a number of complex, inter-acting environments in which non-technical factors play a crucial role. Thus, it is of paramount importance that emphasis is placed on a multi-disciplinary, participatory approach in the planning, design, construction, maintenance, etc., of LVSRs.

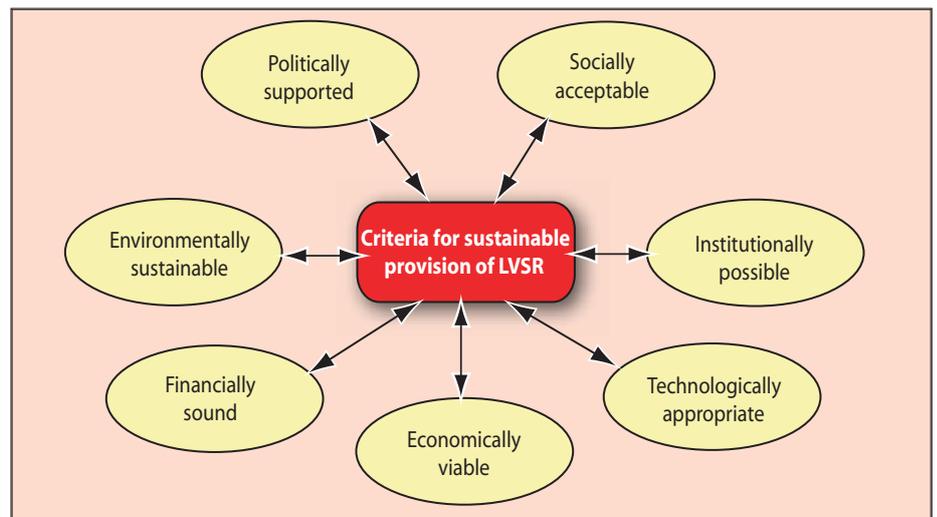


Figure 2.6 - A new framework for sustainable provision of LVSRs

Achieving sustainability in the provision of LVSRs requires an important shift of emphasis from a relatively narrow focus to a more broadly focused, multi-dimensional approach in which a number of influential factors need to be considered as indicated in Table 2.5.

Table 2.5 - Factors affecting the provision of LVSRs in the SADC region

Environment	Sustainability factors
<ul style="list-style-type: none"> ● Political 	<p>Government policy: Often no coherent policy in place.</p> <ul style="list-style-type: none"> ● Need to highlight the key benefits to be derived from LVSRs leading to the development of a comprehensive policy that: <ul style="list-style-type: none"> ○ promotes sustainability in all aspects of LVSR provision ○ covers wider social and economic goals of poverty alleviation by implication, employment creation ○ promotes the use of appropriate technology as well as environmental awareness <p>Political and public perceptions: Tendency to favour conventional approaches and standards with perceived minimum “risk” attached to them.</p> <ul style="list-style-type: none"> ● Need to maintain continuous dialogue with political and public stakeholders in order to: <ul style="list-style-type: none"> ○ highlight pros and cons of alternative solutions in a balanced and transparent manner ○ more determinedly “sell” proven innovative approaches and appropriate, non-traditional standards on the basis of quantified benefits

<ul style="list-style-type: none"> ● Social 	<p><i>Social issues: Tend to be neglected or to be subordinate to technical and economic issues.</i></p> <ul style="list-style-type: none"> ● Adopt strategies that: <ul style="list-style-type: none"> ○ support cost-effective labour-based methods of construction and maintenance ○ ensure community participation in mainstream policy, planning and decision making ○ eliminate gender biases and promote participation by women in labour-based activities ○ promote activities and investment for sustainable enhanced livelihoods ○ minimise the amount of resettlement and, where unavoidable, mitigate its effects by expeditious and compensated resettlement
<ul style="list-style-type: none"> ● Institutional 	<p><i>Institutional capacity: Often inadequate. Growing trend towards establishment of more autonomous central and local road authorities.</i></p> <ul style="list-style-type: none"> ● Adopt strategies that: <ul style="list-style-type: none"> ○ promote commercial management practices to foster institutional, economic and technical efficiency in the provision of LVSRs ○ reduce and eventually phase out in-house, force account operations in favour of contracting out of works to the private sector ○ define and develop an optimal environment for the development of local contractors
<ul style="list-style-type: none"> ● Technical 	<p><i>Technology choice: A wide range of options is available for designing, constructing and maintaining LVSRs.</i></p> <ul style="list-style-type: none"> ● Adopt strategies that: <ul style="list-style-type: none"> ○ employ appropriate design standards and specifications ○ utilise technologies that create employment ○ use types of contract that support the use of local contractors ○ promote road safety in all aspects of LVSR provision
<ul style="list-style-type: none"> ● Economic 	<p><i>Economic analysis: Traditional approaches are often unable to capture the full benefits of LVSR provision.</i></p> <ul style="list-style-type: none"> ● Adopt strategies that: <ul style="list-style-type: none"> ○ integrate social, environmental and economic elements in project appraisal ○ use appropriate evaluation tools capable of quantifying social, economic and environmental costs and benefits
<ul style="list-style-type: none"> ● Financial 	<p><i>Funding: Usually inadequate to meet minimum requirements.</i></p> <ul style="list-style-type: none"> ● Adopt strategies that: <ul style="list-style-type: none"> ○ promote commercialisation in the roads sector ○ establish sustainable sources of funding
<ul style="list-style-type: none"> ● Environmental 	<p><i>Environment: Generally regarded as the price to be paid for development and often neglected.</i></p> <ul style="list-style-type: none"> ● Adopt strategies that: <ul style="list-style-type: none"> ○ minimise the physical impacts of construction and maintenance ○ take account of socio-cultural impacts (community cohesion) ○ resource management (recycling of non-renewable materials) ○ recognise that climate change should be taken into account in the design process

2.5.4 Main Components of LVSR Provision

The four major components of LVSR provision that will typically be undertaken within the new SADC institutional framework are as follows:

- Planning
- Design
- Construction
- Maintenance

These components have important but changing impacts on the end result - a *Low-volume Sealed Road* - in terms of their “level of influence”¹¹. Figure 2.7 illustrates the essential features of the “level of influence” concept in terms of how the effect on the total life-cycle costs of a LVSR project decreases as the project evolves.

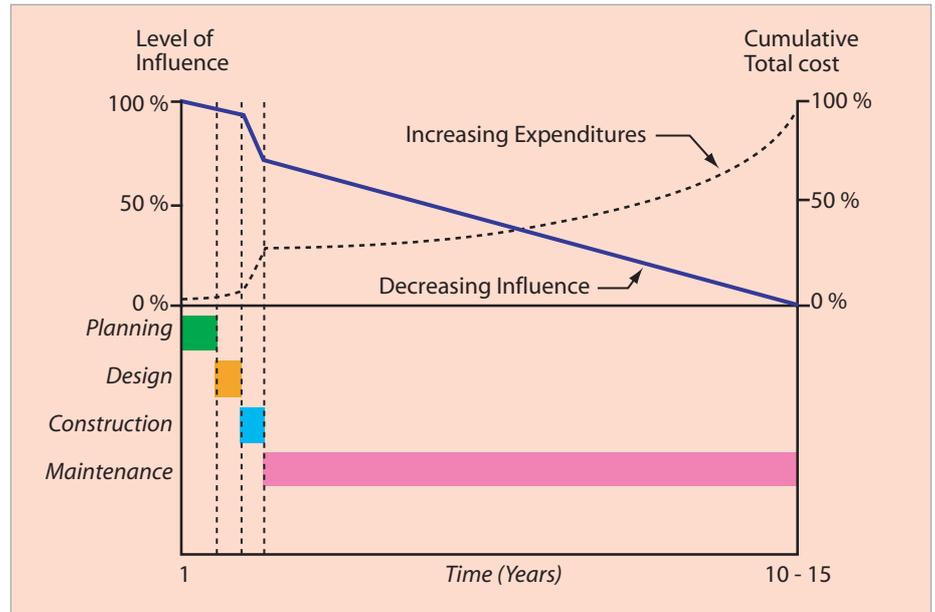


Figure 2.7 - Influence level of LVSR components on total costs

In essence:

- Costs during the planning and design phases are relatively small compared with the total expenditure and are incurred during a relatively short period of the project's life. However, their downstream level of influence is very large in terms of decisions and commitments made during the early phases of the project.

This emphasizes the importance of employing a broadly-based, holistic approach to the planning of LVSRs with the main stakeholders being involved in the decision-making process. In addition, the designs employed (geometric and pavement) should be appropriate and relevant to the environment in which the road is being constructed.

- The capital costs for construction are a fraction of the operating and maintenance costs associated with a pavement life-cycle. However, the decisions made during the construction phase, and the methods of construction adopted, can have a great impact on the cost of maintaining the road.

This emphasizes the importance of ensuring a high degree of quality control in the use of local materials and the adoption of construction methods that are appropriate to the multi-dimensional environment in which the road is being provided.

- Maintenance occupies a significant number of years in the life of the project and the type and cost of maintenance required is influenced significantly by the preceding planning, design and construction phases.

This emphasizes the importance of ensuring that the maintenance phase is prolonged as much as possible to extend the useful life of the road and the period of time during which benefits are incurred.

- At the beginning of the project, the roads agency controls all factors (100 per cent influence) in determining future expenditures. The key issue is how to optimize the use of scarce resources in the provision of LVSRs in an efficient, effective, appropriate and sustainable manner.

The subsequent chapters of the Guideline deal in turn with the main components of LVSR provision - planning, design, construction and maintenance - with particular emphasis on the "level of influence" concept described above.

2.6 Summary

The key points raised in this chapter are:

1. Roads are central to economic development and poverty alleviation as well as to creating opportunities for employment in the SADC region. Despite the substantial investments made in road infrastructure, road transport costs remain very high, particularly in rural areas, and this has had an adverse impact on the regional economy.
2. The road network of about one million kilometres is characterised by relatively low traffic levels (< 200 vpd) outside of urban areas, variable design standards, poor road conditions and a very serious road safety problem.
3. More than 80% of the regional road network is unpaved. In the medium to long term, continuous gravelling or regravelling of these roads is unsustainable. Consideration must be given to sealing them, where viable, at an affordable cost.
4. New, more sustainable, broadly focused, multi-dimensional approaches are required to deal effectively and efficiently with the management of the large kilometrage of unsurfaced roads.
5. The region has embarked on major reforms of the road sector with the objective of managing and financing roads within a more commercialised environment. This will have a profound effect on the way in which the sector operates in future and provides the potential for substantial improvements in the provision of LVSRs.
6. The main components of LVSR provision - planning, design, construction and maintenance - have important but changing impacts on the end result in terms of their “level of influence”.

This chapter puts into context the challenges that road agencies in the region face in providing LVSRs in a sustainable manner - challenges that are addressed in subsequent chapters of the Guideline.

2.7 References and Bibliography

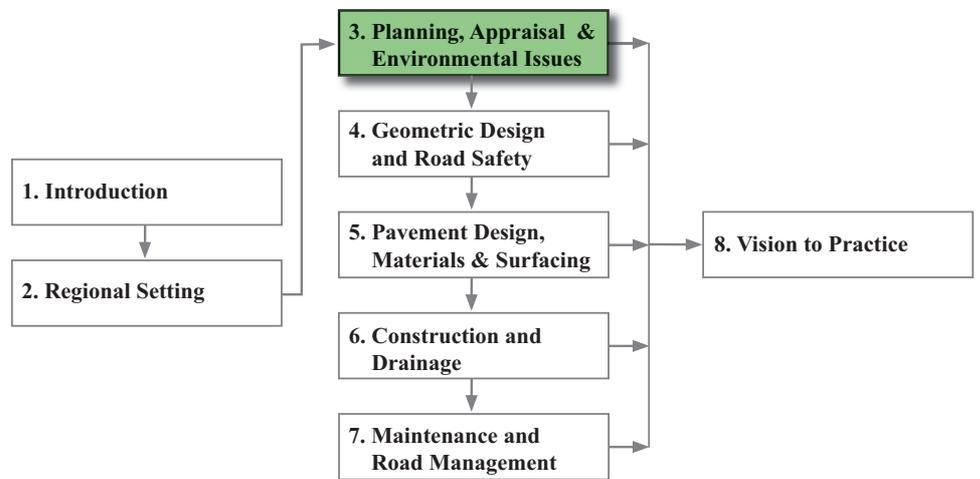
References

1. SATCC (1998). *SADC Protocol on Transport, Communications and Meteorology*. Maputo.
2. SATCC (1999). *Model Legislative Provisions. Road Network Management and Financing*, Maputo.
3. NEPAD (2002). *Main Report: Short-term Action Plan Infrastructure*. NEPAD Secretariat, Midrand.
4. Southern Africa Consulting Group (SAGP) (1998). *Transport and Communications Integration Study for Southern Africa*. Review Final Report. Vol. 1: Summary and Main Report. Maputo, 31 March, 1998.
5. Hine J L and S Ellis (2001). *Agricultural Marketing and Access to Transport Services*. Rural Transport Knowledge Database. TRL Limited. Crowthorne.
6. African Development Bank (2000). *Report on Regional Integration in Africa*. African Development Bank, Abidjan.
7. Transport Research Laboratory, Ross Silcock Partnership and Overseas Development Administration (1991). *Towards Safer Roads in Developing Countries – A Guide for Planners and Engineers*. TRL, Crowthorne.
8. Parker N A (1997). *The Socio-Economics of Paving Low-volume Roads*. Keynote Paper, 1.º Simpósio Internacional de Pavimentação de Rodovias de Baixo Volume de Tráfego, Rio de Janeiro, 5 a 10 de Outubro de 1997.
9. The World Bank (1996). *Sustainable Transport: Priorities for Policy Reform*. The International Bank for Reconstruction and Development, Washington, D.C.
10. Intech Associates (2001). *Low-cost Road Surfacing (LCS) Project. Rationale for the Compilation of International Guidelines for Low-cost Sustainable Road Surfacing*. LCS Working Paper No.1.
11. Barrie D and B Paulson (1978). *Professional Construction Management*. McGraw-Hill Book Company, New York.

Bibliography

- Behrens L C (1999). *Overview of Low-volume Roads: Keynote Address*. 7th Int. Conf. On Low-volume Roads. Transportation Research Record No. 1652. TRB, Washington.
- CAPSA (1989). *Cost Effective Low-volume Roads*. Workshop Session, 5th Conf. on Asphalt Pavements for Southern Africa, 1989.
- Cavelle D C (1993). *Transport and Economic Performance: A Survey of Developing Countries*. World Bank Technical Paper 232. Africa. Technical Department Series, World Bank, Washington, D.C.
- Department of Transport (1992). *Towards Appropriate Standards for Rural Roads. Discussion document*. Project Report PR 92/466/001, Pretoria.
- Department of Transport (1993). *Guidelines for Upgrading Low-volume Roads*. Project Report PR 92/466/002, Pretoria.
- Division of Roads and Transport Technology (1990). *The Design, Construction and Maintenance of Low-volume Rural Roads and Bridges in Developing Areas*. CSIR, Pretoria.
- Edmonds G A (1979). *Appropriate Technology for Low-volume Roads*. 2nd Int. Conf. on Low-volume Roads. Transportation Research Record No. 702. TRB, Washington.
- European Communities - Commission (1996). *Towards sustainable transport infrastructure: A sectoral approach in practice*. Office for Official Publications of the European Communities, Luxembourg.
- Gichaga F J and N A Parker (1988). *Essentials of Highway Engineering*. Macmillan Publishers Limited, London.
- Heggie I G (1995). *Management and Financing of Roads: An Agenda for Reform*. World Bank Technical Paper 275 Africa Technical Series. World Bank, Washington, D.C.
- Howe J D G F and P Richards (1984). *Rural Roads and Poverty Alleviation*. Intermediate Technology Publications Ltd., London.
- Lebo K and D Schelling (200x). *Design and Appraisal of Rural Road Infrastructure: Ensuring Basic Access for Rural Communities*. World Bank Technical paper No. 496. The World Bank, Washington, D.C.
- Lees R and A Tostensen (1982). *Regional Cooperation in Southern Africa: The Case of the Southern African Development Coordination Conference (SADCC)*. Review of African Political Economy. No. 23, Gaborone.
- Mandaza I and A Tostensen (1994) *Southern Africa in Search of a Common Future: From the Conference to a Community*. Printing and Publishing Company of Botswana, Gaborone.
- Millard R S (1979). *The Craft of Highway Engineering*. 2nd Int. Conf. On Low-volume Roads. Transportation Research Record No. 702. TRB, Washington.
- Oglesky H O (1990). *Dilemmas in the Administration, Planning, Design, Construction and Maintenance of Low-volume Roads*. Transportation Research Special Report 160, TRB, Washington.
- UNESCO (1967). *Low-Cost Roads: Design, Construction and Maintenance*. The Butterworth Group, London.

Chapter 3



Planning, Appraisal & Environmental Issues

3

3.1	Introduction	3 - 1
3.1.1	Background	3 - 1
3.1.2	Purpose and Scope of Chapter	3 - 2
3.2	Planning.....	3 - 3
3.2.1	General Approach	3 - 3
3.2.2	Planning Framework	3 - 3
3.2.3	Planning Considerations	3 - 4
3.2.4	External Factors.....	3 - 6
3.2.5	Planning Tools.....	3 - 7
3.2.6	Stakeholder Consultations	3 - 9
3.2.7	Surveys.....	3 - 10
3.3	Appraisal.....	3 - 14
3.3.1	Investment in LVSRs	3 - 14
3.3.2	Life-Cycle Costing	3 - 14
3.3.3	Quantification of Costs and Benefits	3 - 16
3.3.4	Project Costs	3 - 17
3.3.5	Project Benefits	3 - 18
3.3.6	Cost-Benefit Analysis	3 - 20
3.3.7	Ranking Methods	3 - 23
3.3.8	Implications of Using Revised Approaches	3 - 24
3.4	Environmental Issues	3 - 25
3.4.1	Introduction.....	3 - 25
3.4.2	The Environment	3 - 25
3.4.3	Typical Causes of Environmental Problems	3 - 26
3.4.4	Environmental Impact Assessments	3 - 28
3.4.5	Assessing Environmental Impacts	3 - 31
3.5	Summary.....	3 - 33
3.6	References and Bibliography.....	3 - 34

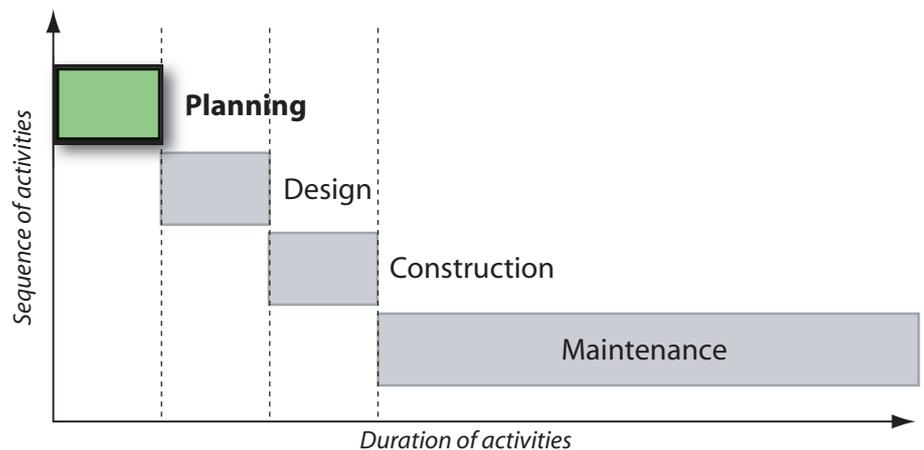
Planning, Appraisal & Environmental Issues



3

3.1 Introduction

3.1.1 Background



As indicated in Chapter 2, planning exerts a substantial level of influence on the downstream aspects of LVSR provision in terms of its impact on the subsequent design, construction and maintenance phases. The planning phase can therefore be rightly 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 an optimal, sustainable solution, i.e. one which satisfies the multiple needs of stakeholders at minimum life-cycle costs.

It is noteworthy that planning technologies and techniques that are often applied in the region generally draw little distinction between low-volume and high-volume roads even though these roads have quite different characteristics. As a result, many aspects of LVSR sustainability are not adequately addressed. Failure to revise or adapt these planning approaches to cater specifically for low-volume roads can lead to the adoption and implementation of sub-optimal solutions that are unsustainable.

The appraisal of LVSRs also requires careful consideration. This is largely because the traditional tools that are available for their evaluation are generally not adequate for capturing the full range of benefits - often of a predominantly social rather than economic nature - that arise from their upgrading. This indicates the necessity for adopting methods of appraisal that include more socially oriented investment criteria so as to accord with the social objectives of poverty alleviation. Fortunately, new, customised economic evaluation models are being developed which are better suited than hitherto for appraising the upgrading of unpaved roads to a bituminous standard.

Prior to the start of the 1990's, environmental impact assessments of road projects were generally not required and, where carried out, were done largely at the insistence of donors. However, environmental issues are now assuming greater importance than hitherto and environmental degradation is no longer being regarded as the price to be paid for development. More and more environmental units are being established within parent ministries to ensure that appropriate mitigation measures are employed on road projects. This requires an integrated framework for dealing with environmental issues in a comprehensive and systematic manner.

3.1.2 Purpose and Scope of the Chapter

The main purpose of this chapter is to outline a generalised approach to planning which is holistic in nature, taking into account the many external factors that affect the process. The chapter also highlights approaches that are typically adopted in the appraisal of LVSRs and provides guidance on their adequacy for dealing with the full range of benefits arising from upgrading earth/gravel roads to a sealed standard. Finally, the chapter considers the environmental issues facing road authorities in the region and the various methods available for mitigating the adverse impacts of road construction and maintenance.

3.2 Planning

3.2.1 General Approach



A road where one or more of the seven dimensions of sustainability is missing.

Current approaches to the planning of LVSRs place greater emphasis than hitherto on the important issue of *sustainability*. Achieving sustainability in the provision of roads continues to elude transport professionals in many countries. There are still many examples of roads being constructed which, because of lack of sustainability in one way or another, often as a result of inadequate maintenance, have resulted in wasted investments.

As highlighted in Chapter 2, a holistic approach is required in which all dimensions of sustainability are addressed at the planning stage. This places more weight on multi-disciplinary planning in which teams consisting of planners, engineers, environmentalists, etc. work together with stakeholders in order to reach optimal solutions in the most cost-effective way. Such an approach provides the best chance of achieving long-term sustainability of projects and is strongly promoted in this Guideline.

Planning for labour-based construction and maintenance works has also taken on a new emphasis as more and more SADC governments recognise the benefits of adopting this approach, where viable, as a means of providing much needed employment.

3.2.2 Planning Framework

A major challenge faced by planners and engineers in the SADC region is to ensure that the planning and appraisal procedures produce outputs that have the full support of decision makers. Such a framework should be transparent, relatively simple to carry out, unambiguous and equitable. Table 3.1 presents a generalised framework for this purpose.

Table 3.1 - Framework for planning and appraisal

Project Cycle	Planning Activity	Typical Evaluation Tools	Output
Identification	Selection	Policy resource analysis Master Plans Local/regional plans	Long list of projects
Feasibility	Screening	Livelihoods analysis Integrated Rural Accessibility Planning	Shorter list of projects
Design	Evaluation	Cost-benefit analysis - consumer surplus (e.g. RED) - producer surplus - compound ranking - multi-criteria analysis	Short list of projects
Commitment and negotiation	Prioritisation	Budget considerations - ranking by economic or socio-economic criteria	Final list of projects

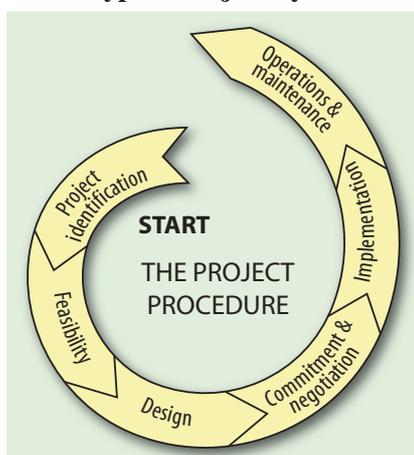
When needs are great and resources limited, selection methods are necessary to make sure that only the roads with the greatest impact are constructed. Such methods should not be too costly to apply in proportion to the investment involved, nor should they be so complicated that few understand how they work. Ideally, selection methods should ensure that few good candidate projects will be rejected and not too many poor ones accepted.

In principle, the planning and appraisal processes are structured activities which start from the general and work towards the particular in relation to both data and project ideas¹. The main features of the planning and appraisal processes are as follows:



Proper selection and screening of candidate road projects at an early stage of the planning process are important.

Typical Project Cycle



It is important that both the client and the contractor share a common vision on the standard of the road to be constructed.

Box 3.1 - Planning and appraisal processes

- **Selection:** This is a multi-sectoral and multi-disciplinary process which should generate sufficient projects to ensure that no potentially worthwhile ones are excluded from consideration. The output is a long list of projects determined on the basis of an *unconstrained policy resource analysis* that satisfy national road transport policy.
- **Screening:** Defines the constraints within which specific planning solutions must be found, i.e. a *constrained policy resource analysis*. The output is a shorter list of projects that justify further, more detailed, analysis.
- **Evaluation:** The shorter list of projects is subjected to a detailed cost-benefit appraisal for which various methods are available. The output is a final list of projects which satisfy a range of criteria - political, social, economic, environmental - at least cost.
- **Prioritisation:** Ranks the “best” projects in order of merit up to a cut-off point dictated by the budget available.

3.2.3 Planning Considerations

The procedures described in the planning and appraisal framework shown in Table 3.2 are common to any type of road project. However, there are aspects of it that are of particular significance in the planning and appraisal of LVSRs that often do not emerge from conventional approaches. These are summarised below:

Table 3.2 - Project cycle and related activities

Stage	Issues to be considered
Project identification <ul style="list-style-type: none"> • Project objectives 	<ul style="list-style-type: none"> • Are the strategies being adopted supportive of government policy? (e.g. employment creation). • Are they relevant to the current and future needs of beneficiaries? • Are they cognisant of the multiple objectives and views of stakeholders? • Have effective communication channels with stakeholders been created? Are they gender sensitive?
Feasibility <ul style="list-style-type: none"> • Design criteria • Cost-benefit analysis • Socio-economic assessment • Road safety assessment • Environmental assessment • Livelihoods 	<ul style="list-style-type: none"> • Is there adequate participatory planning and consultation with public and private sector stakeholders? • Do the design criteria take full account of the specificities of LVSRs, including non-motorised traffic? • Are appropriate evaluation tools being used? • Has a base line environmental survey been undertaken? • Has a road safety audit been incorporated in the project?
Design <ul style="list-style-type: none"> • Design standards • Pavement/surfacing design 	<ul style="list-style-type: none"> • Are the geometric, pavement design and surfacing standards technically appropriate? • Are they environmentally sound? • Are specifications and test methods appropriate to local materials being used?
Commitment & negotiation <ul style="list-style-type: none"> • Contract documentation 	<ul style="list-style-type: none"> • Do designs accommodate construction by labour-based methods? • Do they include environmental protection measures? • Have tender documents been prepared and contract strategies adopted that facilitate involvement of small contractors?



The end result - a successfully completed project that meets the requirements of all stakeholders by satisfying the seven key dimensions of sustainability.

Labour-based construction: The economically efficient employment of as much labour as is technically feasible to produce as high a standard of construction as demanded by the specification and allowed by the funding available. This implies an optimal balance between labour and equipment.

Labour-intensive construction: The use of as much labour as possible by substituting men for machines often to satisfy short-term needs. This implies an imbalance between labour and equipment and, invariably, an economically inefficient end product.

“We know that employment is the first step towards escaping from poverty”.

Juan Somavia, Director General of the International Labour Organisation (ILO), 2001.

Implementation <ul style="list-style-type: none"> • Construction • Inspection and monitoring • Environmental mitigation 	<ul style="list-style-type: none"> • Have labour-based rather than equipment-based methods of construction been adopted where feasible? • Are environmental mitigation measures contained in the contracts? Are they enforceable? • Have specific measures been included in the contract to cater for health and safety matters such as HIV/AIDS?
Operations and maintenance <ul style="list-style-type: none"> • Performance evaluation • Maintenance operations 	<ul style="list-style-type: none"> • Have the various indicators of socio-economic well-being been monitored and evaluated? • Are there adequate arrangements for community participation in road maintenance? • What are the lessons for the future?

Thus, in the planning and appraisal of LVSRs, it is necessary to consider carefully the multi-dimensional range of issues highlighted in Table 3.2 that can significantly influence the output of the process.

Labour-Based Projects

In view of the emergence of labour-based approaches as a viable alternative to some aspects of the more traditional plant-based approaches, the planning of such projects merits special consideration. Without appropriate technical and financial planning from the inception of a project, serious problems may ensue, which may ruin the initiative and bring into disrepute the practicability and objectives of labour-based projects.

Many items need to be investigated in terms of their suitability for labour-based methods of construction or maintenance. Contractual aspects need to be established and appropriate designs undertaken. Such planning must extend beyond engineering technology and the practicality of construction and also consider such factors as the financing and management of labour-based projects. Guidance and training on such issues is provided by a number of international organisations in the SADC region, including the International Labour Organisation Advisory Support, Information Services and Training (ILO/ASIST).

Box 3.2 - Why labour-based construction?

The primary objective of labour-based projects is to complete construction efficiently and economically within a specified time. Secondary objectives include:

- Employment creation.
- Creation of local entrepreneurs.
- Optimization of the use of local resources.
- Creation of skills.
- Improvement of labour productivity.
- Construction of a technically sound, economically efficient product.

For many people, labour-based work may be their first formal job and a future doorway to other forms of work. Moreover, money which would go out of the community is retained and the skills attained can be applied later in the maintenance of the project throughout its life, or on other similar projects.

3.2.4 External Factors

There are a number of external factors, many of them of a non-technical nature, that directly or indirectly affect the planning process itself or the outcomes from that process. It is important to be aware of them when devising an appropriate planning procedure and, where possible, to take them into account. These various factors are listed in Table 3.3.

Table 3.3 - External factors that affect the planning of LVSRs

Environment	Factor	Implications on approach to LVSR provision
Political	<ul style="list-style-type: none"> ● Government policy ● Political perceptions ● Political involvement 	<ul style="list-style-type: none"> ● Influences practice. Covers issues such as poverty alleviation, sustainable socio-economic development, technology choice, employment creation, standards, sources of funding. ● Tendency to favour conventional approaches and standards with perceived minimum "risk" attached to them. There is a need to communicate effectively, quantify and "sell" innovative approaches and appropriate, non-traditional standards. ● To be expected. Will tend to influence decision-making. Highlight pros and cons of alternative solutions in a balanced, transparent manner and maintain continuous dialogue with stakeholders.
Social	<ul style="list-style-type: none"> ● Poverty alleviation ● Sustainable livelihood ● Gender considerations 	<ul style="list-style-type: none"> ● Implies use of labour-based rather than fully plant-based methods, where feasible. ● Enhance local participation and resource mobilisation by involving the people who will ultimately benefit from the projects. ● Understanding community strengths and weaknesses, assets, vulnerability to shocks and constraints, governance issues and policies needed. ● Eliminate gender biases by integrating the transport needs of women in the mainstream of policy and planning. ● Promote participation by women in labour-based construction and maintenance programmes and training to assume supervisory roles.
Institutional	<ul style="list-style-type: none"> ● Organisation 	<ul style="list-style-type: none"> ● Growing trend towards establishment of more autonomous central and local roads authorities. ● Greater scope for generating accountability for results in road programmes and moving from force account to contracting out of work to the private sector.
Technological	<ul style="list-style-type: none"> ● Technology choice 	<ul style="list-style-type: none"> ● Need for cost-effective strategies that utilise the dual output of road infrastructure and employment creation.
Economic	<ul style="list-style-type: none"> ● Evaluation 	<ul style="list-style-type: none"> ● Road benefits are often not limited to use of road, but also from the way in which the road is financed, designed, constructed and maintained. There is a need to capture monetary and non-monetary benefits in the evaluation framework.
Financial	<ul style="list-style-type: none"> ● Funding ● Sustainability 	<ul style="list-style-type: none"> ● Usually very scarce. Financing proposals must look increasingly at minimum standards, limited donor funding and local funding of recurrent maintenance costs. ● Sustainability of funding has become a critical issue. There is a need to commercialise operations where possible and involve stakeholders in the maintenance of facilities.
Environmental	<ul style="list-style-type: none"> ● Impact 	<ul style="list-style-type: none"> ● Need to capture social as well as environmental impacts in the evaluation of LVSRs. ● Address health-threatening impacts as a high priority.

Decision making should be based on rational technical, economic or social factors which, ultimately, should be coincident with the best political options. However, frequently, the political factors take precedence over technical, economic or social factors.

3.2.5 Planning Tools

Policy Analysis

The objective of policy analysis is to define, in general terms, the constraints within which specific planning solutions must be found. Constraints may relate to such factors as government policy on employment, provision of accessibility, income distribution and regional development as well as technical factors such as type of terrain and transport facilities, level of existing traffic, capacity and expertise of the local construction industry, availability of finance, etc.

Master Plans

Master plans or regional plans are used in many SADC countries to help in determining priorities for the future. These plans are not transport specific but relate to all sectors and help to identify investment requirements and priorities over a defined period. It is at this stage that new road projects will first be identified.

During the preparation of a master plan it is important that transport planners liaise closely with other Ministries. In the rural context particular priorities will include education, health and agriculture. It is also important that extensive consultation is undertaken with local communities and opinion leaders.

Livelihoods Framework

“Livelihoods Analysis” is a useful approach to adopt in order to identify the ways in which any particular investment intervention will impact, benefit or disadvantage the local community². A rural livelihoods analysis provides a framework for understanding how any proposed changes will affect personal or community livelihoods in the longer term. It focuses directly on how the local community uses and develops its social (S), human (H), financial (F), natural (N) and physical (P) asset structure (see Figure 3.1).

It is clear that transport interacts with many aspects and dimensions of a person’s or a community’s livelihood. For example, substantial benefits could be obtained if the labour requirements involved in collecting water, firewood or taking crops to market could be reduced. The provision of all-season road access could reduce the vulnerability of rural communities by removing seasonal isolation, and reducing transport costs and travel times to essential economic and social services.

“A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the long and short term.”

Chambers and Conway, 1992².

H = human capital: the skills, knowledge, ability to work and good health are important to the ability to pursue different livelihood strategies.

P = physical capital: the basic infrastructure (transport, shelter, water, energy and communications) and the production equipment and means that enable people to pursue livelihoods.

S = social capital: the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods.

F = financial capital: the financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) and which provide them with different livelihood options.

N = natural capital: the natural resource stocks from which resource flows that are useful for livelihoods are derived (e.g. land, water, wildlife, biodiversity, environmental resources.)

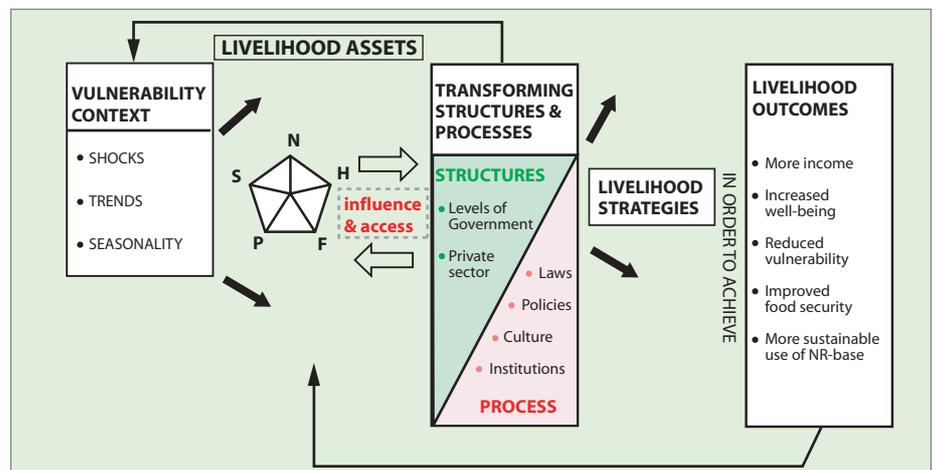


Figure 3.1 - Sustainable livelihoods framework

Integrated Planning Techniques for Transport

Master plans and the sustainable livelihoods approach are both general multi-sectoral planning tools but the specific focus is not on transport interventions. Transport may or may not be one of the interventions that are identified. However, there are a number of integrated planning techniques that specifically address transport issues. Their common thread is that planners need to address a range of issues in improving the accessibility of rural people to essential economic and social services through a combination of improved infrastructure, improved transport services and the improved location of the services themselves.

Integrated Rural Accessibility Planning (IRAP) was developed by the ILO³ and is probably the most widely used planning technique of its type. IRAP has been used in many countries in the region, including Tanzania and Malawi. The approach integrates rural households' mobility needs, the siting of essential social and economic services, and the provision of appropriate transport infrastructure. Communities are involved at all stages of the planning procedure. It is based on a thorough but easy to execute data collection system that seeks to rank the difficulty with which communities access various facilities.

Box 3.3 - Integrated Rural Accessibility Planning

In this approach, an Accessibility Indicator (AI) is calculated for various facilities in each community. It is a function of the number of households (N), the average travel time to a facility (T), the target travel time (T_m) and the frequency of travel (F):

$$AI = N * (T - T_m) * F$$

Typical facilities included are health, education, water and fuel. The accessibility indicators are ranked in descending order and interventions are prioritised in this way. Results of this process are discussed at a participatory workshop and interventions identified which most effectively reduce time and effort spent.

Network-Based Planning

Traditionally, investments in roads have been evaluated on a link by link basis with less consideration given to the contribution that each link - competing for investment - makes to the connectivity or accessibility of the entire network. To overcome such short-comings, network-based planning approaches are increasingly being used to analyse the road system as a whole in order to prepare long-term strategic planning expenditure for road development and maintenance under various budgetary and economic scenarios.

Unfortunately, the situation confronting many SADC countries is one in which funding is available for maintenance of only part of the road network. In such situations it has become necessary to identify a "core road network" which is reviewed periodically and will expand or contract depending on local circumstances. Such networks often include roads of different classes that are considered to be an essential part of the total network so that links are maintained between all the communities throughout the country.

Models such as HDM-4 can be used for network-based planning purposes. However, as is often the case in many rural network situations, the necessary data required by such models are often not available, making such models inappropriate. Thus, procedures that involve a high level of stakeholder consultation are likely to be more effective for rural network planning purposes. However, there seems to be little information in the form of manuals on community-based network planning procedures.



Benefits of engaging in consultations with local communities at all stages of the project cycle include local knowledge of risks such as flood levels, location of resources, traffic flows, etc.

3.2.6 Stakeholder Consultations

Why Have Stakeholder Involvement?

The objective of consultation is to ensure that the road planning process is undertaken in an accountable and transparent manner. This is important for the overall benefit of the affected stakeholders and for the country at large. Consultations should be carried out throughout all stages of the project cycle and should be undertaken in such a manner as to allow full participation of the authorities and the public with the following typical aims:

- establishing background information on the project from all possible sources
- identifying viable alternatives for the project
- taking on board the views of stakeholders at all stages of the project
- reaching a consensus on the preferred choice of project(s)

Decisions on transport planning and prioritisation in the SADC region have often been taken without considering the transport requirements of the people being affected by the investment. Insufficient consultation has led to the inappropriate use of resources both in terms of their usefulness to rural communities but also in terms of their impact on social and cultural traditions. To rectify this shortcoming it should be ensured that:

- local people are involved in the selection, design, planning and implementation of programmes and projects that will affect them
- local perception, attitudes, values and knowledge are taken into account
- a continuous and comprehensive feedback process is made an integral part of all development activities

Who are the Stakeholders?

Many people have an interest in road projects and all interested groups need to be identified and consulted in the road selection process. The primary stakeholders are those people whose social and economic livelihoods will be directly affected by the project and include:

- rural communities
- farmers group
- market traders
- transport operators

Some other interest groups are important in the decision-making process, even though their own lives may not be affected directly by the project. These include:

- district leadership
- district's works agencies
- national roads department
- local and national politicians

Because leaders' standpoints can differ significantly from the experiences of "average" village members, it is important for any consultation process to go beyond the leadership to the grass roots.



Stakeholder involvement in the decision-making process is critical for long-term sustainability of any road project.

Consultation Techniques

There are a number of recognised participatory techniques for working with communities to determine their transport needs. These usually entail the use of trained facilitators to visually represent community livelihoods to identify constraints and needs. Typical techniques include:

- Participatory Rural Appraisal (PRA).
- Rapid Rural Appraisal (RRA).

Other methods include public hearings through political leaders, and direct community consultation. Workshops are often a good way of undertaking initial prioritisation exercises, delivering key messages and receiving feedback. It is important that all consultation techniques are well organised, that all the relevant stakeholders have been invited and that the deliberations take place in an interactive and transparent manner.

3.2.7 Surveys

Following from the first two phases of the project cycle there will be an initial selection of roads put forward for possible improvement and funding. Before final decisions can be made it is important to obtain information that is specific to the roads concerned. This involves conducting various road transport surveys which can help to pinpoint measures (technical, institutional and financial) for improving efficiency. These surveys may also provide supporting evidence for community perceptions on transport or, exceptionally, may provide some contradictory arguments that would need to be resolved. Participatory enquiry also supports a much greater focus on poverty issues and the role of transport in livelihoods⁴.

Engineering Surveys

Engineering condition surveys need to be undertaken in order to identify the present condition of the road, the nature of proposed interventions, the quantities of work and the costs of the interventions and the future condition of the road. The interventions required for different treatments need to be identified and costed with the engineering surveys. It is important that alternative options are considered in the detailed appraisal.

Of particular importance to low-volume sealed roads is the provision of year round access and the social and economic benefits that arise from that. Therefore, it is important that there is some engineering judgement on the length of time that impassability or traffickability problems affect the road.

The term “traffickability” is relatively new and stems from research in Tanzania that showed that traffic levels tend to fall during the wet season even on roads in good condition. Typically, motorised traffic volumes will fall in the wet season to 80% of their dry season level. However, on poor quality roads this difference is even more marked and traffic can fall to 35% of dry season traffic levels, as shown in Figure 3.2. For the purposes of this Guideline it can be assumed that roads have traffickability problems when wet season traffic levels fall below 50% of dry season levels.



Traffickability of unpaved roads is adversely affected during the wet season.

Traffickability versus Passability:

Traffickability: A road is defined as having traffickability problems when the percentage of wet season traffic falls below 50% of the dry season traffic.

Passability: A road is defined as having passability problems when it is completely closed to motorised traffic for either part of or all of the year.

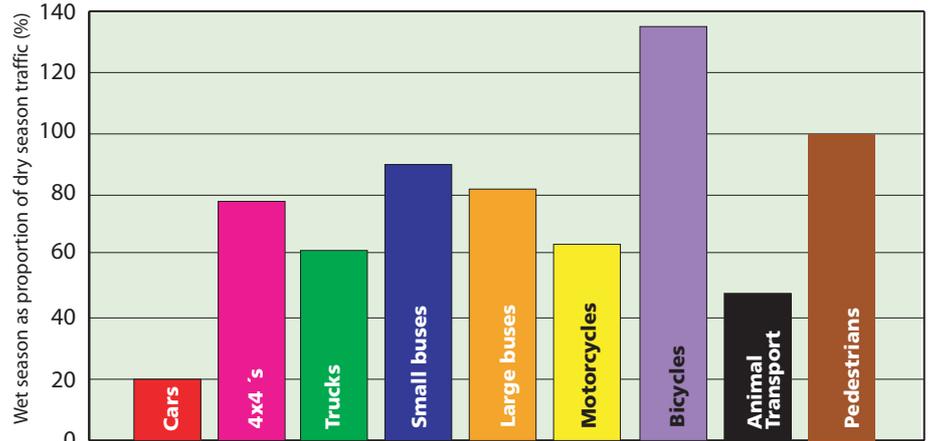


Figure 3.2 - The difference in wet season and dry season traffic levels on poor quality roads in Tanzania

Traffic Surveys

Traffic counts are one of the most important items of data for both geometric and pavement design as well as for planning purposes in terms of evaluation of economic benefits derived from construction of LVSRs. For these purposes, it is necessary to ascertain the volume and composition of current and future traffic in terms of motorcycles, cars, light, medium and heavy goods vehicles, buses, and, importantly, non-motorised vehicles and pedestrians.

The three most commonly used types of traffic surveys for LVRs are:

- Automatic Traffic Surveys.
- Manual Traffic Surveys.
- Moving Observer Methods.

Although the methods of traffic data collection may vary, the objective of the each method remains the same - essentially to obtain an estimate of the Annual Average Daily Traffic using the road, disaggregated by vehicle type. Prediction of such traffic is notoriously imprecise, especially where the roads serve a predominantly developmental or social function. Thus, the timing, frequency and duration of traffic surveys should be given very careful consideration in terms of striking a balance between cost and accuracy. As indicated in Figure 3.3, short duration traffic counts in low traffic situations can lead to large errors in traffic estimation and, in this respect, Moving Observer methods are likely to be particularly inaccurate.

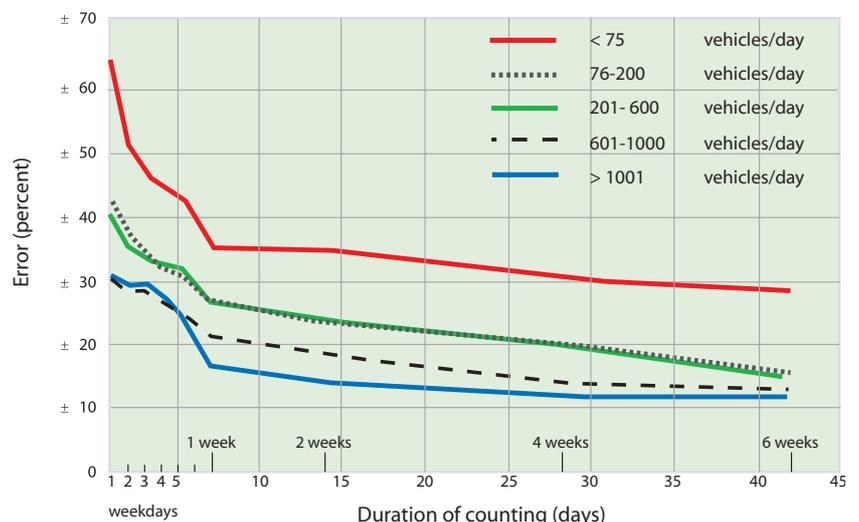


Figure 3.3 - Errors in ADT estimates from counts of varying duration⁵

The accuracy of traffic counts can be improved by increasing the count duration or by counting in more than one period of the year. Improved accuracy can also be achieved by using local knowledge to determine whether there are days within the week or periods during the year when the flow of traffic is particularly high or low.

Local knowledge should also be used to select appropriate locations for conducting the traffic counts to ensure a true reflection of the traffic using the road and to avoid under - or over-counting.

Origin and Destination Surveys, using a variety of survey techniques, are sometimes carried out to establish the nature of travel patterns in and around the area of enquiry. These surveys, which can be quite labour-intensive, serve a number of useful purposes including a quantitative assessment of the amount of traffic likely to be affected by the proposal and the consequent impacts on various elements in the road system.

Axle Load Surveys

Axle load surveys provide critical and essential information that is required for both cost-effective pavement design as well as preservation of existing roads. The importance of this parameter is highlighted by the well-known “fourth power law” which exponentially relates increases in axle load to pavement damage (e.g. an increase in axle load of 20% produces an increase in damage of about 120%).

Axle load surveys can be expensive to undertake and should be carefully planned and organised in relation to the level of resources that can be committed to the survey (time, personnel and money) and the objective of the survey which could be:

- determination of vehicle equivalence figures (pavement design)
- overload control (pavement preservation)

The type of equipment which may be used for axle load surveys also varies widely and includes:

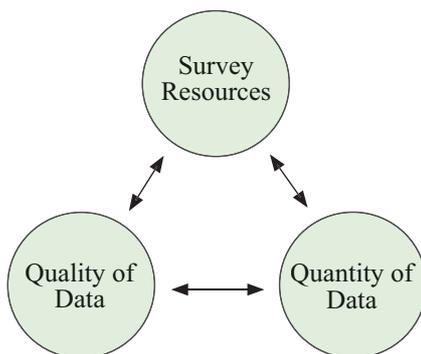
- static or dynamic weighing equipment
- manual or automatic recording of loads
- portable or fixed installation

The quality of the data obtained will depend on the type of equipment used, the duration of the survey and the degree of quality control performed. In general, the higher the quality of the data, the greater will be the resources required to collect them.

There is an almost inevitable trade-off between available resources and the accuracy obtainable from a sample survey. The art of good survey design is to know when the optimal value for money from the survey is achieved. Further constraints exist for the data analysis stage. Some analysis techniques require expertise, computer hardware and software which may not always be available. Thus, the choice of analysis procedures may also involve trade-offs.



Portable weighbridge system.



Trade-offs in undertaking an axle load survey.



Measurement of rear axle load using portable weighbridge.



Axle load survey in progress. Such surveys are typically carried out over a 24 hour period for seven days.

Ultimately, an appropriate choice of equipment should be made in relation to such factors as:

- accessibility to back-up support (technical and maintenance)
- ease of installation and use
- accuracy of measurement required
- acquisition and operational cost of equipment

It is also important that axle load surveys are carried out in a systematic and standardised manner and separated from weighbridge measurements undertaken for the purpose of enforcing axle load limits. Guidelines currently exist in a number of SADC countries for carrying out axle load surveys.

Box 3.4 - Minimum information typically derived from axle load surveys

- Axle loads of all heavy vehicles whether empty or loaded.
- Vehicle category.
- Loading in each direction of the road.

Each axle in a multi-axle combination shall be measured separately. The survey point should also be equipped with sufficient capacity to weigh all heavy vehicles that are passing in one direction at a time, both empty and loaded.

3.3 Appraisal

3.3.1 Investment in LVSRs

The road sector consumes a considerable part of the overall infrastructure investments made in the SADC region and, with an increased focus on poverty reduction, there is an increasing emphasis on those for LVSRs. However, investment in such roads should be based on a set of clearly understood needs for them. *The process of establishing those needs requires detailed consideration of both the economic and social roles of roads and these, in turn, must be seen in the context of larger community needs for accessibility and mobility.* Certainly the provision of roads will be only one of the mechanisms used to satisfy those needs.

The various short-term effects and longer-term impacts of such road investments may be depicted roughly as shown in Figure 3.4. They are not just a progression in time, they are also a progression in certainty with the more distant developments being more difficult to achieve and less certain to materialise.

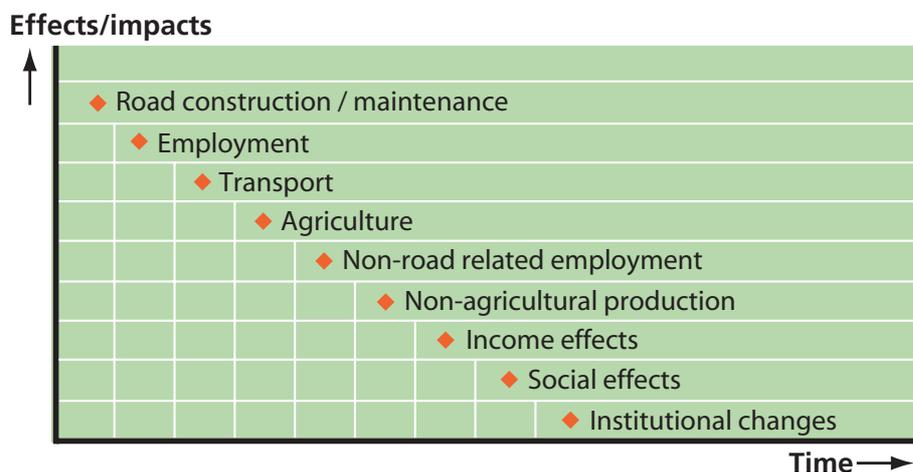


Figure 3.4 - Effects and impacts of road investments over time⁶

From the perspective of investment in roads only, employment is regarded as certain. *Such employment, and thus the potential for assisting the poor, is obviously enhanced by the use of labour-based methods.* With the exception of employment, all the rest of the other effects and impacts are indirect. Whether they occur or not depends on two factors:

- (1) that traffic materialises as a result of the road improvement
- (2) that this traffic is operating more efficiently

3.3.2 Life-Cycle Costing

Having identified a short list of projects, it is the purpose of an economic appraisal to ensure that the options considered represent a cost effective way of delivering the road. Appraisals driven by economic requirements will be relatively easy to identify via benefit-cost analyses. However, traditional appraisal frameworks do not cater well for economic justification of LVSRs as poverty reduction and other social benefit issues are more difficult to quantify and tend to be ignored.

Life-cycle costing uses economic evaluation techniques to select, from a series of options, the most economically appropriate new road project and the maintenance and/or rehabilitation treatment to be applied to an existing road.

In traditional approaches to undertaking an economic analysis, the basic objective is to determine the optimum mix between the costs of the project (related to the design standard) and the benefits from the project in terms of transport cost savings and other secondary benefits such as social and environmental benefits. The purpose is to find the investment option that *minimises life-cycle costs*.

Figure 3.5 shows the conceptual total road transport cost curve which is made up of the construction/rehabilitation costs, maintenance costs and road user costs. It shows that as construction/rehabilitation costs increase (because of higher design standards) road user costs are typically reduced. The optimum road design standard is attained when the sum of the project costs are minimised. This optimum standard varies in relation to traffic level and the associated relative mix of construction, maintenance and user costs.

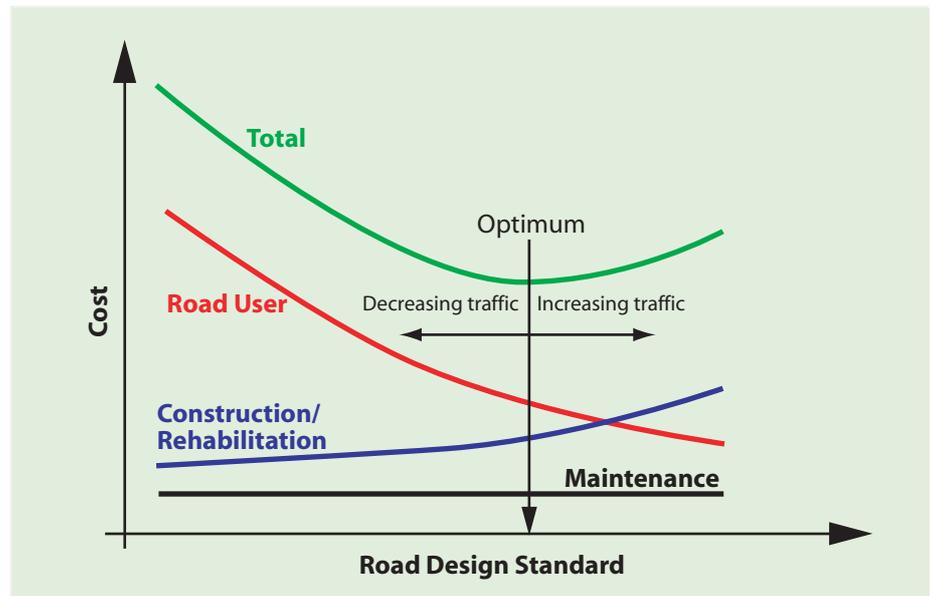


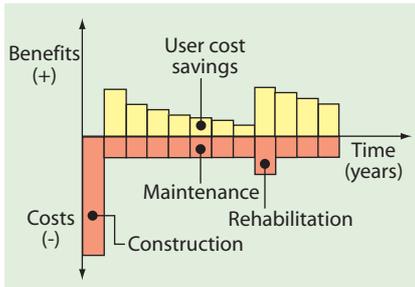
Figure 3.5 - Economic analysis of optimum road design standards

For a given traffic level, if the road were to be constructed to a standard higher than the optimum, then the benefits derived from a reduction in road user and maintenance costs would not sufficiently offset the costs of initial construction and the resulting investment would be sub-optimal. This highlights the importance of ensuring that appropriate standards are adopted in the planning, design, construction and maintenance of LVSRs. As might be expected, the optimum design standard for a LVR is lower than for a HVR.

Principles of Economic Appraisal

Several methods exist for the economic appraisal of road paving projects for which the primary objectives are to determine:

- the appropriate size of investment and the returns to be expected from this investment
- the appropriate geometric and structural design standards for the size of investment in order to obtain the expected returns
- the economic and socio-economic impact of investments such as the improvement to the community of industrial, agricultural, educational and health services



Distribution of costs and benefits during the life-cycle of a road option.

Through identifying, quantifying in monetary terms, and comparing the costs and benefits of different options, this technique is able to provide guidance on the design, prioritisation and selection of candidate road projects by addressing a wide variety of key decision-making issues. For instance:

- is the investment economically justifiable?
- if there are a range of alternative investments, which option gives the best economic returns?
- is the timing of the proposed project optimal?
- should components of the project be phased in over a period of time?
- how does risk and uncertainty affect the choice of projects?
- if funds are limited and there are many worthwhile investments, which should be built first?

An economic analysis considers the project from a national point of view. In an economic cost benefit analysis, the total costs and benefits that arise from a project are identified and measured, irrespective of who incurs the costs or benefits from the project. In contrast to a financial analysis, no monetary transaction needs to take place for an economic benefit or cost to be incurred.

Main components: The main components of an economic evaluation are as follows⁷:

- The identification of at least two different cases or scenarios; this will involve one *base or “without investment” case* and at least one *project or “with investment case”*.
- The *planning time horizon* i.e. the period over which the evaluation is made.
- An estimate of the project *investment costs* specified in *economic price terms*.
- The *benefits* of the project or projects specified in *economic price terms* estimated from the differences in the costs of the with and without cases.
- A year-by-year determination of the costs and benefits of the different projects over their design lives, using discounted cash flow techniques to bring them all to their *present value* in terms of *economic decision criteria* such as NPV, BCR or IRR.

An investigation of how robust or reliable the results are through the use of *sensitivity analysis* or *risk analysis*.

3.3.3 Quantification of Costs and Benefits

There are two principal methods of quantifying project costs and benefits in economic terms, the Consumer Surplus approach and the Producer Surplus approach:

(1) **Consumer surplus approach:** This is the orthodox approach to estimating the economics of road investments which assumes a reduction in transport costs arising from savings in vehicle operating costs⁸. The direct benefits to road users - the *consumer surplus* - equals the product of the number of trips and the cost saving per trip.



Transporting bananas and other food-stuff by bicycles.

The consumer surplus approach is normally used for those projects where traffic levels are likely to be sufficient for road user costs savings to justify funding of the project. The minimum traffic threshold which makes this approach appropriate to use is difficult to define beforehand but is likely to be of the order of 50 - 100 vpd.

(2) **Producer surplus approach:** In situations where no road exists and a substantial improvement in vehicle accessibility is planned to help develop an area, the producer surplus approach may be the most appropriate way of estimating agricultural benefits arising from road investment⁹. The producer surplus approach estimates the predicted benefits arising from the reduced cost of agricultural produce which will normally be the same as that predicted by a consumer surplus approach. However, when the producer surplus method is used, passenger benefits and other non-agricultural cost savings still need to be estimated separately.

The agricultural production and the size of the producer benefits are predicted from the rise in farm gate prices brought about by the decline in costs of transporting produce to market, as well as the decline in transport costs of agricultural inputs. However, several difficulties have been identified with the application of this method, including the need for substantial amounts of data, which may be either unavailable or of questionable reliability, and the fear of double counting. For such reasons, the use of the producer surplus method is not recommended unless there is a great deal of knowledge about agriculture and its likely response to changes in input and output prices.

3.3.4 Project Costs

There are two main areas to address in calculating project costs:

- 1) The project costs for a range of alternative infrastructure standards.
- 2) Technology choice and the options available from labour-based to equipment intensive.

The main project costs include:

- planning/design costs
- construction/supervision costs
- road agency costs (administration, operation and maintenance)
- road users' costs (VOC and TTC)

Construction and maintenance costs can vary significantly according to the standards to which the road is built. There are significant cost advantages from using the LVSR standards as set out in this guideline and it is important to have a detailed knowledge of these costs in the appraisal process. Table 3.4 gives the main options and the likely impact on construction costs.

Table 3.4 - Options for reducing construction costs

Option	Potential Benefits
Replacing a conventional geometric design process by a “design by eye” approach, where appropriate, and minimising deviations from existing alignments.	Reduced earth works and environmental damage. Earthworks can be typically 30% of total construction costs in rolling terrain.
Use of more appropriate pavement designs and natural gravel rather than crushed stone.	Reduced pavement costs due to lesser haulage distances and reduced materials processing costs.
Considering a range of infrastructure standards.	Allows an optimum standard to be adopted which minimises total transport costs.
Utilising an existing gravel wearing course e.g. as base or subbase .	Reduced haulage distances and materials costs.
Compacting subgrade and pavement layers to refusal, where feasible, rather than to arbitrary prescribed levels.	Increased density, reduced road deterioration and increased maintenance intervals.
Adopting appropriate surfacing technologies such as sand seals and Otta seals.	Reduced haulage distances, reduced processing costs.
Increasing the use of labour and local resources where appropriate.	Lower economic/financial costs for specific tasks.
Using seals as a spot improvement measure.	Reduced surfacing costs whilst maintaining year round access.



Short sections of road in poor condition can benefit significantly from spot improvement works.

The use of LVSR technology for spot improvements has, potentially, very significant applications on a wide range of roads that do not justify providing a seal over the entire length but could benefit from spot sealing works. These spots might include areas where there is significant seasonal difficulty in maintaining access such as on steep slopes or areas that are prone to flooding. They may also include stretches through towns and villages where, for social and environmental reasons, a sealed road would reduce dust nuisance and improve safety. Spot improvement strategies, particularly for the lower volume roads, provide a good way of meeting the planning objectives of maintaining basic access while minimising total transport costs.

3.3.5 Project Benefits

Changes in the *efficiency of transport* are the essential mechanism by which benefits from road building are transferred or released⁶. These changes are more than likely to occur with the sealing of an earth/gravel road in the form of a reduction in vehicle operating costs (VOC). However, other benefits of a broader socio-economic nature are also likely to occur and, by meeting specified social objectives, offer scope for achieving poverty reduction.

The benefits arising from the upgrading of a LVR typically include:

- developmental benefits - such as benefits to generated traffic
- social benefits - access to facilities through improved passability
- road user cost savings - such as reduction in VOC and TTC
- road agency benefits - such as reduction in maintenance costs

In general, the more competitive and less distorted an economy, the more likely that the primary benefits will cover the full consequences of a road investment. However, for the purpose of this Guideline, there is a case for including secondary benefits, particularly in circumstances where:

- existing traffic volumes are relatively low
- new road investments are made in remote rural areas
- a relatively large change in transport costs is anticipated
- there are unused resources

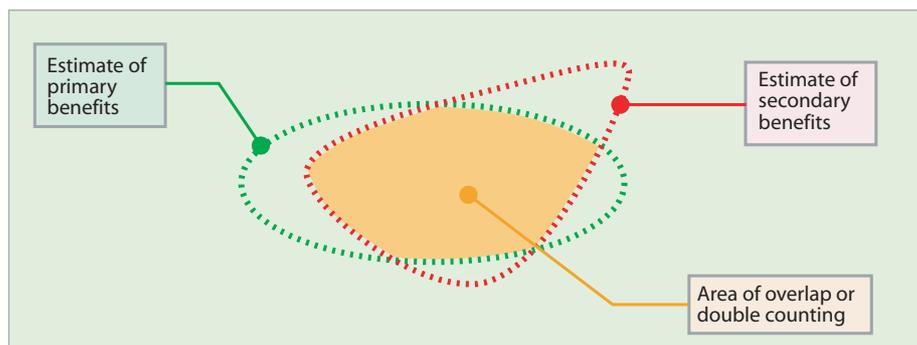


Figure 3.6 - Overlap of primary and secondary benefits

Social Benefits

Social benefits are not only some of the most difficult to quantify but, also, there is no universally agreed method for incorporating them within an economic analysis. Furthermore, a simplistic addition of social and economic benefits is likely to lead to problems of double counting.

The following provides some of the options that could be considered for incorporating social benefits within an economic analysis.

- (1) Where roads suffer from impassability or traffickability problems there will be additional benefits from improved road provision that create year round access. The principal social benefits come from improved access to health facilities and education services, employment opportunities and social interaction. Little research has been done on the best way to quantify these benefits but practical approaches have tended to factor up conventional VOC savings for the period a road suffers either passability or traffickability problems.
- (2) It is possible to identify key social criteria such as targeting the poorest areas, reducing isolation to basic services and markets. These would have to be identified on a project by project basis following consultation with all the relevant stakeholders. In a similar way to the approach indicated above, VOC benefits could be factored up if the improvement of a particular road met these social criteria.
- (3) Benefits from education and health facilities can be estimated from improved access and the resulting improvements from income earning opportunities. For example, benefits from increased school enrolment levels can be estimated based on higher life earnings of the children who would have otherwise remained unskilled. Health benefits can be assessed based on reduced sick days away from work and the associated net income. However, such an approach may involve considerable field data collection and analysis.
- (4) Quantifying social benefits in the same units as economic benefits¹⁰. In this approach, it is assumed that the population within a distance of 5 kilometres on either side of the road will receive social benefits as a result of the road improvement. In so doing, social factors are converted to the same units as VOC savings.

Research from Tanzania suggests that, on average, just over 30% of the total tonne kilometres is carried by non-motorised transport on low-volume roads. This figure ranged from just over 8% for higher volume roads (over 150 vehicles per day) to over 60% for the lowest volume roads (less than 10 vehicles per day).

Benefits to Non-Motorised Traffic

In many SADC countries non-motorised traffic constitutes a significant proportion of the traffic on low-volume roads and, in many cases, this traffic represents the majority of total tonne kilometres. *Benefits to non-motorised traffic represent significant savings that are not captured in a conventional consumer surplus analysis and therefore, alternative methods need to be considered.*

Although there has been limited research into the impacts of road improvements on non-motorised transport there are a number of sources of information that will help planners to make estimates of the potential benefits. Table 3.5 sets out the sources and the type of information available.

Table 3.5 - Sources of information for non-motorised transport

Source of information	Type of information
Roads Economic Decision Model (RED) ¹¹	Calculates VOCs for pedestrians, animal carts, and bicycles.
Appraisal of investments in improved rural access. Economist guide ¹²	Contains a number of mini-guides including one on calculating VOCs for non-motorised transport based on HDM 4 relationships.
A handbook of rural transport vehicles in developing countries ¹³	Contains look-up tables for a wide range of motorised and non-motorised vehicles for different infrastructure quality and distances.
Ghana prioritisation procedure ¹⁴	Provides VOC savings for bicycles and pedestrians following road improvements.

Where estimates of benefits to non-motorised transport are available it is appropriate to add these to the benefits from motorised transport.

3.3.6 Cost-Benefit Analysis

Use of Investment Appraisal Models

The primary function of a road investment appraisal model is to calculate the costs and benefits of road construction, road maintenance and road user costs for a specified analysis period. This is accomplished by modelling the interrelationships between the environment, construction standards, maintenance standards, geometric standards and road user costs. Such models can be used to perform a number of economic analyses, one of which is to identify unpaved roads that may be potential candidates for paving.

Typical components of a life-cycle cost analysis are shown in Figure 3.7 for a *base or “without investment” case* (gravel road) and a *project or “with investment case”* (paved road).

In very general terms, paving a gravel road will be economically justified when the net present value (NPV) of the sum of savings in VOCs and maintenance costs, relative to a well-maintained gravel road, is at least as great as the NPV of upgrading costs. Where not captured in the investment appraisal model, socio-economic benefits will need to be evaluated separately after the economic appraisal has been carried out.

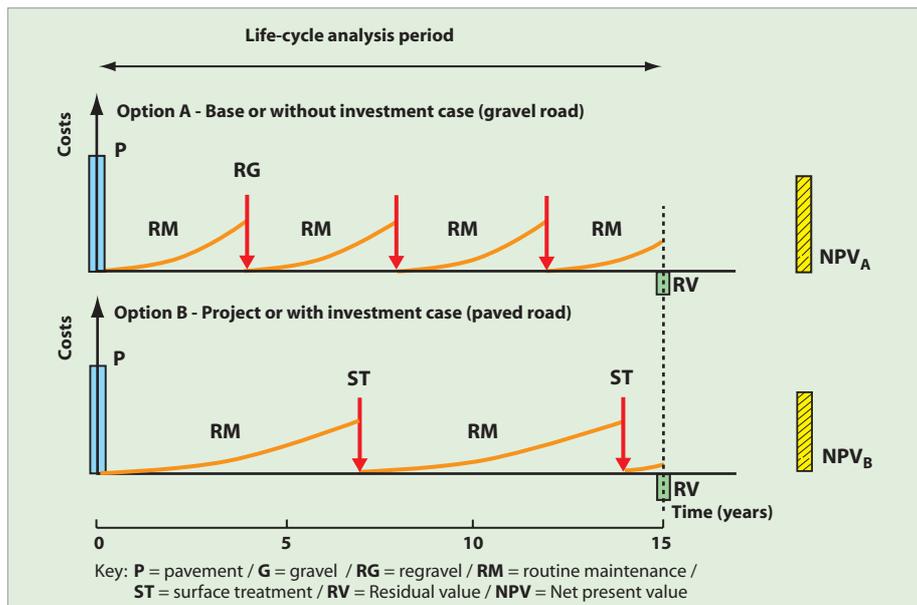


Figure 3.7 - Typical components of a life-cycle cost analysis

Characteristics of Main Project Types

Candidate projects for upgrading typically fall in the following categories, viz:

- Basic accessibility projects: including upgrading tracks and earth roads to gravel roads.
- Mobility projects:
 - (a) bitumenising existing gravel roads
 - (b) strengthening/expanding capacity of existing bitumenised roads

Investment in the above types of project is generally motivated by quite different reasons and yields quite different types of benefits. For convenience, these project types may be categorised in relation to broad traffic bands as follows:

Category I – less than 50 vpd: Investments in this category of road are usually poverty-targeted with a focus on social rather than economic objectives. Thus, a least-cost or cost-effectiveness approach is usually adopted and investment models are generally not appropriate for such roads¹⁵.

Category II – 50 to 200 vpd: (Primary focus of this Guideline): Investments in this category of road give rise to a mix of economic, social and environmental impacts depending on their function and level of traffic carried, which can include a significant proportion of non-motorised traffic.

Category III – more than 200 vpd: investments in this category of road give rise to predominantly economic impacts in the form of reduced transport costs, as well as to environmental impacts.

Suitability of Investment Appraisal Models

The economic evaluation of donor-funded road projects in the SADC region generally requires the use of an internationally recognised investment model. The following models which adopt the *consumer surplus* approach have been used for that purpose:

- Road Transport Investment Model (RTIM) developed by the UK Transport Research Laboratory¹⁶.
- PIARC’s Highway Development and Management Model (HDM-4)¹⁷.

Unlike models such as the South African CB-Roads¹⁸ and SURF¹⁹ models, which were developed specifically for local conditions, models such as RTIM and HDM were developed to be applicable in a large number of countries covering a wide range of conditions. Moreover, they are the result of the collaboration of a number of international organisations and, as a result, the latest version of the HDM model, HDM-4, has become the *de facto* model for use in the region, together with a more recently developed and simplified derivative, the Roads Economic Decision Model (RED)¹⁰.

Whereas the HDM-4 model presents a very good framework for the economic analysis of road investments, it is neither customized for LVRs nor does it capture all the benefits associated with such roads. In contrast, RED has been customized for LVRs and offers a number of other advantages which are contrasted with HDM-4 in Table 3.6.

Table 3.6 - Comparison of HDM-4 and RED appraisal investment models

Model	Advantages	Disadvantages
HDM 4	<ul style="list-style-type: none"> ● Globally used model. ● Extensive research on VOC and deterioration relationships. ● Can be used for strategic planning i.e. can assess networks. ● Now includes NMT. 	<ul style="list-style-type: none"> ● High data requirements. ● Does not include social benefits¹. ● Cannot deal with passability and traffickability issues. ● Road roughness is often not an appropriate measure of condition for LVRs. ● Not well suited for low traffic levels.
RED	<ul style="list-style-type: none"> ● Has limited data requirements. ● Can accommodate NMT and some social benefits. ● Can be run from a spreadsheet. ● Can accommodate impassability issues. ● Can be used for ranking projects. ● Well suited for traffic levels in range 50 – 200 vpd. 	<ul style="list-style-type: none"> ● NMT categories are limited to four. ● Would have to be calibrated for Low-volume sealed roads.

1 – to be included in a later version

Table 3.7 provides a general guide to the applicability of commonly used investment models in the SADC region for evaluating LVSRs. The preferred choice of model depends largely on the nature of the impact triggered by the investment intervention.

Table 3.7 - Applicability of investment models to LVSR evaluation

Factor		Project Type		
		Access	Mobility	
			Basic	Advanced
Motivation		Social	Socio-economic	Economic
Traffic band		< 50 vpd	50 – 200 vpd	> 200 vpd
Traffic type		NMT	NMT - MT	MT
Relative benefits	Social	High	Medium	Low
	Economic	Low	Medium	High
Appropriate model		Least Cost	RED	HDM-4

Least Cost Approaches

The goal of the Least Cost Approach is to employ the most appropriate and cost-effective intervention which provides a minimum level of reliable, all-season passability for the locally prevailing means of transport.

As indicated in Table 3.6, those road improvements in which economic impacts are dominant (traffic is typically > 200 vpd and is predominantly motorised) are best evaluated by investment models such as HDM-4. However, at lower traffic levels (traffic typically 50 - 200 vpd) where NMT is significant and social benefits are dominant, RED would be the more appropriate investment model to apply.

3.3.7 Ranking Methods

Ranking Methods are important for two reasons. First of all it is unlikely that funds will be sufficient for all projects that are economically or socially justified and hence projects need to be placed in an order of priority. The use of investment appraisal models can facilitate this. Secondly, as discussed above, some important benefits cannot be easily quantified and may not be included in appraisal models. Therefore ranking methods that allow such benefits to be taken into account in the appraisal process are essential if the ‘best’ projects overall are to be selected for implementation.

Multi-criteria Analysis: These methods adopt a multi-objective approach which seeks to incorporate both economic and non-economic goals into an evaluation framework²⁰. The approach assumes that the full set of attributes characterising a project cannot be expressed by a single parameter. Instead, the framework should include a number of criteria for evaluating the project in socio-economic terms such as economic benefits, economic costs, distribution of economic benefits, accessibility to social services, employment, etc. Quantitative measures of each of these criteria must then be defined in their own units to facilitate transforming the spectrum of physical measures for each criterion into utility value terms. Completion of the utility analysis depends upon the decisionmaker’s articulation of his preferences amongst the various criteria.

As with other planning systems it is important that communities are fully informed both in the selection of relevant criteria and in the subsequent results. Problems may arise where consultation has not taken place or where the complexity becomes too great because of too many variables.

The advantage of adopting such an approach is that a number of factors can be included to reflect wider political and socio-economic needs. However, the disadvantages are that the addition of other factors complicates the analysis and more data needs to be collected.

Compound Ranking Methods: These methods rank projects according to factors that are considered to be relevant to the investment decision rather than derive economic benefits that can be used in a cost-benefit analysis. The approach enables social and political factors to be considered alongside economic factors and is based on the following principles²¹:

- factors included should reflect the objectives of the investment programme
- each factor is measured in its own units (for example, number of people gaining access to services)
- factors are weighted to reflect their impact on the programme objectives

Compound ranking methods utilise a points scoring system which is rather subjective. They are probably most appropriate when non-economic objectives are part of the investment objectives for which a “least cost” approach would be adopted.

3.3.8 Implications of Using Revised Approaches

The implications of using the revised approaches recommended in this Guideline are a significant reduction in both the initial construction and longer terms maintenance costs. Coupled with the use of an investment model which is able to quantify important socio-economic benefits, the effect is to reduce the threshold level at which it is economically justified to pave an earth/gravel road (see Table 3.8).

Table 3.8 - Factors influencing the traffic threshold for upgrading

Parameter	Impact
Use of more appropriate pavement designs	Reduced costs
Use of more appropriate geometric designs	Reduced costs
Increased use of natural/unprocessed gravels	Reduced costs
Quantified impacts of depleted gravel resources	Reduced costs
Benefits from non-motorised transport	Increased benefits
Quantified adverse impacts of traffic on gravel roads	Increased benefits
Reduced environmental damage	Increased benefits
Quantified assessments of social benefits	Increased benefits

The impact of these factors is illustrated conceptually in Figure 3.8 which reflects the outcome of recent research²² and indicates that, in some circumstances, bitumen sealing of gravel roads is economically justified at traffic levels of less than 100 vpd. This is in contrast to the previously accepted figures for Sub-Saharan Africa, which indicated that it was only economic to provide a bitumen surface at traffic levels over 200 vpd.

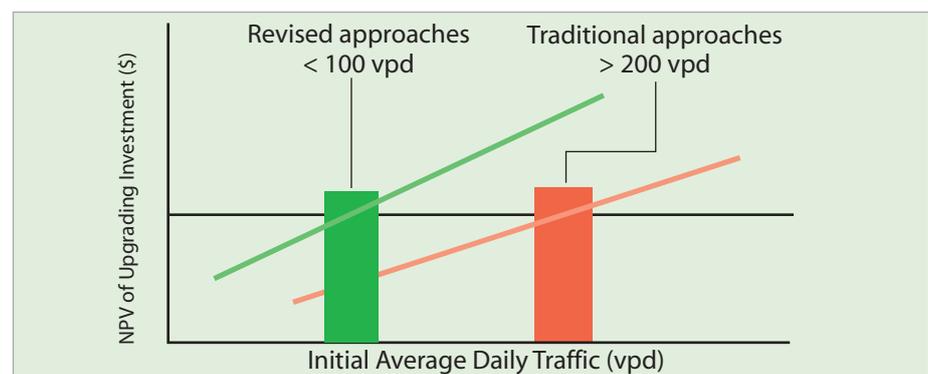


Figure 3.8 - Break-even traffic levels for paving a gravel road: Traditional versus revised approaches

The Net Present Value (NPV) is simply the difference between the discounted benefits and costs over the project analysis period. A positive NPV indicates the project is economically justified at the given discount rate.

3.4 Environmental Issues

3.4.1 Introduction

Any development brought about by man, such as the construction of roads, inevitably produces an impact on the environment. In practice, therefore, it must be accepted that modifications to the natural environment are an inevitable result of attempts to achieve social and economic progress, alleviate poverty and improve human welfare.

LVSRS in the region are generally constructed to improve the economic and social welfare of those using the roads or served by them. By their very nature, such roads are agents of change which can bring both benefit and damage to the existing balance between people and the environment. In the past, the attention of many SADC countries was focused almost exclusively on the potential benefits from these new or improved road facilities. In contrast, the resulting environmental problems have received little attention, largely because they were considered to be either unimportant or the price to be paid for development²³.

More recently, all SADC governments have become increasingly conscious of the impact of unbridled development on the environment and the recognition that, in the long term, environmental conservation and economic development are not only compatible but interdependent and mutually reinforcing. This has raised a number of issues which must now be faced in an attempt to create a balance between much needed development on the one hand and environmental care on the other.

This section considers the environmental issues facing road authorities in the SADC region with a focus particularly on LVSRS. The importance of establishing appropriate policy guidelines and the role of environmental impact assessments in LVSR provision is considered together with the main environmental impacts likely to be encountered and mitigating measures for overcoming them.

3.4.2 The Environment

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. As illustrated in Table 3.9, there are four key cornerstones of the environment:

- ecological
- economic
- social and
- physical

Each of the cornerstones of the environment includes a range of factors which should be considered at all stages of the planning cycle, as discussed further in this chapter.

Safeguarding the future

All human activity depends on the Earth and its natural resources, but it sometimes threatens the delicate balance of the environment. The greatest challenge we face today is to bring about improvements in the living conditions of millions of people while protecting and safeguarding the environment for future generations.

Overseas Development Administration (ODA), UK. Action for the Environment. May 1992.

What price the environment?

The environment is not a free resource in infinite supply. It provides a wide range of services which underpin all productive activities and contributes to human welfare in a number of direct ways. Although it may not be possible to put a conventional price on the environment, it still has a value for those who work and live in it.



Elephants crossing a main road that traverses a game park.



Un-renovated borrow area - typical of many countries in the SADC region.

Table 3.9 - Cornerstones of the environment

E N V I R O N M E N T	● Ecological	<ul style="list-style-type: none"> - impact on flora and fauna - deforestation - disturbance of natural eco-system - decrease in bio-diversity - threats to exotic and non-indigenous species - depletion of scarce material resources - regressive or progressive soil erosion
	● Economic	<ul style="list-style-type: none"> - capital costs (design and construction) - maintenance costs - flood damage costs - loss/degradation of agriculture/arable land - sterilisation of land for future use - land value reduced (designated borrows, severed farms)
	● Social	<ul style="list-style-type: none"> - severance/dislocation of local communities - adverse impacts on women - destruction of cultural antiquities - conflicts arising from changing land use/ownership of land - traffic accidents - health and safety (e.g. danger to humans, especially children, and wildlife from drowning in borrow pits) - construction impacts
	● Physical	<ul style="list-style-type: none"> - aesthetic - e.g. loss of natural beauty and scars on landscape - natural vegetation is not, or cannot, be replaced - noise, air, water pollution - dust impact - disruption of drainage courses

3.4.3 Typical Causes of Environmental Problems

The following are typical causes of environmental problems related to the provision of LVSRs.

- **Design defects:** These create problems when they are not anticipated and the project fails to include remedial measures. For example, measures taken to keep water off the road can cause problems elsewhere. Upstream preventative measures can interfere with natural river flows. Drains concentrate and speed up flow, sometimes causing flooding and soil erosion downstream.
- **Poor project documentation:** Unless remedial measures are clearly reflected in project documents (e.g. Terms of Reference or contract documents) they may not be fully implemented. This often results from use of standard contract documents which do not allow for the special circumstances of the project. For example, standard contract documents for roads often include specifications requiring the contractor to “cut and dispose of soil within the transverse profile”, or to “carry surplus material to spoil”. When such specifications are inadvertently applied in steep, mountainous terrain - particularly if hillsides are intensely cultivated - the dumping of soil over the edge of the road formation can have devastating results.
- **Presence of construction activities:** Temporary site works are typically characterised by borrow pits, ruts in the road created by vehicle wheels and drainage ditches which provide ideal breeding grounds for insects (particularly mosquitoes). Construction workers may kill local fauna for the pot, while the canteen refuse normally associated with construction camps

encourages the proliferation of insects and vermin. One of the most serious diseases spread by construction crews in many SADC countries is malaria. Such impacts can generally be avoided by including appropriate remedial measures in contract documents.

- **Weak environmental institutions:** Successful remedial measures depend on the effectiveness of local environmental institutions, including those dealing with the regulation of land-use. For example, when new roads are being constructed in undeveloped areas, it should be mandatory for the project to be cleared by the local planning agency responsible for dealing with the planned and spontaneous development that may occur in response to the project. However, such provisions will only be effective if the local environmental agency has the skills, manpower and authority to ensure that the contractor complies with the requirements. If the poor performance of local environmental institutions is likely to affect project implementation, this should be evaluated and attended to before the project is approved.



Gravel stockpile for road construction - causes gradual depletion of a finite, non-renewable resource - an unsustainable activity.

The Special Case of Borrow Pits

The extraction of substantial amounts of non-renewable natural resources for road construction in SADC countries is over 150 million cubic metres per annum and has the potential to create significant damaging effects (negative impacts) on the local environment and its inhabitants.



Children exposed to risk of drowning and poor quality water. Ponding and poor drainage also increases the level of mosquito-borne disease.

Box 3.6 - Specific impacts of borrow pits in the SADC region

- Material resources:
 - permanent loss of natural resources
- Morphological damage:
 - modification of the natural drainage
 - increased soil erosion and siltation of watercourses by disturbance of soil
 - destabilisation of slopes
- Ecology:
 - loss of wilderness and forest
 - displacement of species and habitats
 - loss of potential productivity of agricultural land
- Pollution:
 - contamination of water and soil by fuel and oil spillage
 - generation of dust during the processing, loading and transporting of materials
 - increased dust generated by vehicles along access tracks
 - littering
- Social and health impacts:
 - creation of habitats for disease
 - landscape alteration and interference with natural beauty
 - bisection of communities or farms
 - loss of land legacy
 - loss of antiquities, cultural heritage, areas of cultural concern (e.g. graves)
 - hazards to pedestrians and animals, including open or unmarked trial pits, demarcation beacons, etc
 - safety risks to local population by exposure to heavy plant and traffic
 - noise of drilling, blasting, traffic and plant



Very often, worn out construction plant is abandoned and becomes an eyesore. The contract documents should cover removal of unwanted plant to an approved area.

Borrow pit rehabilitation



(a) Original pit used for construction.



(b) Borrow pit rehabilitation in progress after one year.



(c) Full rehabilitation of borrow pit achieved after 3 years.

Other environmental impacts associated with the construction of roads in the SADC region include:

- hard rock quarries
- river bed gravel pits
- hill slope pits

Recent surveys carried out by the UK Transport Research Laboratory²⁴ in two countries have shown that:

- Historically, restoration of borrow pits has been the exception rather than the rule. On average, only around 15% of borrow pits are restored after extraction of materials.
- The environmental damage caused by improper extraction and rehabilitation practices can extend over a wide area and may only become apparent after project completion. Examples include soil erosion causing siltation of natural water courses. Around 50% of worked borrows had excessive land erosion.
- Environmental damage caused by pits is often most severe in areas important for subsistence farming. Only 4% of land previously used for farming was under cultivation after extraction of material.
- Contractors often leave pits open at the request of the land owner, because these are seen as a useful mini-reservoir to provide water for animals, washing and bathing. However, this practice poses severe risks to humans caused by exposure to stagnating water and mosquito borne disease.

Following on from the TRL survey, improved guidelines for borrow area management have been developed²⁴. These guidelines consider:

- planning and access issues
- top soil and overburden removal and stockpiling
- rehabilitation procedures and disposal of soil
- safety (e.g. health and disease, warning signs and fencing, littering and fuel spillages)

The guidelines also contains advice for use in contract documents.

3.4.4 Environmental Impact Assessments

Responsibility for applying sound environmental policies rests with the executing agencies in the SADC region, usually the roads agencies, guided and assisted by environmental units within the agency. However, increasingly, dedicated environmental Departments and Ministries are being established. In carrying out these responsibilities, staff should be guided by the overarching objective of ensuring that projects are designed and implemented according to sound principles which minimise adverse impact and enhance benefits. A variety of procedures need to be followed at various stages of the project cycle in order to achieve these objectives. These procedures normally involve some kind of environmental impact assessment (EIA).

The EIA Process

EIA is not an outcome. Rather, it is a process for improving the quality of the outcome and can be applied to any proposal²⁵. The process is flexible and adaptable and can be tailored to suit the circumstances of any road project. In essence, an EIA evaluates foreseeable impacts, both beneficial and adverse, and helps to reveal mitigating measures and alternatives as well as to optimise positive impacts while reducing or limiting negative impacts.



Road upgrading requires careful planning to minimise adverse impacts on the natural environment.

The main components of the EIA include:

- establishing the need for the project
- identifying and quantifying the full range of potential impacts on the natural and social environments
- formulating remedial procedures for avoiding, mitigating and compensating for these impacts
- reflecting remedial measures in the project documents
- ensuring that remedial measures are complied with during the project implementation

The EIA process is usually integrated into the project cycle as a means of improving the quality of the outcome. Community involvement in this process is important and necessary as it seeks to solicit information, views and concerns that only the affected community can provide. It can take many forms and fit into the process at any or all stages depending on the type of project. It can involve a broad range of interest groups and individuals or it may only require limited involvement. The process is set out in outline in Table 3.10.

Table 3.10 - A framework for EIA

Phase of project cycle	Activity	Objective
Project identification	Initial screening	- register “danger signals” - avoid unnecessary investigation where impacts are likely to be minimal
Feasibility	Environmental appraisal	- predict main impacts - assess importance of effects - indicate key mitigating actions required - present implications to decision makers
Design	Environmental impact assessment	- predict in detail likely impacts, including cost implications - identify specific measures necessary to avoid, mitigate or compensate for damage - present predictions and options to decision makers
Commitment & negotiation	Environmental enforcement	- ensure environmental mitigation measures are included in the contract documents
Implementation	Environmental monitoring	- ensure environmental mitigation measures are being complied with during construction
Operations and maintenance	Environmental audit	- assess the extent of implementation of a project against the requirements derived from the EIA - ensure lessons learned are incorporated in future projects

The output of the EIA is often formalised into an *environmental impact statement (EIS)* which, in some SADC countries, is mandatory for many road projects. Such a report would typically cover the following:

- brief description of project
- brief description of existing environment
- likely impact of project

- mitigation and protection measures
- consideration of “no change” alternative
- summary and conclusions

The EIS should provide a better understanding of the linkages between society, the natural environment and the sustainable use of inherited resources.

An important component of the EIA is the *environmental audit* which seeks, in essence, to assess the implementation of a project against requirements derived from the EIA. The audit can be viewed as a “snapshot” of the environmental situation at a given site and at a given time. It does not attempt to predict the potential impacts of planned investments but, rather, to serve as a source of baseline information which may complement or substitute for normal EIAs, depending on the type of project.

Box 3.7 provides an example of a checklist of issues that would typically be considered in an EIA for a LVSR.

Box 3.7 - Typical check-list of issues to be considered in an environmental impact assessment for LVSRs⁷

Consequential developments: Will the project stimulate land clearance for agriculture, the development of industry or mineral extraction? What steps can be taken to mitigate long-term adverse effects?

Social factors: Has adequate provision been made for vehicle, pedestrian and NMT safety? Are the geometric standards adopted likely to require additional safety countermeasures (e.g. signing, education programmes)?

Geotechnical damage: Has the project been designed to minimise the possibility of landslides and other geotechnical problems? Have long-term maintenance consequences been taken into account?

Materials resources: Will the project result in the unacceptable depletion of material resources that may be needed for subsequent maintenance or other construction projects? Will borrow pits be restored and can their effect on the landscape be minimised?

Drainage: Will the project result in increased risks from flooding or landslides as a result of disturbing natural drainage patterns? Will later development of agricultural land and other settlements affect hydrological conditions so that drainage works and bridges must be modified? Will any water impoundments create health hazards?

Ecology: Have the effects on animals and plants been considered? Has an ecological reconnaissance been carried out to assess effects?

Other factors: Are air pollution, noise and vibration, and visual intrusion issues of concern in the project? If so, what can be done to mitigate the effects?

Value of the EIA

Effective use of scarce resources is becoming increasingly important in a climate of decreasing funding and increased community demand for the improved efficiency and performance of SADC’s new generation of more autonomous roads agencies. In this regard, the EIA process offers the following benefits:

- alternative projects are systematically considered
- the decision-making process is more transparent

- environmentally significant issues are identified at an early stage
- a bridge is provided between the roads agency and the public it serves
- the community is reassured that its needs are being considered
- the roads agency is forced to consider the broader issues of its work
- local information provided through involvement of the community can improve the accuracy and relevance of the information collected for the project
- the risk of aborting a project at an advanced stage due to public dissatisfaction with the project is reduced
- interaction between technical, economic and environmental factors leads to optimum design and improved technical and economic efficiency

Legislative Aspects

The effectiveness and success of an Environmental Impact Assessment (EIA) depends on the extent to which it is actively used and incorporated into different stages of a normal project planning process. In most SADC countries, an EIA has become a formal legal or administrative requirement. However, there is a need in each SADC country to institutionalise the entire process of environmental management by setting up a duly constituted organisation with the necessary authority and legal backing to enforce government environmental policy.

3.4.5 Assessing Environmental Impacts

Assessing the likely effect of a road project on the environment can be accomplished through an EIA as described above. However, quantifying these impacts is more difficult. Unlike monetary impacts, non-monetary impacts cannot be calculated, assessed or compared with each other in a standardised manner. Nonetheless, non-monetary impacts should be considered in a transparent and accountable manner. An impact assessment procedure to evaluate each of the non-monetary impacts has been developed so that these can be considered together with or compared to monetary impacts²⁶. The procedure is based on the following three factors:

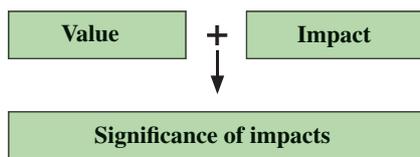
- value
- magnitude
- significance

When evaluating each of the non-monetised impacts the following steps apply:

- (1) Assess the value of areas influenced by the project and characterised with respect to the most important impacts.
- (2) Determine the nature and magnitude of impacts through qualitative descriptors.
- (3) Assess the overall significance of the impacts for the project.

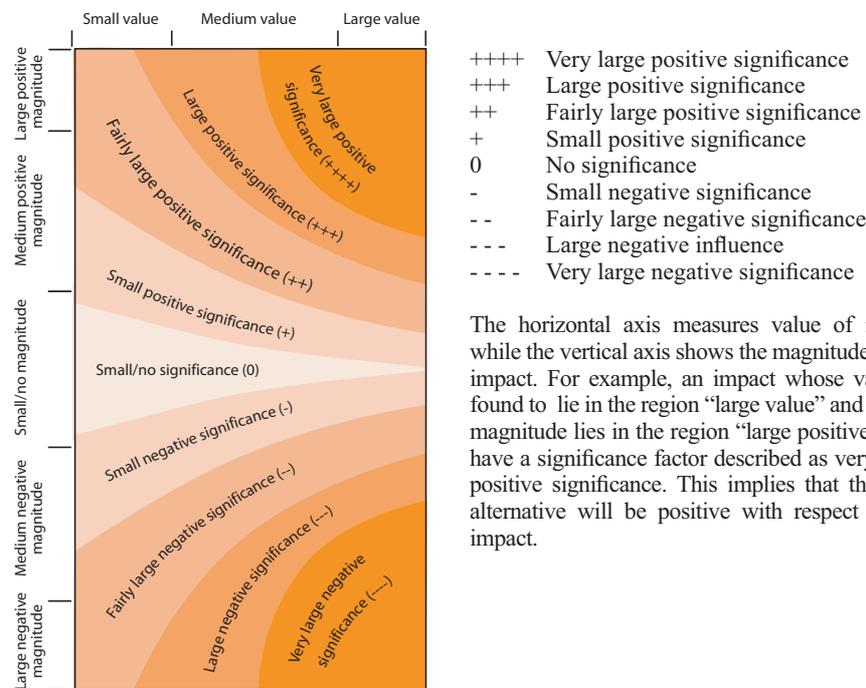
The significance of the various impacts can be assessed by combining the value and magnitude of the impact. The general principle is that the larger the value and vulnerability of the project, the more significant is the impact, whether positive or negative.

Impact assessment is a systematic evaluation of the relevant advantages (benefits) and disadvantages (costs) that a new road plan or improvement of existing roads will generate regardless of the unit of measurement, i.e. whether measurable in monetary units or not.



General principle of assessing non-monetary impacts.

A general scale for assessing the significance of the impacts is shown below, ranging from very negative (- - - -) to very positive (+ + + +) and is illustrated in Figure 3.9.



The horizontal axis measures value of impact while the vertical axis shows the magnitude of the impact. For example, an impact whose value is found to lie in the region “large value” and whose magnitude lies in the region “large positive”, will have a significance factor described as very large positive significance. This implies that the road alternative will be positive with respect to the impact.

Figure 3.9 - A framework for assessing the significance of impacts on LVSR projects²⁶

An example of the process of assessing the value of the natural environment, the magnitude of the impacts, as well as the significance of the impacts is shown in Figure 3.10.

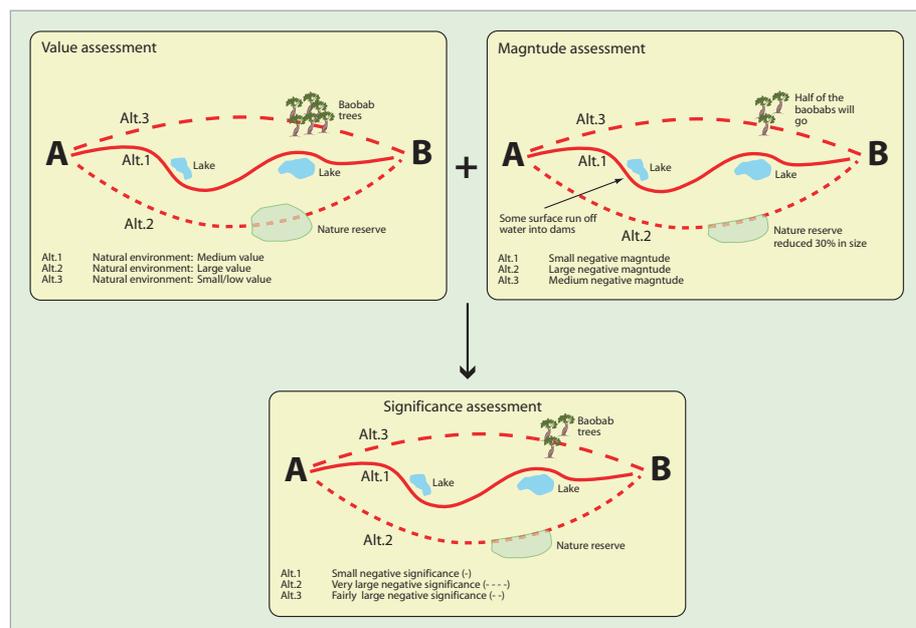


Figure 3.10 - Example of assessing value, magnitude and significance of impacts on LVSRs²⁷

3.5 Summary

The key points arising in this chapter are:

1. Planning and appraisal procedures should consider a wide range of external factors, many of them of a non-technical nature, that affect the planning process if long-term sustainability of the investment is to be achieved.
2. Stakeholder consultations are critical in the planning process for which there are a number of techniques which should be undertaken as appropriately and as transparently as possible.
3. The traditional methods of investment appraisal are generally not adequate for capturing the full range of benefits - often of a social rather than economic nature - arising from the provision of LVSRs. More recently developed models, such as the World Bank's Roads Economic Decision (RED) model, are better suited for appraising such roads.
4. The implications of adopting cost-reducing measures, such as the use of more appropriate pavement and geometric design methods and wider use of natural gravels rather than crushed stone, in combination with the use of appraisal models, such as RED, are a lowering in the traffic threshold level for sealing an earth/gravel road from the previous figure of over 200 vpd to less than 100 vpd.
5. Environmental issues are assuming greater importance in the region than hitherto. Environmental impact assessments (EIA) should become an integral aspect of all LVSR projects. The effectiveness of the EIA will depend on the extent to which it is actively used and incorporated into different stages of the project planning process.

The important processes of planning and appraisal have been covered in this chapter together with environmental issues. Decisions made during the initial planning phase are particularly influential and have a high impact on the subsequent stages of LVSR provision, including those of geometric design and the associated road safety issues covered in Chapter 4.

3.6 References and Bibliography

References

1. Heggie I G (1972). *Economic Evaluation of Engineering Projects: A Comprehensive Approach to Planning Transport Facilities*. Proceedings of the UK Institution of Civil Engineers. Paper 7500S, London.
2. Carney D (1998). *Implementing the Sustainable Rural Livelihoods Approach. Sustainable Rural Livelihoods – What Contribution Can We Make?* (ed Diana Carney). Papers presented at the Department for International Development's Natural Resources Adviser's Conference, London. July 1998.
3. International Labour Organisation (ILO) (1996). *Integrated Rural Accessibility Planning in Lao PDR*. August 1996.
4. Fouracre P (2001). *Rural Transport Survey Techniques*. Rural Transport Knowledge Base, Rural Travel and Transport Programme. TRL Limited, Crowthorne.
5. Howe J D G F (1972). *A Review of Rural Traffic-Counting Methods in Developing Countries*. RRL Report LR 427. Road Research Laboratory, Crowthorne.
6. Howe J D G F (1998): *Impact of Rural Roads on Poverty Alleviation in Developing Countries*. Third International Workshop on Secondary Rural Roads, 19-21 May 1998, Jozefow. IHE Working paper T&RE-21.
7. Transport Research Laboratory (1988). *A Guide to Road Project Appraisal*. Overseas Road Note 5, TRL, Crowthorne.
8. Van der Tak H G and A Ray (1971). *The Economic Benefits of Road Transport Projects*. World Bank Staff Occasional paper No. 13, The World Bank, Washington, D.C
9. Carnemark C, J Biderman and D Bovet (1976). *The Economic Analysis of Rural Road Projects*. World Bank Staff Working Paper No. 241, The World Bank, Washington, D.C.
10. Robinson R (1999): *A New Approach to Quantifying Economic and Social Benefits for Low-volume Roads in Developing Countries*. Impact Assessment and Project Appraisal, Volume 17, No.2, London. June 1999.
11. Archondo-Callao R (1999). *Roads Economic Decision Model (RED) for Economic Evaluation of Low-volume Roads*. Sub-Saharan Transport Policy Program Technical Note No. 18. World Bank, Africa Regional Office, Washington, D.C.
12. DFID (2001). *Appraisal of Investments in Improved Rural Access: Economists Guide*. Department for International Development, London.
13. Crossley P C and S D Ellis (1996). *A Handbook of Rural Transport Vehicles in Developing Countries*. Silsoe College, Cranfield University.

14. Government of Ghana (2001). *Development of a Feeder Road Prioritisation Method. Dept. of Feeder Roads*. Vol I Working Documents: Vol. II Support Documents.
15. Howe J D G F (1997). *Least-Cost Planning Methodologies in Rural Transport*. Working Paper T&RE 19. International Institute for Infrastructural, Hydraulic and Environmental Engineering, Delft.
16. Parsley L L and R Robinson (1982). *The TRRL Road Investment Model for Developing Countries*. TRL Report LR 1057, Crowthorne.
17. Kerali H, R Robinson and W D O Paterson (1996). *The New Highway Development And Management Tools (HDM-4)*. 75th TRB Conference, Washington D.C.
18. South African Roads Board: (1993). *Cost-Benefit Analysis Of Rural Road Projects: Program CB Roads*, User Manual version 4.1, South African Department of Transport, Chief Directorate: National Roads, Pretoria.
19. Southern African Bitumen and Tar Association (SABITA) and Council for Scientific and Industrial Research (CSIR). (1989). *Economic Warrants for Surfacing Roads: Manual 7*. CSIR, Pretoria.
20. Koch J A, F Moavenzadeh and K S Chew (1979). *A Methodology for Evaluation of Rural Roads in the Context of Development*. In Proceedings of Transportation Research Record 702; Low-volume Roads: Second International Conference, 1979. Transportation Research Board.
21. Anderson M (1995). *Why Are Rural Roads So Important?* New World Transport '95 (Sterling Publications, London).
22. Gourley C S and P A K Greening (2001). *Cost-Effective Designs for Low-volume Sealed Roads in Tropical and Sub-Tropical Countries*. TRL Unpublished Report PR/OSC/167/99, Crowthorne.
23. Lionjanga A V L (1999). *Environmental Problems Facing Road Authorities in Africa*. PIARC XIX World Road Congress, Marrakech, 22-28 September, 1991.
24. Gourley C S and P A K Greening (1999). *Environmental Damage From Extraction Of Road Building Materials: Results And Recommendations From Studies In Southern Africa*. TRL Unpublished Report PR/OSC/169/99, Crowthorne.
25. Tideman J (1990). *Environmental Impact Assessment: A Process for Effective Management of Resources*. Highway Engineering in Australia - December 1990, Sydney.
26. Norwegian Public roads Administration. (1995). *Impact Assessment of Road Projects*. Norwegian Public Roads Administration, Oslo.
27. Roads Department, Botswana (2001). *Planning and Environmental Impact Assessment of Road Infrastructure*. Guideline No.5. Roads Department, Ministry of Works, Transport and Communications, Gaborone.

Bibliography

Austrroads (1994). *Environmental Strategy*: Austrroads Publication No. AP-27/94. Sydney.

Austrroads (1995). *Strategy for Ecologically Sustainable Development*. Austrroads Publication No. AP-40/95. Sydney.

Austrroads (2003). *Environmental Considerations for Planning and Design of Roads*. Austrroads Publication No. AP-R217, Sydney.

Beenhakker H and A Lago (1983): *Economic Appraisal of Rural Roads: Simplified Operational Procedures for Screening and Appraisal*. Staff Working Paper 610. World Bank, Washington, D.C.

Creightney C D (1993). *Transport and Economic Performance – A Survey of Developing Countries*. World Bank Technical Paper No. 232. Africa Technical Department Series. Washington, D.C.

Crossley P and S D Ellis (1996). *A Handbook of Rural Transport Vehicles in Developing Countries*. Silsoe College, Cranfield.

Devres Inc. (1980). *Socio-Economic and Environmental Impacts of Low-volume Roads: A Review of the Literature*. A.I.D. Program Evaluation Discussion Paper 7. Washington, D.C: Agency for International Development.

Ellis S D (1999). *Livelihoods of Poor People - What Contribution Can Transport Make?* Workshop Report 29. Department for International Development, London.

Fujimura M and J Weiss (2000). *Integration Of Poverty Impact Economic Analysis: Issues In Theory And Practice*. EDRC Methodology Series Number 2, Asian Development Bank.

Hine J L and M Cundill (1994). *Economic Assessment Of Road Projects: Do Our Current Procedures Tell Us What We Want To Know?* International workshop on Impact Evaluation and Analysis of Transport Projects in Developing Countries, Bombay, December 1994.

Hine J L, P R Fouracre and M Witkiss (2001). *Road Planning, Funding and Funds Allocation*. TRL Unpublished Report PR/INT/211/01.

Howe J D G F and P Richards (1984). *Rural Roads and Poverty Alleviation*. Intermediate Technology Publications Ltd., London.

Howe J D G F (1997). *Rural Transport Projects: Concept Development, Justification and Appraisal*. Lecture Series at the World Bank, September 20-24, 1999.

Howe J D G F (2001). *Socio-Economic Impact Of Rural Transport Interventions And Poverty Alleviation*. Rural Transport Knowledge Base, TRL, Crowthorne.

- Kumar A and P Kumar (1999). *User-friendly Model for Planning Rural Roads*. Transportation Research Record 1652, Transportation Research Board, Washington, D.C.
- Little I M D and M F G Scott (1976). *Using Shadow Prices*. Heinemann Educational Books.
- Malmberg-Calvo C (1997). *The Institutional and Financial Framework of Rural Transport Infrastructure*. SSATP Working Paper No. 17, Sub-Saharan African Transport Program. The World Bank, Washington D.C.
- McRobert J, Styles E, Giummarra G, McArthur M, and Sheridan G (2001). *Environmental Practices Manual for Rural Sealed and Unsealed Roads*. ARRB Transport Research Ltd., Melbourne.
- Overseas Development Administration (ODA). (1996): *The Manual of Environmental Appraisal*.
- Riverson J D N, J Gavira and S Thriscutt. (1991). *Rural Roads in Sub-Saharan Africa - Lessons from World Bank experience*. World Bank Technical Paper No. 141, Africa Technical Department Series. Washington, D.C.
- Stock, E and J de Veen (1996). *Expanding labour-based Methods for Road Works in Africa*. World Bank Technical Paper No. 347. Washington, D.C.
- Transport Research Laboratory (1988). *A Guide to Road Project Appraisal*. Overseas Road Note 5, TRL.
- Tsunokawa K and C Hoban (ed). (1997). *Roads and the Environment: A Handbook*. World Bank Technical Paper 376. Washington, D.C.
- The Institution of Civil Engineers, UK (1982). *Highway Investment in Developing Countries*. Proceedings of the Conference 'Criteria for Planning Highway Investment in Developing Countries', Café Royal Conference Centre, London, 17 - 18 May 1982.
- World Bank. (1999). *Managing the Social Dimension of Transport. The Role of Social Assessment*. World Bank, Social Assessment Thematic Team, Washington, D.C.
- World Bank. (1997). *Roads and the Environment: A Handbook*. World Bank Technical Paper No. 376. Washington, D.C.

