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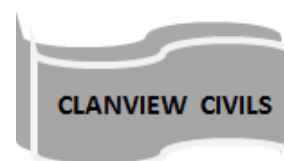
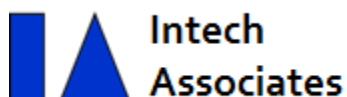
## Scoping Study for Establishment of Pilot Project to implement tractor-based road maintenance approaches in Zambia



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**Final Assignment Report, Volume 1, April 2016**



# SCOPING STUDY FOR ESTABLISHMENT OF PILOT PROJECT TO IMPLEMENT TRACTOR-BASED ROAD MAINTENANCE APPROACHES IN ZAMBIA

**Project Reference: ZAM2059A**

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## Abbreviations and Acronyms

|        |   |
|--------|---|
| AFCAP  | African Community Access Partnership                                    |
| CEO    | Chief Executive Officer   |
| CRN    | Core Road Network   |
| DFID   | Department for International Development                                |
| hp     | horse power   |
| km     | kilometre   |
| kW     | KiloWatt  |
| LRA    | Local Road Authority  |
| MA     | Ministry of Agriculture   |
| MLGH   | Ministry of Local Government & Housing                                  |
| MSMEs  | Micro Small and Medium Enterprises                                      |
| NAMSSC | National Association of Medium and Small Scale Contractors              |
| NCC    | National Council of Construction of Zambia                              |
| NRFA   | National Road Fund Agency   |
| RDA    | Roads Development Agency  |
| ReCAP  | Research for Community Access Partnership                               |
| RMS    | Road Maintenance Strategy   |
| SSA    | Sub Saharan Africa  |
| TDU    | Training and Demonstration Unit   |
| TEVETA | Technical Education, Vocational and Entrepreneurship Training Authority |
| ToT    | Training of Trainers  |
| TT     | Tractor Technology  |
| USA    | United States of America  |
| US\$   | United States dollar  |
| VAT    | Value Added Tax   |
| ZAWIC  | Zambian Association of Women in Construction                            |
| ZMW    | Zambian Kwacha  |
| ZNS    | Zambia National Service   |

## EXECUTIVE SUMMARY

This Scoping Study report 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 assignment involved consultations with key stakeholders in the roads, Local Government, training and agricultural sector, credit institutions, potential equipment suppliers, and potential partners in the private sector.

The study concludes 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 report also looks at 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 Road Maintenance Delivery Deficit. The various initiatives will go a long way towards achieving the Roads 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 and detailed in this report.

The study report provides the strong basis for the stakeholders to develop a pilot training demonstration unit for tractor technology in road works 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.

## 1. Introduction

### Project Context

All-season road based transport is a vital enabler for rural development, social and economic activities (especially agriculture) and community wellbeing, particularly for vulnerable groups (women, children). Currently the majority of the rural road networks in Zambia are unpaved (earth and gravel standard) and as such require regular maintenance input to retain acceptable levels of access. However, unpaved road network maintenance is generally substantially under-funded in the Sub-Saharan Africa region (SSA) and Zambia is no exception. There is a clear demand, therefore, for innovative and cost-saving approaches to maintenance activities. Currently, Routine maintenance of unsealed roads, where achieved, is usually based around the use of imported motorised graders which are expensive to buy and operate in the prevailing high-finance-cost environment. They are also over-powered for the Routine maintenance, and even the Period maintenance, tasks.

Within appropriate road environments, agricultural tractor-based technology is a lower-cost proven alternative to the use of high-cost specialist plant for low volume unsealed road maintenance. There is no established unit in Zambia to demonstrate and train for this more affordable and more sustainable tractor based technology.

### Related Initiatives

Related projects include previous and on-going experience with tractor-based technology in the region; in Zimbabwe, Kenya and Mozambique. Not only are towed graders manufactured in the region (e.g. in Zimbabwe; for more than 50 years, and in South Africa), there is a wide range of other regionally made, road construction and maintenance attachments that the agricultural tractor can work with to offer a total road rehabilitation and maintenance package based on the use of agricultural tractors.

Synergies with other programmes in Zambia have been explored, including current initiatives to work with the private sector in Zambia to explore rent-to-own mechanisms for tractors to support the agricultural sector.

### Project Partners

The study has identified and engaged a number of Zambian Partners in this tractor technology road works, and potentially rural services, initiative:

- Roads Development Agency (RDA) - Lead agency
- National Road Fund Agency (NRFA)
- Ministry of Local Government & Housing
- Zambia National Service (ZNS)
- Ministry of Agriculture (MA)
- National Council of Construction of Zambia (NCC)
- Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA)
- MUSIKA & AgDevCo
- Zambian Association of Women in Construction (ZAWIC)
- National Association of Medium and Small Contractors (NAMSSC)
- Private sector equipment suppliers
- Professional and commercial representation bodies

These organisations were consulted and involved in the stakeholders’ workshops during this scoping study phase. All expressed a high level of interest in the tractor technology potential. Discussions were also held with a number of local equipment suppliers and credit organisations to explore their potential contributions.

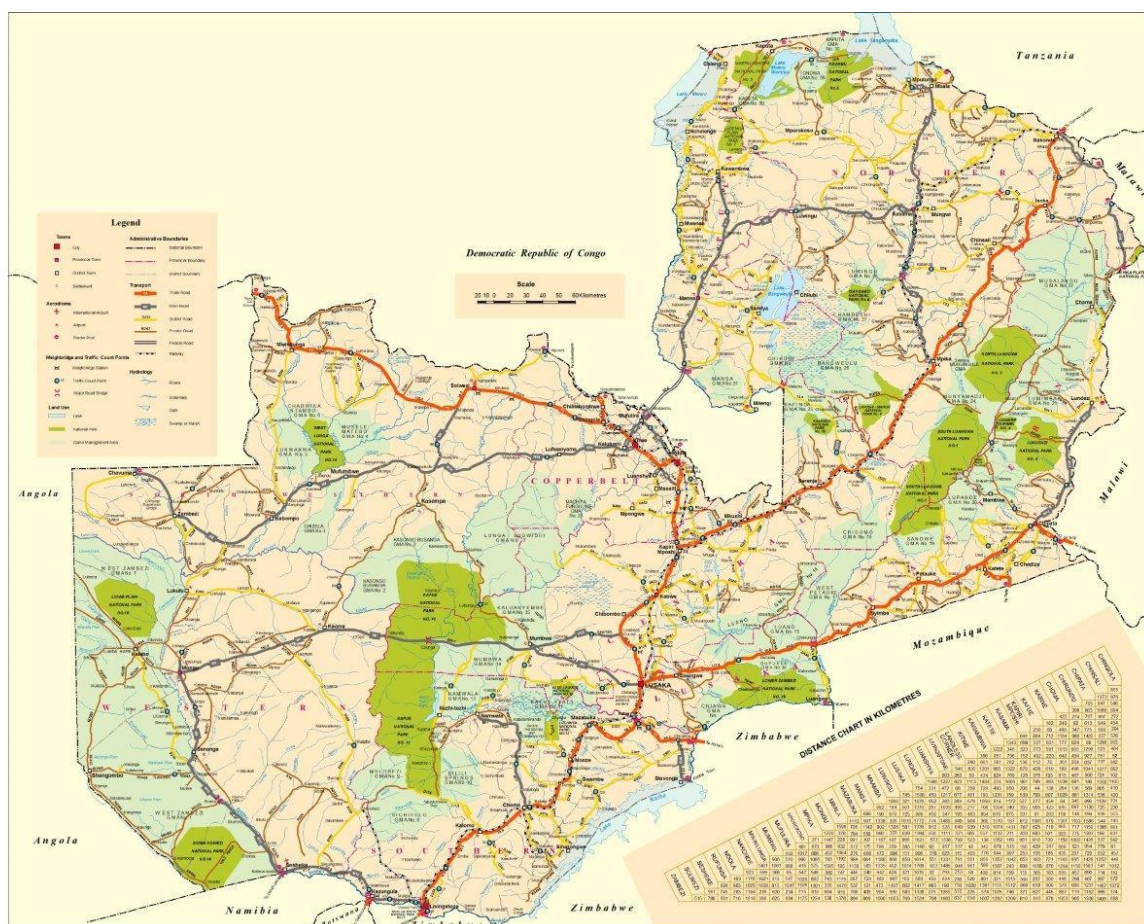
### Objective

The objective of the scoping study is to investigate the arrangements, organisation requirements and costs of setting up a Tractor Technology (TT) training demonstration unit for rural roads in Zambia and to pilot the tractor based road maintenance approach in the local environment.

Based on the outcome of the scoping study, a Practical Training - Demonstration Unit (TDU) is proposed to be set up in an appropriate setting with enabling conditions for the TDU. This would be the object of a follow-on project based on recommendations in this Scoping Study Report.

## 2. The Zambia Road Network, Asset Management Responsibilities, Budgets & Resources

Figure 2.1 - Map of Zambia showing Major Roads and Towns



### The Road Network Asset

Zambia has a road network estimated to extend to about 77,700 km of public roads classified under various categories. These are:

- Trunk roads
- Main roads
- District roads
- Primary roads
- Secondary roads
- Tertiary feeder roads
- Urban roads
- Parks roads

Not all of the network links are inventoried. The Table 2.1 below indicates the approximate extent of the road asset and the responsibilities for their management and maintenance.

**Table 2.1 – Summary of the Zambian road network and responsibilities**

--

| Road Class <sup>1</sup>                        | Responsibility | Core Road Network <sup>2</sup><br>December 2002 (km) | Total Surveyed<br>Network (km) | Total Estimated<br>Network (km) |
|--|----------------|--|--------------------------------|---------------------------------|
| <i>Core Roads</i>                              |                |  |                                |                                 |
| <b>Trunk (T)</b>                               | RDA            | 3,088  | 3,088                          | 3,088                           |
| <b>Main (M)</b>                                | RDA            | 3,691  | 3,691                          | 3,691                           |
| <b>District (D)</b>                            | RDA            | 13,707   | 13,707                         | 13,707                          |
| <b>Urban (U)</b>                               | LRA            | 5,294  | 5,625                          | 5,294                           |
| <b>Primary Feeder (PF)</b>                     | LRA            | 14,333   | 15,317                         | 15,800                          |
| <b>Primary Tourist (TR)<sup>3</sup></b>        | ZAWA/LRA       | -  | -                              | -                               |
| <i>Non-core roads</i>                          |                |  |                                |                                 |
| <b>Secondary Feeder (SF)</b>                   | LRA            | -  | -                              | 10,060                          |
| <b>Tertiary Feeder (TF)</b>                    | LRA            | -  | -                              | 4,424                           |
| <b>Park Roads</b>                              | ZAWA           | -  | -                              | 6,607                           |
| <b>Community Roads</b>                         | LRA            | -  | -                              | 5,000                           |
| <i>Unclassified roads</i>                      |                |  |                                |                                 |
| <b>Unclassified roads<sup>4</sup><br/>(UC)</b> | LRA            | -  | -                              | 10,000                          |
| <b>Total</b>                                   |                | <b>40,113</b>  | <b>41,428</b>                  | <b>77,671</b>                   |

Source: RDA Road Maintenance Strategy

The RDA Network Condition Report (2013) advised that about 72 per cent of the unpaved Primary Feeder Roads were in poor condition with only 18 and 10 per cent in fair and good condition respectively. The Urban roads on the other hand recorded 49 per cent in good condition while 32 and 19 per cent was in poor and fair conditions respectively.

#### Road Asset Management Responsibilities and Historical Context

The Road Development Agency (RDA) is a statutory institution created through an Act of Parliament (Roads Act Number 12 of 2002) charged with the responsibility to provide, care, maintain and

construct public roads in Zambia. The RDA has delegated part of its responsibility to manage roads to the Local Roads Authorities in line with the provisions of the legislation. Historically most of the roads in Zambia were constructed after independence in 1964. During this period the Zambian economy was performing well, supported by the revenue generated through income from the copper mines. The mines were nationalized in 1972 and this triggered a decline in the economic performance of the country. The increase in oil prices further worsened the situation. Roads that had been constructed did not receive adequate maintenance and this resulted in ongoing deterioration of most of the road infrastructure that had been constructed.

The RDA recognises this adverse regression and in the recently published Road Maintenance Strategy (2014) the CEO states:

*“This Road Maintenance Strategy is designed to create a clear pathway for the provision of road maintenance activities on the Core Road Network (CRN). The RMS is geared towards ensuring that there is timely implementation and improved quality of maintenance on the CRN, which will enhance the life span of roads and related infrastructure. This will have the added benefit of reducing the vehicle operating costs to the road users and also contribute to general job creation in the road sector. More so, it will contribute to increasing the capacity of the local contracting industry.”*

Regarding introducing an Asset Management culture, the Strategy states:

*“Strict adherence to Asset Management principles will go a long way to ensuring that resources for maintenance are applied optimally to realize value from the Road Assets. The approach to Asset Management will improve on stewardship and accountability; communication and relationships with service users; risk management and financial efficiency.”*

The strategy recognises that some of the key shortcomings are, insufficient funding, the lack of local contractor capacity, general organisational and supervisory capacity and an inefficient procurement system.

The RDA will develop Maintenance Manuals based on best practice to ensure that maintenance is carried out timely and to the best quality.

### **Budget and Resources**

According to the RDA Maintenance Needs Report of 2012, the Critical Road Network in Zambia required US\$721 Million equivalent to cover maintenance needs for the period 2012 – 2016. By 2014 only 21.5 % of this requirement had been allocated to maintenance. Greater emphasis has been, and continues to be, on new construction, rehabilitation and reconstruction. The rural feeder roads are least considered for funding.

As discussed in the Rationale (following) the introduction of tractor based technology will radically reduce the network maintenance funding requirements from the estimated (and clearly unsustainable) network maintenance cost of US\$2,400 per km/year.

### **3. Network Asset Management Challenges**

From discussions with stakeholders and review of published documentation, the road asset management challenges to be tackled can be summarised as:

- (i) The historical background of road asset management in Zambia has been characterized by neglect of road maintenance in favour of new construction and rehabilitation. This has had a very big negative impact on road access in the country and particularly on rural feeder roads. The priority ranking for provision of these roads has been very low resulting in poor access provision in most rural areas.
- (ii) The procurement of services for construction and maintenance has been riddled with bureaucracy resulting in delays in implementing the projects.
- (iii) Private sector capacity to supervise road works is limited resulting in poor quality work being produced by contractors and paid for by government.
- (iv) Private sector contractor capacity is limited and has negatively affected the quality of product produced by the private sector.
- (v) There is very poor maintenance culture for roads in Zambia and this has resulted in the road network deteriorating to alarming proportions.
- (vi) Grossly inadequate funding and loose institutional arrangements for the management of rural feeder roads have exacerbated the problem of lack of maintenance.
- (vii) It is clear that the past technology focus on imported heavy equipment is both unaffordable and unsustainable. It is necessary to develop local capacity, and affordable and manageable approaches to road maintenance.

These are significant tasks that will require a concerted and energetic campaign by the various stakeholders if the past decline in asset value and serviceability is to be arrested and reversed.

#### 4. Rationale for Tractor Based Road Maintenance in Zambia



**Figure 4.1** – Motor grader used for maintenance of unpaved rural roads, (Image: Intech Associates)

The Zambian rural road network is substantially only constructed to earth or gravel standard. Traditional maintenance techniques for these roads have normally been based on the use of heavy equipment; particularly motor graders (Figure 4.1), for the essential maintenance of the camber and side drainage system. Due to a range of factors these approaches are expensive and suffer from serious funding and operational constraints. Consequently, the rural road network remains in generally poor condition. The unfortunate consequence for the rural communities and agricultural sector is high risk of deprived accessibility, poor services and excessive transport costs. Other risks are crop losses and poor producer prices. This all

contributes to a constraining cycle of impediments to rural development and poverty reduction.

Heavy equipment based methods are anyway not suited to most rural roads, which are relatively narrow, compared to main roads. However, the principal disadvantage is the enormous capital investment costs of heavy equipment operations. They also involve very high equipment finance (or opportunity), operating, maintenance and mobilization costs; usually necessitating the use of low bed transporters to move them between work sites. They also require specialist operational and support skills and resources. With relatively low fleet numbers in the country there are serious support and spares issues. With most unpaved road maintenance and rehabilitation equipment tasks fundamentally requiring no more than 100hp, the use of heavy equipment is an extremely expensive, inflexible and avoidable luxury.



**Figure 4.2** – 100hp, 4WD Agricultural Tractors now available in the rural areas. (Image: Commons).

Market rates for credit/finance are in the range 25 – 35% per annum. Therefore, the opportunity cost of capital is very high. This suggests that an alternative low-capital approach is required.

Fortunately, there are **proven** alternative, low-capital solutions available. Currently a range of low cost but powerful, premium brand tractors (e.g. Figure 4.2) are now more widely available to the agricultural sector in Zambia. The brands are established and have good backup support with future spares availability for the national fleets assured. It is estimated by MA managers that there are more than 4,000 agricultural

tractors in the Zambia national fleet, mostly deployed to the agricultural sector for commercial and small scale crop farming.

There is now the prospect to address many of the road sector maintenance deficiency issues by utilizing proven tractor technology for road rehabilitation, spot improvement and maintenance techniques at a much lower cost than traditional heavy equipment approaches.

**Unit rate costs savings for many tasks are expected to be more than 50%.** See Annex in Volume 2.

The tractors can be used with a range of low cost, simple attachments for the various road construction and maintenance activities. Thus, rural tractor utilization would be raised, benefiting



**Figure 4.3** – 2 tonne towed grader manufactured in Zimbabwe for more than 50 years (Image: Intech Associates).

both road and agricultural sectors with lower unit costs. Consequently, road maintenance will become cheaper, more affordable and more sustainable, and agricultural production and rural transport costs will be reduced.

The tractor attachments; such as towed graders, loaders, trailers and bowsers, could be manufactured locally, potentially contributing to the support of the local commercial economy. Light towed graders have been manufactured for over 50 years in neighbouring Zimbabwe (Figure 4.3). 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 Micro, and Small

and Medium Enterprises (MSMEs) in an environment where credit/capital is scarce and expensive. Table 4.1 illustrates the versatility of the wheeled agricultural tractor to provide low cost services to the various rural sectors.



**Figure 4.4** – Pre-war Caterpillar tractor towed grader with rubber tyre modifications. Still in regular use after 50 years (Image: Intech Associates)

Regarding the key road maintenance activities of grading, the power requirement for light (Routine) grading is about 70hp (52kW) in conjunction with a 2 tonne towed grader. For heavy (Periodic) grading, which involves recovery of lost camber on earth and gravel roads, or reshaping of the coarse material, stone macadam surfaces, the power requirement is about 100hp (75kW) with a towed grader of 4-5 tonnes weight.

Motor graders were developed originally just before the Second World War (they took over from the universal use of tractor towed graders - Figure 4.4). By 1955 the largest Caterpillar motor grader was still only 100hp; sufficient for both

heavy and light grading. However, since then the size and power of motor graders has been steadily

increasing, so that the smallest mainstream model is now rated at about 140hp. Various models up to more than 500hp are now available. This power and size development is likely to have been driven by the developed economy (and particularly USA) wage rates rising from less than US\$1 per hour in 1939 to the current US skilled operator basic rate of about US\$22 per hour. In a developed, low capital cost economy it is natural to place as much power as economically appropriate in the hands of the high cost operator. Such a rationale is totally misplaced in a country such as Zambia, where credit/finance costs are extremely high and labour wage rates are substantially lower. The fact remains that modern agricultural tractor technology is flexible and powerful enough for many roadworks tasks, and is proven.

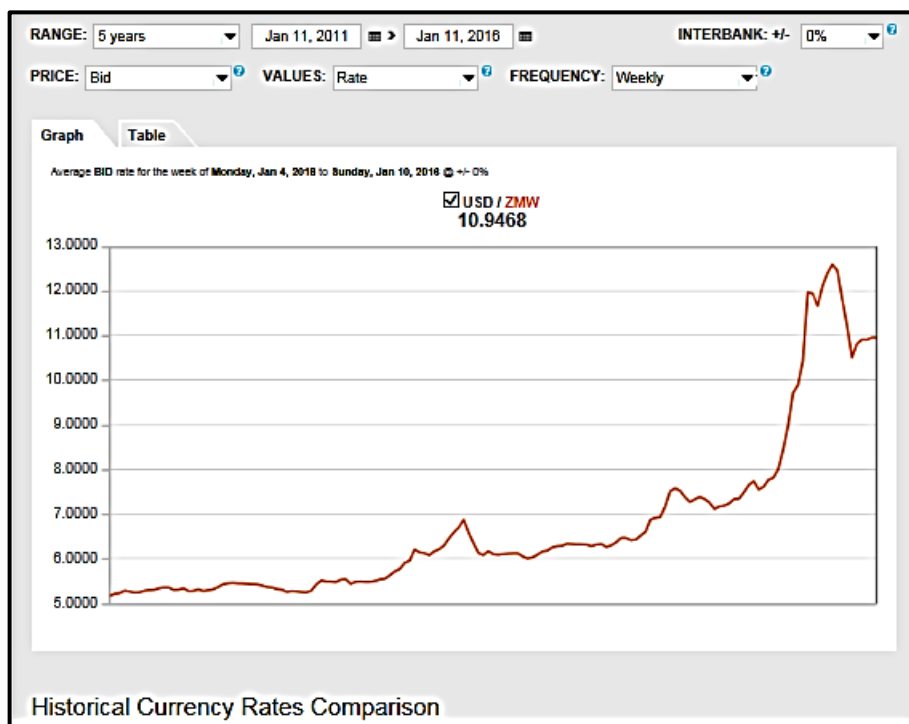
**Table 4.1 - Potential Agricultural Tractor Applications in the Rural Economy**

| <b>SECTOR</b>                                     | <b>OPERATIONS</b>   |
|---|---|
| <b>AGRICULTURE</b>                                | Ploughing, Harrowing, Rotovating, 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, Fencing (post hole boring)   |
| <b>FORESTRY</b>                                   | Winching, Loading, Hauling, Poling, Sawing, Access Roads  |
| <b>ROADS (paved and unpaved)</b>                  | 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 tyred/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, Temporary Accommodation (towed caravan/workshop) |
| <b>AGRO-PROCESSORS</b>                            | Threshing, Hulling, Milling, Haulage  |
| <b>MUNICIPAL (non-road)</b>                       | Garbage Skips, Water Haulage, Night Soil Disposal   |
| <b>WATER SECTOR (non-road)</b>                    | Pipeline Excavation, Pipe Laying, Cranage, Loading, Earth Dam Construction, Irrigation Channel Construction, Water Pumping, Water Haulage, Borehole Drilling  |
| <b>BUILDING CONTRACTORS</b>                       | Materials Haulage, Excavation (back hoe/ripper/scarifier/compressor & pneumatic tools), Loading (front shovel)  |
| <b>MINING/ QUARRYING</b>                          | Stone Crushing (from PTO), Loading, Access Roads, Materials Haulage   |
| <b>TRANSPORTERS</b>                               | Loading, Short Haulage: Goods, Materials & Personnel  |
| <b>PLANT HIRE COMPANIES</b>                       | Hire to Others for all the applications in this table   |
| <b>RESEARCH/ ACADEMIC/ TECHNICAL INSTITUTIONS</b> | Demonstration<br>Training   |
| <b>NGOs</b>                                       | Any of the above operations   |

Source: *Handbook of Intermediate Equipment, for Road Works in Emerging Economies*, Petts, 2012.

All heavy civil engineering equipment is being imported and at high cost, along with the necessary spares to keep the equipment working. The depreciation of the Zambian Kwacha over recent years (Figure 4.5) means that there is now even more reason to try to introduce lower cost items that can achieve the same results, and to seek local/regional manufacture.

**Figure 4.5** - Depreciation of the Zambian Kwacha against the US\$ over the last 5 years



Source: Oanda

Tractor technology in roadworks is proven in modern times in emerging nations and, as mentioned previously, was the norm in the USA before the Second World War. Unfortunately, in a sector that is characterised by the extensive use of equipment, the current norm is to try to replicate western, high capital investment, heavy equipment approaches. This is not helped by a sector that is commonly managed by civil engineering professionals with skill sets focussing on road, drainage, materials and bridge planning, design and construction, and schooled in transferring technology from advanced economic environments. Furthermore, many have little knowledge of the mechanical, economic and market aspects of equipment ownership vital for efficient road asset management and maintenance. The accessibility to equipment cost data and Norms (prevalent in developed economies) is missing in Zambia. Fundamental management decisions on technology choice and cost are therefore severely compromised.

**The case for introduction of tractor technology into the Zambian rural road sector is powerfully demonstrated.**

As with any new approaches, it will be necessary to test, pilot and evaluate systems in the local conditions before wider allocation. Awareness creation, confidence building and demonstration of the capabilities and benefits will be essential, along with the training of supervisors and practitioners in

the (locally) new methods. It is therefore strongly advised that local trials of suitable equipment are carried out and the research widely disseminated.

Contract documentation must allow, and even encourage, application of financially and economically attractive tractor based methods.

**Training and demonstration programmes will also be required. It is therefore proposed that the establishment of a practical training-demonstration unit, to cater for the introduction and establishment of tractor technology roadworks in Zambia, is an essential initiative in this process.**

## 5. Existing Sector Training Arrangements -

The National Council for Construction of Zambia (NCC) is a statutory body that was established to promote and build capacity in the construction industry. It is responsible for:

- Development and promotion of the construction industry in Zambia
- Provision for affiliation of professional bodies and organisations involved in construction or related industry
- Regulation of construction industry
- Training of personnel involved or engaged in the construction industry.

The NCC is situated in Lusaka and has training facilities suitable for conducting training. The centre has spacious lecture rooms, accommodation facilities for male and female trainees, a materials laboratory, dining facilities and a workshop for repair and maintenance of equipment or for carrying out mechanical training. The centre currently runs a number of courses that can be tailored to suit the requirements of the proposed practical demonstration and training unit. A number of new courses will be required to meet the range of skills development required for the tractor based road works technology. The head of the NCC is enthusiastic regarding the opportunity to cooperate with the RDA - AFCAP initiative in the provision of training. The centre has seven MF tractors that will require minor refurbishment and the head of the NCC has indicated that some of the tractors could be used for the training and demonstration project.

**Figure 5.1 - Lecture Rooms at NCC**



**Figure 5.2 - Training Halls NCC**

The ZNS carried out in-house training. It is likely that cooperation between NCC and ZNS will be developed to share the considerable task of sector capacity development for the tractor technology approaches. There are also various government, private and other vocational training centres in Zambia that provide skills development for the road sector. The University of Zambia and the Copperbelt University also provide courses in Civil Engineering. These are also important stakeholders to be engaged in the tractor technology uptake.

## **6. Tractor Technology needs and market assessment for demonstration-training services**

From discussions with stakeholders, a range of training services will be required to support the introduction and roll out of tractor based technology; aimed principally at the road sector, but also utilising the synergies with the agricultural sector. Uptake of courses will depend on funding made available for capacity building and human resource development by the various organisations and individuals with interests in applying the technology.

It is estimated that approximately 40,000 km<sup>1</sup> of rural roads in Zambia will have potential for application of tractor technology for road maintenance activities. This includes the Primary Feeder Roads and other Classified and Unclassified Roads. The following outline requirements have been assessed and presented to the first Stakeholders' workshop. Although a detailed market assessment will be necessary for each course, the forum endorsed the outline estimates of the range of skills development required.

It is envisaged that the following new or adapted courses will be required to operationalise and mainstream tractor technology for the road and rural services sectors (approximate participant numbers are indicated based on 40,000km network coverage):

- Road Asset Managers (Provincial/HQ level) - 10 every 3 years

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<sup>1</sup> This is based on tractor technology probably being appropriate for application on approximately 80% of the Primary Feeder, Secondary Feeder, Tertiary Feeder, Park, Community and Unclassified Roads. There is also potential for tractor activities associated with bituminous paved road rehabilitation.

- Road Asset Coordinators (District level) - 40 every year
- Road Foremen - 40 every year
- Road Supervisors/Overseers - 80 every year
- Tractor Operators/Drivers - 80 every year
- Towed Grader Operator - 80 every year
- Mechanical Artisan - 40 every year
- Tractor Mechanic - 20 every year
- Admin/Clerical Staff - 40 every year
- Tractor Owner Business Skills - 80 every year
- Roads Decision Makers (Councillors/Engineers/Consultants) - 80 every year
- Agricultural Extension Officers (particularly drainage & contouring) - 160 every year

As part of the strategy to introduce an asset management culture to the road sector, the two asset management courses will be an important new initiative.

The mechanical artisan courses will be important with regard to good practice management of equipment, by supporting a Routine maintenance culture with respect to equipment management. It is clear from experience that daily and weekly regimes of greasing, lubricating and checking equipment in conjunction with scheduled servicing (planned maintenance), enables tractor operating lives of 10,000 hours to be achieved, with the minimisation of repair bills.

Regarding Tractor owner business skills, it will be vital to build this capacity with owners to exploit the range of business opportunities and ensure the viable ownership of the equipment. MUSIKA is willing to cooperate in this respect from their existing experience aimed at the agricultural sector operations.

In addition to the local market, there will be opportunities for Zambia to develop as the regional centre for the tractor technology. There are currently no other such training and demonstration opportunities in the SSA region. Furthermore, universities that offer local resource based technology courses, such as Birmingham University in UK, currently do not offer field experience of tractor based roadworks. This is an opportunity that could be developed.

## **7. Course accreditation arrangements**

The consultant team visited the Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA) offices situated in Lusaka. TEVETA is an institution which was established through an Act of parliament – TEVET Act No 13 of 1998 which established TEVETA whose responsibility is to interpret and implement the TEVET policy which declares in general terms the government intention to develop a system that will satisfy the real demands and requirements of the labour market and socio economic conditions prevailing in Zambia. The TEVET Act provides for the accreditation and registration of assessors, examiners and trainers. The organisation has a full complement of staff ready to cooperate with the RDA - AFCAP project. Representatives from TEVETA and NCC attended the stakeholders' workshops.

## **8. Appropriate works planning, management, task, productivity, contingency, recording, costing, performance & cost benchmark systems**

### **Asset Management Systems**

The history of network deterioration through lack of even basic maintenance discussed in Chapters 2 and 3 suggest that a radically new approach to asset management of the rural road network is required. This should include detailed knowledge of the extent and features of the network (Inventory), its deployment (maps) and its current and historical condition (surveys and database). This is vital information for decisions by network managers.

Such a system needs to be simple and affordable (not data-heavy computer systems that drain resources and are difficult to maintain in themselves).

It is proposed to pilot such an approach at District level. Such an approach will have synergy with the regional AFCAP Project No. 10636A GEN2018A - Research on New Asset Management Approaches for Maintaining and Improving Local Road Access. It is recommended that a dialogue be established with this project.

It is envisaged that such a pilot asset management system would form part of the proposed pilot demonstration-training District operations.

### **Implementation – Force account or Private Sector?**

Over recent decades there has been a noticeable trend towards a policy of private sector maintenance implementation of roadworks. Unfortunately, this has not been accompanied by a rigorous assessment of the advantages and disadvantages of force account versus contracting the works in the local environment. Nor has there generally been a comprehensive assessment of the pre-requisites for success of either approach. Furthermore, hybrid systems, of for example hiring in or hiring out fleet or individual equipment items, have not been seriously considered or accommodated. Both of the basic systems have been successfully used for tractor based maintenance in the region (Mozambique and Zimbabwe).

### **Works Cost Systems**

For the success of any system, decision making needs to be based on good data and local experience. In developed economies, such as the UK, detailed costs and breakdown are readily available to clients and contractors (e.g. Spon's Civil Engineering and Highway Works Price Book 2015). Every construction and maintenance sector activity is broken down into labour, materials and equipment cost components, based on regular sector monitoring. There is therefore a realistic benchmark for works costing. This knowledge is rarely available in emerging economies such as Zambia. Furthermore, the challenges of equipment costing in the Zambian environment, means that rational costing is seldom done. Consequently, clients are unaware of real base costs and contractors tend to bid or confer in escalating costs.

It is evident that a system of costing and updating the costs of ownership and operation of equipment items is required for good management decision making on both the client and contractor side. This should include expected benchmark productivity and component costs.

The proposed pilot demonstration programme will enable this to be achieved. Arrangements would then be required to keep such a system updated.

We need to pilot the range of tractor based Routine and Periodic maintenance activities in the Zambian environment to:

- Confirm equipment capability in the local environment
- Determine benchmark daily output/productivity Norms
- Determine benchmark unit costs in the local environment
- Establish benchmark hire rates for equipment in the local environment (both wet and dry rates)
- Compare to heavy equipment methods and demonstrate the cost savings

The cost rates will need to be in a format that they can be easily updated for current fuel, labour, new price and interest rate costs, for sustainable application into the future.

Stakeholders should agree who will be responsible for such a system, and where the resourcing will be secured on a sustainable basis.

To achieve the basic data for rural unpaved road maintenance, the following performance research is recommended.

#### **Research on Road Maintenance Equipment Performance in the Zambian Environment**

It is proposed to evaluate the performance and cost parameters (for a range of finance and equipment life scenarios) of the following options for construction/rehabilitation and maintenance grading/shaping of earth and gravel road camber using tractor based equipment manufactured in Africa:

- Motor grader
- 70hp Tractor and 2 tonne towed grader
- 100hp Tractor and 5 tonne towed grader
- Labour major shaping followed by Tractor and 2 tonne towed grader finishing
- Watering and compaction with the above options

The performance and real costs involved with these options with a range of finance cost and life (depreciation) scenarios needs to be investigated and documented. This will form the basis of the benchmark cost system previously proposed.

### **9. Field demonstration-training unit possible location, ownership, institutional and management arrangements, and mission statement**

The 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 include:

- 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
- 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 is 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 is suggested that the vesting of the responsibilities with 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
- Be ready to agree a commitment to continue with the tractor demonstration unit activities for a renewable rolling forward period of time.

A Mission Statement for discussion and refinement could be:

*“The Tractor Technology Training Demonstration Unit (TDU) is managed by the National Council for Construction of Zambia (NCC). Its aim is to support the introduction and application of cost-effective tractor based road works technology and rural services provision on a national basis. This will be achieved through provision of academic and field training and the demonstration of good practice in the road works themselves, and management of the associated equipment. The*

*TDU also supports awareness creation regarding tractor technology solutions to the public and decision makers, and research of improved tractor technology methods in the Zambian environment.”*

## **10. Stakeholders Workshops and TDU Coordination Committee**

The First TDU Stakeholders workshop was hosted by the RDA at Southern Sun Hotel in Lusaka on 4 February 2016. Invited stakeholders were principally from the public sector. The workshop endorsed the findings of the Scoping Study and agreed to proceed with a second workshop with a wider range of stakeholders; including private sector organisations. The second workshop at the same venue on 6 April 2016 achieved wider endorsement of the TT and TDU proposals, drafted a schedule of required activities and assigned tentative responsibilities for each component of the implementation programme.

Importantly, the second workshop agreed to form a TDU Coordination Committee. It was agreed that the membership and representation will provisionally be:

- Joseph Goma - Roads Development Agency (RDA) – also providing Secretariat
- Alinani Msisya - National Road Fund Agency (NRFA)
- Eng. Chanchule - Ministry of Local Government & Housing
- Capt. Hunphrey Ndalama - Zambia National Service (ZNS)
- TBA - Ministry of Agriculture (MA)
- Ernest Nshindano - National Council of Construction of Zambia (NCC)
- Mr Bowa - Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA)
- Francis Mwape - Association of Consulting Engineers of Zambia
- James Luhana - MUSIKA
- Dorothy Mulwila - Zambian Association of Women in Construction (ZAWIC)
- Nkosi Hlazo - National Association of Medium and Small Contractors (NAMSSC)
- TBA - Private sector equipment suppliers

It was agreed that the first meeting of the TDU Coordination Committee would take place on 8 April 2016.

The details, participants and presentations of the workshops, and outcome from the first TDUCC meeting are contained in The Annexes in Volume 2.

## **11. Model Intermediate Technology Equipment (ITE) contract documents and arrangements**

It is recommended that the available Zambian contract documentation models be reviewed to assess their role and effectiveness in encouraging and facilitating the adoption and application of tractor technology roadworks. The options should include:

- Contract on-carriageway Routine maintenance
- Contract off-carriageway Routine maintenance
- Hire in of specific equipment items (access to under-utilised local farmer owned equipment)

- Hire out of specific equipment items (revenue source for under-utilised Council equipment)
- Spot improvement works (such as climate resilience initiatives: camber rehabilitation, raising 'sunken' road sections, culvert installation/upgrading, spot paving, drainage upgrading, erosion control etc.)
- Periodic re-gravelling.

Issues of free choice of technology by the supplier (labour/intermediate equipment/heavy civil engineering equipment), inflation, late payment, cost adjustment, hiring-in of the many idle tractors from farmers, ownership or hire of towed grading or other attachments, need to be accommodated. The benchmark cost systems previously discussed should be made available to both client and service provider, and regularly updated.

Registration arrangements for tractors based contractors should be reviewed. The regulations regarding accessibility of these enterprises to the 20% sub-contracting quota criteria should be included.

## **12. The resources and costs required for the setting up and establishment of the Demonstration- Training Unit and associated guidance documents.**

### **Physical Assets**

The physical classroom training facilities for the main tractor technology training activities at the NCC training centre are ideal. The existing physical capacity is sufficient.

For engineer and management training (both national and international), participants could be housed at nearby hotels.

Accommodation for field training will need to be reviewed as part of the process of selection of the pilot district.

The NCC centre also has equipment workshop facilities for mechanical training, and also laboratory testing.

### **Trainer Resources**

Regarding trainer resources, NCC will need to review existing staff capacity and assess any training of trainers (TOT) and new recruitment needs.

With respect to training curricula, NCC will need to review and develop the framework for new courses and develop the training materials. Outside support may be required for this function. Support is also being offered from MUSIKA on training with respect to commercial and business aspects.

### **Equipment**

The following tractor based technology equipment will be required to satisfy trials, field training in pilot district and mechanical workshop training purposes:

#### **Routine Maintenance**

- 2 No. 70hp 2WD agricultural tractors
- 2 No. 2 tonne towed graders (J Mann, Zimbabwe) – proven performance

- 2 No. 5 tonne 2 axle general purpose heavy duty trailers
- 2 No. 4,500 litre single axle water bowsers
- 10 No. tyre drags – locally fabricated
- 1 No. 3 point linkage ripper attachment – to be trialled

#### **Periodic Maintenance and Rehabilitation**

- 2 No. 100hp 4WD agricultural tractors
- 2 No. 5 tonne towed graders (CMC, Kenya) – proven performance
- 2 No. 5 tonne towed graders (Rogue, RSA) – to be trialled
- 2 No. 5 tonne towed Pneumatic Tyred Rollers (PTR)
- 2 No. 5 tonne 2 axle general purpose heavy duty trailers
- 2 No. 4,500 litre single axle water bowsers
- 1 No. trailed ripper attachment – to be trialled

Photographs of the key equipment are included in Volume 2 of this report. Budget costings are also provided.

Regarding reference materials, the Handbook of Intermediate Equipment (2012) is a useful equipment selection and costing resource. However, it needs to be expanded to include commercially orientated management and business aspects. This could be achieved through cooperation with MUSIKA.

### **13. Procurement of Equipment**

The key task in the application of tractor technology to the unpaved rural roads sector is that of grading. Two types of grading are required.

Where the roads are in ‘maintainable’ condition; i.e. there is still residual camber and raised sufficiently above the surrounding ground or drainage, then light grading will be sufficient. This can be achieved using a light towed grader (about 2 tonnes) and a 70hp agricultural tractor.

Where the camber has been lost, then rehabilitation or heavy grading is required. This requires a heavier 4/5 tonne towed grader and a 100hp 4WD agricultural tractor. Watering and compaction facilities are also required, which can also be towed by tractors.

A global review of towed graders has been carried out. About 10 models have been identified and their specifications reviewed. The authors have excellent experience with two models:

- Zimbabwe made (J Mann, Harare) 2 tonne towed grader: ex- works price US\$13,000
- Kenya Made (CMC Nairobi) 5 tonne towed grader: ex-works price US\$24,000

These are proven models.

A further model made by Rogue (Pietermaritzburg) in RSA looks to be comparable to the Kenya model, and cheaper. The Model RG300A Towed Grader, complete with scarifier attachment, costs US\$14,000 ex-works. However, the authors do not have experience with this model. It is recommended that a study tour be organised with selected Zambian stakeholders to visit the manufacturers and see and

appraise one of the graders operating nearby. The manufacturer has indicated that they could arrange this.

Regarding the other equipment attachments, most are manufactured in the region.

In view of common past problems of inappropriate procurement:

- The equipment procurement and ownership arrangements need to be agreed
- The responsibility for equipment management and maintenance needs to be agreed
- Appropriate and rigorous procurement documentation needs to be prepared
- If specific supplier items are not proven, they need to be reviewed and trialled in Zambia (e.g. RSA towed grader)
- It must be clearly stated that supplied equipment is NEW and not USED
- Procured equipment needs to be inspected for compliance.

User manuals and Spares manuals must be procured and used in developing operator and mechanical support training materials.

## 14. Other Issues

### Reducing Maintenance Liabilities

Two complementary strategies are recommended to improve maintenance performance and make best use of the resources available.

- Reduce the Maintenance Burden, and
- Increase the Maintenance Capacity.

Poorly constructed or rehabilitated roads will have a higher maintenance burden than those constructed according to the specifications and are appropriately designed to the local environment. Compliance with specifications and standards are particularly important in this respect.

In broad terms, it may be possible to reduce maintenance liabilities by about a third through application of this strategy. Network coverage of the available maintenance resources could correspondingly be increased by up to about 50%.



Tackling the following deficiencies at road construction and rehabilitation stage can substantially reduce maintenance liabilities, and improve effectiveness of resources:

- Raise sunken road sections
- Provide necessary side drains and adequate turn outs
- Provide adequate cross and relief culverts
- Ensure culverts installed at CORRECT level, adjusting road alignment
- Restrict carriageway width to standard
- Ensure adequate camber (4-6% on unpaved surfaces)
- Ensure use of good quality surface materials (Earth and Gravel)

- Provide erosion protection where required
- Avoid dry weather grading without watering and compaction.

The previous Chapters discussed the ways in which tractor technology can substantially improve road maintenance capacity. Adoption of tractor technology approaches will typically reduce unit road maintenance works costs by about 50%. This would represent a further approximate doubling of potential network coverage.

#### **Engagement and Cooperation with the Agricultural sector.**

There appears to be limited dialogue between the agriculture and rural roads sector. This is a common situation in Sub-Saharan Africa. However, the existing substantial tractor resource in Zambia, estimated to be more than 4,000 machines, has enormous economic potential. It is understood that the majority of tractors owned by rural farmers and operators suffer from very low utilisation; maybe in the order of 100 – 300 hours per year. Research by Hancox and Petts in Tanzania and Uganda focussing on tractor owners, found typical utilisation rates of 200 – 400 hours per year. This low utilisation is caused by a limited season, where tractors are used for land preparation, sowing and harvesting. Tractors often stand idle or unproductive outside of this generally 3 - 4 month period. Owners have difficulty in repaying credit agreements and risk repossession.

It will be possible to create a market for the tractors in the off-season in agriculture, by offering road sector work throughout the rest of the year.

This will require closer cooperation between the two sectors, awareness creation, training and capacity building to realise the enormous potential to raise tractor utilisation, and reduce unit operating costs and ‘payback’ periods.

Both sectors need to cooperate to create an ‘enabling environment’ for tractor based enterprises to survive and thrive. The following issues need to be reviewed:

- Guaranteed access to certain categories of work
- Access to benchmark costing data
- Appropriate contract documentation and arrangements for the range of works
- Adequate arrangements in contracts for cost escalation
- Payments on time arrangements

#### **National Roll-out programme for the tractor based approaches**

Once the pilot and tractor training demonstration unit is established, plans will need to be developed for a national roll-out programme. This will require adequate actual and forward budgets to be developed. Perhaps a demonstration-training unit of good practice will need to be developed in each province.

For national roll-out the following will be required:

- National policy and strategy on tractor based road works
- Comprehensively develop the Asset Management Culture
- Adequate budget allocation for the various tractor initiatives
- Future budget allocations for a national programme of roll out and finally, last but not least:

- Identify ‘Champions’ to lead and drive the roll out.

### Mobilise more Maintenance Resources

It is clear that the current level of maintenance resourcing is grossly inadequate and that the network asset value is continuing to waste.

To arrest and turn around this asset deterioration it is necessary to investigate ways to achieve increased maintenance resource allocations to the sector. These could include:

- Introduce simple but appropriate asset management systems at district level, including inventory and condition data
- Reward good asset management with increased allocations
- Demonstrate to decision makers that 3-5% of the asset value spent each year on maintenance prevents more than 20% annual loss in asset value
- Encourage the commercial sector to recognize good asset management through publicity and awards.

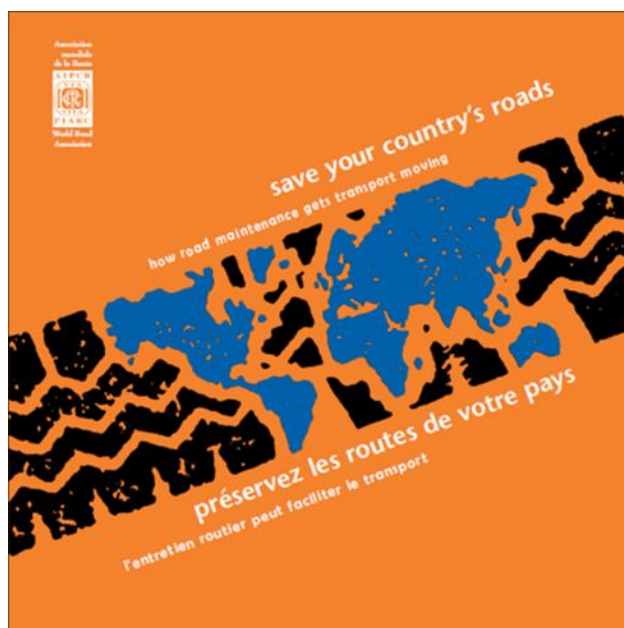
### Awareness Creation and Dissemination

It will be necessary to develop a programme of awareness creation, dissemination and uptake of the tractor technology. Key senior managers, decision makers and political figures will need to be convinced of the wide benefits of adoption of the tractor approaches.

Briefing material, such as the World Road Association’s (PIARC) Save Your Country’s Roads, should be updated and used to create this general maintenance awareness. A similar ‘10 minute’ briefing document should be developed specifically for tractor based roadworks and rural services provision.

Tractor technology applications will in effect be a new approach in Zambia. It will be vital to arrange for a programme of awareness creation and dissemination to encourage uptake and ‘embedment’. The campaign could include the following components:

- Publicity material
- Politicians and Decision makers briefing
- Media campaign
- Educational materials
- Posters at District level in local languages
- Video programmes for TV and decision makers waiting rooms



## 15. Next Steps

The initial draft report was circulated to stakeholders for comments and feedback. These comments were incorporated in this second draft also circulated to stakeholders and endorsed at the follow up stakeholders' workshop held in Lusaka on 6<sup>th</sup> April 2016. This Final Scoping Study report consolidates the second workshop findings, decisions and comments.

It is envisaged that plans for the pilot demonstration and training initiatives, plus equipment procurement and any support requirements will now be developed by the newly formed TDU Coordination Committee with the support of AFCAP.

And finally a quotation from Dambisa Moyo, a Zambian author:

***“After more than five decades of the wrong diagnosis, it is time now to turn the corner and take the harder but indisputably better road.”***

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