Introduction of tractor based rural road maintenance approaches in Zambia

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Abstract.

This paper investigates the need, rationale and challenges of introducing more affordable and sustainable unpaved road maintenance in Zambia through the introduction of proven agricultural tractor based technology methods. The paper discusses exploratory consultations with key stakeholders in the road sector, Local Government, national service, training and agricultural sector, credit institutions, potential equipment suppliers, and potential partners in the private sector.

The investigations concluded that there are clear cost and sustainability advantages for the introduction of such approaches. In broad terms, unit road maintenance costs could be approximately halved, thus doubling the possible network coverage with the already available funds. The paper also looks at the potential to reduce the maintenance burden and generate increased maintenance funding.

Therefore, with the introduction of tractor based maintenance technology and complementary initiatives, there is a real prospect of substantially reducing the current Rural Road Maintenance Delivery Deficit. The various initiatives will go a long way towards achieving the Zambian Road Development Agency (RDA) declared Maintenance Strategy of improved and sustainable road network asset management.

Important complementary outcomes will include support for the development of the indigenous Micro Small and Medium Enterprises (MSMEs) and increased utilisation and profitability of the existing (under-utilised) tractor fleet in the agricultural sector. There will be local employment creation benefits through the works, involvement of local communities, and potential local manufacturing possibilities.

The paper reports on the process of investigation, analysis, stakeholder consultation through a series of workshops, and proposed initial establishment of a tractor technology training and demonstration unit prior to national roll out of the new tractor based approaches.

Keywords: Road Maintenance, Agricultural Tractor, unpaved roads, Low Cost, Sustainable.

1 Introduction

There are considerable challenges facing rural communities in developing regions, not the least of which is the lack of reliable road transport access throughout the year. With typically less than 20% (World Bank, 2008) of the classified road networks constructed to paved standards and with generally sub-optimal maintenance regimes, many communities suffer poor or severed unpaved access for long periods. This is a substantial constraint to social and economic development of rural communities. Considering that this is the situation after at least a century of the era of motor transport, the rural road networks in many countries are expected to continue to be mostly unpaved for the foreseeable future. The sector must recognize this situation and develop appropriate and affordable strategies for maintaining and enhancing the vital networks of earth and gravel roads that serve rural communities.

Road maintenance approaches in economically Emerging and Developing Countries (EDCs) have generally been derived from practices in developed countries. In the post 2nd World War period this has been based on the use of heavy equipment, with motor graders at the forefront of camber and drainage system maintenance of unpaved roads.

These methods suffer from a number of technical and operational problems in developing and emerging economies (Petts, 2012) and are high-capital, import-intensive and expensive. They are generally inappropriate for a resource-constrained, high-cost (and scarce) finance and low-labour-wage environment. Micro, Small and Medium Enterprises (MSMEs) face major challenges to enter and survive in the equipment intensive road sector market due to the high cost of credit or its unavailability to contracting enterprises (Larcher, 1999). Although the obvious solution appears to be adoption of labour-based methods, there are significant management, institutional and safety issues with such an alternative (O'Neill et al, 2010).

We need to find an intermediate approach, and the use of intermediate equipment, such as the agricultural tractor, offers a solution to the current challenges faced due to the dependence on the use of imported heavy and expensive equipment. In developing countries, agricultural tractors are desirable to increase productivity and reduce the farm work burden, particularly for the poor. Wider rural community benefits are also possible through tractor use for transport, water provision (including earth dam construction), irrigation, power generation, crop processing. However, these often cannot be achieved due to the relatively high capital costs (compared to labour approaches) for the usual agricultural-sector-only orientated application for tractors. Generally low annual productive utilization and lack of local knowledge regarding good resource management and cost-effective applications often mean poor returns on the capital investment in the tractor equipment in a high-cost-of-capital environment (Hancox and Petts, 1999). This severely hampers efforts to improve the efficiency of rural activities.

However, bringing agricultural tractor technology to the rural road sector will increase overall annual equipment utilization, reduce unit costs to more affordable levels and accelerate 'payback' of the capital investment for owners; a truly 'win-win' situation for all stakeholders.

The paper reports on the process of investigation, analysis, stakeholder consultation through a series of workshops, and proposed initial establishment of a tractor technology training and demonstration unit prior to national roll out of the new tractor based approaches.

2 Heavy Equipment Issues

Sophisticated heavy civil engineering equipment is typically designed for, and generally manufactured in, high-wage, low-investment-charge economies. Whereas USA plant operator

wages are in the order of US$22/hour (USA Bureau of Labor Statistics, 2013) and commercial finance was as at 2016 relatively easily available at annual interest rates of about 5%, wage rates in developing countries are a fraction of US rates and commercial credit, where available, often costs in the range 20 - 35% per annum. Heavy plant is expected to operate with close support and high annual utilisation; usually designed for a specific single function or task with high efficiency operation.

Many problems encountered in the road sector in emerging and developing countries with heavy equipment can be attributed to the application of inappropriate technology when constructing and maintaining rural roads with low or marginal economic returns (see Box 1).

Box 1

PROBLEMS OFTEN ASSOCIATED WITH SOPHISTICATED IMPORTED HEAVY EQUIPMENT FOR ROADWORKS IN DEVELOPING COUNTRIES

Operational:

- Dedicated function (can only be used for one operation)
- Inter-dependence (e.g. dozer, loader, trucks, motorgrader, bowser, roller all required for gravelling – fleet idle when ONE link in the chain breaks down #)
- Lack of continuity of workload for plant items of dedicated function
- Usually based at locations remote from worksites – plant transporters required and long mobilization/demobilization distances involved

Technical:

- High pressure hydraulic systems
- Sophisticated mechanisms and hydraulics
- Disposable components; difficult to repair or refurbish

Local Support and Equipment Maintenance:

- Limited local market for equipment sales of each model
- Specialist repair and maintenance skills, tools and facilities required (often only available in the capital city or regional centre)
- Few dealers able to provide the necessary close support
- Long spares supply lines and delivery times
- Frequent model 'improvements' causing spares stocking and procurement problems and 'planned' obsolescence

Cost:

- All equipment and spares imported – consuming scarce foreign exchange
- High capital and finance costs
- High costs of stocking and provision of spares

RESULT - low availability & high overall costs!

 # Breakdowns are usually power unit or transmission related. By comparison, tractor power units can be reassigned between tasks if a breakdown occurs.

Source: Intech Associates (2012)

A further deficiency in the current rural road 'maintenance' regime in many countries is that in the dry season the motor graders are usually deployed without the support of watering and compaction equipment. In dry conditions, this operation disturbs the compacted soil/gravel road surface, fails to re-consolidate it after grading and simply creates a loose, dusty surface even more susceptible to erosion by traffic. It is no surprise that large sections of unpaved road have become 'sunken' or 'canal' profiles which can become impassable in wet weather. People and vehicles using the road after dry weather grading are coated with dust, as are any adjacent properties and crops. Grading without watering and compaction should normally be confined to the 'wet' season so that traffic consolidation occurs at no cost to the road authority.

From the foregoing, it is therefore evident that a low capital, flexible and local-resource-based approach would be more appropriate for developing countries for many road sector operations where there is a clear choice of technology (TRB 1981). Tractor technology offers the flexibility of different task applications according to season and multi-sector applications potential.

3 Agricultural Tractor Benefits

Agricultural Tractors are the simplest and cheapest mobile power source available in developing countries (Petts, 1997). Investigations in many countries have identified the potential for considerable construction and maintenance works cost savings and beneficial flexibility from the introduction of wheeled tractor based technologies and Intermediate Equipment approaches. These approaches could be adopted by both own-force and the contracting sector to achieve substantial reduction in capital costs and reduced unit costs for a range of work items.

All of this would be achieved with the essential outcome of the same, or improved, quality and durability of work for national, regional and local road authorities.

The potential benefits (Petts, 2012) for the various stakeholders can be summarised as:

Road works – lower unit works costs, greater logistical flexibility, lower capital and operating costs;
Market – provides complementary market opportunities between heavy equipment and labour technologies for improved market flexibility and efficiency. Opportunities for local MSMEs to enter market and provide sub-contracting and multi-sector services at low capital outlay;
Rural Communities – improved accessibility, lower transport costs, employment opportunities, better prices for crops, less crop wastage;
National Economy – more serviceable roads at lower cost, MSME development, local equipment manufacturing capacity development and export potential, imported equipment substitution, reduced importation of fuel and spares, rural and urban employment increases in related works and industry, increased tax base;
Agricultural sector – improved roads, lower input and output costs, development of rural sector agricultural services based on tractor technology for increased tractor utilisation, farm income diversification, and lower cultivation processing and transport costs; and
Environmental – Lower carbon footprint of tractor technology.

Although wheeled tractors have been developed and designed for the agricultural sector, there is a large range of **proven** applications in the road and other rural sectors as indicated in Table 1 (Petts, 2012).

Table1 Agricultural Wheeled Tractor Applications in the Rural Sectors (Source: Petts, 2012)

SECTOR	OPERATIONS
AGRICULTURE	Ploughing, Harrowing, Rotavating, Sub-soiling, Haulage, Access Road Construction/Maintenance, Land clearance and levelling, Root removal, Planting, Seed Drilling, Fertiliser Application, Pesticide/Herbicide Application, Harvesting, Loading, Pond Construction, Dam Construction, Borehole Construction, Contour drains, and Fencing (post hole boring).
FORESTRY	Winching, Loading, Hauling, Poling, Sawing and Access Roads.
ROADS (paved and unpaved)	Gravel Haulage, Water Collection Haulage and Distribution, Personnel Transport, Bridge & Culvert Materials Haulage, Fuel Haulage, Plant Haulage (low loader trailer or semi-trailer), Towed Grading (heavy and light), Dragging, Towed Compaction (rubber tyre/steel roller), Earthworks Excavation & Haulage (towed scraper), Excavation (back hoe/ripper/scarifier/compressor & pneumatic tools), Loading (front shovel), Grass & Bush Control, Spreading Materials, Bitumen Sealing (towed bitumen/emulsion heater/sprayer), Stone crushing (towed crusher and screens), Chippings Transport, Recycling pavement (milling attachment), Brushing/Sweeping, Mixing (disc harrow), Slurry Sealing (mixer and spreader), Premix Patching Material Production, and Temporary Accommodation (towed caravan/workshop).
AGRO-PROCESSORS	Threshing, Hulling, Milling and Haulage.
MUNICIPAL (non-road)	Garbage Skips, Water Haulage and Night Soil Disposal.
WATER SECTOR (non-road)	Pipeline Excavation, Pipe Laying, Cranage, Loading, Earth Dam Construction, Irrigation Channel Construction, Water Pumping, Water Haulage and Borehole Drilling.
BUILDING CONTRACTORS	Materials Haulage, Excavation (back hoe/ripper/scarifier/compressor & pneumatic tools) and Loading (front shovel).
MINING/ QUARRYING	Stone Crushing (from PTO), Loading, Access Roads and Materials Haulage.
TRANSPORTERS	Loading and Short Haulage: Goods, Materials & Personnel.
PLANT HIRE COMPANIES	Hire to others for all the applications in this table.
RESEARCH/ ACADEMIC/	Demonstration and

TECHNICAL INSTITUTIONS	Training.
NGOs	Any of the above operations.

4 Regional Experiences

4.1 Experiences in Zimbabwe

An Agricultural Tractor Based Road Maintenance System was developed in Zimbabwe from 1985 to 1998 to look after roads that had been constructed under the Germany - Zimbabwe cooperation agreement. The programme involved construction of 25,000km of roads and development of an institution to maintain the considerable investments.

The maintenance concept which was applied uses fixed maintenance areas; each one covering between 150 - 200km of road network. Through practice, this length of road was established to be the optimum length a single unit can effectively maintain. A single operational unit comprises an agricultural tractor, a towed grader, tractor drawn trailer and a tractor drawn water bowser. Tyre drags are deployed at approximately one every 10km.

Working on fixed maintenance areas makes it easier to define road maintenance tasks to be carried out on sections of the roads. This is so because the roads supervisor will be familiar with common defects occurring during the wet and dry season. Appropriate remedial actions can therefore be predicted, planned and budgeted for. The frequency of road maintenance cycles varies according to traffic, terrain and climate. The Zimbabwe experience is based on a system operated under force account arrangements. A total of 180 maintenance areas were defined, each equipped with a maintenance unit, a supervisor and a dedicated maintenance budget allocated per kilometre of road under maintenance.

Lessons learnt

The system has proved to be effective as it has provided regular and timely response to road maintenance needs throughout the year. This was made possible by the size of maintenance areas allocated per tractor together with personnel and a dedicated budget. Frequent in-house training kept skills relevant and the system functional while the responsible institution was well funded and had authority to make management decisions without seeking clearance though a rigorous consultative process. Authority to manage road activities was decentralized to Provincial and District staff. The use of force account ensured continuity of work and better knowledge of the road behaviour; as the same personnel remained in charge of the same sections of road for many years. This knowledge enabled semi-skilled supervisors to be able to know areas prone to damage and plan appropriate reaction. The use of the tractor as the only motorized equipment meant that all activities could be done by changing the accompanying attachment to the tractor. The repair and maintenance of the tractor and attachments is relatively simple and trained artisans responsible for the routine checks on the tractor ensured that it was well kept and serviced. All these arrangements resulted in long equipment life (typically 10,000 hours per tractor) and a reduced cost for road maintenance. Records of expenditure and progress were well documented and quarterly review seminars assisted in planning and managing of the programme. Roads that were incomplete or awaiting for construction were not included on the maintenance programme. This requirement encouraged the Local Authorities to carefully plan the roads and prioritize them for construction in order to secure funding for maintenance.

Challenges

The routine maintenance system worked efficiently and effectively for over ten years. However, the whole system relied on funding from central government and as soon as the resources were no longer readily available due to seriously deteriorating national economic conditions, the system suffered. Plans to replace the tractors after their full life were not realised due to financial constraints. The tractors became old and worn out and the system also failed to meet planned targets. The cost of repair and maintenance of tractors increased further; increasing the annual road maintenance costs per kilometre. Failure to fully resource periodic maintenance re-gravelling also led to widespread de facto downgrading of many route sections to earth standard. This is a universal problem. Estimates (Petts, 1992) of classified road re-gravelling in Kenya highlighted the average network cycle to be only once every 70 years, whereas gravel surface attrition losses should necessitate a cycle approximately 10 times more frequent. The use of force account usually does not allow cost systems to reflect the full cost of maintenance; as other expenses such as salaries, unit infrastructure maintenance and initial cost of equipment are paid for by government. All related costs of finance, importation and taxes and other overheads are absorbed by government hence the actual total cost over a period of time is difficult to ascertain; although this can be achieved (Gongera & Petts, 2003). It is estimated that the overall cost of the routine maintenance system is about the equivalent of US$600/km/year in current prices, including investment and amortisation costs.

4.2 Experiences in Kenya

Agricultural tractors were successfully used for the haulage of surfacing gravel in the national Rural Access Roads Programme (RARP) and Minor Roads Programme (MRP) in Kenya (Intech, 1990), on rural road networks eventually totalling more than 11,000km over a period of 16 years.

A Kenya Classified Road network maintenance study (Intech, 1991) identified the potential to use agricultural tractors and labour techniques to rehabilitate the wider earth and gravel road networks. The resulting pilot project co-funded by Sida, Danida, KfW and SDC proved the viability. (Intech, 1993).

The Pilot Project used the civil service force account operational structure plus casual labour employment in two districts. Half of the classified road networks in those districts were rehabilitated (700km) and brought under effective maintenance in 18 months. Camber and drainage system were restored, new/upgraded culverts were provided where required, and spot surfacing improvements were made on problem network sections. This was achieved without any formal design documentation, merely with good training, operational manuals and good direction and supervision.

Lessons learnt from the Kenya Experience

The pilot project demonstrated that earth and gravel roads could be successfully and inexpensively rehabilitated using agricultural tractor and local labour techniques, and brought under affordable maintenance. It was shown that earth roads on most soils could be shaped into a camber and adequate side and turn out drains provided with cross drainage at required locations. These roads could normally be trafficked by cars and light trucks within hours of rain cessation due to the running surface quickly draining and regaining resilience to vehicle wheel damage. The various tractor attachments were successfully designed and manufactured locally. 100hp (75kW) rated 4WD tractors were adequate for all rehabilitation and maintenance operations. The locally made 5 tonne towed grader could achieve heavy regarding, even without a scarifier attachment. Earth and gravel road rehabilitation rates were between 0.6 and 1.13 km/tractor-grader/day. Direct costs (equipment, labour, hand tools,

transport and equipment support) of camber, side and turnout drainage was less than US$700/km (1993 prices). Finance, overhead and spot improvement costs were additional (Intech Associates, 1993).

Outstanding issues

The pilot project successfully tackled the technical, training and operational aspects of tractor and labour based earth and gravel road rehabilitation and maintenance. However, the investigations identified a range of institutional, finance, manpower management and small scale contractor issues to be addressed before successful wider application.

4.3 Experiences in Mozambique

Soon after the protracted war in Mozambique, rural road access was a priority for the government.

The Mozambique government adopted the Zimbabwe tractor-based road maintenance model and started with a pilot project in Tete and Manica Provinces. ECMEP, a government owned company was charged with the responsibility of carrying out the Emergency Road Opening Programme. The programme was co-funded by the Mozambique and German governments. The tractor based road maintenance system was extended to cover Zambezia, Sofala and Inhambane provinces after the pilot. Zambezia province opened up 2,700km, while Inhambane opened 276 km. Unlike the Zimbabwe set up, where implementation was achieved through force account, Mozambique used small and medium enterprise contractors. An initial training programme for the contractors was conducted while a consultant supervised the works. The roads were packaged into lots and a bill of quantities was prepared. Tenders were floated and contractors bid for the works.

The maintenance operations were carried out in the same way as the Zimbabwe setup. The maintenance areas defined were provided with a contractor who had the requisite equipment. Maintenance base camps like the ones in Zimbabwe were constructed for each maintenance unit. Dedicated budgetary provision for these roads was set aside by the Road Fund. Tenders were for periods of two years with provision for extension by one year if the contractor's performance was acceptable. Payment certificates were prepared based on the bill of quantity and work done by the contractor.

Lessons learnt from the Mozambique experience

The use of private contractors in Mozambique has promoted growth of the private sector and increased employment. However, owing to the limited number of participating contractors, the perceived advantage of competing companies is not realized as the same companies compete within each province and little or no effective competition is realized. There is a likelihood that contractors are colluding during the tendering process and avoid competing against each other by putting in rates that favour the selected contractor among themselves.

The new contractors require more frequent training and mentoring until they can manage on their own. The limiting factor is that after the expiry of the initial two year's contracts they are not guaranteed more work hence investing in new equipment for road maintenance becomes high risk.

The use of tractors as the only motorized equipment has proved to be effective since the general knowledge to repair an agricultural tractor is available. The delays in releasing funds

for a new financial year interfere with the planning for maintenance and results in delayed intervention; the concept of preventive maintenance is therefore defeated. In Inhambane where roads have been constructed using marginal materials (calcrete) the system works well and routine activities are effective for both labour and equipment based interventions.

Outstanding issues

There is need to develop capacity for the mechanical staff to repair and maintain equipment use during maintenance of roads. The private sector also needs support to expand the contractor base and improve on pricing and competitive bidding.

Government needs to improve on the disbursement mechanisms during the period at the beginning of the financial year.

A benchmark works and operations costing system (especially for equipment ownership and operating costs) is required to be regularly updated. In this way both clients and contractors would have a reference point to bid and judge tenders.

The use of spare capacity from the tractors needs to be incorporated into the farming practice for small holder farmers to benefit from the available resource.

5 Managing Technological and Operational Changes

To achieve effective and sustainable operational change it will be necessary to assess, and carefully and comprehensively consider the various physical, technical, financial, economic, institutional, human resource development, political, social and cultural factors and challenges influencing the operational environment. It will be necessary to agree appropriate measures to achieve effective and affordable implementation through stakeholder consultation and commitment.

The process should recognise the prerequisites for a sustainable Low Volume Road asset management system (SADC, 2003):

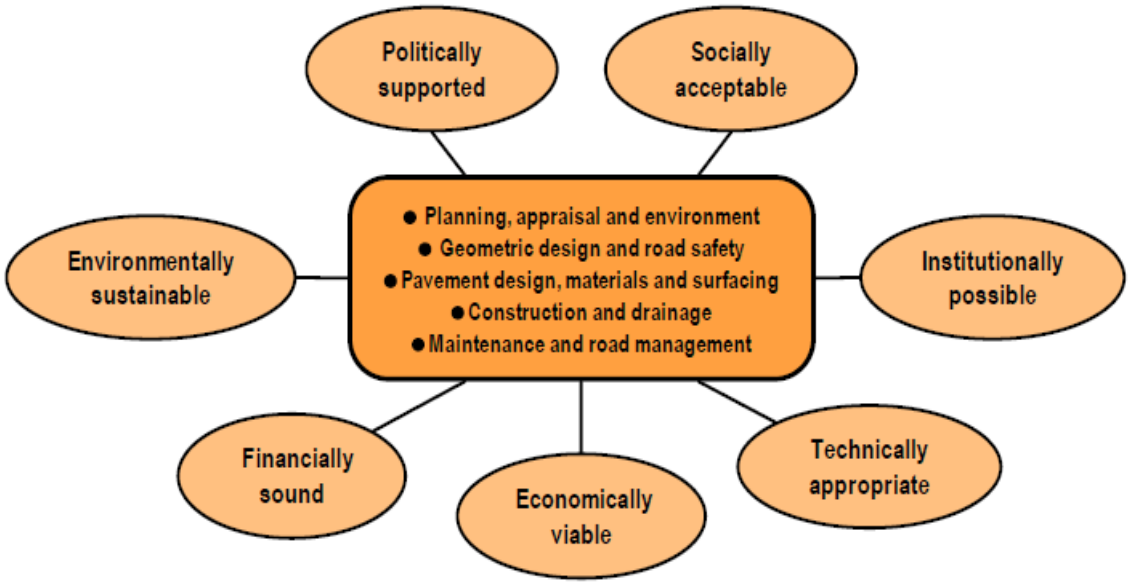

Figure 1 - Prerequisites for a sustainable Low Volume Road asset management system

6 Scoping Investigations in Zambia

A Scoping Study was carried out in 2016 by Intech Associates and Clanview Civils (Intech-Clanview 2016) for RDA and Africa Community Access Partnership (AFCAP) to investigate the need, rationale and challenges of introducing literature review, consultations with key more affordable and sustainable unpaved road maintenance in Zambia through the introduction of proven agricultural tractor based technology methods. The assignment involved stakeholders in the road sector, local government, financing, national service, training and agricultural sectors, credit institutions, potential equipment suppliers, and potential partners in the private sector. Evidence on the issues and potential benefits of the adoption of tractor technology for rural road works and associated rural activities was compiled, presented and discussed in a series of workshops attended by representatives from a range of interested stakeholder organisations.

The study and workshops concluded that there are clear cost and sustainability advantages for the introduction of such approaches. In broad terms, unit road maintenance costs could be approximately halved, thus doubling the possible network coverage with the already currently available funds. The report also looked at potential to reduce the maintenance burden and generate increased maintenance funding.

It was discovered that with the introduction of tractor based maintenance technology and complementary initiatives, there is a real prospect of substantially reducing the Road Maintenance Delivery Deficit. The various initiatives will go a long way towards achieving the Road Development Agency (RDA) declared Maintenance Strategy of improved and sustainable road network asset management.

Important complementary outcomes will include support for the development of the indigenous Micro Small and Medium Enterprises (MSMEs) and increased utilisation and profitability of the existing (under-utilised) tractor fleet in the agricultural sector. There are local employment creation benefits through the works, involvement of local communities, and potential local manufacturing possibilities. An initial stakeholder workshop endorsed the proposals recommended by the consultants.

The physical environments of the successful tractor based operations in the region are similar to those found in Zambia. However, it is recognised that the knowledge and experience of tractor based roadworks is currently limited in Zambia. It will be necessary to review and build on the force account and contracting experiences in Kenya, Mozambique and Zambia. It is necessary to develop an understanding of the challenges in the local environment in Zambia and build local awareness, experience and implementation capacity through demonstration and training functions.

The study provided the strong basis for the stakeholders to develop a pilot training demonstration unit for tractor technology in road works commencing in 2017, and the following beneficial roll-out of the approaches on a national scale.

A follow up workshop broadened the range of stakeholders, developed an outline framework for implementation and formulated an interim Training and Demonstration Unit (TDU) Coordination Committee.

7 Stakeholder Workshops Outcomes and Recommendations

The final Stakeholders Workshop agreed that a district based training demonstration and pilot unit is required to be established within easy travelling distance of Lusaka. This is not only for ease of access for trainees (both national and international), but also to be able to provide good access to decision makers and managers.

The establishment of the unit will require a range of complementary initiatives to be taken to assure the success of the tractor based roadworks approach. The issues presented and agreed at the workshop included:

- Establish a District based demonstration-training unit of Good Practice;
- Procure demonstration and training equipment;
- Pilot the various tractor applications in Zambian conditions;
- Develop and manage a range of tractor technology training courses;
- Develop appropriate registration arrangements for tractor based contractors;
- Create an 'enabling environment' for tractor based enterprises to survive and thrive;
- Develop effective awareness creation and dissemination materials and programmes;
- Mobilise improved levels of maintenance resources;
- Improve cooperation and generate joint benefits with the Agricultural sector; and
- National Roll-out programme for the tractor based approaches.

The First Workshop proposed a number of possible options for pilot districts. However, the responsibility for overseeing the pilot district will lie with the Ministry of Local Government & Housing (MLGH). They will also be responsible for assuring adequate funding of the piloting and management operations. It was recommended that MLGH enter into discussions with candidate districts in liaison with RDA and prepare proposals.

For sustainability, there will have to be a budget line created for the training demonstration unit (TDU) with forward budgets running into the future. Although the 'ownership' of the TDU will involve the interests of a range of stakeholders, it was suggested that the vesting of the responsibilities with the National Council for Construction (NCC) will best assure the long term sustainability. Close initial and ongoing cooperation with the other stakeholders will need to be established.

In summary; a district needs to be selected for establishing a demonstration system of good practice tractor based roadworks. A suitable district should have sufficient funding allocated to them for core network maintenance and ideally:

- Have Councillors committed to, and ready to 'champion', the tractor technology approach;
- Agree to open data accessibility and management regarding all aspects of the road maintenance and equipment funding and operations;
- Be within easy travelling distance of Lusaka (training base);
- Be responsible for the care and maintenance of any equipment assigned;
- Have arrangements to hire in tractors from suitable local entities as required; and
- Be ready to agree a commitment to continue with the tractor demonstration unit activities for a renewable rolling forward period of time.

8 Conclusions and Recommendations

Conclusions

There are proven low-cost, tractor-based alternatives to rehabilitation and maintenance of earth and gravel rural roads, compared to heavy equipment or labour based methods.

However, the very positive experiences have generally not been disseminated and taken up outside of their development locations. There was limited awareness of these methods on initial investigations in Zambia.

The Scoping Study carried out an extensive investigation to explore the need, rationale and challenges of introducing more affordable and sustainable unpaved road maintenance in Zambia through the introduction of proven agricultural tractor based technology methods. It enabled a coordinating committee of interested stakeholders to be formed and prepare the framework for a national tractor technology training-demonstration unit to be established.

From past experience of development and introduction of new technologies and methods in an African low volume rural roads context it is clear that it is essential to develop a comprehensive programme of awareness creation and collective ongoing commitment among the stakeholders in the various related potentially beneficial sectors and organisations.

Recommendations

For successful uptake in Zambia, the consultation process and workshops recommended that a number of issues need to be addressed in consultation with the interested stakeholders.

There is need for wider appreciation a number of key aspects of roadworks, including the real costs of ownership and operation of equipment, particularly for intermediate equipment. This is important as it provides basis for calculating costs that will assist clients and contractors during bidding processes. Benchmark works and operations costing systems (especially for equipment ownership and operating costs) are required; to be regularly updated, for clients and contractors. There is also need to develop contract documentation to allow and promote tractor applications in road works. There is a need to integrate farming and provision of roads as a way of achieving economic utilization of equipment in a range of rural applications.

There is a need for wider dissemination of knowledge regarding tractor-based road works and rural applications regarding the media, academic and professional institutions, the public and national/community leaders. Training is required to be widely available for agricultural tractor based roadworks. This includes mechanical as well as planning and operational skills. There is also a need for practical demonstration units of good practice for these techniques.

Further research and cooperation with the agricultural and water sectors is required to exploit the obvious synergies in tractor applications to realize mutual benefits for the rural communities while providing basic access and further develop the road networks in an affordable way.

Concerted efforts are required to ensure that adequate finances are raised sustainably to fund at least basic access road infrastructure for rural communities to exploit the relatively low cost tractor and supporting labour technology approaches. Efforts are required to ensure timely processing of due contract payments.

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