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TITLE: **Provision of Low-Volume Sealed Roads: Time for a Re-Think by Decision Makers**

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ABSTRACT

The effective and efficient provision of low-volume sealed roads (LVSRs) requires a major departure from traditional practice. Documentation relating to the provision of such roads is often based on technology emanating from developed countries. Although these standard approaches have been revised to some extent, they are still often inappropriate for situations where locally prevailing conditions are very different from those for which the traditional approaches were developed.

It is clear that new, more holistic approaches, requiring a paradigm shift in thinking, are required if LVSRs are to be provided on a more sustainable basis. To this end, the Southern African Transport and Communications Commission (SATCC), now the Division of Infrastructure and Energy in the Southern Africa Development Community (SADC) secretariat, commissioned the development of a Guideline on Low-Volume Sealed Roads.

The main purpose of this paper is to present more holistic, innovative and sustainable approaches to the provision of LVSRs that are contained in the Guideline. The paper highlights the results of the research on which the guideline is based and outlines the challenges faced by road authorities in adopting the results of research and the application of innovative practices.

1. INTRODUCTION

Road transport is essential for the operation of a country's economy. The rural road network in most of the SADC region is typical of many African countries and those in a number of other developing countries worldwide. It is characterized by relatively low traffic levels (< 200 vehicles per day outside urban areas), variable design standards, poor road conditions and a very serious road safety problem. Approximately 80 per cent of the network is unpaved and such roads impose a huge maintenance burden on the road authorities. Furthermore, gravel resources are being depleted rapidly in some areas and therefore the process is unsustainable.

In many countries, much of the initial documentation for the provision of roads was inherited at independence and stems from technology and research carried out in Europe and the USA some 30 - 40 years ago, usually in vastly different environments. Furthermore, many of the current approaches for rural roads are based on roads designed to carry considerably higher volumes of traffic. Thus the methods often reflect inappropriate technologies and do not address developing country conditions in terms of traffic, human resources, climate and materials; rarely is local knowledge recognized.

2. RESEARCH AND INNOVATION

Recognizing these issues, research in road engineering specifically addressing the problems of rural roads has been carried out for many years. For example, TRL, in collaboration with national and local road authorities, has been at the forefront of research in various aspects of road technology aimed at deriving local specifications, designs and techniques for improving the cost-effective delivery of low-volume roads (LVRs).

The research has identified anomalies in our previous understanding and has questioned many of the accepted paradigms associated with the provision of LVRs, indicating that such

roads can be provided more cheaply and cost effectively. When the results of this research have been implemented, usually in the countries in which it has taken place, the impact has invariably been highly beneficial. However, there has, in general, been poor uptake as a whole.

3. THE PROJECT

In recognition of the need to raise awareness and encourage application of the more recent developments in low-volume road technology, the Southern African Transport and Communications Commission commissioned TRL to prepare a *Guideline on Low-volume Sealed Roads* (LVSRs). The project was funded jointly by the UK Department for International Development, the Norwegian Agency for Development Cooperation and the Swedish International Development Cooperation Agency.

The first draft of the *Guideline* was written following a series of five technical workshops attended by delegates that included government officials, consultants, contractors, researchers and representatives from the SADC member states. The key purposes of the workshops were to overcome the barriers that existed between countries, including language barriers, to share and transfer knowledge, to build an authoritative and influential team to take the project forward and to ensure local ownership. At these workshops, the format of the document and the outline contents of each chapter were debated and agreed.

Further workshops were held to review the first draft and the resulting recommendations were incorporated into the final draft document. National workshops were then held in each of the 13 member states that had participated in the compilation of the *Guideline*. Thus the project included a total of 18 workshops underlining the almost unprecedented degree of consultation that was considered essential to achieving the objectives that had been set for the project and for the *Guideline* document.

4. THE RESEARCH

4.1 Pavement design, materials and surfacing

LVRs present a particular challenge to road designers. For roads carrying high volumes of traffic, pavement performance is mainly dependant on vehicle load-associated stresses which are reasonably well understood. In contrast, environmental effects tend to determine the performance of LVRs (Figure 1). Such effects are quite complex and are much less well understood, although considerable performance evidence now exists to guarantee economic road design. Very few pavement design methods cater adequately for these environmental effects.

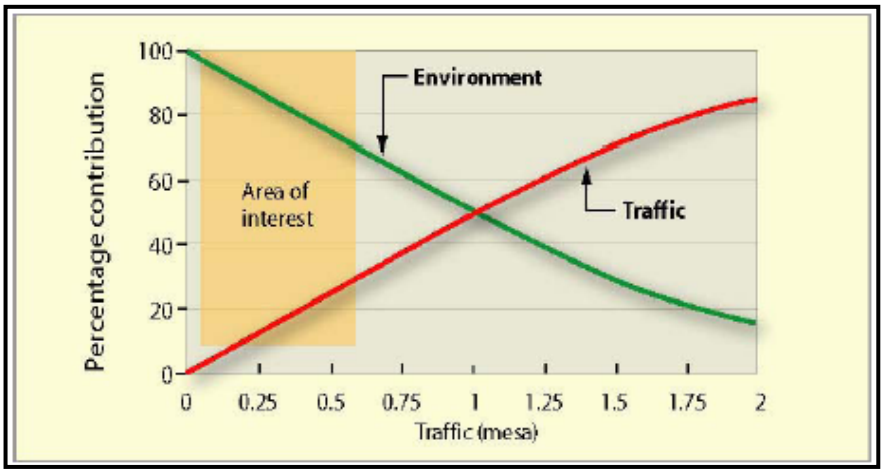

Fig. 1: Traffic loading versus dominant mode of distress

Successful cost-effective design calls for an imaginative 'systems' approach which can be applied in a flexible manner to cater for the characteristics of LVRs in relation to the prevailing environment.

Recent research work carried out in southern Africa [1] indicated that the following issues were the most important for the design of LVRs:

- selection criteria for roadbase materials;
- subgrade strength or design class;
- crown height above drain level;
- sealing of road shoulders;
- geo-climatic zone;
- traffic.

The results of the research were incorporated into a pavement design method that reflects the importance of local environmental factors and the wider use of locally available materials [1,2].

Materials: Materials make up 70% of the cost of a typical rural road. To reduce costs it is essential that as much use as possible is made of locally available 'low-cost' materials. However, until relatively recently, many of the design criteria for using naturally occurring materials have reflected specifications appropriate to temperate zones, with 'ideal' particle size distributions and low plasticity [3]. Application of such specifications often precludes the use of many local materials which do not meet these standards. However, research work carried out in the southern African region [1,4] has shown that many natural gravels have performed well as pavement materials, often despite overloading and poor maintenance. Considerable use can therefore be made of many so-called marginal materials when appropriate local specifications for them have been developed from research studies.

Surfacing: For many years, the standard surfacing for LVRs in the SADC region has been surfacing dressing, although there have been a number of modifications to this technique including the Cape Seal used in South Africa. Whilst this type of seal still has wide application, there are alternatives available which are often more appropriate, cost-effective and easier to apply than surface dressings. These include graded aggregate (Otta) seals [5], sand seals, slurry seals, hand-packed stone, stone setts and concrete blocks, etc. many of which are especially suited to labour-based construction techniques and the construction plant used by small-scale contractors.

4.2 Geometric Design and Road Safety

Many of the geometric design standards used in developing countries are a direct translation from overseas practice with little modification to compensate for local operational differences [6]. Such standards are geared to higher traffic volumes, greater need for all-weather accessibility, and a relatively high level of service for the traffic. Indeed, there has generally been little difference in approach to the design of low-volume or high volume roads. The use of conventional standards results in LVRs that are relatively expensive to build and maintain, particularly where substantial earthworks are required. More appropriate standards are required.

Road safety: Safety and cost considerations generally provide an appropriate basis for defining minimum design criteria for LVRs. Substantial savings in construction costs can be achieved by adopting 'relaxed' standards which are more flexible and responsive to local conditions. This includes, for example, using a 'design by eye' approach [7] where no formal alignment calculations are made and where engineering judgment and simple surveys can be used to define the alignment and identify where spot improvements are necessary. In this way maximum use can be made of the existing formation thus reducing the amount of earthworks.

Recent advances in road design applicable to LVRs have seen the introduction of the Design Domain Concept [8] which recognizes that there is a range of values which could be adopted for a particular parameter within absolute upper and lower limits. Values adopted for a particular design parameter within the design domain will provide an acceptable though varying level of performance in average conditions in terms of safety, operations, economic and environmental consequences.

In many developing countries, traffic operations often involve a mixture of both motorised and non-motorised traffic. Furthermore, pedestrian flows are often very high, particularly in urban and peri-urban areas but also in rural areas where the road often acts as the main footpath linking communities (Figure 2). Ironically, traffic surveys, which form the basis of highway improvement schemes, rarely include counts of slow moving traffic or pedestrians [9]. This can result in designs that do not cater for the needs of the most vulnerable road users who are put at risk, leading to large numbers of accidents, typically 30 to 50 times higher per capita than in developed countries.

Measures to improve road safety include the use of road safety audits, for both new roads and for the upgrading of existing roads, as an essential element in the design process. Such audits provide an effective means of checking the safety aspects of LVRs in order to detect potential safety hazards before the road is open to traffic. There is also much scope for adopting a range of proven low-cost accident-preventative counter-measures determined from experience in many countries [9,10].

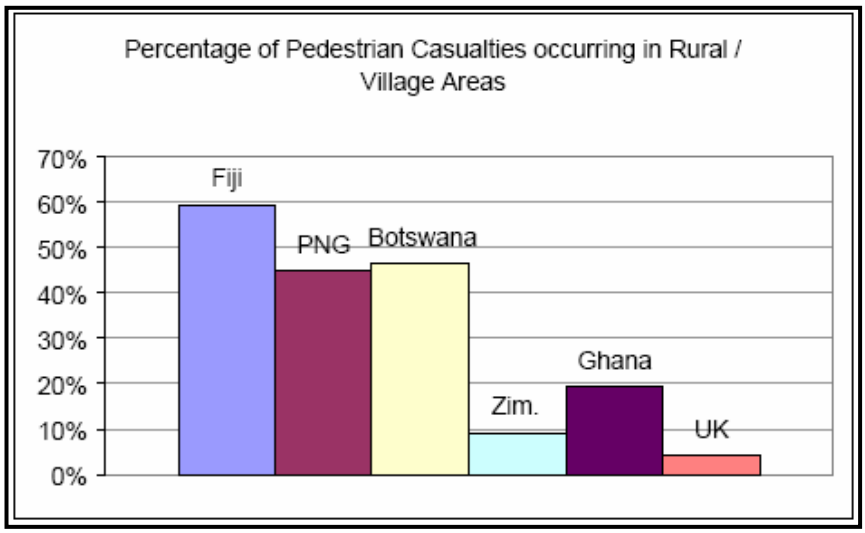

Fig. 2: Pedestrians and non-motorised traffic often constitute a significant proportion of traffic on rural roads.

4.3 Construction Methods and Drainage

Compaction: In many design manuals, the levels of compaction or density to be achieved during construction are defined as a proportion of the maximum dry density that can be obtained in a standard laboratory test. However, with many road-building materials and the use of modern plant, higher densities can be achieved with relatively little additional compaction effort. Thus, 'compaction to refusal' with the heaviest plant available will often provide a substantial benefit in terms of increased pavement stiffness and potentially longer pavement life.

Deep compaction techniques using high energy impact compactors have also been used to economic advantage in the construction of a number of road projects in Southern Africa [11]. These compactors produce a deep, well-balanced and relatively stiff pavement structure which is comparatively less sensitive to overloading than shallower pavements of similar nominal structural capacity.

In many circumstances considerable long-term benefits can be achieved using these methods for a relatively small additional cost during construction.

Labour-based Methods: In many countries in the region there is a trend to devolve the responsibility for rural roads to district councils. As a result, many councils are now responsible for relatively small networks containing few surfaced roads. In these circumstances, the maintenance of these roads (and the construction of relatively short sections of new road) can be carried out more cost-effectively using labour-based methods and appropriate types of plant and equipment that are suited to small-scale contractors.

Unfortunately, a negative perception still persists in some countries that labour-based methods are slow, costly and sub-standard. This is not the case; labour-based technology is a structured method of providing or maintaining infrastructure to a *specified* standard whilst optimizing the use of labour under fair working conditions. The use of labour is supplemented with appropriate equipment where necessary for reasons of quality or cost.

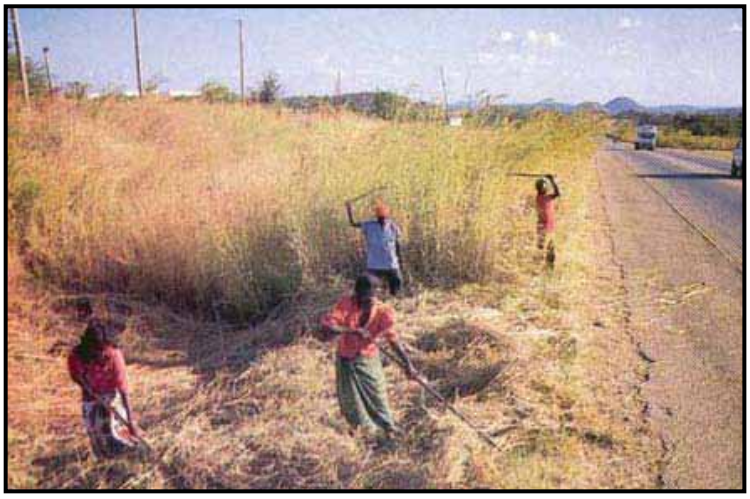

Photo 1: Grass cutting – a typical labour-based routine maintenance activity.

Drainage: Because of the sensitivity of many naturally occurring materials to moisture, both internal and external drainage plays a particularly important role in the performance of LVRs. For example, research has highlighted the importance of maintaining a minimum height of the crown of the road above the level of water in the side drains (this is especially important through cuttings). Measures such as sealing shoulders, deepening side drains, raising the height of embankments, or using other techniques to create a drier environment for the road pavement, can increase the opportunities for using locally available materials and significantly reduce costs.

4.4 Maintenance

Whereas design and construction of LVSRs are dominated by engineering issues, maintenance is essentially a multi-dimensional issue in which the management and technical aspects dominate and are influenced by political, social and institutional issues. For example, the use of maintenance works as a poverty alleviation tool through appropriate community involvement is assuming increasing importance.

Maintenance currently constitutes one of the major preoccupations of road agencies in many developing countries. As indicated in Figure 3, there was a rapid expansion of the road network in many developing countries in the immediate post independence era between the early and mid-1960's. At that time, most of the annual road expenditure was incurred on road construction. However, some 40 years later, with most of the trunk road network in place, annual expenditure on roads in many countries is dominated by maintenance costs.

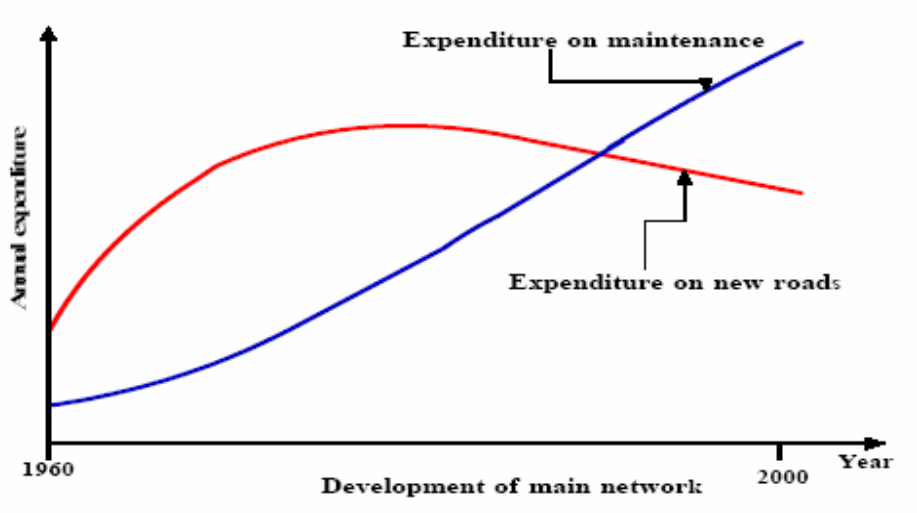

Fig. 3: Pattern of road expenditure in the SADC region

The *Guideline* includes suggestions on how to improve the maintenance and management of LVSRs, primarily through adopting appropriate institutional arrangements, management strategies and technical standards. Aspects of maintenance operations are not covered in detail as sufficient reference texts exist in this area, while technical approaches are limited to those innovative or less publicised aspects which support the philosophies promoted by this Guideline. Guidance is also given on criteria for establishing road management systems to assist road agencies in the overall management of their road networks.

5. SUSTAINABILITY

Despite the technical advances that have been made, full implementation will not be achieved unless the methods are *sustainable* in the long term, an essential prerequisite if progress towards achieving the higher developmental goals is to be made. A major re-think is needed in the way that we approach the problem. Figure 4 illustrates the components that contribute to developing sustainable solutions.

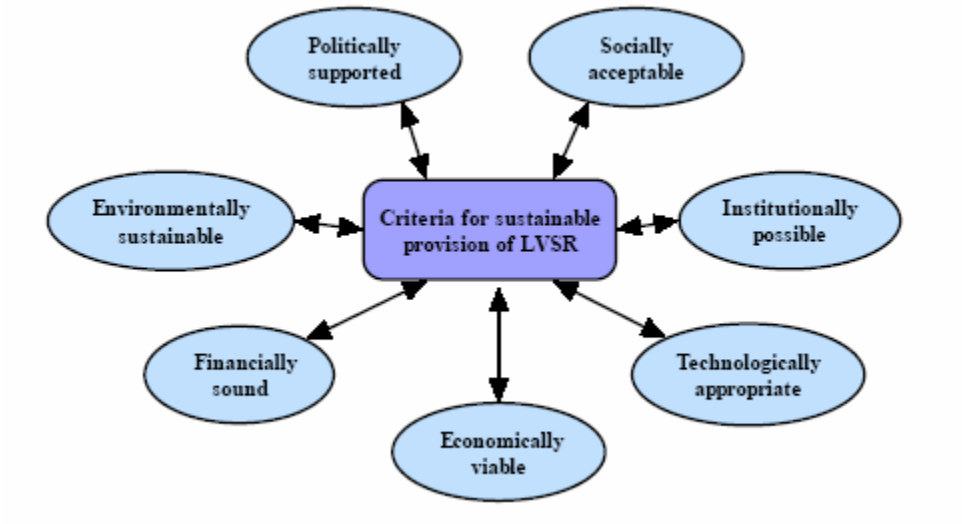

Fig. 4: Components of sustainability for low volume roads

The development of appropriate technical solutions has been one of the main thrusts of the research and one of the outcomes of the technical developments is that the economic balance between what is viable and what is not viable has changed.

5.1 Economically viable

Hitherto, the use of conventional LVR design and construction methods plus conventional cost benefit analyses such as those embodied in investment appraisal models such as HDM III, rarely indicated the cost effective upgrading of a road to a bituminous standard at traffic levels less than about 200 vehicles per day. By using the technical solutions described in the *Guideline*, applying a sealed road surface becomes justifiable in whole-life terms at traffic levels considerably less than 100 vehicles per day. What is more, traditional methods of investment appraisal rely on benefits arising from the reduced costs for motorised road users; such methods are not suitable for quantifying the multiple benefits of LVRs. This is because many of the benefits arising from the provision of LVRs are of a social rather than economic nature and the beneficiaries also include non-motorised traffic and pedestrians.

In view of the above, it is recommended that appraisal methods are used that are able to capture the non-economic benefits and, in so doing, integrate social, environmental and economic elements in project appraisal. When this is done, justification for providing a sealed road surface at much lower levels of traffic becomes possible (Figure 5).

The shortcomings of the conventional methods of investment appraisal are currently being addressed to some extent through the development of models such as PIARC's HDM-4 and the recently developed Roads Economic Decision model (RED)[12]. The *Guideline* provides information on this approach and current research which is underway to improve the tools and methods of investment appraisal.

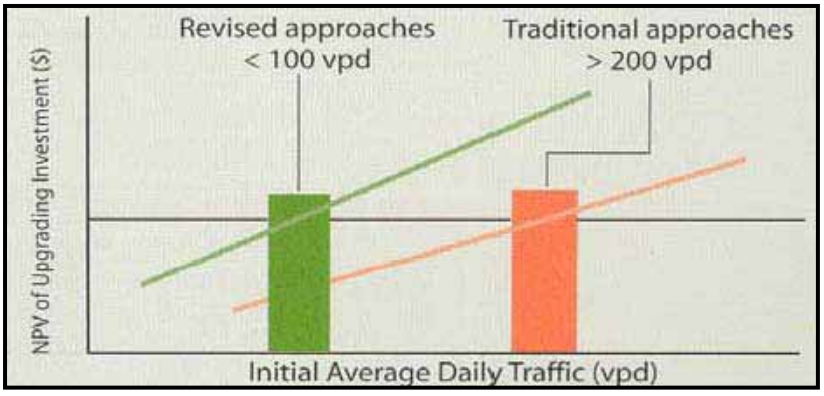

Fig. 5: Breakeven traffic levels for paving a gravel road: Traditional versus revised approaches

5.2 Financially attainable

Traditionally, funds for LVRs have been provided by central government. Such funds, particularly for maintenance, have been inadequate to meet the minimum requirements for sustainability. Indeed, the road maintenance crisis in Africa has been the subject of great concern to international aid donors for twenty years or more and the Road Maintenance Initiative (RMI), led by the World Bank, has sought solutions to this problem [13]. Alternative financing mechanisms, such as the establishment of dedicated Road Funds, coupled with institutional reforms designed to bring private sector skills into the road sector, have been underway in many countries during the past few years and considerable progress is being made.

Within this changing environment it is apparent that the perceived risk of adopting more innovative solutions in the provision of low-volume roads is considerably less and the climate is more favourable for greater implementation; it is for these reasons that the production of the *Guideline* at this time is particularly opportune.

5.3 Environmentally sustainable

Some degradation of the environment has often been regarded as the price to be paid for economic development, with the result that environmentally unsustainable solutions have often been adopted. For example, in many countries natural gravel is being depleted at an alarming rate and an increasing number of borrow pits are being opened in the search for good quality gravels Fortunately attitudes to the environment have changed quite markedly in recent years and many governments have become aware that, in the long term, environmental conservation and economic development are mutually reinforcing. It is now abundantly clear that more sustainable solutions are needed, for example, the depletion of gravel can be arrested if a sealed surface is provided for LVRs.

Typical causes of environmental concern include:

- Inadequate planning – e.g. environmental impacts are not considered in appraisal procedures
- Design defects - little or no allowance is made for dealing with environmental impacts on site
- Poor project documentation - e.g. contracts that make it difficult to enforce environmental measures
- Weak institutions – e.g. insufficient legal backing to implement environmental measures.

To address these issues, environmental audits are being introduced. Such audits provide an understanding of the linkages between society, the natural environment and the sustainable use of resources. The causes and effects of environmental impacts need to be recognized and envi-

ronmental management needs to be extended to all road construction operations. Understanding the environmental issues at both local and national level is an essential requirement for good design of LVRs and the *Guideline* provides advice on this.

5.4 Politically supported

This is always an essential requirement for sustainability. However, there is always a tendency to avoid perceived risk and to favour conventional methods and conventional technical solutions. Consequently, there is a continuous need to engage in dialogue with political and public stakeholders to promote alternative solutions, which, in some cases, might be significantly different from accepted practice. Such arguments should be based on their proven performance in the region. The approach adopted for the development of the *Guideline* was essentially part of this process but continuous promotion will be required until the methods are fully enshrined in country specifications and standards.

5.5 Socially acceptable

The importance of rural roads extends to all aspects of the economic and social development of rural communities yet it is rare in developing countries for road authorities to consult in a serious manner with the local people about the planning, design, construction or the maintenance of these roads. However, where this has been done the outcomes have invariably been beneficial [14]. Such matters as the use of labour-based methods for construction and for ongoing and community-based maintenance, provision for safer crossings, consideration of specific types of non-motorised vehicles and pedestrians, encouragement of small-scale contractors, etc. are just some of the issues that can be improved through local consultation.

Consultations with stakeholders at all stages of the project cycle have been found to be of paramount importance to ensure that local perceptions, attitudes, values and knowledge are fully taken into account. Such consultations also promote a continuous feedback process that is made an integral part of all development activities. Insufficient consultation can lead to the inappropriate use of resources both in terms of usefulness to rural communities and impact on social and cultural activities.

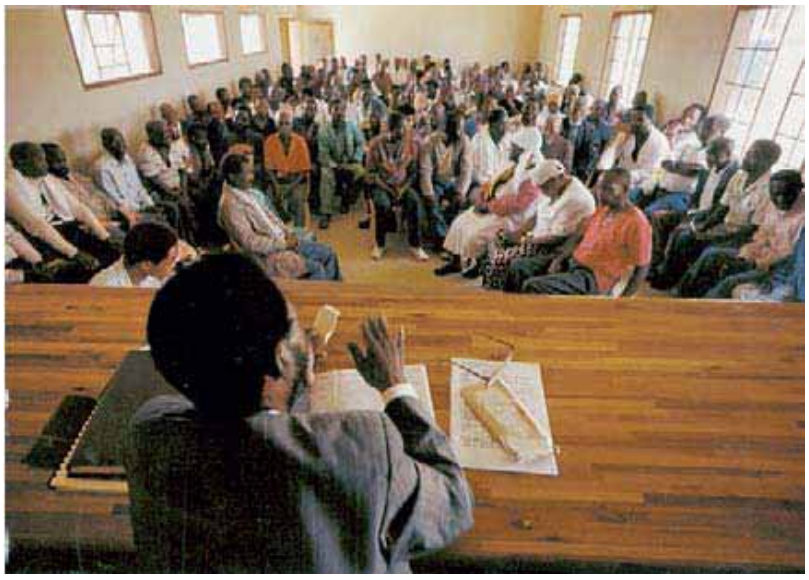

Photo 2: Consultations with stakeholders

Examples of appropriate planning techniques include Integrated Rural Accessibility Planning developed by the International Labour Organisation (15) which integrates the mobility needs of rural households, the siting of essential social and economic services and the provision of appropriate transport infrastructure. Another example is the 'Sustainable Rural Livelihoods' approach that is useful for identifying the impacts of any particular investment on the lives of the local community. Based on experiences in the region, the *Guideline* provides advice and references to deal with these issues.

5.6 Institutionally possible

The capabilities of the public sector institutions responsible for roads in many countries in the region have been inadequate for various reasons, with the result that roads have been provided in a relatively inefficient and costly manner. Current institutional reform in the region is concerned with improved management of the road infrastructure and is also closely connected with the problem of securing adequate and stable funding. Solutions include a more commercialized approach to the provision of LVRs that fosters greater efficiency (Figure 6).

New management structures are being introduced in several of the countries in the region and in most cases this entails the reduction and eventual phasing out of public sector, force account (i.e. in-house) operations in favour of contracting out to the private sector and, ultimately, the establishment of more autonomous roads authorities. It is perhaps too early to say how successful this will be in the long term - there are still many problems to solve – but the process is underway and the timing is right for publication and promotion of the *Guideline*.

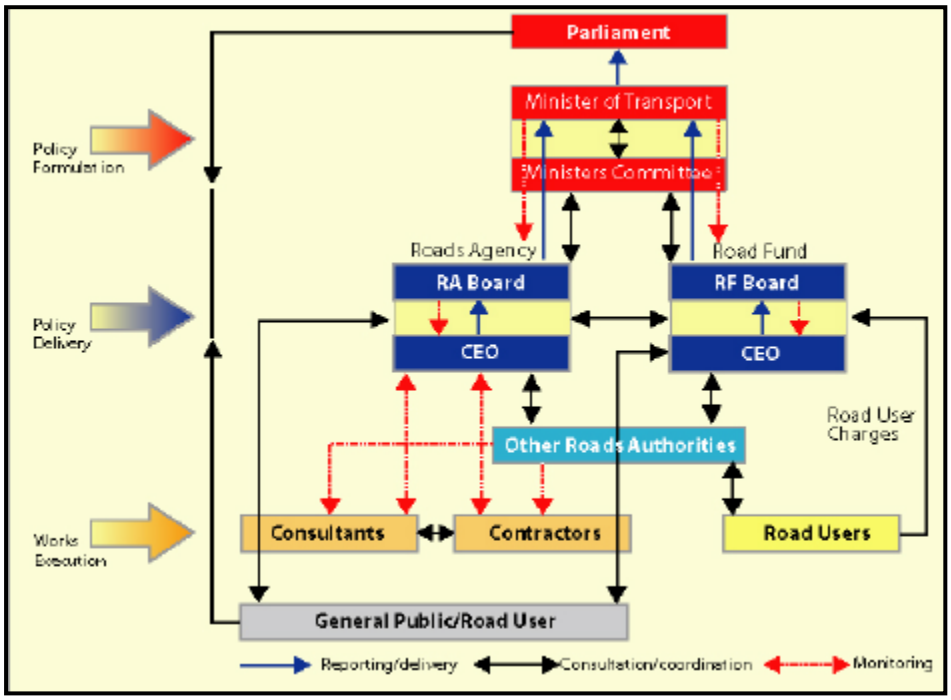

Figure 6: SADC institutional framework for management and financing of roads [16].

6. PATHWAY TO IMPLEMENTATION

The benefits of the Guideline will only be achieved if the approaches recommended are implemented in the first instance. However, the path from research to implementation is a tortuous and time-consuming one. It has been estimated that in engineering, in each of the steps in the pathway which begins in attaining funding for research through to implementation, the magnitude of difficulty increases by a factor of between 2 and 8. These activities include carrying out the research, processing the recommendations, developing standards, disseminating the information to actual implementation. Thus, it can be quite difficult to get the results of engineering research put into practice, despite the evidence that very large savings can accrue, where this has been done.

The implementation pathway can be accelerated by understanding the process that is involved in technology transfer, identifying the likely obstacles to such transfer and then adopting a strategy that seeks to mitigate them. Figure 7 presents a model of the technology transfer process as it applies to the LVSR Guideline [17].

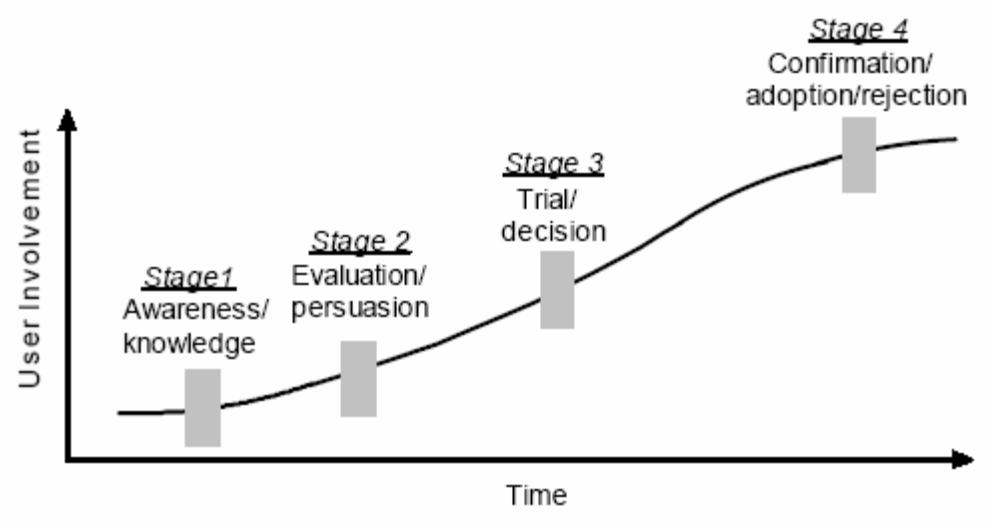

Fig. 7: Phases in uptake/adoption of new technology

Stage 1: Initial awareness raising and subsequent consensus on the need for developing the guideline.

Stage 2: Undertaking and evaluating the results of regional research, including obtaining "buy-in" for implementation through the process of stakeholder involvement in the development of the Guideline.

Stage 3: Modifying conventional specifications and contract types to suit local conditions and undertaking demonstration projects to engender support from all stakeholders to embrace the new approaches embodied in the guideline.

Stage 4: Confirming or rejecting the recommendations of the guideline based on stakeholders perceptions of the substantial potential benefits of implementing the recommendations of the Guideline.

Resistance to change remains an obstacle, but the implementation process can be accelerated by adopting a well-managed strategy to overcome various obstacles which are discussed below.

6.1 Overcoming obstacles

Policy

- It is important that the key messages from this Guideline on the ***benefits*** to be derived from LVSRs are included in the debate leading to the development of a policy document. The policy should cover such issues as poverty alleviation, employment creation, technology choice, etc. The outcome of this process will dictate the type of planning system that is most appropriate.

Political and public perceptions

- More effort needs to be expended on educating politicians and the general public as to the basis on which technical standards are determined so that they are more readily accepted in practice. Ranking policy changes according to their political costs and benefits can help policy makers obtain support from politicians and the general public.

Axle load control

- Effective control of overloading requires a strong political will which is sometimes not evident. The move towards new methods of overload control, as contained in the SADC memoran-

dum on Vehicle Loading, provides a strategy for substantially reducing overloading which is costing the region dearly in terms of premature distress of road infrastructure.
However, whilst overloading decreases the life of all road pavements, there is now evidence that for some pavement structures, the damaging factor may be less than that predicted by the 4^{th} power law. This may also be a contributing factor to the better than expected performance of many natural gravel road bases.

Risk

- The perceived risks associated with the use of non-standard materials and non-traditional designs often reflect the gap between written knowledge in country manuals, (often outdated) and standards and specifications (often imported and inappropriate) and more recent knowledge acquired through applied research. More frequent updating of country documentation would reduce the perception that more recent approaches are more risky rather than being more appropriate and reflecting current knowledge. The improved knowledge of the environmental influences on pavement performance together with the holistic approach recommended in the *Guideline*, enable the perceived risks associated with the use of less conventionally accepted designs, practices and materials to be sensibly managed and for many more un-surfaced roads to be sealed economically without additional risk.

Social

- Where labour-based operations are indicated, governments will need to make a clear policy commitment for change. This will call for special institutional arrangements, comprehensive planning as well as effective managerial and administrative systems and procedures.

Institutional

- In countries where reforms and institutional changes have been introduced in road management and financing, these have tended to have had a positive influence and have resulted in improved efficiencies and more effective management of road networks. Such reforms are to be encouraged.

Technical

- It is vital that designs appropriate to local conditions and road users are applied, that local research-based knowledge is adequately reflected in standards and that specifications for the use of locally available materials reflect their performance in local environments. The use of imported standards leads to unnecessarily costly solutions that impede investment in developmental projects. Country documentation for road provision needs to be reviewed and updated.

Economic

- Appraisal methods are being developed that include the benefits to non-motorised users and research is being undertaken to quantify the social benefits associated with LVSR provision. It is important that the methods used to appraise investment in rural road projects include these factors.

Financial

- Historically, funding assigned for essential activities to preserve investments in the road sector was often diverted to other sectors with, in some cases, the premature failure of roads that were essential to a country's economy. Where reforms have been implemented, dedicated funding is now made available from fuel levies and other sources to supplement national budgets and these funds are managed in a way that assures that essential activities are carried out as part of a planned strategy of asset management and such reforms should be encouraged.

Environmental

- Road projects often have an adverse impact on the local environment. Measures are available which mitigate these impacts. The establishment of a government body and regulations to address

environmental issues, including those related to road provision should be expedited, if not already in place.

7. SUMMARY

Research has shown quite clearly:

- that traditional highway engineering, applicable to roads with higher volumes of traffic, is not appropriate for rural roads in developing countries;
- the importance of adopting more holistic, sustainable approaches 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, test methods, for assessing the adequacy of local materials for rural roads;
- the advantages of adopting more appropriate but safe 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.

The Guideline not only identifies and explains the results of the research but specifically identifies and addresses the challenges faced by road authorities in adopting the results. Perhaps one of the most important outputs of the research, combining many of the results and innovations of the last few years, is that it can now be shown to be justifiable to provide a sealed (or bituminous-surfaced) road rather than a gravel road at traffic levels that are very much lower than hitherto (Photos 3 and 4).

Photos 3 and 4: Gravel versus bituminous surfacing

The *Guideline* also provides a source of comprehensive references and bibliography of local and international experience. It is produced in a loose-leaf format to allow for updating, in electronic CD format, and is posted on the SADC website www.sadc.int. The *Guideline* has been produced in English, French and Portuguese.

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 in the provision of low-volume roads.

Thus the *Guideline* is designed to provide an easily 'digestible' synthesis of practical, state-of-the-art approaches to rural road provision based on regional knowledge and experience, but also taking account of international best practice.

The *Guideline* primarily reflects the needs of the SADC region and the prevailing environments in which local roads are provided, including the different types of road users but the concepts are also more widely applicable. It is expected to lead to an increase in sealed roads constructed at an affordable cost and to an appropriate standard.

In justifying the construction or rehabilitation of such roads, the benefits of each are estimated according to the principles outlined in the *Guideline* itself. The economic benefits alone are often sufficient to justify the investment, but when social benefits are also included the case for the adoption of the *Guideline* becomes unassailable, even at very low traffic levels.

The principle beneficiaries are the rural communities whose livelihoods are at their most vulnerable when road access is poor, affecting agricultural output, health, inter-community access to family and friends, education and, indeed, all services that depend on the road network. At district level, the target institutions are the implementing authorities charged with responsibility for building and maintaining the road network, the local small-contracting community and the communities themselves, many of whom maintain their own roads or are employed by local labour-based contractors. Other stakeholders that benefit are central Ministries, Rural Roads Departments, labour-based contracting associations and the like.

Although the *Guideline* was conceived to address problems associated with rural roads, the concepts are equally applicable to any roads carrying relatively low volumes of traffic, for example many roads in urban and peri-urban areas, village and township roads.

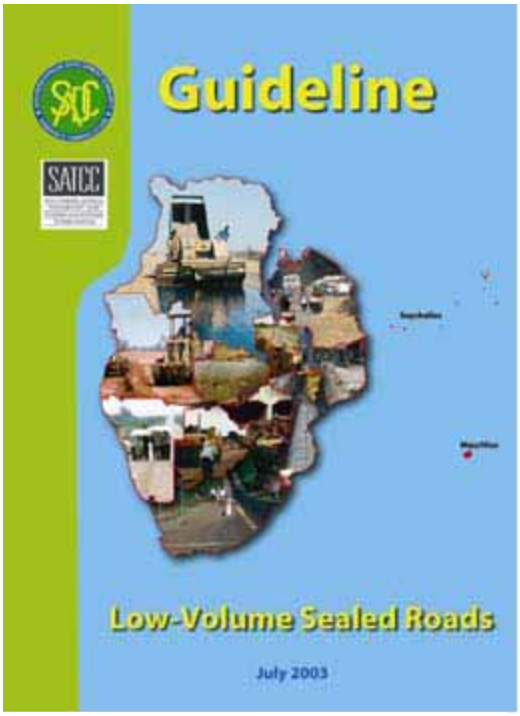

Fig. 8: The SADC Guideline on Low-Volume Sealed Roads

8. ACKNOWLEDGEMENTS

The production of the *Guideline* has been a team effort involving experts and practitioners from many countries. Key contributors are acknowledged in the *Guideline* document but the authors of this paper wish again to acknowledge the contributions made by the many individuals, both international and those representing the SADC member states, to the SADC officials and to the donors whose funding made it possible.

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