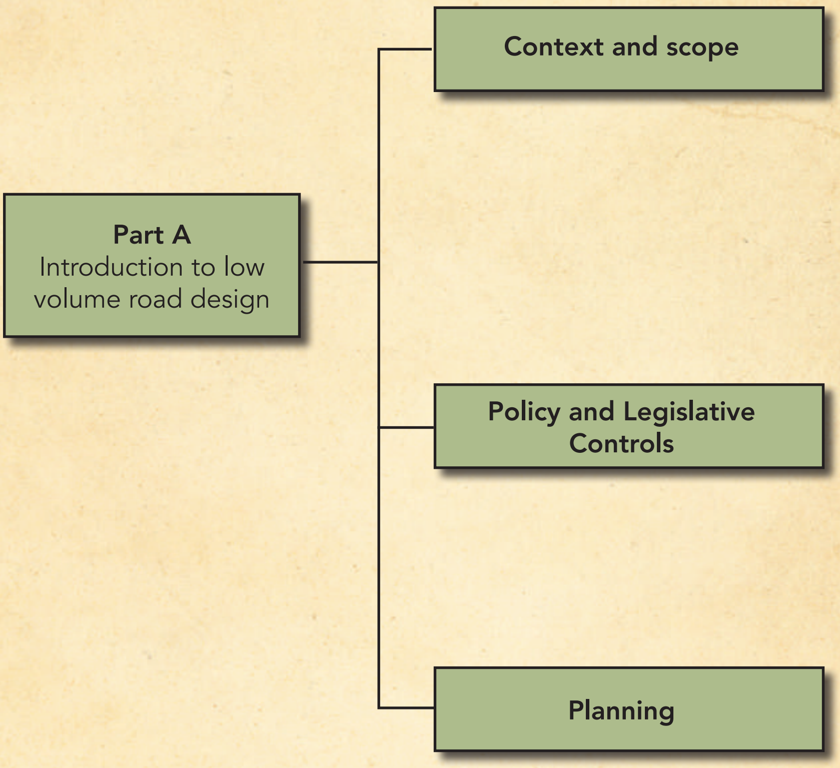
PART A

INTRODUCTION TO LOW VOLUME ROAD DESIGN



FOREWORD

Low volume roads in Ethiopia typically carry less than 300 vehicles per day and provide important links from homes, villages and farms to markets and offer the public access to health, education and other essential services. These roads also provide important links between Wereda Centres and the Federal road network.

Many aspects of the design and construction of roads in Ethiopia, has stemmed from technologies and practices emanating from Europe and the USA some 40 years ago. These practices have to some extent been modified in the intervening years, but the basic philosophy of road provision has remained the same. While these "standard" approaches might still be appropriate for much of the main trunk and link road network, they remain overly conservative, inappropriate and far too costly for application on much of the country's rural road network. In facing the challenges of improving and expanding Ethiopia's low volume rural road network, application of the traditional planning, design, construction and maintenance approaches cannot provide the solution.

Many innovative practices and unconventional techniques, often developed and proved through years of research, have not found the degree of application and implementation that they should. Opportunities are missed that would provide better and lower cost engineering solutions and more sustainable low volume roads.

There is a wealth of local and international information, experience and research that when utilised, can change current practices and thinking and provide Ethiopia with an appropriate and affordable low volume road network. To benefit fully from these advances and to see necessary improvements implemented on the ground, Ethiopian Roads Authority (ERA) has developed its first comprehensive national road design manual, technical specifications and bidding documents specifically for low volume roads. The task was completed with the assistance of a team of international experts commissioned through DFID's Africa Community Access Partnership (AFCAP).

Compilation of the documents was undertaken in close consultation with the local industry and regional authorities. The Federal and Regional Roads Authorities, the contracting and consulting industry, the universities, training schools, the road fund and other industry stakeholders all participated in the formulation of the documentation. Local issues and experience on the geometric, earthwork, drainage, pavement and surfacing design for low volume roads were discussed and debated at length. Of particular interest were aspects of better use of local materials; materials selection and specification; testing and improvement of materials; construction methods and the utilisation of approaches such as labour-based and intermediate equipment technology; route selection; works specifications; and contracting of small works. Much of this debate and other resource materials developed during the compilation of the manual have been captured and are available from the ERA website:www.era.gov.et

Importantly, in supporting the preparation of the documents, a series of thematic peer review panels were established that comprised local experts from the public and private sector who provided guidance and review for the project team. Mainstreaming of social and cross-cutting aspects received special attention and a peer panel of local experts developed a welcome addition to the design process in terms of Complementary Interventions.

The draft manual was published in 2011 and used extensively on the Universal Rural Roads Access Programme (URRAP). Comments received from users of the manual have been incorporated in the 2016 version. The 2016 version also incorporates recent innovations in Low Volume Road design and construction practices from Ethiopia and the region.

On behalf of the Ethiopian Roads Authority I would like to take this opportunity to thank DFID, Crown Agents, Cardno Emerging Markets, and the AFCAP team for their cooperation, contribution and support in the development of the low volume roads manual and supporting documents for Ethiopia. I would also like to extend my gratitude and appreciation to all of the industry stakeholders and participants who contributed their time, knowledge and effort during the development of the documents. Special thanks are extended to the members of the various Peer Panels and Executive Review Groups, whose active support and involvement guided the lead authors and the process.

I trust that the low volume roads manual will provide the essential information needed to guide our design engineers in the provision of appropriate and sustainable low volume roads.

Araya Girmay

Director General of the Ethiopian Roads Authority

PREFACE

The Ethiopian Roads Authority is the custodian of the series of technical manuals, standard specifications and bidding documents that are written for the practicing engineer in Ethiopia. The series describe current and recommended practice and set out the national standards for roads and bridges. They are based on national experience and international practice and are approved by the Director General of the Ethiopian Roads Authority.

This Manual for Low Volume Roads forms part of the Ethiopian Roads Authority series of Road and Bridge Design documents.

Companion documents and manuals include the Standard Technical Specifications, Standard Detailed Drawings and Standard Bidding Documents.

The complete series of documents, covering all roads and bridges in Ethiopia, are contained within the series:

- Route Selection Manual
- Geometric Design Manual
- Site Investigation Manual
- Geotechnical Design Manual
- Pavement Design Manual Volume I (Flexible and Unpaved Pavements)
- Pavement Design Manual Volume II (Rigid Pavements)
- Drainage Design Manual
- Bridge Design Manual
- Manual for Low Volume Roads
- Standard Environmental Procedures Manual
- Standard Technical Specifications and Method of Measurement for Roadworks
- Standard Specifications and Method of Measurement for Labour Based Construction of Wereda Roads
- Standard Drawings
- Standard Bidding Documents for Road Work Contracts
- Quality Manual.

These documents are available to registered users through the ERA website: www.era.gov.et

Manual Updates

Significant changes to criteria, procedures or any other relevant issues related to new policies or revised laws of the land or that is mandated by the relevant Federal Government Ministry or Agency should be incorporated into the manual from their date of effectiveness.

Other minor changes that will not significantly affect the whole nature of the manual may be accumulated and made periodically. When changes are made and approved, new page(s) incorporating the revision, together with the revision date, will be issued and inserted into the relevant chapter.

This version of the Low Volume Roads Manual is released in draft for a limited period during which the industry at large is encouraged to put it into practice and to feed back to the ERA Director General any suggestions for inclusion or improvement.

All suggestions to improve the draft Low Volume Roads Design Manual should be made in accordance with the following procedures:

- Users of the manual must register on the ERA website: www.era.gov.et
- Proposed changes should be outlined on the Manual Change Form and forwarded with a covering letter of its need and purpose to the Director General of the Ethiopian Roads Authority.
- Agreed changes will be approved by the Director General of the Ethiopian Roads Authority on recommendation from the Deputy Director General (Engineering Operations).
- Registered users and authorities will be notified of any changes to the manual.

ETHIOPIAN ROADS AUTHORITY
CHANGE CONTROL DESIGN MANUAL

MANUAL CHANGE	This area to be completed by the ERA Director of Quality Assurance
Manual Title ______________	CHANGE NO. ______ (SECTION NO. CHANGE NO) ______________

Section Table Figure Page	Explanation	Suggested Modification

Submitted by (Name/Designation): ______________

Company/Organisation: ______________

Address: ______________

eMail: ______________ Date: ______________

Manual Change Action

Authority	Date	Signature	Recommended Action	Approval
Registration				
Director Quality Assurance				
Directors Region				
Deputy Director General Eng. Ops				

Approval / Provisional Approval / Rejection of Change:

Director General ERA ______________ Date: ______________

ACKNOWLEDGEMENTS

The Ethiopian Roads Authority (ERA) wishes to thank the UK Government's Department for International Development (DFID) through their Africa Community Access Programme (AFCAP) for their support in developing this Low Volume Roads design manual. The manual will be used by all authorities and organisations responsible for the provision of low volume roads in Ethiopia.

From the outset, the approach to the development of the manual was to include all sectors and stakeholders in Ethiopia. The input from the international team of experts was supplemented by our own extensive local experience and expertise. Local knowledge and experience was shared through a series of four *"information gathering"* workshops followed by a review workshop to discuss and debate the contents of the draft manual. ERA wishes to thank all the individuals who gave their time to attend the five workshops and provide valuable inputs to the compilation of the manual.

In addition to the workshops, Peer Groups comprising specialists drawn from within the local industry, were established to provide advice and comments in their respective areas of expertise. The contribution of the Peer Group participants is gratefully acknowledged.

The final review and acceptance of the document was undertaken by an Executive Review Group. Special thanks are given to this group for their assistance in reviewing the final draft of the document.

Finally, ERA would like to thank Crown Agents (AfCAP 1) and Cardno Emerging Markets (AfCAP 2) for their overall management of the project

Executive Review Group	
Individual	**Organisation**
Bizuneh Kebebe	Civil Works Consulting Engineers
Efrem Degefu	Beacon Consulting Engineers plc
Bekele Jebessa	Ethioinfra Consultants
Dawit Dejene	Civil Works Consulting Engineers
Shimeles Tesfaye	SPICE
Teshome Worku	CORE Consulting Engineers
Assefa Addisu	Assefa Social Consult
Frew Bekele	Ethiopian Roads Authority
Biniam Girma	Ethiopian Roads Authority
Alemayehu Ayele	Ethiopian Roads Authority

Project Team		
Name	**Organisation**	**Role**
Bekele Negussie	ERA	AFCAP Coordinator for Ethiopia
Abdo Mohammed	ERA	Project Coordinator
Alemayehu Ayele	ERA	Project Coordinator
Deribachew Mezgebu	ERA	Project Coordinator
Daniel Nebro	ERA	Project Coordinator
Abeba Berhanu	ERA	Project Coordinator
Frew Bekele	ERA	Project Coordinator
Colin Gourley	ERA and DFID	Specialist Adviser
Rob Geddes	AFCAP	Technical Manager
Les Sampson	AFCAP	Project Director
John Rolt	AFCAP	Lead Author
Mike Pinard	AFCAP	Lead Author
Lulsaged Ayalew	AFCAP	Lead Author
Bob Carson	AFCAP	Contracts Expert
Rob Petts	AFCAP	Specialist Contributor
Jasper Cook	AFCAP	Specialist Contributor
Gareth Hearn	AFCAP	Specialist Contributor
Manaye Ewunetu	AFCAP	Specialist Contributor
Gerrie van Zyl	AFCAP	Specialist Contributor
Kingstone Gongera	AFCAP	Specialist Contributor
Pat Loots	AFCAP	Specialist Contributor

ACRONYMS

>	:	Greater than
<	:	Less than
%	:	Percentage

A

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AC	:	Asphalt Concrete
AFCAP	:	Africa Community Access Partnership
AIDS	:	Acquired Immune Deficiency Syndrome or Acquired Immunodeficiency Syndrome
ALD	:	Average Least Dimension
ARRB	:	ARRB Group, formerly the Australian Road Research Board
ARVs	:	Antiretroviral
ASTM	:	American Society for Testing and Materials

B

BC	:	Binder Course (Base Course)
BDS	:	Bid Data Sheet
BSD	:	Bituminous Surface Dressing
BRD	:	Bituminous Road base

C

CB	:	Clay Brick (fired)
CBO	:	Community Based Organisation
CBR	:	California Bearing Ratio
CI	:	Complementary Interventions
CMG	:	Crown Agents Core Management Group
COLTO	:	Committee of Land Transport Officials (South Africa)
CPT	:	Cone Penetrometer Test
CS	:	Cobblestone

D

DBM	:	Drybound Macadam (Dense Bitumen Macadam)
DC	:	Design Class
DCP	:	Dynamic Cone Penetrometer
DF	:	Drainage Factor
DFID	:	UK Government's Department for International Development
DMT	:	Dilatometer Test
DS	:	Dressed Stone
DV	:	Design Vehicles

E

EF	:	Equivalency Factor
e.g.	:	For example (abbreviation for the Latin phrase exempli gratia)
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
ENS	:	Engineered Natural Surfaces
EOD	:	Environmentally Optimised Design
ERA	:	Ethiopian Roads Authority
ERTTP	:	Ethiopian Rural Travel and Transport Programme
esa	:	Equivalent Standard Axles
ESIA	:	Environmental and Social Impact Assessment
EVT	:	Equiviscous Temperature

F

FACT	:	Fine Aggregate Crushing Test
FED	:	Final Engineering Design

G

g/m²	:	Grams per Square Metre
GDP	:	Gross Domestic Product
GM	:	Grading Modulus
gTKP	:	Global Transport Knowledge Partnership
GVW	:	Gross Vehicle Weight

H

ha	:	Hectare
HDM 4	:	World Bank's Highway Development and Management Model Version 4
HIV	:	Human immunodeficiency virus
HPS	:	Hand Packed Stone
HVR	:	High Volume Road

I

ICB	:	International Competitive Bidding
ICT	:	Information Communication Technology
IDA	:	International Development Association
i.e.	:	That is (abbreviation for the Latin phrase id est)
ILO	:	International Labour Organisation
IMT	:	Intermediate Means of Transport
IRR	:	Internal Rate of Return
ITB	:	Instructions to Bidders

K

km	:	Kilometre
km²	:	Square Kilometre
km/h	:	Kilometres per Hour
km/hr	:	Kilometres per Hour

L

LIC	:	Labour Intensive Construction
LVR	:	Low Volume Road
LVSR	:	Low Volume Sealed Road

M

m	:	Metre
m²	:	Square Metres
m³	:	Cubic Metres
MCB	:	Mortared Clay Brick (fired)
MCS	:	Mortared Cobblestones
MDS	:	Mortared Dress Stone
Mesa	:	Million Equivalent Standard Axles
mg/m³	:	Milligram per Cubic Metre
mm	:	Millimetre
mm²	:	Square Millimetre
mm³	:	Cubic Millimetres
m/s	:	Metres per Second
MC	:	Medium Curing
MoFED	:	Ministry of Finance and Economic Development
MPa	:	Megapascal (a unit of pressure equal to 1000 kilopascals (kPa), commonly used in the building industry to measure crushing pressure of bricks)
MS	:	Mortared Stone

MSSP : Mortared Stone Setts or Pavé
MoWUD : Ministry of Works and Urban Development

N

NBP : Non-Bituminous Pavement
NCB : National Competitive Bidding
NCT : National Competitive Tendering
NGO : Non-Government Organisation
nm : Nanometre
NMT : Non-Motorised Transport
NRC : Non-reinforced Concrete
NRCP : Non-reinforced Concrete pavement

O

OMC : Optimum Moisture Content)
ORN : Overseas Road Note
ORRA : Oromiya Rural Roads Authority

P

PCU : Passenger Car Unit
PDM : Pavement Design Manual
Pen. : Penetration
PI : Plasticity Index
PM : Plasticity Modulus
PPA : Public Procurement Agency
PPP : Public Private Partnership
PSD : Particle Size Distribution
PSNP : Productive Safety Net Programme

R

R : Radius
RC : Reinforced concrete
Ref : Reference
RFP : Request for Proposals
RRA : Regional Road Authority
RS : Road Safety
RSC : Research Steering Committee
RTS : Road Transport Service

S

SADC : Southern African Development Community
SBL : Sand Bedding Layer
SDMS : Surfacing Decision Management System
SE : Super Elevation
SMEs : Small and Medium Enterprises
SSP : Stone Setts or Pavé
SEPT : Small Element Pavement Tiles (Structures)

T

TBA : To Be Advised
Tc : Time of Concentration
ToR : Terms of Reference
TRL : Transport Research Laboratory

U

UK : United Kingdom
USA : United States of America

USCS	:	Unified Soil Classification System
USD	:	United States Dollar
UTRCP	:	Ultra Thin Reinforced Concrete Pavement

V

VI	:	Impinging Velocity
V_{AVE}	:	Average Velocity
VP	:	Parallel Velocity
vpd	:	Vehicles per Day
VOCs	:	Vehicle Operating Costs
VST	:	Vane Shear Test

W

WBM	:	Waterbound Macadam
WC	:	Wearing Course

GLOSSARY OF TECHNICAL TERMS

Aggregate (for construction)
A broad category of coarse particulate material including sand, gravel, crushed stone, slag and recycled material that forms a component of composite materials such as concrete and asphalt.

Asphalt
A mixture of inert mineral matter, such as aggregate, mineral filler (if required) and bituminous binder in predetermined proportions.

Atterberg limits
Basic measures of the nature of fine-grained soils which identify the boundaries between the solid, semi-solid, plastic and liquid states.

Binder, Bituminous
Any bitumen based material used in road construction to bind together or to seal aggregate or soil particles.

Binder, Modified
Bitumen based material modified by the addition of compounds to enhance performance. Examples of modifiers are polymers, such as PVC, and natural or synthetic rubbers.

Bitumen
A non-crystalline solid or viscous mixture of complex hydrocarbons that possesses characteristic agglomerating properties, softens gradually when heated, is substantially soluble in trichlorethylene and is obtained from crude petroleum by refining processes.

Bitumen, Cutback
A liquid bitumen product obtained by blending penetration grade bitumen with a volatile solvent to produce rapid curing (RC) or medium curing (MC) cutbacks, depending on the volatility of the solvent used. After evaporation of the solvent, the properties of the original penetration grade bitumen become operative.

Bitumen, Penetration Grade
That fraction of the crude petroleum remaining after the refining processes which is solid or near solid at normal air temperature and which has been blended or further processed to products of varying hardness or viscosity.

Bitumen emulsion
An emulsion of bitumen and water with the addition of an emulsifier or emulsifying agent to ensure stability. Conventional bitumen emulsion most commonly used in road works has the bitumen dispersed in the water. An invert bitumen emulsion has the water dispersed in the bitumen. In the former, the bitumen is the dispersed phase and the water is the continuous phase. In the latter, the water is the dispersed phase and the bitumen is the continuous phase. The bitumen is sometimes fluxed to lower its viscosity by the addition of a suitable solvent.

Bitumen Emulsion, Anionic
An emulsion where the emulsifier is an alkaline organic salt. The bitumen globules carry a negative electrostatic charge.

Bitumen Emulsion, Cationic
An emulsion where the emulsifier is an acidic organic salt. The bitumen globules carry a positive electrostatic charge.

Bitumen Emulsion Grades

Premix grade: An emulsion formulated to be more stable than spray grade emulsion and suitable for mixing with medium or coarse graded aggregate with the amount smaller than 0.075mm not exceeding 2%.

Quick setting grade: An emulsion specially formulated for use with fine slurry seal type aggregates, where quick setting of the mixture is desired.

Spray grade:	An emulsion formulated for application by mechanical spray equipment in chip seal construction where no mixing with aggregate is required.
Stable mix grade:	An emulsion formulated for mixing with very fine aggregates, sand and crusher dust. Mainly used for slow-setting slurry seals and tack coats.

Cape Seal
A single application of binder and stone followed by one or two applications of slurry.

Cement (for construction)
A dry powder which on the addition of water and other additives, hardens and sets independently to bind aggregates together to produce concrete.

Chip Seal, Single
An application of bituminous binder followed by a layer of stone or clean sand. The stone is sometimes covered with a fog spray.

Chip Seal, Double
An application of bituminous binder and stone followed by a second application of binder and stone or sand. A fog spray is sometimes applied on the second layer of aggregate.

Collapsible soil
Soil that undergoes a significant, sudden and irreversible decrease in volume upon wetting.

Complementary Interventions
Actions that are implemented through a roads project which are targeted toward the communities that lie within the influence corridor of the road and are intended to optimise the benefits brought by the road and to extend the positive, and mitigate the negative, impacts of the project.

Concrete
A construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel or crushed stone plus a fine aggregate such as sand), water, and chemical admixtures.

Concrete Block Paving
A course of interlocking or rectangular concrete blocks placed on a suitable base course and bedded and jointed with sand.

Crushed Stone
A form of construction aggregate, typically produced by mining a suitable rock deposit and breaking the removed rock down to the desired size using crushers.

Design speed
The maximum safe speed that can be maintained over a specified section of road when conditions are so favourable that the design features of the road govern the speed.

Dispersive soil
Soil in which the clay particles detach from each other and from the soil structure in the presence of water and go into suspension.

Distributor
A vehicle comprising an insulated tank with heating and circulating facilities and a spray bar capable of applying a thin, uniform and predetermined layer of binder.

Expansive soil
Typically, a clayey soil that undergoes large volume changes in direct response to moisture changes.

Filler
Mineral matter composed of particles smaller than 0.075mm.

Fog Spray
A light application of diluted bitumen emulsion to the final layer of stone of a reseal or chip seal or to an existing bituminous surfacing as a maintenance treatment.

Gravel
A naturally-occurring, weathered rock within a specific particle size range. In geology, gravel is any loose rock that is larger than 2mm in its largest dimension and not more than 63mm.

Kebele
Administrative division in Ethiopia equivalent to sub-district or ward. Smallest administrative unit in Ethiopia.

Labour Based Construction
Economically efficient employment of as great a proportion of labour as is technically feasible throughout the construction process to produce the standard of construction as demanded by the specification and allowed by the available funding. Substitution of equipment with labour as the principal means of production.

Low Volume Road
Roads carrying up to about 300 vehicles per day and less than about 1 million equivalent standard axles over their design life.

Otta Seal
Sprayed bituminous surfacing using graded natural gravel rather than single-sized crushed rock.

Paved Road
A road that has a bitumen seal or a concrete riding surface

Prime Coat
A coat of bituminous binder applied to a non-bituminous granular pavement layer as a preliminary treatment before the application of a bituminous base or surfacing. While adhesion between this layer and the bituminous base or surfacing may be promoted, the primary function of the prime coat is to assist in sealing the surface voids and bind the aggregate near the surface of the layer.

Reseal
A surface treatment applied to an existing bituminous surface.

Rejuvenator
A material (which may range from a soft bitumen to petroleum) which, when applied to reclaimed asphalt or to existing bituminous surfacing, has the ability to soften aged, hard, brittle binders.

Seal
A term frequently used instead of "reseal" or "surface treatment". Also used in the context of "double seal" and "sand seal" where sand is used instead of stone.

Selected layers
Pavement layers of selected gravel materials used to bring the subgrade support up to the required structural standard for placing the subbase or base course.

Site Investigation
Collection of essential information on the soil and rock characteristics, topography, land use, natural environment, and socio-political environment necessary for the location, design and construction of a road.

Slurry
A mix of suitably graded fine aggregate, cement or hydrated lime, bitumen emulsion and water, used for filling the voids in the final layer of stone of a new surface treatment or as a maintenance treatment (also referred to as a slurry seal).

Slurry-bound Macadam
A surfacing layer constructed where the voids in single-sized stone skeleton are filled using bituminous slurry.

Subgrade
The native material underneath a constructed road pavement.

Surface Treatment
A general term incorporating chip seals, micro surfacing, fog sprays or tack coats.

Surfacing
The layer with which traffic makes direct contact.

Tack Coat
A coat of bituminous binder applied to a primed layer or to an existing bituminous surface as a preliminary treatment to promote adhesion between the existing surface and a subsequently applied bituminous layer.

Ultra-thin Reinforced Concrete Pavement (UTRCP)
A layer of concrete, 50 mm thick, continuously reinforced with welded wire mesh.

Unpaved road
Earth or gravel road

Wearing Course
The upper layer of a road pavement on which the traffic runs and is expected to wear under the action of traffic.

Waterbound Macadam
A pavement layer constructed where the voids in a large single-sized stone skeleton are filled with a fine sand.

Wereda
Administrative division in Ethiopia equivalent to district.

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1. CONTEXT AND SCOPE OF THE MANUAL FOR LOW VOLUME ROADS

1.1 Introduction

This Manual for Low Volume Roads promotes rational, appropriate and affordable provision of low volume roads in Ethiopia. In doing so it aims at making cost effective and sustainable use of local resources. The Manual reflects local experience and advances in low volume road technology gained in Ethiopia and elsewhere.

The Manual is fully adaptable for different clients and users. It has application for roads at a federal level and administered by the Ethiopian Roads Authority, regional level for roads administered by the Regional and Rural Roads Authorities and district level for roads administered by district (Wereda /Kebele) administrations or communities. The document caters for interventions that deal with individual critical areas on a road link (spot improvements) through to providing total rural road link designs. In the latter case, this could comprise different design options along the total road length.

The Manual is intended for use by roads practitioners responsible for the design, construction and maintenance of low traffic earth, gravel or paved (sealed) roads. It is appropriate for roads which, over their design life, are required to carry an average of up to about 300 vehicles per day, and less than about 1.0 million equivalent standard axles (mesa). The Manual complements and links to the ERA design manuals for higher traffic roads and is accompanied by ERA documents dealing with Technical Specifications, Drawings and appropriate level Bidding Documents.

1.2 Contents of the Manual

The Manual is divided into seven parts:

- Part A, this part, provides an overview of the Manual, its application, context, use and introduces the philosophy of low volume road design.
- Part B provides the engineering details and guidance on the application of the national standards for the design of low volume roads. It also sets out typical design controls that should be considered during the design process and the national design standards for low volume roads in Ethiopia. These are mandatory standards that must be adhered to by the Engineer. Departures from these standards are only permitted in exceptional circumstances and with the prior approval of the relevant authorities.
- Part C describes how Complementary Interventions and activities can be introduced into the road works contract and how these can add value and impact to the project for the Client and beneficiary communities, and users.
- Part D provides guidance on the construction of low volume roads and small structures. It provides advice on procurement of work, quality control on site and Technical Auditing.
- Part E provides the engineering details and guidance on the design of low level structures and water crossings for low volume roads.
- Part F provides detailed guidance on the provision of Trail Bridges.
- art G describes commonly occurring defects on low volume roads and how these should be addressed through maintenance. It is accompanied by a field maintenance guide.

1.3 Application of Appropriate Standards

Application of appropriate design standards for low volume roads in Ethiopia aims to optimise construction and maintenance costs and meet the requirement to:

- Improve the economic and social well-being of rural communities and access to social and other services;
- Facilitate inclusion of different ethnic and other groups in society;
- Lower road user costs and promote socio-economic development, poverty reduction, trade growth and wealth creation in rural areas;
- Protect and manage non-renewable natural resources and reduce import dependency.

The Client for the low volume road works could be a Wereda Administration, a Regional Roads Authority or the Ethiopian Roads Authority. The Client could also be a local level administration such as a Kebele

Administration, community organisation or cooperative. Road works, whether undertaken by a contractor, through an in-house capability or by community will require a design. This design will work towards satisfying a national standard set for a particular type of road. The degree of sophistication of the design will, in general, increase as the standard of the road increases. However, this does not mean that earth or gravel roads are any easier to design than a first generation low volume sealed road. Often it is quite the contrary.

The road Design Engineer is normally supported by a team of individuals, with varying specialities, and equipped to deal with all aspects of the road design. The job of the design team is to provide a robust technical design (geometric, drainage and pavement) and to reflect this in the instructions to bidders, conditions of particular application, the special provisions to the specifications, the bills of quantities and the detailed drawings. The design team should also include (or consult) environmentalists and social development specialists for additional specialist inputs.

The general approach to the design will be guided by the Client and will build on information and data collected during the project pre-feasibility and feasibility stages. The Client will have a budget in mind for the works, the location and route will be known in outline, and the preferred approach to the works will also be known, for example labour or equipment based. The Client may also have views and guidance on apportioning works and contract size, technical issues, social, environmental and time constraints. The job of the road Design Engineer will then be to develop the project within and around these boundaries and limitations, whilst at the same time alerting the Client to issues and problems that may limit or require adjustment of expectations.

The approach to the design of low volume roads follows the general principles of any good road design practice. There are, however, subtle differences from the traditional road design practice. This manual sets out to provide the Design Engineer with the requisite tools that will provide the Client with an optimised design based on the financial, technical and other constraints that define the project.

Optimising a design requires a multi-dimensional understanding of all of the project elements and in this respect all design elements become context specific. The design team therefore needs to be able to work outside their normal areas of expertise and to understand implications of their recommendations or decisions on all other elements of the design.

The successful design of low volume roads relies on:

- A full understanding by the Design Engineer of the local environment (natural and social);
- An ability to work within the demands of the local environment and to turn these to a design advantage;
- Recognition and management of risk;
- Innovative and flexible thinking through the application of appropriate engineering solutions rather than following traditional thinking related to road design;
- A client who is open and responsive to innovation;
- Guaranteed routine and periodic maintenance.

There is an onus on the Design Engineer to provide a road that meets the expected level of service. Design engineers are traditionally conservative and build in factors of safety that cater for their perceptions of risk and extremes of caution. This approach does not necessarily encourage innovation, uses scarce or inappropriate resources, and may result in high financial costs for the Client and the country. There is also often a temptation to provide or upgrade roads to a future level of service not justified by economics, by other project projections or by road user requirements. This type of approach absorbs available resources and prevents extension of access. It is the role of the Design Engineer to properly represent the Client's and country's interests.

The level of attention and engineering judgement required for optimal provision of low volume roads is no different and in most cases is higher than that required for the provision of other roads. The Design Engineer needs to draw on all of their engineering skills, judgement and local experience if appropriate designs are to be developed without incurring unacceptable levels of risk. This manual will assist the Engineer in that task.

1.4 Road Network Classification

The functional classification of roads in Ethiopia is based on five classes:

- **Trunk roads**: roads linking Addis Ababa to centres of international importance and to international boundaries;
- **Link roads:** connecting centres of national and international importance such as principal towns and urban centres;
- **Main access:** connecting centres of provincial importance;
- **Collectors:** connecting locally important centres to each other or to a more important centre or to a higher class road; and
- **Feeder roads:** connecting minor centres such as a market to other parts of the network.

Low volume roads can be represented in all five of these functional classes.

Roads in Ethiopia can be further divided into three categories depending on ownership and the authority responsible for them. These are:

- Federal (the responsibility of the Ethiopian Roads Authority);
- Regional (the responsibility of the Regional or Rural Roads Authorities); and
- Other rural roads (the responsibility of local authorities at Wereda or Kebele level or communities).

ERA is responsible for major roads falling into the higher design classes, predominantly DC5 and above, but also has a substantial stock of roads below DC5. Regional and local authorities are responsible for roads in classes DC4 – DC1.

Figure A.1.1 shows the definitive classification of roads in Ethiopia based on geometric standards with the appropriate level of service.

<table>
<tr><th colspan="6">Road Functional Classification</th><th>Geometric Standards</th><th>Level of Service</th><th>AADT</th></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="5">TRUNK</td><td rowspan="4">HIGH VOLUME</td><td>DC8</td><td rowspan="2">A</td><td>>10,000</td></tr>
<tr><td></td><td></td><td></td><td rowspan="4">LINK</td><td>DC7</td><td>3,000 - 10,000</td></tr>
<tr><td></td><td></td><td></td><td>DC6</td><td rowspan="2">B</td><td>1,000 - 3,000</td></tr>
<tr><td></td><td></td><td rowspan="3">MAIN ACCESS</td><td>DC5</td><td>300 - 1,000</td></tr>
<tr><td></td><td rowspan="3">COLLECTOR</td><td rowspan="5">LOW VOLUME</td><td>DC4</td><td rowspan="3">C</td><td>150 – 300</td></tr>
<tr><td rowspan="4">FEEDER</td><td></td><td></td><td>DC3</td><td>75 – 150</td></tr>
<tr><td></td><td></td><td></td><td>DC2</td><td>25 – 75</td></tr>
<tr><td></td><td></td><td></td><td></td><td>DC1</td><td rowspan="2">D</td><td><25</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Track</td><td></td></tr>
</table>

Figure A.1.1: Road classes in Ethiopia

Level A: The highest level of service. Traffic is free flowing, with the volumes and types of traffic easily accommodated. Safety is a high priority. Design speed is very important and takes precedence over topographic constraints.

Level B: Traffic may not flow smoothly in all situations. Safety is a high priority, but some safety controls may need to be enforced. Design speed is important, but topography may dictate some design changes and controls.

Level C: The efficiency of traffic movement and flow is not a limiting factor. Traffic will be accommodated, but some design controls may need to be applied. Safety provisions are adapted to lower and variable speed scenarios. The topography will dictate alignment and the design speed.

Level D: Service level is geared to provision of access rather than efficiency. Design standards for water-crossings may allow service interruption and some roads may even be closed to protect these assets. Other design standards for geometrics, surfacing and safety will reflect lower speed environments and access requirement.

The density of roads in most areas of Ethiopia is relatively low and many existing low volume roads are relatively long (>25km). Alternative routes are often long or non-existent and the consequences of disruption are high. It is prudent therefore to adopt design standards that provide an appropriate level of reliability and service commensurate with the functional characteristics of the road.

While there are exceptions to every rule, low volume roads in Ethiopia can be considered as roads carrying less than 300vpd and generally of DC4 standard or below and meeting C or D service level criteria. The majority of roads in Ethiopia carry relatively low levels of traffic, and most carry less than about 300 vehicles per day. Such roads are referred to as "low-volume" roads in this manual and all are an essential component of the road system. Their importance and reach extends to all aspects of the economic and social development of rural communities and the country at large.

1.5 Definition of a Low Volume Road

There has been much debate about the precise definition of a low volume road but the concept is quite straightforward. A low volume road is simply one designed for a low volume of traffic. This traffic level for a definition is relatively arbitrary simply because the characteristics that define a low volume road change gradually as the design traffic increases. This is primarily because as traffic level increases most road authorities are prepared to provide an increasing level of service and to adopt a more risk free approach. Therefore, standards and costs increase.

The level of traffic that is most common for classifying a road as low volume is a cumulative number of equivalent standard axles of less than 1.0 million during a design life of 15 years or an Annual Average Daily Traffic (AADT), estimated for the middle of the design life, of 300 motorised 4 or more wheeled vehicles per day. This latter figure is sometimes set at 500 AADT and even 1000 AADT.

However, the most important aspect of such roads is that at low traffic levels the engineering requirements set out in most manuals and specifications indicate that the performance of the road is much more dependent on environmental influences than it is on traffic, as indicated figuratively in Figure A.1.2. This has very important ramifications on many aspects of the design of such roads, as outlined in this chapter.

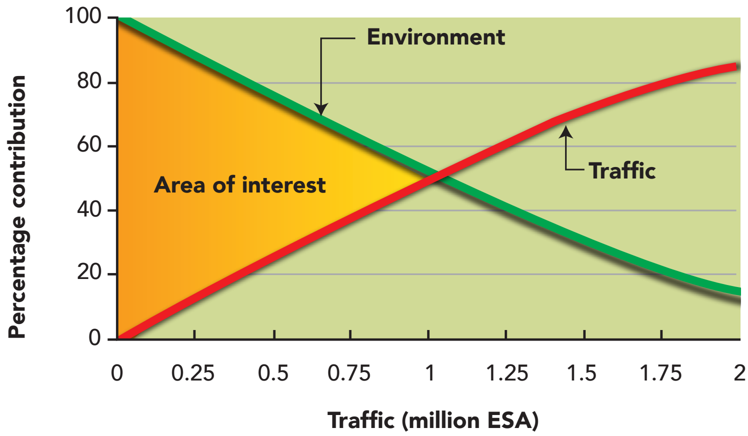

Figure A.1.2: Environment, traffic and road performance.

1.6 Low Volume Road Design Principles

Ethiopia is a country of great geographical, geological and climatic diversity. Altitudes range from the highest peak at Ras Dejen, 4,620 meters above sea level, down to the Afar Depression at about 110 meters below sea level. Ethiopia's high plateaus and mountain ranges, usually above 1500 meters are characterised by precipitous edges and dissection by numerous rivers and streams. These areas constitute about 45 percent of the total area and are inhabited by close to 80 percent of the population.

Below 1500 meters are the lowland areas, located in the north-west, east and south. The vast majority of these areas support nomadic and semi-nomadic pastoralism. The descent to the southwest and west leads to the semi–humid lowlands. Climatic regions range from arid, tropical rainy to temperate rainy areas.

Soils are highly variable and often problematic, available materials for construction can be very variable or scarce and involve long haulage.

Hence, traditional engineering, and traditional road engineering in particular, is challenging in the face of such diversity. For low volume road provision the challenges can be even greater. Low volume roads provide important links from homes, villages and farms to markets and offer communities access to health, education and other services. These roads also provide important links between Kebele and Wereda centres and the Federal road network. Given their importance, design engineers need to work with and around such challenges. Clients also need to be flexible and adaptable, if low volume roads are to be provided at reasonable cost.

Typically, in Ethiopia, low volume roads are unpaved with a gravel or earth wearing surface. Budgets for the maintenance and improvement of these roads are constrained. In facing the challenge of improving the low volume road network, the application of the conventional planning, design, construction and maintenance philosophies used for higher traffic roads is unlikely to provide an optimal solution.

In determining cost-effective solutions for the provision of low volume roads it is important to understand the mechanics of how the road deteriorates in the first place. Deterioration of the existing unpaved low volume roads in Ethiopia is governed by the type of material used on the surface (earth to gravel); the strength of the underlying soil (soft, erodible and/or expansive), the type and action of traffic (pedestrian to heavy vehicles) and probably most importantly, the influence of the environment within which the road is constructed or is to be constructed. This includes both the natural or bio-physical environment and the human environment. It includes the interaction between the different environmental factors and the road structure. Some of these factors are uncontrollable, such as those attributable to the natural environment, including the interacting influence of climate (e.g. wind, rainfall and intensity), local hydrology and drainage, terrain and gradient. Collectively, these will influence the performance of the road and the design approach needs to recognise such influences by providing options that minimise the negative effects. Other factors, such as the construction and maintenance regime; safety and environmental concerns; and the extent and type of traffic are largely controllable and can be more readily built into the design approach.

Typical road environment factors are presented in Figure A.1.3 and covered in more detail in Part B of the Manual.

Figure A.1.3: Framework for Sustainable Provision of Low Volume Roads

1.7 Low Volume Earth and Gravel Roads

Surface materials suitable for use in road construction, need to resist wear and abrasion in dry weather and promote surface drainage and run-off in wet weather. Under traffic they need to resist whip off, dust generation and be strong enough when compacted to resist deformation. The compacted material needs to resist erosion and scour.

The nature and strength of the underlying soil is critical in determining the performance of low volume roads, particularly in periods of wet weather. Many rural roads are characterised by deep rutting, where the road formation is not strong enough to support the traffic loads. Some roads have loose and/or stony materials on the surface, leading to dusty, rough and/or slippery conditions. Potholes create difficult and unsafe surfaces. Severe erosion and scouring may prevent access by any form of motorised, and many types of intermediate, transport. Transverse scouring can start at the edge or on the side slope of the road and work its way to the centre of the carriageway. Longitudinal scour occurs where water flows against the direction of road crossfall. Inadequate scour protection in drainage ditches may lead to serious erosion, dangerous conditions for road users, local access restrictions and, in extreme conditions, loss of valuable agricultural land along the road.

Rural access may be prevented for long periods during the rains when streams and rivers start to flow. In some situations, a section of road may be completely washed away by flowing water. When the rains have eased or stopped some sections of the road may be subject to saturation and ponding. This weakens the underlying soils and any traffic may churn up the surface causing deep rutting or deformation. Vehicles may not be able to pass or may get stuck.

Plate A.1.1: Typical Access Problems

This problem is worsened in areas where there is a prevalence of expansive clays (locally known as black cotton soils). These soils have high agricultural potential but, because of their highly expansive properties, become very weak when wet. Moreover, during the dry season, the soil shrinks and cracks appear which may extend to the surface of the pavement. When wet, the soil often cannot support even the lightest vehicles. Where gravel is placed directly over this material it may rut or deform under the influence of traffic and mix into the weak soil below.

Vehicle operating costs (VOCs) are high on roads with high roughness and restricted access. VOCs include repairs, maintenance, fuel and tyre replacement. The consequence is that transport operators tend to avoid roads with high roughness and other defects forcing people to walk long distances to reach the nearest point where transport services are prepared to operate.

Dust is often overlooked as a problem on unpaved roads. It is caused by the action of traffic and wind. Unpaved roads lose fine material which can travel hundreds of metres from the road. The dust affects other road users, pedestrians (and especially school children who need to walk along the road frequently), houses, shops and crops near the road. Roads in dry areas can lose large quantities of surface fines per kilometre per year. Dust has significant and costly social (cleanliness), health (eye and respiratory hazards), environmental (crop and natural habitat damage) and economic (vehicle and equipment damage, pedestrian and vehicle safety) consequences. Approaches to alleviate dust problems, particularly in populated areas are proposed in the Manual.

Gravel for road works is a non-renewable natural resource in many areas. On unpaved roads part of the gravel is a sacrificial layer because it is lost from the road due to the action of traffic and weather. It must be replaced periodically. Optimal materials for gravel surfaced roads are not commonly found in Ethiopia, and it is possible to lose 25 – 35mm of gravel per annum. Such heavy loss of gravel can also be related to contamination with underlying weak subgrade material, e.g. black cotton soil, and the use of angular and light weight wearing gravel (e.g. cinder).

Gravel roads require a continuous cycle of reshaping and regravelling to maintain the required running surface and the desired level of service. The type of materials prevalent in Ethiopia and the hilly and mountainous terrain in many areas present significant challenges to achieving this type of maintenance. Screening and blending techniques are available to improve the properties of gravel materials that are found locally, and such techniques are described in the Manual.

The provision of a surfacing material that gives the desired level of service at an affordable cost is a major technical challenge for unpaved roads. Durable and functional water crossings are also needed to ensure all weather passability, and effective maintenance arrangements are essential. These challenges are recognised in the Manual, which provides a range of options and recommended solutions.

1.8 Low Volume Sealed Roads

This Manual draws on international research carried out over several decades. This research was carried out by a number of research organisations in collaboration with national road authorities, including the Ethiopian Roads Authority. Much of the research was aimed at deriving local specifications, designs and techniques for improving the cost-effective provision of low volume roads sealed with a bituminous or alternative, non-bituminous surfacing and the development of more appropriate geometric, drainage and pavement design standards. Innovative construction techniques and methods were identified that optimised the use of local labour, introduced intermediate equipment techniques and improved opportunities for the local private sector to participate in road construction and maintenance.

The research questioned existing procedures associated with paved surfacing design for low volume roads. This research, combined with local experience, provided a basis for understanding how such roads deteriorate leading to the development of revised standards, specifications and design methods that make better use of locally available materials and demonstrate an effective range of viable bituminous and non-bituminous surfacing technologies.

The approaches adopted for the design of low volume sealed roads differ in a number of fundamental respects from roads carrying higher traffic volumes. In particular, the relative influences of road deterioration factors are significantly different. For LVRs carrying below about 1.0 Mesa during their design life, the deterioration caused by traffic is usually quite small and pavement deterioration is primarily controlled by how the road responds to environmental factors such as moisture changes in the pavement layers, fill and subgrade and to the effects of age hardening of bituminous surfacings. The appropriate design options for low volume roads therefore need to be responsive to a wider range of factors captured in the road environment, the most critical being factors concerned with drainage, both within the pavement layers themselves (internal drainage) and externally to prevent water entering the pavement in the first place.

The role of the Design Engineer is to recognise and design to these parameters and optimise the design to the expected performance. This is known as an environmentally optimised design (EOD) approach. EOD takes account of road environment changes along the alignment and the design responds to these changes (for more details see Part B).

1.9 Surface Improvement Technology

Gravel and earth roads are particularly vulnerable to the effects of the road environment. A range of more durable surfacing options, other than gravel or earth are available for low volume roads. These include thin bituminous surfacings, and non-bituminous surfacings such as cobbles, hand packed stone and even thin concrete. The selection, design and use of the various surfacing options with the design standards and specifications are described in Part B.

Improved surfacings may be provided for the entire length of a road, or only on the most vulnerable sections. The approach may include dealing only with individual critical sections (weak or vulnerable sections; roads through villages or settlements) on a road link (spot improvements), or providing a total whole rural link design, which could comprise different design options along its length.

The choice of surfacing type, and when to use it, involves a trade-off between initial cost, level of service and maintenance requirements. Cobblestone may use locally available resources and require very little maintenance, but it gives a relatively rough riding surface. It is normally only used on town roads or where roads are liable to frequent flooding. Surface dressings provide smoother riding surfaces but may require more expensive earthworks and pavement layers, as well as imported bitumen, specialised equipment and skilled operators. Appropriate selection of surfacing type is driven to some extent by the required service level.

Surface dressings should not be constructed where there is no capacity for routine maintenance, including pothole repairs and crack sealing, as well as periodic re-sealing. Edge break is a common problem on sealed roads due to vehicles and pedestrians moving on and off the road, and needs to be controlled through appropriate road width, provision of stopping places, and kerbing.

The challenge for the Design Engineer for a low volume road is to achieve the required level of service, using appropriate engineering approaches and materials, and to minimise costs over the whole life of the road. This should be done in a context-sensitive way that recognises the needs of the road agency, the road user, the road environment and the prevailing maintenance management regime.

1.10 Context Sensitivity

In addition to ensuring that the design developed is technically appropriate and affordable, the Design Engineer needs to bear in mind other factors that could influence the success of the low volume road design approach, its implementation and its long term sustainability. This requires a broadly focused, multi-dimensional, multi-disciplinary and context-sensitive approach in which a number of other influential factors are considered, illustrated in Figure A.1.4.

1.10.1 Political Support

Demand for low volume road provision needs to be framed under a national policy driven by government and should be supported at the highest level. The cross-sectoral influence of low volume road provision and its role in under-pinning other sectoral development strategies and poverty alleviation programmes should be highlighted, quantified and understood.

The approach adopted for low volume road provision should complement national plans, policies and strategies and should be responsive to wider needs and demands, including:

- The social and economic goals of poverty alleviation and development;
- Increasing rural accessibility;
- The use of appropriate technology, promotion of the domestic construction industry and employment creation;
- Protection of the environment;
- Cost minimisation and improved efficiency.

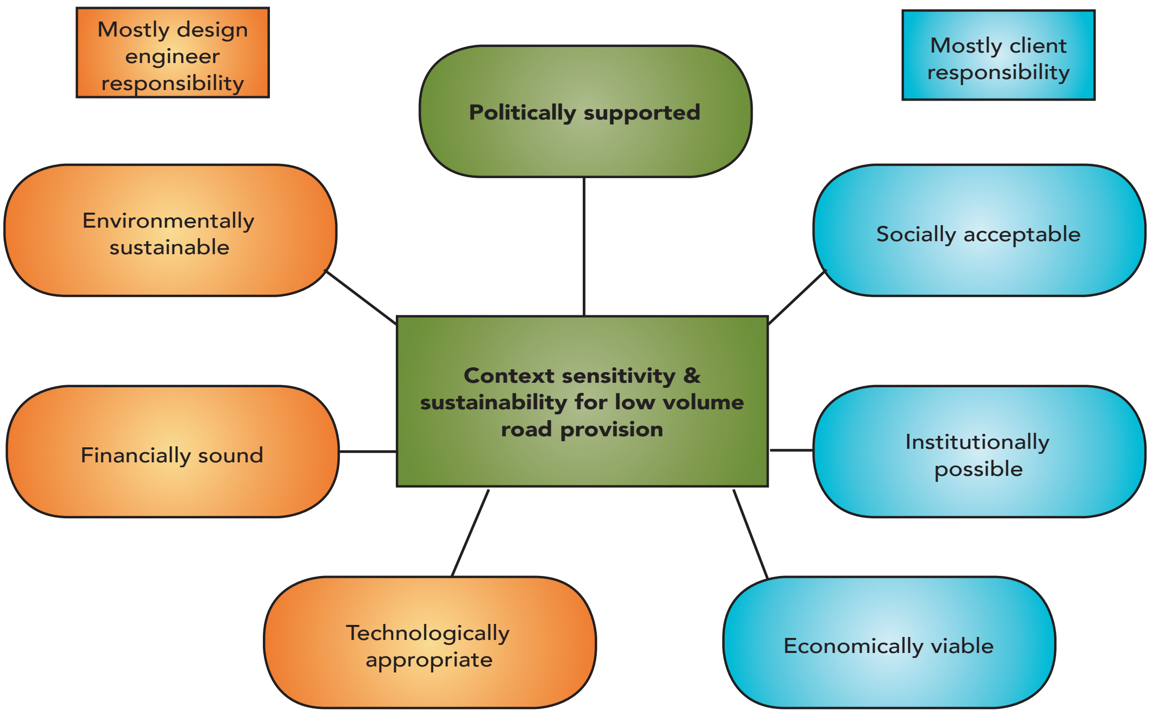

Figure A.1.4: Framework for Sustainable Provision of Low Volume Roads

There is a need to maintain dialogue with political and public stakeholders in order to highlight the advantages of design approaches and alternative, often unfamiliar, solutions selected for low volume road provision. The language used for advocacy should be carefully chosen and should avoid negative connotations such as "low standard"; "low cost" and "marginal", because these terms may give the impression that the proposed technical solution is not fit for purpose.

1.10.2 Social Acceptance

Provision of low volume rural road networks should be managed in a way that:

- Ensures community participation in planning and decision making;
- Eliminates gender bias and promotes participation by women in the road sector;
- Promotes activities and investment for sustainable livelihoods (including Complementary Interventions described in Part C);
- Promotes road safety in all aspects of low volume road provision.
- Supports cost-effective labour-based and intermediate equipment methods of construction and maintenance; and
- Minimises resettlement and mitigates unavoidable resettlement through appropriate compensation.

1.10.3 Institutional Capacity

Road authorities and clients should:

- Promote institutional, economic and technical understanding in the provision and management of low volume roads;
- Promote commercial management practices;
- Develop a conducive environment for the development of national contractors;
- Ensure that design, construction and maintenance approaches for low volume roads are represented on all tertiary civil engineering training curricula.

1.10.4 Technology Choice

Technologies for designing, constructing and maintaining low volume roads should:

- Employ appropriate design standards and specifications;
- Utilise intermediate equipment technology options and reduce reliance on heavy equipment imports;

- Promote road construction and maintenance technologies that create employment opportunity;
- Use types of contract that support the development of domestic contractors and consultants;
- Be robust to the uncertainties and variability of climate and recognise potential impacts of climate change.

Good design of roads should be associated with good construction and maintenance. Therefore, workmanship and maintenance culture are important factors in achieving sustainable provision of LVRs.

1.10.5 Economic Viability

Economic appraisal for low volume roads should:

- Employ tools for low volume roads that should be capable of quantifying social, economic and environmental costs and benefits;
- Ensure investment decisions for low volume roads are based on an assessment of whole life costs.

1.10.6 Financial Sustainability

Sustainable provision of low volume roads depends on the sustainable provision of funding to the sector in that:

- Roads should not be upgraded to engineered standards if funding is not in place for routine and periodic maintenance requirements.
- Designs should not be adopted that require excessive allocation of maintenance resources.

1.10.7 Protection of the Environment

The design and management of low volume roads should:

- Minimise the physical impacts of construction and maintenance activities on the natural environment;
- Take account of socio-cultural impacts (community cohesion);
- Optimise resource management and allow for recycling of non-renewable materials; and
- Minimise any detrimental impacts on the natural environment and contribution to climate change.

2. POLICY AND LEGISLATIVE CONTROLS

2.1 Policy

Government policy, national legislation and development planning dictate the underlying principles of low volume road design. This includes, for example, environmental controls, road safety legislation, promotion of the use of labour or application of intermediate equipment based technologies to encourage local participation and the development of Small and Medium Enterprises. Authorities may choose to put emphasis on Complementary Interventions, as set out in Part C.

2.2 Legal Framework

Environmental and Social Impact Assessments promote maintenance of the road corridor environment in at least the same condition as it was before the road construction project started. Engineering designs must make provision for protective and mitigation measures. Key documents that must be referred to in the design of low volume road projects to assess and address environmental and social safeguards during project planning, design and construction are listed below and summarised in Table A.2.1.

- Legal Framework - in particular Articles 35, 40, 41, 43, 44, 91, 92 – Constitution of the Federal Democratic Republic of Ethiopia
- Proclamation No. 299/2002 – Environmental Impact Assessment
- Proclamation No. 300/2002 – Environmental Pollution Control
- Proclamation No. 295/2002 – Environmental Protection Organs Establishment
- Proclamation No. 209/2000 – Research and Conservation of Cultural Heritage
- Proclamation No 455/2005 – Expropriation of Landholdings for Public Purposes and Payment of Compensation
- Council of Ministers Regulation No 135/2007 –Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purposes
- Proclamation No 456/2005 – Rural Land Administration and Land Use
- Proclamation No. 542/2007 – Forest Development, Conservation and Utilization
- Proclamation No. 541/2007 – Development, Conservation and Utilization of Wildlife
- Proclamation No. 575/2008 – Ethiopian Wildlife Development and Conservation Authority Establishment
- Council of Ministers Regulation No. 163/2008 – Wildlife Development, Conservation and Utilization
- Proclamation No. 197/2000 – Ethiopian Water Resources Management
- Proclamation No. 200/2000 – Public Health
- Development plans of the Federal Government, Regional Governments and Weredas
- Regional States' environmental legislation
- Environmental Protection Authority (EPA) requirements for preparation of EIAs and EMPs
- Funding agency policies, regulations and guidance notes.
- The requirements of existing environmental legislation and related government proclamations are summarised in Table A.2.1. Further information can be found in the ERA Route Selection Manual.

Table A.2.1: Summary of Existing Legislative Requirements

No.	Technical Area	Existing Documentation	Requirements
1	Environmental and Social Impact Assessment (ESIA)	Proclamation on EIAs, EPA guidance note, GTP	Full ESIA on all major urban roads, all rural road programmes, upgrading or rehabilitation of major rural roads. Preliminary ESIA on other rural road works.
2	Land Acquisition (LA) and Compensation	Proclamations on Land Acquisition and Compensation, ERA QMS.	Compensation to be made in accordance with relevant proclamations and regulations.
3	Resettlement Action Plans (RAP)	Funder policies and guidelines; ERA guideline on Resettlement Rehabilitation Policy Framework; and FDRE proclamation on land expropriation and compensation payment.	Only if project is funded by international agency and more than 200 people are to be relocated.
4	Environmental & Social Management Plans (ESMP)	EPA guidance note.	Full ESMP required for all road projects.

3. PLANNING

3.1 General approach

The planning phase of a LVR project can rightly be viewed as the foundation on which the subsequent implementation 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 should take full account of government policies and strategies in the road transport sub-sector.

In order to make optimal use of scarce resources in the provision of new, or upgrading of existing LVRs, it is necessary to plan the road development activities in a comprehensive and coordinated manner. Such planning should be undertaken in a context sensitive manner in which all dimensions of sustainability are addressed. This places more weight on multi-disciplinary planning in which teams of planners, engineers, environmentalists, etc., work together with stakeholders in order to reach optimal solutions in the most cost-effective manner. Such an approach provides the best chance of achieving long-term sustainability of projects and, in so doing, ensures that the available resources are used in the most cost-effective manner.

3.2 Stages in the Planning Process

The various stages/activities typically followed in the planning process are presented in Table A.3.1. In principle, the process comprises structured activities which start from the general and work towards the particular in relation to both data and project ideas.

Table A.3.1: Stages/activities in the planning process

Project Cycle	Evaluation 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

The main features of the planning and appraisal processes for new road projects are as follows:
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: Evaluates the shorter list of projects in more detail by subjecting them 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.
For existing roads which need to be rehabilitated or upgraded, it would not be necessary to undertake the identification and feasibility phases but, rather, to concentrate on the design and commitment and negotiation phases that lead to implementation of the project.

3.3 Planning considerations

The procedures described in the planning and appraisal framework shown in Table A.3.1 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 LVRs that often do not emerge from conventional approaches. These are summarised in Table A.3.2.

Table A.3.2: Project cycle and related planning activities

Stage	Issues to be considered
Project Identification ▪ Project objectives	▪ 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 ▪ Design criteria ▪ Cost-benefit analysis ▪ Socio-economic assessment ▪ Road safety assessment ▪ Environmental assessment ▪ Livelihoods	▪ Is there adequate participatory planning and consultation with public and private sector stakeholders? ▪ Do the design criteria take full account of the specificities of LVRs, 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 ▪ Design standards ▪ Pavement/surfacing design	▪ Are the geometric, pavement design and surfacing standards technically appropriate? ▪ Are they environmentally sound? ▪ Are specifications and test methods appropriate to the local materials being used?
Commitment & negotiation ▪ Contract documentation	▪ 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?
Implementation ▪ Construction ▪ Inspection and monitoring ▪ Environmental mitigation	▪ 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? ▪ Has the construction schedule considered the weather conditions with respect to the different activities, e.g. earthworks, unbound pavement materials, cement concrete and bituminous works with respect to dry and rainy seasons?

Stage	Issues to be considered
Operations & maintenance ▪ Performance evaluation ▪ Maintenance operations	▪ 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 les sons for the future?

3.4 Planning tools

There are a number of tools that may be used to undertake rural accessibility planning. They include:

- Policy Analysis
- Regional Development Plans
- Livelihoods Framework
- Integrated Planning Techniques
- Multi-Criteria Analysis
- Network-Based Planning.

Policy Analysis

The objective of the 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.

Regional Development Plans

Regional and wereda development plans are used to determining priorities for future investments in infrastructure. 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 road projects for rehabilitation and upgrading will first be identified.

During the preparation of a regional development plan it is important that transport planners liaise closely with other sectors. 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 political 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 community. 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, human, financial, natural and physical asset structure.

Integrated Planning Techniques

Regional Development 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) has been developed by the International Labour Organisation (ILO) and has been used in several countries of the world. 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.
In the IRAP approach, an Accessibility Indicator (AI) is calculated for various facilities in each community as follows:

$AI = N \times (T - Tm) \times F$

N = number of households

T = average travel time to a facility

Tm = target travel time

F = frequency of travel

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.

Multi-Criteria Analysis

Multi-Criteria Analysis provides a means of prioritising investments in rural roads through the consideration of the current condition of each road link its economic and social importance. For rural roads such data typically include:

- Traffic on the road;
- The population served by the road;
- Agricultural output of the area served by the road;
- Existing social facilities such as schools and clinics along the road.

The condition of each road link is assessed and a score allocated. This is known as a "Condition Index". Roads in poor condition have a high Condition Index. Priority factors are then determined for traffic, population, agriculture and social facilities, with weightings applied to each factor depending on their importance. A "Priority Score" for each road link can be then calculated by multiplying the Condition Index by the traffic, agriculture, social and population priority factors. The equation is as follows:

$\text{Priority Score} = \text{Condition Index} \times TF \times AF \times SF \times PF$

TF= Traffic factor

AF = Agriculture production factor

SF = Social facilities factor

PF = Population factor.

The result of this analysis is that roads in poor condition but with high social and economic importance are selected first for maintenance or improvement interventions.

The Priority Score for each road link should be determined on the basis of weights and points allocated to each factor in a participatory and transparent manner. This will ensure that the outcome is accepted by all stakeholders.

Network-Based Planning

Investments in LVRs have traditionally been evaluated on a link by link basis with less consideration given to the connectivity or accessibility contributions of links to the entire network. Network-based planning enables contributions from the various links to be considered in such a way that the travel needs of the people or the community in an area are met to the maximum extent possible in a collective way at the lowest development cost.

Network-based planning is particularly useful where a "core road network" needs to be identified in situations where funding is available to maintain only part of the total road network. Such a network often includes 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. This network can be reviewed periodically and will expand or contract depending on local circumstances.

Models such as HDM-4 can be used for network-based planning purposes. However, the necessary data required is often not available at local level, making such models inappropriate. Thus, procedures that involve a high level of stakeholder consultation and a multi-criteria analysis are likely to be more effective for rural network planning purposes.

Stakeholder consultations

The objective of stakeholder 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 are often taken without considering the transport requirements of the people being affected by the investment. Insufficient consultation can lead 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.

Types of 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 groups;
- Market traders;
- Transport operators and road users.

It is important to ensure that women's needs are heard and addressed as part of the stakeholder consultations indicated above.

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:

- Wereda Administration;
- Regional Roads Authorities;
- Ethiopian Roads Authority
- Local and national political leaders.

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.