Practical demonstration on provision of affordable access through road Maintenance, Spot Improvement and Upgrading interventions

Final Report

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Cover Photo: Courtesy of District Development Fund Road Maintenance Unit Umguza District Zimbabwe and Patricia Petts, Intech Associates.

<table>
<thead>
<tr>
<th>Version</th>
<th>Author(s)</th>
<th>Reviewer(s)</th>
<th>Date</th>
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<tbody>
<tr>
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<td>23 May 2015</td>
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</tbody>
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Abstract
There are considerable challenges facing rural communities in developing regions, not 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. Traditional maintenance techniques for these roads have normally been based on the use of motor graders for routine maintenance. Due to a range of factors these approaches are usually expensive and suffer from serious funding and operational constraints. Consequently, rural road networks often remain in poor condition. The practical demonstration was intended to offer the 7th African Technology Transfer Conference participants an opportunity to view a viable and proven alternative for affordable and sustainable maintenance of unpaved rural roads. Using an agriculture tractor and several low cost attachments to the tractor, routine road maintenance and a range of improvement activities can be achieved at relatively low cost by intermediate equipment.

Key words
Road Maintenance, Agricultural Tractor, Rural Road, Intermediate Equipment, Developing Regions, Low Cost, Local-Resource-Based, Sustainable.

Acronyms, Units and Currencies
$ United States Dollar (US$ 1.00 ≈ provide conversion to local currencies)
PDU Practical Demonstration Unit
AFCAP Africa Community Access Partnership
ASCAP Asia Community Access Partnership
DDF District Development Fund
UK United Kingdom (of Great Britain and Northern Ireland)
UKAid United Kingdom Aid (Department for International Development, UK)

AFRICA COMMUNITY ACCESS PARTNERSHIP (AFCAP)
Providing solutions for safe and sustainable rural access across Africa

AFCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable rural access for all people in Africa and Asia. The AFCAP partnership supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources. The AFCAP programme is managed by Cardno Emerging Markets (UK) Ltd.

See www.afcap.org
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1 Executive summary

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.

Traditional maintenance techniques for these roads have normally been based on the use of motor graders for routine maintenance. Due to a range of factors these approaches are usually too expensive and suffer from serious funding and operational constraints. Consequently, rural road networks often remain in poor condition. The unfortunate consequence for the agricultural sector is poor accessibility and high transport costs. Crop losses are often high and producer prices poor. This all contributes to a constraining cycle of impediments for communities and rural development. Most of the people in rural areas in developing countries depend on agriculture. Poor access has a direct bearing on production and marketing of produce, and prices achieved by the producers.

The practical demonstration was intended to offer the 7th African Technology Transfer Conference participants an opportunity to view a viable and proven alternative for sustainable maintenance of unpaved rural roads. Using an agriculture tractor and several low cost attachments to the tractor, routine road maintenance and a range of improvement activities can be achieved at relatively low cost by intermediate equipment. Possible follow up initiatives are discussed.
2 Background

The state of rural roads in most Emerging Nations remain in poor condition with an estimated one billion people (World Bank report) living more than two kilometres from an all season access road. Limited financial resources and competing demands often place low traffic volume roads near the bottom of the priorities of many governments. The 7th Africa Technology Transfer conference offered a unique opportunity to address the problem and to present participants the occasion to learn about and discuss viable and proven options for rural road maintenance. It is within this background that a proposal was made to carry out a practical demonstration of tractor based solutions to rural development, with specific reference to road maintenance and agricultural synergies through the support of AFCAP. The demonstration was carried out near Bulawayo in a small district called Umguza in Zimbabwe.

Umguza district is in Matebeleland North province of Zimbabwe. It is one of seven districts making up the province. The entire province lies in agro ecological region V characterized by low rainfall, stunted grass and scattered trees. On average the region receives 400mm of rainfall per year. The soil type in Umguza is deep unconsolidated Kalahari sands with very little clay. Natural lateritic or quartz gravel for road surface application is difficult to locate and normally occurs in vleis and river beds. Matebeleland North province has a total of 2248km of rural unpaved roads managed using 20 maintenance base camps. Below is a summary table of the road network:

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>LENGTH OF ROADS (km)</th>
<th>No of BASE CAMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binga</td>
<td>347</td>
<td>3</td>
</tr>
<tr>
<td>Bubi</td>
<td>170</td>
<td>1</td>
</tr>
<tr>
<td>Hwange</td>
<td>270</td>
<td>2</td>
</tr>
<tr>
<td>Lupane</td>
<td>434</td>
<td>4</td>
</tr>
<tr>
<td>Nkayi</td>
<td>362</td>
<td>4</td>
</tr>
<tr>
<td>Ttsholotho</td>
<td>469</td>
<td>4</td>
</tr>
<tr>
<td>Umguza</td>
<td>196</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2248</td>
<td>20</td>
</tr>
</tbody>
</table>

The tractor technology demonstration was arranged on road C103 which links the main Bulawayo - Harare road to Ntabazinduna Rural Service Centre (See Figure 1). The road is 12 km long and gravelled. It carries more than 50 vehicles a day. This is regarded as high for the class of road.

The management and resourcing of the rural road network maintenance is described in Reference 1.

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1 Vlei: a shallow natural (usually seasonal) pool of water
3 Research and dissemination objective

The objective of the demonstration was to show how the agricultural tractor can be used to do tow grading on an unpaved (earth or gravel) road. The agricultural tractor can also be used with a wide variety of attachments, all able to be locally manufactured and complimenting different activities on road maintenance and in other rural sector activities (Reference 10).
4 Methodology

A section of 200 metres of the road was selected for the trial. The road condition was observed and noted prior to grading. The surface was uneven, with some longitudinal ruts, other surface defects and surface material generally displaced away from the road centre line by traffic. The section was then worked on using a tractor drawn grader. Each pass of the tractor and grader was used to initially move material back towards the road centre line. Following passes were used to spread the material outwards to form the required shape camber. The section was completely re-graded and the result compared with the initial condition of the road prior to grading.

5 Results

The road section worked on showed a marked improvement as the process had restored the camber and removed ruts, corrugations and pot holes. The operation of the towed grader was relatively simple as the operator used the grader control wheels to shift and position the grader blades to achieve the required finish. The cutting blade attitude was positioned in the central ‘neutral’ position; suitable for both cutting and spreading.

The demonstration showed that using an agricultural tractor and a towed grader, rural unpaved roads can be graded effectively at a lower cost than heavy equipment. The fuel consumption on a tractor per 8 hour day is about 40 litres, compared to 160 litres needed on a motorized grader. The progress achievable per day for routine maintenance grading is a maximum of 10 kilometres using either a tractor drawn grader or a motorized one. The cost of a motorized grader imported from overseas is in the region of US$250 000, compared to US$13 000 for a towed grader and about US$22 000 for the tractor. The tractor can use a wide range of attachments while the motorized grader only has a single function. A total maintenance capability tractor based unit with towed grader, water bowser, trailer and tyre drags can be set up for a new equipment cost of less than US$40 000, making the approach ideal and affordable for small scale contractors or local authorities.

The demonstration also showed delegates how to plan for routine work and explore synergies with the agriculture sector in order to use the tractor when it is not occupied on the road works. This increases the annual equipment utilization and hence it becomes an economically viable option.

The repair and maintenance of an agricultural tractor is relatively easy and low cost compared to repair of a motorized grader. Spares requirements are limited and low cost. The skills required to operate a towed grader are also much simpler as opposed to operating a motorized grader.

6 Conclusion

After the demonstration delegates were able to assess the effectiveness of the tractor based method. The repair and maintenance of the equipment is relatively easier than for a motorized grader. The technology can be adapted for different conditions where gravel and earth roads require maintenance.

7 Proposal

Following this demonstration, representatives from a number of national road authorities expressed strong interest in introducing tractor based road works in their countries. Experience has shown that introduction of a new technology or approach requires careful preparation and recognition of the process of knowledge development and application through to effective ‘embedment’, as shown in Figure 2. Demonstration and Training have a vital role to play in the effective ‘Uptake’ process.
Where national or local road authorities intend to introduce tractor technology on their rural road networks, it is proposed that a scoping study be carried out to explore the requirements to set up a demonstration-training unit as a vital part of the process. The study should be carried out by a team experienced in the various technical, economic, institutional and operational aspects of tractor technology for road works in both the force account and private sector environments. Experience in practical course development and delivery is also important.

The scoping study would be intended to explore the range of issues and possible challenges involved in setting up a viable and sustainable Demonstration-Training unit in institutional, operational, technical and financial terms.

The Scoping Study should investigate the following aspects of the possible development of a Tractor technology Demonstration Training Unit for the Rural Road Sector:

- Field demonstration-training unit possible location, ownership, institutional and management arrangements, and mission statement
- Market assessment for demonstration-training services and tractor application possibilities
- Range of Courses, curricula and materials to be offered, for example Training courses for: operators, field mechanics, foremen, engineers/managers, community leaders
- Accreditation arrangements
- Spot improvement works and Environmentally Optimised Design (EOD) possibilities
- Identify core rural road network and a methodology for ranking priorities for spot improvement and maintenance
- Network Baseline road inventory and condition systems and requirements
• Appropriate works planning, management, task, productivity, contingency, recording, costing, performance & cost benchmark systems
• Establishment and publishing of comprehensive benchmark cost data
• Model Intermediate Technology Equipment (ITE) contract documents and arrangements
• ITE management handbook (companion document to existing selection and costing handbook – Reference 14)
• The resources and costs required for the setting up and establishment of the Demonstration-Training Unit.

8 Next Steps
Based on the outcome of the scoping study, a Practical Demonstration-Training unit (PDU) is proposed to be set up in an appropriate setting in any African country with enabling conditions for the PDU. Support from AFCAP could be sought to enable the scoping as well as the setting up of a PDU.

9 Key References
Annex A: Site Visit Handout
Why Tractor Technology?

Many rural road networks are still substantially only constructed to earth or gravel standard. Traditional maintenance techniques for these roads have normally been based on the use of motor graders for maintenance. Due to a range of factors these approaches are usually expensive and suffer from serious funding and operational constraints. Consequently, rural road networks often remain in generally poor condition. The unfortunate consequence for the agricultural sector is poor accessibility and high transport costs. Crop losses are often high and producer prices poor. This all contributes to a constraining cycle of impediments to rural development. There is now the prospect to address all of these issues by utilizing proven tractor technology for road rehabilitation, spot improvement and maintenance techniques at a lower cost than traditional heavy equipment approaches. Thus, rural tractor utilization will be raised benefiting both sectors with lower unit costs. Consequently, road maintenance will become cheaper and more sustainable, and agricultural production and transport costs will be reduced. The tractor attachments; such as towed graders, trailers and bowers can be manufactured locally contributing to the support of the local commercial economy. The capital investment requirements for tractor equipment are also a fraction of those required for heavy civil engineering plant, and are thus more affordable for Small and Medium Enterprises (SMEs) in an environment where credit/capital is scarce and expensive.
EXPENSIVE PROBLEMATIC HEAVY EQUIPMENT
LOW COST FLEXIBLE TRACTOR APPLICATIONS

IDEAL AND AFFORDABLE FOR LOW VOLUME ROAD AND SMALL & MEDIUM ENTERPRISE APPLICATIONS
MUCH CHEAPER TO BUY & OPERATE, MORE FLEXIBLE, LOWER COSTS FOR OWNERS, CLIENTS & COMMUNITIES

CHEAPER

<table>
<thead>
<tr>
<th>MOTORGRADER</th>
<th>TRACTOR &amp; TOWED GRADER UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost = US$250,000</td>
<td>Capital Cost = US$35,000</td>
</tr>
<tr>
<td>5 year repayment interest @15% p.a. = US$112,500</td>
<td>5 year repayment interest @15% p.a. = US$15,000</td>
</tr>
<tr>
<td>Max. Daily output light grading – 10km</td>
<td>Max. Daily output light grading – 10km</td>
</tr>
<tr>
<td>Use – single application only</td>
<td>Multiple use with different attachments</td>
</tr>
<tr>
<td>Recommended length of road per maintenance unit Max. 200km</td>
<td>Recommended length of road per maintenance unit Max. 200km</td>
</tr>
<tr>
<td>Fuel consumption per day – 180 litres/8hours</td>
<td>Fuel consumption per day – 40 litres/8hours</td>
</tr>
</tbody>
</table>

Regular unpaved road routine grading requires only 70hp; not an inefficient 140hp motorgrader

FLEXIBLE – TRACTOR APPLICATIONS

<table>
<thead>
<tr>
<th>SECTOR</th>
<th>OPERATIONS</th>
</tr>
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<tbody>
<tr>
<td>AGRICULTURE</td>
<td>Ploughing, Harrowing, Rotovating, Sub-sowing, Haulage, Access Road Construction/Maintenance, Land clearance and leveling, Root removal, Planting, Seed Drilling, Fertiliser Application, Pesticide/Herbicide Application, Harvesting, Loading, Pond Construction, Dam Construction, Borehole Construction, Contour drains, Fencing (post hole boring)</td>
</tr>
<tr>
<td>FORESTRY</td>
<td>Winching, Loading, Hauling, Poling, Sawing, Access Roads</td>
</tr>
<tr>
<td>ROADS (paved and unpaved)</td>
<td>Gravel Haulage, Water Collection Haulage and Distribution, Personnel Transport, Bridge &amp; Culvert Materials Haulage, Fuel Haulage, Plant Haulage (low loader trailer or semi-trailer), Towed Grading (heavy and light), Dragging, Towed Compaction (rubber tyed/steel roller), Earthworks Excavation &amp; Haulage (towed scraper), Excavation (back hoe/ripper/scraper/compressor &amp; pneumatic tools), Loading (front shovel), Gravel &amp; Bush Control, Spreading Materials, Bitumen Sealing (towed bitumen/mixture heater/sprayer), Stone crushing (towed crusher and screeners), Chipping Transport, Recycling pavement (milling attachment), Brushing/Sweeping, Mixing (disc harrow), Slurry Sealing (mixer and spreader), Premix Patching Material Production, Temporary Accommodation (towed caravan/Workshop)</td>
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<tr>
<td>AGRO-PROCESSORS</td>
<td>Threshing, Hulling, Milling, Haulage</td>
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<tr>
<td>MUNICIPAL (non-road)</td>
<td>Garbage Skips, Water Haulage, Night Soil Disposal</td>
</tr>
<tr>
<td>WATER SECTOR (non-road)</td>
<td>Pipeline Excavation, Pipe Laying, Craning, Loading, Earth Dams Construction, Irrigation Channel Construction, Water Pumping, Water Haulage, Borehole Drilling</td>
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<tr>
<td>BUILDING CONTRACTORS</td>
<td>Materials Haulage, Excavation (back hoe/ripper/scraper/compressor &amp; pneumatic tools), Loading (front shovel),</td>
</tr>
<tr>
<td>MINING/QUARRYING</td>
<td>Stone Crushing (from PTO), Loading, Access Roads, Materials Haulage</td>
</tr>
<tr>
<td>TRANSPORTERS</td>
<td>Loading, Short Haulage: Goods, Materials &amp; Personnel</td>
</tr>
</tbody>
</table>

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Annex B: Site Visit Photographs (Images by Patricia Petts)
BEGINNING OF THE DEMONSTRATION

IMPACT OF THE GRADER AFTER TWO PASSES WITH THE BLADE
ANGLE OF THE BLADE WHEN GRADING

DELEGATES FOLLOWING THE GRADER
THE OPERATOR ADJUSTING THE GRADER BLADE USING THE CONTROL WHEELS

THE GRADING OPERATION
GROUP DISCUSSION AND RESPONDING TO QUESTIONS FROM THE DELEGATES

CONSULTANTS PROVIDING A BRIEF ON THE TRACTOR TECHNOLOGY
DELEGATES INSPECTING THE TRACTOR AND TOWED GRADER

FINISHED SECTION OF THE ROAD AFTER GRADING WITH CAMBER AND SIDE DRAINS RESTORED