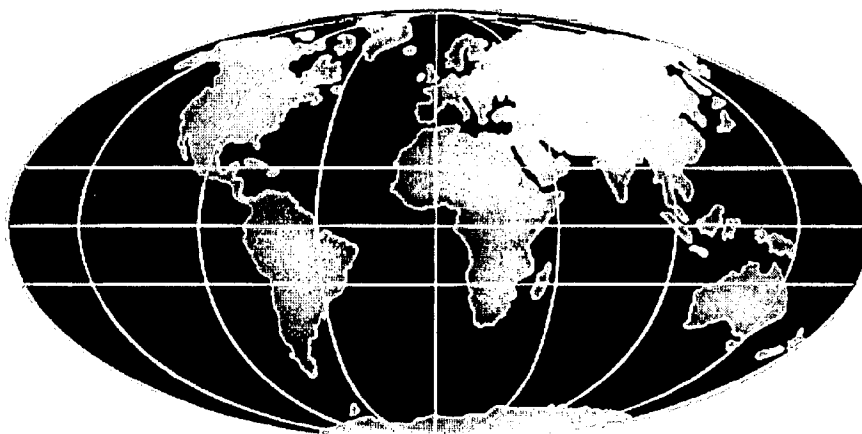


**TITLE:** Improving local resources utilisation in  
roadworks in developing and emerging  
countries

**by:** C S Gourley, R Petts and T Toole



PA3674/01 GOURLEY, C S, R PETTS and T TOOLE (2001). **Improving local resources utilisation in roadworks in developing and emerging countries.**  
*XIVth IRF World Meeting - Palais de Congress, Paris, France, 11 June 2001.*

# IMPROVING LOCAL RESOURCE UTILISATION IN ROADWORKS IN DEVELOPING AND EMERGING COUNTRIES

C Gourley, R Petts and T Toole

## ABSTRACT

Developing and emerging economies are characterised by a resource base that is fundamentally different from that found in developed countries. For example, unskilled and semi-skilled labour is abundant and relatively cheap (wages less than US\$5/day) in many African, Asian and Central/South American economies. This contrasts starkly with the costs and resources associated with supporting import-dependent heavy civil engineering plant which now make the equipment intensive approach unsustainable for many road construction and maintenance operations in developing countries.

Furthermore, experience over the past twenty to thirty years in developing countries has shown that conditions, standards and work practices in the road sector differ considerably from those in developed countries. Use of local resources can be far more cost effective and appropriate. From a broader economic, political and social perspective it makes more sense to seek optimal use of locally available resources before importing expensive equipment, materials and expertise on a large scale. Maximising local capacity, particularly if adopted as part of a broader strategy aimed at reducing the costs of providing and maintaining infrastructure, can lead to significant increases in the mobility and access to services of rural and urban communities. Coupled with more flexible approaches to the provision of road maintenance and construction services, sustainable employment opportunities become a distinct possibility beyond the initial resource-intensive building period.

Arguably, improving local resource utilisation requires greater understanding and deployment of effective technical and organisational skills than when modern, so-called "state of the art" approaches are employed. It is also now widely recognised that in most cases the technologies and approaches taught in standard, developed country educational curricula do not meet the requirements of developing countries. Engineers and managers, need to make the most rational choices of technology and implementation and this requires an awareness of needs and real costs, as well as an appreciation of the economic and social dimensions. There is, therefore, a need to "mainstream" approaches that will encourage better utilisation of local resources and develop the necessary capacity and user confidence in their application.

This paper presents the rationale for, and reviews progress towards better local resource utilisation in roadworks. It describes current and recent initiatives in the field and provides specific examples of the potential benefits of adopting appropriate standards and priorities, the impact of quality standards on subsequent performance and cost-effectiveness, and the relative productivity of alternative equipment and labour technologies.

The paper discusses the following issues:-

- Labour based roadworks and Intermediate equipment
- Effective use of resources
- Priorities for rural roads
- Current developments and future requirements

The examples are primarily viewed from an engineering and economic perspective and focus on the provision and management of unpaved roads, although the general principles and issues also have wider application.

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## IMPROVING LOCAL RESOURCE UTILISATION IN ROADWORKS IN

## DEVELOPING AND EMERGING COUNTRIES

C Gourley<sup>1</sup>, R Petts<sup>2</sup> and T Toole<sup>1</sup>

(1: TRL Ltd, 2: Intech Associates)

### 1. INTRODUCTION

Developing and emerging economies are characterised by a resource base that is fundamentally different from that found in developed countries. For example, unskilled and semi-skilled labour is abundant and relatively cheap (wages less than US\$5/day) in many African, Asian and Central/South American economies. This contrasts starkly with the costs and resources associated with supporting import-dependent heavy civil engineering plant which now make the equipment intensive approach unsustainable for many road construction and maintenance operations in developing countries.

Furthermore, experience over the past twenty to thirty years in developing countries has shown that conditions, standards and work practices in the road sector differ considerably from those in developed countries. Use of local resources can be far more cost effective and appropriate. From a broader economic, political and social perspective it makes more sense to seek optimal use of locally available resources before importing expensive equipment, materials and expertise on a large scale. Maximising local capacity, particularly if adopted as part of a broader strategy aimed at reducing the costs of providing and maintaining infrastructure, can lead to significant increases in the mobility and access to services of rural and urban communities. Coupled with more flexible approaches to the provision of road maintenance and construction services, sustainable employment opportunities become a distinct possibility beyond the initial resource-intensive building period.

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issues also have wider application.

## 2. TERMINOLOGY

Before, progressing further, it is useful to define some of the terminology used in this paper. The various definitions and interpretations of terminology used in the appropriate technology roadworks sector are given in Box 1.

### Box 1: DEFINITIONS

The following definitions are used based on Petts (1997):

#### **LOCAL RESOURCES:**

These can include human resources, local government, private, NGO and community institutions, local entrepreneurs such as contractors, consultants, industrialists and artisans, local skills, locally made or intermediate equipment, local materials such as timber, stone, bricks, and marginal materials, locally raised finance or provision of materials or services in kind.

#### **LABOUR BASED ROADWORKS\*:**

Operations carried out principally by manual methods. They may be supported by intermediate equipment for activities not ideally suited to labour methods, e.g. medium-long distance haulage and heavy compaction. Labourers usually walk or cycle to work each day from their homes. By contrast, a truck transporting labour from a camp or depot to the work site on a daily basis to carry out manual activities is an *EQUIPMENT BASED* system; the truck is the major cost component and if it is not available every working day, then the system is compromised.

#### **LABOUR BASED CONTRACTOR:**

An individual labour contractor, a labour-only contractor or a contractor principally using labour but who owns or hires-in intermediate equipment for certain activities.

#### **LABOUR EXTENSIVE ROADWORKS:**

Large numbers of labour used for various roadworks activities with the prime objective of creating temporary or permanent employment rather than achieving sustainable efficient systems.

#### **INTERMEDIATE EQUIPMENT:**

Simple or intermediate equipment designed for low initial and operating costs, durability and ease of maintenance and repair in the conditions typical of a limited-resource environment, rather than for high theoretical efficiency. It is preferable if the equipment can also be manufactured or fabricated locally. Examples of Intermediate Equipment are agricultural tractors, trailers, towed graders and other tractor towed items, pedestrian rollers.

#### **HEAVY EQUIPMENT:**

Sophisticated civil engineering equipment designed for, and manufactured in, high-wage, low-investment-charge, economies. Expected to operate with close support and high annual utilisation. Usually designed for a single function with high efficiency operation. Examples of Heavy Plant are motorgraders, dozers, front end loaders, traxcavators, specialist dump trucks, self propelled rollers.

*\*This term is adopted for this paper as most closely representing the efficient labour roadworks programmes in the experience of the authors.*

## 3. LABOUR BASED ROADWORKS

Under the active encouragement of the International Labour Office (ILO) and other agencies, labour based (LB) roadworks (as opposed to labour extensive roadworks) have been introduced to about 35 countries in Africa and Asia over the last three decades. This is not to say that these methods are something new or relatively limited in extent. Some countries, notably around the Indian sub-continent and Asia, have always applied LB roadworks where,

due to the prevailing economic and social conditions, the approach is the most appropriate for the majority of roads.

The reintroduction of LB methods in other countries has been caused partly by the recognition of the potential social, financial and economic advantages of these methods. However, in many cases it has been the increased recognition through experience, that in many countries or regions, it can be difficult or impossible to support and maintain imported sophisticated heavy equipment. There is also now a general willingness amongst certain development agencies to support appropriate technology roadworks programmes and this has also helped to bring about an increasing opportunity for change.

Labour based roadworks have had their greatest successes with construction and rehabilitation projects. The inherent policy, institutional, management and funding problems of road maintenance have, in part, constrained the success rate of LB maintenance works to a more modest scale. The efficiency and sustainability of road maintenance systems in the developing world is expected to improve as more countries decentralise activities and support these through dedicated funds allocated through the Road Boards.

An example of success with a LB approach has been the construction/rehabilitation of some 11,000km of gravel standard roads under the Rural Access and Minor Roads Programmes (RARP & MRP) in Kenya since 1974. This represents almost 20% of the national classified road network. The roads were brought under a routine maintenance lengthman system using labour living alongside the roads. Kenya is now preparing for a national programme to extend labour based methods (supported with agricultural tractors) to the majority of its approximately 55,000 km unpaved classified road network. This programme will involve a radical shift from using the traditional 100% construction/rehabilitation approach to implementation of a partial rehabilitation/spot improvement strategy supported by the establishment of an effective system of routine maintenance. The programme will also attempt to move from a largely direct labour management system to the development and establishment of an effective small scale local contracting capacity. The approach recognises the need for a change in focus from building new roads and carrying out full rehabilitation works, to maintenance and ensuring basic access and passability on the existing network. It also recognises the limitations of available financial and physical resources and at the same time fits well with local and international poverty alleviation and sustainable livelihood strategies. This change in direction will necessarily be forced on many other emerging and developing countries.

There is now an increasing cadre of engineers and managers in many developing countries with direct experience of labour based roadworks methods. This, and increased confidence of the approach within the development community, has helped to overcome earlier prejudices within the engineering fraternity.

#### **4. INTERMEDIATE EQUIPMENT**

Intermediate equipment often is, or can be, manufactured locally to meet some of the needs of the roadworks sector. It can be tractor-based, self propelled, animal drawn or hand operated. Capital costs of local manufacture can be significantly lower than importing more sophisticated equipment and plant. Other potential benefits include easier maintenance, lower operating costs and the added advantage of increasing the local manufacturing capability (which creates local skilled employment). This in itself should encourage greater

sustainability, lower financing costs and increased capacity than would come with sole reliance on sophisticated imported equipment and technology. Box 2 outlines some of the operational, support and technical problems met when using inappropriate technologies and plant.

<p style="text-align: center;"><b>Box 2</b></p> <p style="text-align: center;"><b>PROBLEMS OFTEN ASSOCIATED WITH SOPHISTICATED IMPORTED EQUIPMENT</b></p> <p><b>Operational:</b></p> <ul style="list-style-type: none"><li>• Dedicated function (can only be used for one operation)</li><li>• Inter-dependence (e.g. dozer, loader, trucks, motorgrader, bowser, roller all required for gravelling – what happens when ONE link in the chain breaks down?)</li><li>• Lack of continuity of workload for plant items of dedicated function</li></ul> <p><b>Technical:</b></p> <ul style="list-style-type: none"><li>• High pressure hydraulic systems</li><li>• Sophisticated mechanics and hydraulics</li><li>• Disposable components; difficult to repair or refurbish</li></ul> <p><b>Local Support:</b></p> <ul style="list-style-type: none"><li>• Limited local market for equipment sales of each model</li><li>• Specialist repair and maintenance skills, tools and facilities required (often only available in the capital city)</li><li>• Few dealers able to provide the necessary close support</li></ul> <p><b>Cost:</b></p> <ul style="list-style-type: none"><li>• All equipment and spares imported – consuming scarce foreign exchange</li><li>• High capital and finance costs</li><li>• High costs of stocking and provision of spares</li></ul> <p><b>Equipment Maintenance:</b></p> <ul style="list-style-type: none"><li>• Long spares supply lines and delivery times</li><li>• Frequent model “improvements” causing spares stocking and procurement problems and “planned” obsolescence</li></ul>
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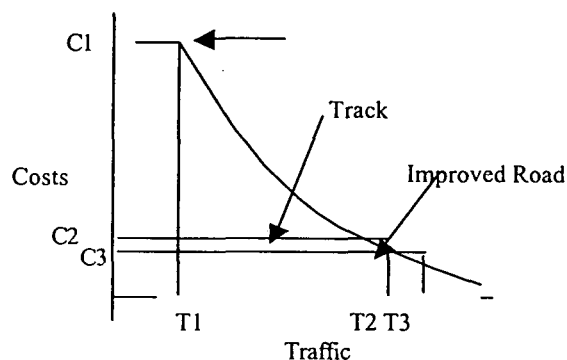
## 5. EXAMPLES OF THE EFFECTIVE USE OF RESOURCES

The challenge for today's planners and engineers is to maximise the efficiency of both minor and main roads within available budget constraints, and thereby contribute to increased economic activity and productivity. Considerable evidence exists in the form of case study examples and sound principles to guide recommendations in this area. These are considered under the headings of maintenance approach, construction operations and equipment selection. Most importantly, the examples quoted are to a large extent practical, and in many cases fully within the remit of the planner and contractor. In each case they significantly affect the cost and durability of the end product.

**Maintenance Approach:** Hine (1993), using evidence collected from a study in Ghana, suggests that the benefits of adding a new vehicle access using simple methods is over one hundred times greater, from the viewpoint of farmers, than upgrading a similar length of earth track to gravel standard. This study looked at the effect of access standards on farm gate prices, and produced the results summarised in Table 1 below and graphically represented in Figure 1.

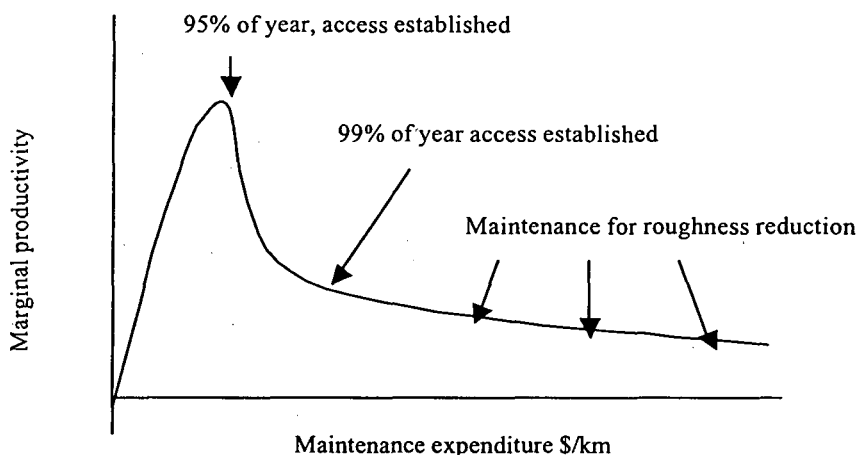
	Length of access to be upgraded	
	5 km	20 km
Upgrade from earth to gravel road	0.08	0.29
Upgrade from path to earth road	11.4	70.6

**Table 1**  
Percentage increase in farm-gate price of maize with improved access



**Figure 1**  
Graph of Cost Effectiveness of Upgrading to a Motorable Track

For the most lightly trafficked roads, adoption of a spot improvement approach to facilitate road access for most of the year, rather than adoption of traditional roughness reducing measures have been shown to be a very efficient method to best use scarce financial and engineering resources. Ellis and Hine (1998) have demonstrated how the approach can produce maximum productivity benefits.



**Figure 2** Graph of Cost Effectiveness against Standard of Road

This is illustrated in Figure 2. In this example 'Marginal Productivity', defined as the 'economic gain per incremental increase in maintenance expenditure', is maximised by the provision of access for 95% of the year. That is, acceptance of accessibility except on a few days when through a combination of climatic and soil conditions vehicular access is not permitted or possible. Costs are likely to be of the order of a few hundred dollars per kilometre for interrupted access, whereas near guaranteed access requires higher expenditure, perhaps 2 or 3 times more, which produces significantly lower benefits. Finally, roughness reducing measures produce the lowest benefits per \$ of investment.

The careful selection of granular surfacing materials combined with the application of sufficiently frequent routine grading and dragging can significantly reduce periodic maintenance expenditures, and total costs' (Toole 1987). This is shown in Table 2 in terms of the relative wear rates of calcareous materials in Botswana. The effectiveness of routine maintenance to roughness reduction is generally well documented, and virtually no benefits



with respect to material loss were estimated.

Material Type	Strategy	ML Per Year Per 100 VPD	Relative water rates
Plastic Gravel (Calcrete)	No Maintenance	20	1.0
	Wet season light grading (1 in 11,000 Vehicle passes)	13	0.7
	Sheeting & light grading (1 in 3,000 Vehicle passes)	6	0.3
Clayey sand (calcified Sand)	No Maintenance	41	2.1
	Wet season light grading (1 in 11,000 Vehicle passes)	18	0.9
	Sheeting & light grading (1 in 3,000 Vehicle passes)	13	0.7

Table 2 Rate of material loss related to maintenance strategy and material type

Simply increasing the camber of an unpaved road to 6 per cent, or so, and restoring this through maintenance operations, can extend the maintenance cycle by a factor of 4 or 5 (Rolt 1979). This finding was determined during the early years of the Kenya Rural Access Programme and has been used to justify cross sectional standards ever since.

**Construction Operations:** If adequate water is not mixed with the materials prior to compaction, maximum roughness levels may be attained after one fifth the normal time (traffic) (Toole 1987). The effect of compaction moisture content on the performance of a series of trial sections of unpaved roads constructed in Botswana is represented in Figure 3.

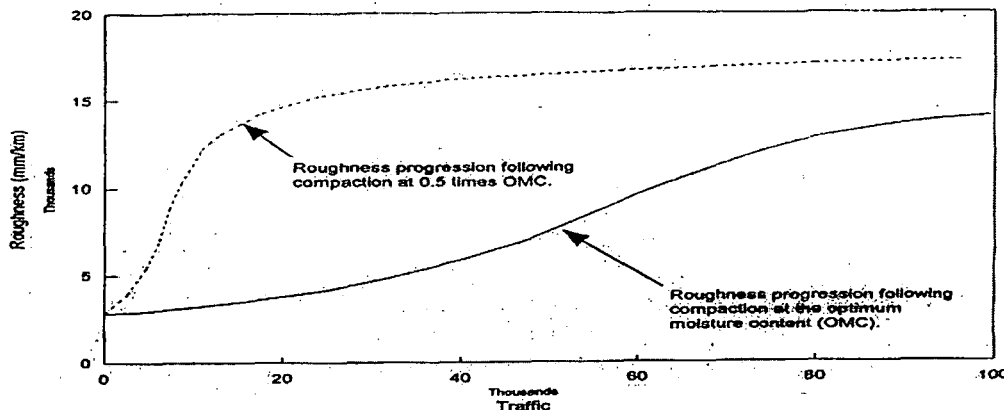


Figure 3 Effect of compaction moisture content on roughness progression

The rate of roughness increase is modified by a function of the ratio of the compaction moisture content to the optimum moisture content. At the site of the trials, traffic chose to drive along adjacent sand tracks if the roughness levels approached 15 m/km IRI.

**Equipment Selection:** Locally or regionally manufactured towed graders can provide an effective substitute for light motorised graders in many circumstances at approximately one quarter of the cost of a conventional approach. Taking due account of productivity levels, resulting savings can be up to 50% per km of road. In other words, twice the length of road can be maintained for the same money (Jones and Robinson 1986). This finding was derived from TRL studies in Kenya that examined the technical performance of alternative equipment, the availability and productivity and costs. The results are illustrated in Table 3 and Figure 4.

Type	Availability	Output (km/Day)	Cost (US\$/Km)
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Motor Grader	30	2	280
Towed Grader	60	1	75

Table 3 Comparison of Tractor-Towed and Motor Graders

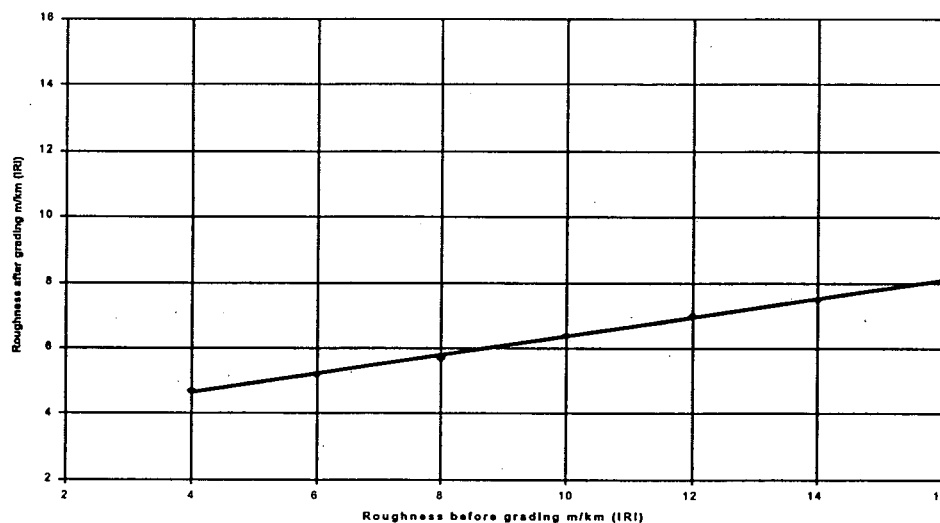


Figure 4 Effects of grading on roughness (Kenya: Motor and Towed Graders)

This is confirmed by a more recent study in Zimbabwe (Intech, 1998) which found that the total cost of the District Development Fund (DDF) routine maintenance system for gravel roads based on tractor and labour methods was US\$260/km/year. This includes all overheads, financing costs and depreciation. This is cheaper than the cost of just *one* motorgrading operation. The system has been established on a network of some 25,000 km.

The availability and careful selection of compaction plant and availability of water can improve output by five or six times (Greening and Toole 1998). This finding was derived from the re-analysis of compaction studies carried out by TRL (Parsons 1992). A series of compaction trials were carried out on a wide variety of compaction plant and soils. These included light and heavy cohesive soils and well graded granular materials, with compaction moistures varying from optimum to dry. Table 4 demonstrates the inefficiency of compacting dry of the optimum moisture both in terms of the passes required and output per hour. The impact of dry compaction on the performance was considered earlier.

Roller Type	Load (drum)	Light Cohesive Soil		Heavy Cohesive Soil		Well Graded Granular Material	
		Opt	Dry	Opt	Dry	Opt	Dry
9 tonne Smooth Deadweight Roller	3.5 T/m	6 (105)	NS	3 (210)	6 (105)	2 (210)	8 (52)

9.3 tonne Smooth Vibrating Roller	2.4 T/m	4 (170)	8 (85)	4 (170)	6 (57)	4 (165)	16 (42)
20 tonne Self Propelled Roller	2.5 T/wheel	4 (253)	NS	4 (259)	8 (65)	4 (260)	16 (43)

Notes: 1.Number of passes for 95% Proctor Density for a 150 mm layer. 2.Output (m3) per hour. 3.NS – not suitable (>16 passes required or ground too soft).

**Table 4. Comparison of Typical Compaction Plant**

Although few results exist from controlled trials, some evidence does exist to provide confidence in the suitability of intermediate plant.

ROLLER	Load	Measured No. of Passes for 95% Proctor MDD at OMC	Estimated No. of Passes for 95% Proctor MDD (output (m3) per hour)	
			Cohesive	Granular
Hand or Animal Drawn Roller (Kenya)	Empty – 0.6 T/m Loaded – 1.4 T/m	8 – 12	Not tested	Not tested
Tractor Towed Smooth Wheeled Roller (Kenya)	Empty – 3.1 T/m Loaded – 3.7 T/m	8 – 12	6 (120)	2 (480)
Tractor Towed Ribbed Roller (Kenya)	Empty – 3.2 T/m Loaded – 3.8 T/m	8 – 12	6 (120)	2 (480)
Twin Drum Pedestrian Operated Vibrating Roller	0.4 T/m	6 – 8	NS ?	3 (50)
Twin Drum Pedestrian Operated Vibrating Roller	0.7 T/m	6 – 8 ??	NS ?	2 (135)

**Table 5 Performance of Intermediate Compaction Equipment**

Drawing on the results of work reported by Greening and Toole (1998) presented in Table 5, the following conclusions can be made. Although the hand drawn and animal drawn rollers were lighter than the equipment used in earlier TRL trials using conventional equipment (Parsons 1992), the number of passes required to achieve the density is still of an acceptable order to make the equipment feasible. The results also indicate the substantially greater productivity of tractor towed equipment, between 3.5 and 9 times more than vibratory equipment for granular soils and 3 times greater for cohesive soils.

## 6. PRIORITIES FOR RURAL ROADS

Encouraging the adoption of appropriate standards for road investment which aim to meet minimum social, economic and technical objectives and maximise use of local resources is essential if rural roads are to be affordable. The main priorities that should be considered are set out in Box 3.

### Box 3 RURAL ROADS

**Priority should be given to:**

- providing and maintaining basic access for all road user groups
- optimising economic solutions as higher traffic levels demand
- consideration of spot improvements where access difficulties are concentrated at specific locations, such as watercourse crossings and steep hill sections.
- adoption of affordable and sustainable engineering standards and technologies
- appropriate quality control for all operations
- identifying and agreeing with all stakeholders the maintenance and rehabilitation tasks which are 'ESSENTIAL' in order to meet policy objectives (i.e. poverty alleviation and sustainable basic rural access)

## 7. LOOKING AHEAD

In the late 1970's it was considered that labour based methods could be financially viable for roadworks with a daily labour wage of US\$4 or less (World Bank Labor and Capital Substitution Studies). In the intervening years many countries have seen their economies stagnate or even retreat in per capita terms and they still fall within this wage rate criteria. At the same time dollar-based equipment inflation has continued to widen the gap between the actual unit costs of labour and capital equipment in many countries. Worsening terms of trade and the poor mechanical support environment have helped to push up the real cost of owning and operating imported, sophisticated, heavy equipment in these countries.

In South Africa LB public works programmes are being established. Even with daily labour tasks of up to about US\$ 10 equivalent, they are still considered to be competitive in *financial* terms with equipment based methods for some operations. The increased overhead management costs of LB methods will not become clear until these systems are fully established, and all start up, overhead and training costs are appreciated. However political, social and other benefits could significantly influence the equation.

We should of course be looking very closely at the *economic and social benefits* of using local labour and other resources as opposed to imported technology. The benefits of employment would arise both directly in the road sector and also indirectly in other sectors. For example, improved employment may generate potential socio-economic benefits through lower crime rates and policing/detention costs, and the related encouragement of investment. There are also obvious national benefits from developing the potential for local manufacturing of hand tools and intermediate equipment.

In consideration of the foregoing it is suggested that any country with a daily agricultural wage rate of less than US\$15 per day should seriously consider the financial, economic, industrial, social and political issues and consequences of a more labour based approach to roadworks. Such criteria would extend the potential for efficient labour based roadworks far beyond the current areas of practice and potentially into areas such as much of Eastern Europe, the former Soviet Republics, and much of South America. Intermediate equipment is often manufactured or widely available in emerging countries, particularly in the agricultural sector. Tractors are already established in many countries, however their current restriction of use to the agricultural sector usually suffers from low utilisation and high unit costs. There

seems to be a significant potential to expand the availability of tractor attachments and operations into other sectors such as rural roads and water (earth dams and pipelines). This in itself would raise utilisation and lower unit costs. The technology is particularly suitable for use by local contractors in view of its flexibility, lower capital and operating costs when compared to sophisticated equipment. It also provides an affordable and manageable progression for successful labour based enterprises (Petts 1997). Certain trends can be expected to continue or develop in the foreseeable future. These include:-

**Less money.** With the ending of the east-west cold war, many more countries are competing targets for aid funding. Internally, it is also likely to become harder to secure finance for new roadworks programmes as priorities are refocused and economies re-structured. Furthermore, more rigorous systems of appraisal and criteria may necessitate additional efforts to obtain funding.

**Construction to Maintenance:** The trend from construction of new roads, to rehabilitation and maintenance of the existing network will probably continue, in view of the poor state of many existing roads, the high benefit-cost ratio of maintenance works and the high cost of construction.

**Full to Partial Rehabilitation:** As an extension of the above trend it is expected that more emphasis will be placed on partial rehabilitation and spot improvement to spread the benefits of the available limited resources and funds.

**Direct Labour (Force Account) to Local Private Sector:** With the increasing problems of operating efficiently in the civil service organisations, there will probably be continued national and international agency pressure to move to parastatal management/operations and the development of the private sector. However the benefits of a well managed and motivated force account organisation should not be overlooked for some operations.

**Transfer of Responsibilities to the Local Communities:** Labour based and intermediate equipment methods are ideally suited to local or community implementation. There is likely to be a planned or *de facto* transfer of responsibility for tertiary networks to local communities, due to the lack of financial and physical resources and management capacity in central government organisations.

**Urban, Peri-Urban and Unplanned Settlement Growth:** With the growth of unemployed and under-employed people in and around the urban centres of developing countries, there will be pressure to provide facilities and infrastructure for them. Appropriate technology road and drainage works will have an important role in satisfying these needs as well as demand for employment.

## 8. ESTABLISHING THE ENABLING ENVIRONMENT

There are a number of constraints that need to be tackled to enable successful development of labour based and intermediate equipment roadworks methods. The initiatives required include:

**Motivation of sector managers and implementers:** There has been an unrelenting decline in the real remuneration of this cadre of personnel in many emerging and developing countries over the last three decades (Robinson 1990). This disastrous deterioration must be arrested and reversed if any system of road technology and

management is to achieve success and sustainability in the future. Appropriate approaches to human resource development and training need to be established on a sustainably funded basis. Management structures need to be adapted to current needs.

**Evaluation and Planning Tools:** Decision makers involved with road network planning and management require improved access to tools for evaluating appropriate technology roadworks options. These should include guidelines at policy and implementation level concerning economic, social, local industrial and political issues, as well as purely financial comparisons.

**Appropriate Standards:** Road standards should be reviewed in the light of current and expected transport (traffic volumes and types) needs, local resources, technology options, affordability and maintenance capability.

**Practical Implementation Guidelines:** There are a number of documents available providing guidelines on the technical aspects of appropriate technology roadworks. However there have been weaknesses in other specific areas, such as guidelines on the specification and procurement of handtools and appropriate equipment, and the development of small scale contractors. Costing guidelines for alternative technologies and methods to include realistic components of overheads and investment are also required. Quality control and testing regimes need to recognise the realities and logistics of rural road works. Furthermore appropriate technology roadworks must be fully assimilated into the academic and professional environment.

**Access to information and know-how:** This aspect of labour based and intermediate equipment roadworks needs to be improved. Establishment of an effective information network is required in this sector, both at national and international level. Organisations such as the IRF, PIARC (World Road Association) through Committee C20 on Appropriate Development, TRL Ltd and other research organisations, and the ILO through their Advisory Support, Information Services, and Training (ASIST) programme could all help fulfil this role.

**Support for Domestic Contractors:** The development of a healthy and effective domestic contracting industry will be an important objective for many emerging and developing countries. This will need to be supported by access to (modest amounts of) affordable capital, as well as viable, continuously funded, sustainable programmes of work and linked to effective payment systems and independent audits. Contract packages need to match the capabilities of local contractors with realistic, equitable and transparent terms and conditions. Fiscal regimes should encourage local resource and enterprise use rather than imported equipment etc.

**Social, Environmental, Health and Safety Aspects:** There is a growing realisation that careful attention must be paid to these issues to ensure successful establishment of appropriate road sector systems.

**Policy Framework:** Above all, setting of appropriate government policies and strategies are needed to positively promote and encourage appropriate technology roadworks and allow their development and establishment in cooperation with communities and other stakeholders.

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