

# Establishment of Tractor-based road works Demonstration-Training Unit in Zambia

Project Closure Report – Volume 1 of 2



**Authors: Robert Petts & Kingstone Gongera**

*AFCAP Project Reference Number: ZAM2059B*

**August 2020**



Citation: Petts, R., Gongera, K., Intech Associates (2020). Establishment of Tractor-based road works Demonstration-Training Unit in Zambia, Project Closure Report, ZAM2059B. London: ReCAP for DFID.

For further information, please contact: Robert Petts, [rob@intech-associates.co.uk](mailto:rob@intech-associates.co.uk)

ReCAP Project Management Unit  
Cardno Emerging Market (UK) Ltd  
Level 5, Clarendon Business Centre  
42 Upper Berkeley Street, Marylebone  
London W1H 5PW United Kingdom



The views in this document are those of the authors and they do not necessarily reflect the views of the Research for Community Access Partnership (ReCAP) or Cardno Emerging Markets (UK) Ltd for whom the document was prepared

Cover and other photos: Intech and Clanview Civils

#### Quality assurance and review table

Version	Author(s)	Reviewer(s)	Date
1	Robert Petts & Kingstone Gongera		25 August 2020
		Henry Nkwanga (ReCAP PMU)	9 September 2020
		Martin Daka (NCC)	9 September 2020
		Christopher Kapasa (RDA)	9 September 2020
		Presley Chilonda (RDA)	9 September 2020

#### ReCAP Database Details :

Reference No:	EMUK10636A	Location	Zambia
Source of Proposal	RDA Zambia	Procurement Method	Tender
Theme	Infrastructure	Sub-Theme	Tractor Technology Road Maintenance
Lead Implementation Organisation	Intech	Partner Organisation	Road Development Agency
Total Approved Budget	£89,925.50	Total Used Budget	£81,925.50
Start Date	7 Aug 2019	End Date	31 August 2020
Report Due Date	31 August 2020	Date Received	25 August 2020

## Abstract

This has been a capacity building project that sought to introduce a cost-effective and sustainable approach to rural road maintenance by using agricultural tractor-based technologies already successfully applied in a number of countries in the region.

This project followed the successful completion and endorsement of a scoping study in 2016 and Phase 1 implementation of the Establishment of a Demonstration and Training Unit (DTU) in Chongwe Municipal Council; east of Lusaka, Zambia. The initiative was being directed by the Zambian Road Development Agency (RDA) with training provided by the National Council for Construction of Zambia (NCC). Local counterpart funding was provided by the Zambia National Road Fund Agency (NRFA). The project was being managed under Phase 2 of implementation.

This report, commissioned by the Africa Community Access Partnership (AFCAP) for RDA, describes the review of the activities of the Consultant's team members and local counterparts in the period up until the termination of Phase 2 of the project, to facilitate the main training and demonstration activities in 2019-20. The Consultants provided remote support between country visits. The progress of the demonstration and training, and related initiatives are described in this report.

The tractor-based road maintenance methods have already been proven elsewhere in the Sub-Saharan Africa region. This project verifies the applicability of these approaches for the Zambian unpaved road network and demonstrates that the adoption of these methods could reduce road maintenance costs by more than 50%.

Due to premature cessation of project activities relating to the Covid-19 pandemic, there are outstanding issues to be addressed; which are discussed in this report. Recommendations are made regarding beneficial follow up.

## Key words

Key Words: Tractor Road Maintenance Zambia Demonstration Training.

## Acknowledgements

The authors would like to express appreciation to Engs. Christopher Kapasa, Presley Chilonda, and the RDA team, Eng. Martin Daka and the trainers of NCC, Eng. Peter Banda of Chongwe MC, and the DTU Coordination Committee members who facilitated the activities of the assignment and introductions to and dialogue with the stakeholders. The various stakeholders and the Coordination Committee members contributed their time and knowledge to support the successful implementation of piloting, training, demonstration and uptake of tractor technology road works applications.

Images: Intech Associates and Clanview Civils

### Safe and sustainable transport for rural communities

ReCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable transport for rural communities in Africa and Asia. ReCAP comprises the Africa Community Access Partnership (AfCAP) and the Asia Community Access Partnership (AsCAP). These partnerships support 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 ReCAP programme is managed by Cardno Emerging Markets (UK) Ltd.

[www.research4cap.org](http://www.research4cap.org)

## Acronyms, Units and Currencies

AFCAP	Africa Community Access Partnership
CEO	Chief Executive Officer
CMC	Chongwe Municipal (formerly District) Council
CRN	Core Road Network
DFID	Department for International Development
DNPW	Department of National Parks and Wildlife
Eng.	Engineer
GoZ	Government of Zambia
hp	horse power
IRCP	Improved Rural Connectivity Project
IRI	International Roughness Index
km	kilometre
kW	KiloWatt
LRA	Local Road Authority
LVR	Low (traffic) Volume Road
MAL	Ministry of Agriculture & Livestock
MoLG	Ministry of Local Government
MSMEs	Micro Small and Medium Enterprises
NAMSSC	National Association of Medium and Small Scale Contractors
NCC	National Council for Construction
NRFA	National Road Fund Agency
OJT	On-the-Job Training
OPRC	Output and Performance based Road Contract
R&D	Research and Development
RDA	Road 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
ZMK	Zambian Kwacha (US\$1 = ZMK 18.6)
ZNFU	Zambia National Farmers Union
ZNS	Zambia National Service

## CONTENTS

### VOLUME 1

Abstract .....	2
Key words .....	2
Acknowledgements .....	2
Acronyms, Units and Currencies .....	3
CONTENTS.....	4
EXECUTIVE SUMMARY .....	6
1. BACKGROUND .....	7
1.1. Overview .....	7
1.2. Project Context .....	7
1.3. Related Projects .....	7
1.4. Project Partners .....	7
2. PROJECT OBJECTIVE.....	8
3. METHODOLOGY .....	8
4. COVID-19 ISSUES .....	8
5. PHASE 1 IMPLEMENTATION .....	9
6. TRAINING CURRICULA .....	10
7. TRAINING MATERIALS .....	10
8. EQUIPMENT PROCUREMENT/HIRE/MODIFICATIONS .....	10
9. BUDGET AND FUNDING ARRANGEMENTS .....	13
10. PRODUCTION DATA FROM THE DTU AND THE BENCHMARK DISTRICT.....	14
11. DATA RESULTS & ASSESSMENT .....	14
12. CHONGWE CORE ROAD NETWORK .....	14
13. SYSTEMS DEVELOPMENT STATUS .....	15
14. UPDATE ON EQUIPMENT CAPITAL COSTS .....	15
15. ECONOMIC CONSIDERATIONS OF TRACTOR TECHNOLOGY ROAD WORKS .....	16
15.1 Economic Environment .....	16
15.2 Assessment of Equipment Costs .....	17
15.3 Economic Analysis.....	20
16. THE GLOBAL CONTEXT .....	22
17. DISSEMINATION AND UPTAKE OF KNOWLEDGE .....	22
18. MEDIA PRODUCTIONS FOR TRAINING & AWARENESS CREATION .....	23
19. PROJECT CLOSURE WORKSHOP.....	23
20. UNRESOLVED ISSUES.....	25
21. LESSONS LEARNED .....	25
22. RECOMMENDATIONS FOR FOLLOW UP .....	26
REFERENCES.....	27

## **VOLUME 2 ANNEXES**

- ANNEX 1      TEVETA Notification of Tractor Technology Courses Approval**
- ANNEX 2      Comparison of Equipment Items Specified and Delivered**
- ANNEX 3      Asset & Maintenance Management Systems For RDA, NRFA & MOLG**
- ANNEX 4      Towed Grading Briefing (handout)**
- ANNEX 5      Project Close Down Action Plan Status**
- ANNEX 6      Detailed Equipment Financial Cost Analyses**
- ANNEX 7      Project Closure Workshop**

## EXECUTIVE SUMMARY

This has been a capacity building project that sought to introduce a cost-effective and sustainable approach to rural road maintenance by using agricultural tractor-based technologies already successfully applied in a number of countries in the region (including Zimbabwe, Mozambique and RSA). This project complemented the Economic Growth through Effective Road Asset Management (GEM) project, also funded under AFCAP that was also implemented in selected Chongwe District. Training of a range of management, technical and administrative personnel from the Chongwe Municipal Council, contractors' and engineering companies as well as staff from the Road Development Agency (RDA) of Zambia and local authorities has been a key element of the project.

This project followed the successful completion and endorsement of a scoping study in 2016 and Phase 1 implementation of the Establishment of a Demonstration and Training Unit (DTU) in Chongwe Municipal Council; east of Lusaka, Zambia; commenced in July 2017. The initiative was being directed by the Zambian Road Development Agency (RDA) with training provided by the National Council for Construction of Zambia (NCC). Local counterpart funding was provided by the Zambia National Road Fund Agency (NRFA).

This report, commissioned by the Africa Community Access Partnership (AFCAP) for RDA, describes the review of the activities of the Consultant's team members and local counterparts in the period up until the termination of Phase 2 of the project, to facilitate the main training and demonstration activities in 2019-20. The Consultants provided remote support between country visits. The progress of the demonstration and training, and related initiatives, are described in this report.

The tractor-based road maintenance methods have already been proven elsewhere in the Sub-Saharan Africa region. This project verifies the applicability of these approaches for the Zambian unpaved road network and demonstrates that the adoption of these methods could reduce road maintenance costs by more than 50%.

Due to premature cessation of project activities relating to the Covid-19 pandemic, there are outstanding issues to be addressed; which are discussed in this report. Recommendations are made regarding beneficial follow up.

The virtual Project Closure Workshop conducted by online Zoom arrangements reviewed the project, and supported the outcomes and proposed follow up recommendations towards national roll-out of the tractor technology road maintenance methods.



## 1. BACKGROUND

### 1.1. Overview

The Africa Community Access Partnership (AFCAP) is a programme of research and knowledge dissemination funded by the UK government through the DFID. AFCAP is promoting safe and sustainable rural access in Africa through research and knowledge sharing between participating countries and the wider community. The first phase of AFCAP commenced in June 2008 and ended in July 2014. The second phase, which will also run for 6 years, commenced on the 1<sup>st</sup> August 2014. The management of AFCAP2 is contracted by DFID to Cardno UK. The aim of the new AFCAP2 initiative, under the overall ReCAP umbrella, is to build on the programme of high quality research established under AFCAP phase 1 and take this forward to a sustainable future in which the results of the research are adopted in practice and influence future policy.

### 1.2. Project Context

All-season road-based transport is a vital enabler for rural development, social and economic activities and community wellbeing, particularly for vulnerable groups (women, children) (Cook et al, 2017). 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, cost-saving approaches to maintenance activities for the unpaved road network. Currently routine maintenance of unsealed roads 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 task.

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 has been no established unit in Zambia to demonstrate and train for this more affordable and more sustainable tractor-based technology.

Following completion of the scoping study which was aimed at investigating the location, institutional and management arrangements, organisation requirements and costs of setting up a Tractor Technology demonstration-training unit (DTU) for rural roads in Zambia, the stakeholders endorsed the recommendations for establishment of the Unit. The outcomes of the study and recommendations thereof are contained in the Report (Petts & Gongera, AfCAP ZAM2059A, Scoping Study Final Report, April 2016).

### 1.3. Related Projects

Related projects include previous and on-going experience with tractor-based technology in the region, for example in Zimbabwe, Mozambique and RSA. Not only are towed graders manufactured in the region (e.g. in Zimbabwe and South Africa), there is a wide range of other road construction and maintenance activities that the agricultural tractor can do to offer a total road rehabilitation and maintenance package based on the use of tractors.

Synergies with other programmes in Zambia have already been explored and details are contained in the Scoping Study Final Report mentioned in section 1.2 above.

Other related AfCAP projects are:

- GEN2018A “Economic Growth through Effective Road Asset Management – GEM”.
- GEN2070A “The use of appropriate high-tech solutions for Road network and condition analysis, with a focus on satellite imagery”.
- GEN2014A Climate Adaptation: Research on Risk Management and Resilience Optimisation for Vulnerable Road Access.

### 1.4. Project Partners

Project partners have been established through AfCAP and the DTU Coordination Committee:



- Regional partner countries, with particular reference to Zimbabwe, Mozambique and South Africa.
- Roads Development Agency (RDA) Planning, Design & Maintenance Departments
- National Council for Construction (NCC)
- Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA)
- Ministry of Local Government & Housing (MLGH)
- Zambia National Road Fund Agency (NRFA)
- Ministry of Agriculture & Livestock (MAL)
- Zambia National Service (ZNS)
- Chongwe Municipal (formerly District) Council (CMC)
- National Association for Medium and Small Scale Contractors (NAMSSC)
- Zambian Women in Construction Association (ZAWIC)
- Road Development Agency – WB Improved Rural Connectivity Project (IRCP)
- The Association of Consulting Engineers of Zambia (ACEZ)
- Zambia National Farmers Union (ZNFU)
- The Department of National Parks and Wildlife (DNPW)

## 2. PROJECT OBJECTIVE

The purpose of this project has been to embark on implementation of the recommendations of the scoping study in a phased manner, focussing mainly on setting up and conducting DTU activities in a selected District as a pilot project; namely Chongwe Municipal Council, east of Lusaka.

This is a capacity building project that seeks to introduce a cost-effective and sustainable approach to rural road maintenance by using tractor-based technologies already successfully applied in a number of countries in the region (including Zimbabwe, Mozambique and RSA). Training of a whole range of personnel from the District, contractors' and engineering companies as well as staff from the Road Development Agency (RDA) of Zambia and local authorities are a key element of the project.

## 3. METHODOLOGY

The project methodology involved preparation of detailed training Syllabi for the critical activities that will capacitate managers and practitioners of tractor-based road works technology to be fully equipped with the necessary skills to perform work efficiently using the technology. Based on the Syllabi, comprehensive training materials were developed for use during the various training courses for the target groups of management and practitioners.

The actual training was devised in two parts; formal classroom training where trainees are taken through the rationale and theoretical components of tractor-based technology, using the training material and syllabi for the relevant courses. The other part of the training involves on-the-job practical demonstration and training where the tractor technology is demonstrated in a real-life situation; this involving performing and demonstrating various work activities. The Zambia project is based in Chongwe Municipal area and the inaugural training session for the first batch of trainees took place from the 15<sup>th</sup> – 19<sup>th</sup> of December 2019 at NCC headquarters, and at the Kanakantapa training site in Chongwe Municipal Council area from 27<sup>th</sup> January to 7<sup>th</sup> February 2020.

In the period up to mid-March 2020, project activities continued at the Kanakantapa training site and preparations for the project close down and measures countering the Covid-19 pandemic were developed.

## 4. COVID-19 ISSUES

Project planning and operations have been seriously disrupted in 2020 by the rapid development of the global Covid-19 pandemic. This has affected both the local Zambian project personnel's activities and has confined the Zambian personnel and Consultant's activities primarily to home-based operations.

The main impact of this Covid-induced project close down has been failure for the planned activities to be satisfactorily completed before the scheduled close down of the ReCAP DTU support activities.

## 5. PHASE 1 IMPLEMENTATION

The preparatory Phase 1 of the Tractor Technology DTU was started in July 2017 and completed in April 2018.

This included the intermediate equipment study tour to Pietermaritzburg, RSA to inspect a manufacturer's premises and witness the demonstration of their heavy towed grader and other tractor based road maintenance equipment. The Phase 1 also included development of the revised Implementation Plan for Phases 2 and 3 of the Project.

Phase 1 included a range of activities which produced the following outputs, summarizing the Phase 1 activities:

- Petts & Gongera (2017), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Report 1 – Inception.
- Petts, Gongera and Petts (2017), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Equipment Evaluation Report.
- Petts and Gongera (2018), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Training Material Review.
- Petts and Gongera (2018), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Project Implementation Plan.
- Petts and Gongera (May 2018), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Phase 1 Final Report.

The Phase 1 final workshop was held in Lusaka in March 2018. The workshop was attended by representatives of all of the main stakeholders. The workshop discussed and endorsed the Phase 1 findings and recommendations, and the proposals for Phase 2 implementation of the project.

The following deliverables were agreed by the participants at the close of the workshop (with outcomes shown in italics):

- Any comments on the draft training materials prepared by the Consultant would be forwarded by Friday 6 April 2018 (*No further comments received*),
- Any suggestions on other courses would be forwarded to the Consultants by Friday 6 April 2018 (*No suggestions received*),
- Any comments on the draft Syllabi would be sent to Kennedy Bowa (TEVETA) by Friday 30 March 2018 (*No further comments*),
- Kennedy Bowa (TEVETA) would hope to gain final approval of all of the course syllabi during the following week (*Final approval has since been gained – Annex 1*),
- Alinani Msisya (NRFA) would investigate budget possibilities within NRFA and liaise with NCC regarding funding the DTU equipment procurement (*Equipment procurement was subsequently arranged by NRFA, however with substantial programme delays*),
- The DTU CC would actively work together to achieve a **July 2018** start for Phase 2 of the project (*Start up was actually delayed until **August 2019***),

- NCC would provide the Consultants with the available non-technical training materials (e.g. Health and Safety and Enterprise Development etc.) by 15 April for inclusion in the Phase 1 report (since completed),
- NCC would develop the remainder of the non-technical training materials by end of May 2018 (*achieved*).

The substantially delayed commencement of Phase 2 of the project was caused principally by issues with the changes of arrangements for, and procurement of, the principal items of equipment. This was not caused by the equipment supplier.

## 6. TRAINING CURRICULA

Following on the completion of the Scoping study and beginning of Phase 1 of the project, the Consultant identified training needs for the successful implementation of the tractor based road works technology. The list below is a summary of the courses identified as part of the training curricula:

- Skills award in operating tractor for road works (Tractor Driver)
- Skills award in operating tractor towed grader (Towed Grader Operators)
- Skills award in road maintenance supervision (Road Maintenance Supervisor)
- Skills award in road works record maintenance (Maintenance Clerk)
- Skills award in tractor based road works equipment repair and maintenance (Field Mechanic)
- Skills award in tractor based road works project management (District Engineers / Project Managers)

The draft curricula were prepared and shared with all the stakeholders for their concurrence. The Syllabi were approved by TEVETA; which is the accreditation board for Zambia examination and training programmes. The compilation of the syllabi was to comply with the project Phase 1 programme milestones. The approval process took over a year and this contributed to the delay of the project implementation.

Due to the Covid pandemic it has not been possible to schedule further training courses following government's announcement banning public gatherings. The Zambian private contractors and consultants have shown interest in the training, but this can only be arranged when the operational situation returns to normal. A copy of the TEVETA letter of Training Courses approval is included in Annex 1.

## 7. TRAINING MATERIALS

During Phase 2 implementation the Consultant prepared the technical and management training modules for all the six identified courses shown above on the syllabi listed above. The preparation of all non-technical training material that relates to administration, HR, management, local procedures, health and safety was the responsibility of National Construction Council. Due to lack of budgeted funds for this activity, the preparation of training material was also delayed until September 2019. This further delayed the project implementation beyond the originally planned timelines.

## 8. EQUIPMENT PROCUREMENT/HIRE/MODIFICATIONS

The Consultant's initial Phase 2 visit coincided with the training visit of the main equipment supplier: Rogue Steel Engineering, from RSA, to the NCC Kanakantapa field training site near Chongwe town.



**Figure 1 Equipment Supplier Training**

Training was provided to the appointed DTU NCC trainers and selected stakeholders were briefed on the equipment. It was also an opportunity for the Consultant to review the equipment and discuss issues relating to its application.

The Consultant had previously made recommendations for procurement of equipment in accordance with the RDA and RECAP project and contract Terms of Reference (Petts & Gongera, 2018). These were intentionally aimed at demonstration and training of Tractor based rural road maintenance operations.

More specifically, this covers Routine and Periodic Maintenance activities; which include:

- Light (routine) grading
- Heavy (periodic) grading
- Tyre dragging
- Materials, hand tools and personnel logistics.

The detailed proposals for procurement were contained in the Equipment Evaluation Report (Petts, Gongera and Petts, 2017), and were as follows:

#### **Routine Maintenance**

- 2 No. 70hp 2WD agricultural tractors
- 1 No. 2 tonne towed grader (From J Mann, Zimbabwe mechanical – proven performance)
- 1 No. 5 tonne 2 axle general purpose, heavy duty trailer
- 1 No. 2,500 litre water bowser units for use on the trailers
- 10 No. tyre drags – locally fabricated.

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

- 2 No. 100hp 4WD agricultural tractors
- 1 No. 5 tonne towed grader (CMC, Kenya) – proven performance
- 1 No. 5 tonne towed grader (Rogue, RSA) – these have been reviewed and deemed suitable for the project
- 1 No. 5 tonne towed Pneumatic Tyred Rollers (PTR)
- 1 No. 5 tonne steel towed roller
- 1 No. 5 tonne 2 axle general purpose heavy duty trailers
- 1 No. 4,500 litre single axle water bowsers.

Recommended procurement specifications were provided.

Unfortunately, the procured equipment varied very substantially from the original recommendations and the Consultant accordingly prepared a thorough review of the delivered equipment items; which is summarised in Annex 2. During Phase 2, most of these issues have been satisfactorily addressed under arrangements managed by NCC & RDA.



In view of the procurement deficiencies, for routine maintenance demonstration and training it was also considered a necessity to arrange procurement of a new 70hp 2WD tractor or rehabilitation of one or more of the existing NCC MF290 tractors. It was also required to procure a 2 tonne towed grader. The final solution was agreed to redeploy a MF290 tractor from the NCC construction unit. Arrangements have been made to hire a light towed grader from DNPW. However, at the time of this reporting (August 2020) the equipment has not yet been transferred to NCC.

The procured compaction equipment delivered was not heavy enough for the periodic maintenance heavy grading operations and a heavier towed roller needs to be procured or hired in. Furthermore, the delivered roller was insufficiently robust for operations when surcharged as intended; leading to one of the roller's frame cracking. The supplier agreed to bear the cost of repair and strengthening the rollers and this activity was completed on 30<sup>th</sup> January 2020

Zambian government has been facing severe funding challenges and the road sector has not been spared. The National Roads Fund Agency has to meet several outstanding payments that are due to various contracts and this puts the procurement of outstanding equipment difficult, due to competing demands and priorities for the Road Fund. This is an observation made by the Consultant based on information gathered during interaction with the RDA and NFRA staff. The fabrication of the tyre drags is in progress while the purchase of minor accessories such as the fuel cap locks and side mirrors for the tractors have not been identified as priority.

As a relevant footnote, the Cat 140K Chongwe motor grader (Figure 2) has been out of action since February 2019 due to an engine split cylinder sleeve and valve issues in the cylinder head. The estimate for a replacement engine is about US\$60,000. This follows the US\$33,000 bill for the transmission replacement advised in the Phase 1 Report (Petts and Gongera 2018). These repair bills alone would have been sufficient funding to procure two basic sets of new, and more easily manageable, tractor routine maintenance equipment (tractors, towed graders, trailers, bowsers and drags).



Figure 2 Chongwe Municipal Council Motorgrader



Figures 3 & 4 Cracked cylinder sleeve and defective cylinder head of the Chongwe motorgrader

Chongwe Municipal Council is considering procurement of new road maintenance equipment to use on the remainder of the network that will not be covered by the DTU activities. The cost savings and greater flexibility of adopting tractor technology equipment approaches is being seriously considered.

## 9. BUDGET AND FUNDING ARRANGEMENTS

Funds for the construction of a shed for the weather protection of all the maintenance equipment were released and its construction is now complete (Figure 5). The NFRA released funds for actual training and for road maintenance operations to the National Construction Council. The operational procedures for use and reporting progress and expenditure have been proposed in detail by the Consultant as part of the support for the project. The prevailing situation due to the pandemic has affected the continuation of activities. The delay in the release of funds has affected the smooth progression of the project.

The agreement between the project parties included two graduate engineers to be provided and funded from the Zambian partners. Unfortunately, this did not materialise, which constrained the management of field operations and data collection.



**Figure 5 – Completed equipment shed at Kanakantapa Training Site**

## 10. PRODUCTION DATA FROM THE DTU AND THE BENCHMARK DISTRICT



**Figure 6 – Location of Chilanga and Chongwe Districts, either side of Lusaka.**

Due to the funding disbursement delays, and now the Covid-19 pandemic and resulting local ‘lockdown’, the Consultants have to date not received any usable data on the NCC, Chongwe or Chilanga maintenance works operations for performance and cost analysis. The operations were initiated early in December when the training started, however the delay in releasing funds to NCC for actual road maintenance operations has led to delays in implementing plans that were prepared in December 2019.

## 11. DATA RESULTS & ASSESSMENT

With no data available, it has not been possible to carry out performance and cost assessment of the various DTU maintenance operations. In view of this, the Consultants have developed costing data from first principles and previous experience of works operations in Kenya, Mozambique and Zimbabwe.

## 12. CHONGWE CORE ROAD NETWORK

Survey data on the ‘Maintainable’ (i.e. only light grading required) roads and those requiring heavy (rehabilitation) grading is still required to be compiled and forwarded to the Consultants.



### 13. SYSTEMS DEVELOPMENT STATUS

The requirement for specific management tools for the improved asset management of the rural road network in Zambia has been identified by this and the GEM<sup>1</sup> Project.

The core ZAM2059B activities of training of public and private sector personnel under the Tractor Technology Demonstration and Training Unit (DTU) are merely the starting point in developing a vibrant and sustainable rural road asset management and maintenance sector based on either force account or Zambian MSMEs implementation.

There are a number of other challenges which have been identified under the Phase 1 and 2 investigations of the project which will influence the implementation plans and programme, and success of the national roll out of the tractor technology methods and good asset management practice. These are discussed in detail in Annex 3.

### 14. UPDATE ON EQUIPMENT CAPITAL COSTS

In preparation for the costing comparison of the heavy equipment and tractor technology options, the following Table 1 sets out the current capital equipment costs for setting up a maintenance unit suitable for a typical 200km road network to carry out all routine maintenance activities and heavy grading, using the two principal technology options.

The capital costs would be representative of either a local authority (District) or local contractor implementation.

Because of global manufacturing and procurement disruption caused by the Covid-19 pandemic, the possible effects on future whole life costing of equipment options will need to be assessed from time to time in the future. Nonetheless, these costs should be regularly updated for management decision making.

**TABLE 1 - ROUTINE ROAD MAINTENANCE & GRADING UNIT EQUIPMENT CAPITAL COSTS**

Suitable for an unpaved road network of 200km			
Applicable for light and heavy grading and miscellaneous routine maintenance			
<b>A. HEAVY EQUIPMENT OPTION</b>			
	ITEM	COST NEW (US\$)	Remarks
1	1 No Caterpillar 120 Motor grader	300,000	Light & Heavy Grading
2	1 No 16,000L water bowser truck	75,000	Watering
3	1 No 10 tonne tipper truck	45,000	General Haulage
4	1 No Caterpillar CS44B 100Hp Compactor	135,000	Compaction
<b>TOTAL UNIT COST NEW (US\$)</b>		<b>555,000</b>	
<b>B. TRACTOR BASED UNIT OPTION</b>			
	ITEM	COST NEW (US\$)	Remarks
1	1 No 70HP 2WD Tractor	20,000	Light Grading & General
2	1 No Light (2T) Towed Grader	15,000	Light Grading
3	1 No 100HP 4WD Tractor	40,000	Heavy Grading & General
4	1 No Heavy (5T) Towed Grader	28,000	Heavy Grading

<sup>1</sup> AFCAP Project No. 10636A GEN2018A

5	1 No Towed Water Bowser 5,000L	15,000	Watering
6	1 No General purpose trailer	12,000	General Haulage
7	1 No 5T deadweight roller	20,000	Compaction
8	10 No Towed drags	3,000	Dry Season Dragging
<b>TOTAL UNIT COST NEW (US\$)</b>		<b>153,000</b>	

**The Tractor Technology option represents a 72% capital cost saving compared to the heavy equipment option.**

Chongwe Council has confirmed that their Caterpillar 140K motor grader (Figure 2) was purchased for approximately US\$300,000 in 2011 and has an average annual utilisation of about 500 hours per year. It is currently awaiting a decision on the procurement and fitting of a replacement engine unit.

Since the start of the Project Phase 1 in July 2017, against the US\$ the Zambian Kwacha exchange rate has depreciated from about 9.0 to the current level of 18.6 (Figure 7). This means that as nearly all of the equipment currently has to be imported, the cost in Zambian Kwacha terms has approximately doubled in this period. This amplifies the local advantages of adopting the tractor technology solutions. Furthermore, most of the tractor attachments could be manufactured locally in Zambia; thus saving foreign exchange and promoting local employment.



**Figure 7 - US\$ to Zambia Kwacha exchange rate variation**

## 15. ECONOMIC CONSIDERATIONS OF TRACTOR TECHNOLOGY ROAD WORKS

### 15.1 Economic Environment

The current interbank interest rate of the Bank of Zambia is 9%. It had been at 14% in May 2017. Current Zambian interbank commercial rates are 18% per annum. The Bank of Zambia reports that current general and food inflation is running at about 16% per annum.

By contrast, the UK interbank rate is currently 0.13% and 12-month inflation rate was 0.7% in May 2020.

Through discussions with a number of banks and finance companies in Zambia, the minimum interest rate for commercial loans starts at about 35% per annum. With additional arrangement fees and insurances, etc., the cost of commercial credit is extremely high, and this issue is seen to be a serious problem for local Micro, Small and Medium Enterprises (MSMEs). Many finance houses and even asset-based lenders are

reluctant to lend for vehicles or mobile equipment due to the risk of mobile assets moving beyond the reach of the lender and invalidating collateral assurance.

## 15.2 Assessment of Equipment Costs

There is very little reliable data available on the costing of equipment and operations for road maintenance in Sub-Saharan Africa. Most data sources are out of date, incomplete or project based and therefore distorted. The road maintenance contracting market in Zambia is very small and does not operate efficiently. It is suspected that there is cross-subsidisation from the relatively large-scale construction activities to the costs of the small quantity of occasional maintenance contract work. Furthermore, World Bank review of Sub-Saharan contracts showed evidence of sector inefficiencies and irregularities (Queiroz, 2012). These include:

- Long periods between bid opening and contract signing
- Significant cost increases during implementation
- Time overrun of the originally contracted period
- Contract value is much more than the Engineer's Estimate
- Half or more firms buying bidding documents do not bid
- Significant number of pre-qualified firms do not bid
- Difference between winning bid and next lowest bid is minimal
- Winning bid is not the lowest bid accepted for detailed examination
- Only one or two bidders
- Cost per km for similar works and unit road works costs are higher than norms.

Road Maintenance costs rarely include all components that are necessary to represent and convey the realistic overall costs of owning and operating equipment in a limited resources environment. Benchmark costing systems are rare in Africa. Even where they do exist, they are usually not regularly updated. This is in stark contrast to developed economies where detailed equipment and task costing data is readily available and regularly updated for clients and contractors to access and refer to. In consequence, African road authorities and contractors are generally both oblivious to the overall real costs and this factor contributes to poor long-term planning, bidding, and thus insufficient asset management.

To carry out an assessment of real costs of owning and operating road works equipment, key parameters to be considered are cost of finance or opportunity costs, and annual utilisation. These will be particularly influential in assessing technology and capital investment options appropriate for rural road works, and especially for road maintenance.

In economically advanced countries such as the Netherlands, for economic evaluation a typical discount rate of 4.5% is applied to transport projects due to the low finance rate (Mouter, 2018). Other European countries such as UK use 3.5% (Treasury Green Book), Denmark 4%. USA (FHWA) uses 7%. For developing countries discount rates of 10 – 20% are typically used to reflect the added risk and higher cost of capital, with the World bank using between 10 – 14% worldwide for transport projects. In contrast, a private investor in a toll road may require a return in excess of 30%.

It should be noted that given the current Covid-19 pandemic constraints and the expected related serious economic aftermath and fallout, all of these benchmarks are likely to be thrown into doubt.

Typically, infrastructure projects and investment decisions are valued using a combination of Internal Rate of Return, Net present Value and payback period. In a constrained resource environment such as Zambia, the finance/opportunity cost of capital is a particularly influential factor. **The high rates of interest suggest a capital minimisation strategy should be most appropriate.**

The 2017 DTU equipment economic analysis (Petts and Gongera. Oct 2017) found that at all rates of interest considered (15%, 25% and 35% p.a.) and annual utilisation rates (500 and 1,000 hours) the tractor technology options are more than 50% less in financial cost than the heavy equipment option. Higher finance costs also have a proportionately higher negative effect on ownership of capital intensive, heavy equipment. Furthermore, for the local private sector the necessity to pay VAT (at 16%) on construction plant and large agricultural tractors (90hp+) mean that the actual real costs of ownership are even higher.

The following tables (2 – 5) have been produced by updating the analyses carried out for the 2017 project report. The tables are for equipment utilisation rates of 500 and 1,000 hours per year in both Zambian Kwacha and US\$, at various opportunity/finance cost rates.

**TABLE 2 – ROAD MAINTENANCE EQUIPMENT COSTS RELATING TO UTILISATION AND FINANCE COST – UTILISATION OF 500 HOURS PER YEAR (ZAMBIAN KWACHA)**

Equipment & Annual Utilisation (hours)	Ownership & Operating Cost PER DAY (excluding VAT on procurement)		
	Opportunity/Finance Costs 15% P. A.	Opportunity/Finance Costs 25% P. A.	Opportunity/Finance Costs 35% P. A.
140hp Motorgrader 500hours/year	ZMK 25,913	ZMK 29,484	ZMK 33,055
100hp Tractor+Heavy Grader 500hours/year	ZMK 8,800	ZMK 9,609	ZMK 10,420
70hp Tractor+Light Grader 500hours/year	ZMK 6,233	ZMK 6,656	ZMK 7,080

**TABLE 3 – ROAD MAINTENANCE EQUIPMENT COSTS RELATING TO UTILISATION AND FINANCE COST – UTILISATION OF 500 HOURS PER YEAR (US\$)**

Equipment & Annual Utilisation (hours)	Ownership & Operating Cost PER DAY (excluding VAT on procurement)		
	Opportunity/Finance Costs 15% P. A.	Opportunity/Finance Costs 25% P. A.	Opportunity/Finance Costs 35% P. A.
140hp Motorgrader 500hours/year	US\$ 1,393	US\$ 1,585	US\$ 1,777
100hp Tractor+Heavy Grader 500hours/year	US\$ 473	US\$ 517	US\$ 560
70hp Tractor+Light Grader 500hours/year	US\$ 335	US\$ 358	US\$ 381

**TABLE 4 – ROAD MAINTENANCE EQUIPMENT COSTS RELATING TO UTILISATION AND FINANCE COST – UTILISATION OF 1,000 HOURS PER YEAR (ZAMBIAN KWACHA)**

	Ownership & Operating Cost PER DAY (excluding VAT on procurement)		
Equipment & Annual Utilisation (hours)	Opportunity/Finance Costs 15% P. A.	Opportunity/Finance Costs 25% P. A.	Opportunity/Finance Costs 35% P. A.
140hp Motorgrader <b>1,000hours/year</b>	ZMK 17,844	ZMK 19,657	ZMK 21,471
100hp Tractor+Heavy Grader <b>1,000hours/year</b>	ZMK 6,807	ZMK 7,264	ZMK 7,720
70hp Tractor+Light Grader <b>1,000hours/year</b>	ZMK 4,994	ZMK 5,271	ZMK 5,547

**TABLE 5 – ROAD MAINTENANCE EQUIPMENT COSTS RELATING TO UTILISATION AND FINANCE COST – UTILISATION OF 1,000 HOURS PER YEAR (US\$)**

	Ownership & Operating Cost PER DAY (excluding VAT on procurement)		
Equipment & Annual Utilisation (hours)	Opportunity/Finance Costs 15% P. A.	Opportunity/Finance Costs 25% P. A.	Opportunity/Finance Costs 35% P. A.
140hp Motorgrader <b>1,000hours/year</b>	US\$ 959	US\$ 1,057	US\$ 1,154
100hp Tractor+Heavy Grader <b>1,000hours/year</b>	US\$ 366	US\$ 391	US\$ 415
70hp Tractor+Light Grader <b>1,000hours/year</b>	US\$ 269	US\$ 283	US\$ 298

The detailed analyses are contained in Annex 6. The main changes from the 2017 evaluation are the substantially changed Kwacha exchange rate and fuel price. In all cases the price advantage of the tractor technology is increased; **with tractor technology always being less than half the cost of using the motorgrader.**

This is thus a very strong argument for the tractor technology adoption on unpaved road maintenance. This will be more so in the highly financially and resource constrained post-Covid era.

Note that for routine light grading (typically 4 passes) the daily route output will be similar for the three technology options. The tractor advantages of easier turning ability and hence quicker pass turnaround, and improved logistics due to being expected to be typically based closer to work locations are not considered. In practice these factors would also add advantage to the tractor options.

An interesting observation from that financial analysis and experience elsewhere, is that all three equipment options are proven to be capable of light grading up to 10 route-km per day (4 passes) under efficient operational and logistical situations (Petts, 1992, and Gongera & Petts, 2003). Applying this potential output to the analysis figures indicates the feasibility of achieving routine maintenance light grading for between about US\$40/km (tractor based) to US\$180/km (motor grader) for each operation even at low utilisation. The tractor options are very substantially cheaper than using a motor grader.

This analysis provided results comparable with reliable data from the Western Cape in South Africa and Namibia. The data indicates light grading operations **for a whole year** are assessed to be in the range

US\$290 to US\$720/km/year, where a variable number of individual gradings would be required to achieve satisfactory routine maintenance.

### 15.3 Economic Analysis

For economic assessment purposes, a discounted comparison of whole life costs between motor grader and tractor equipment was made specifically for routine maintenance light grading operations (Petts and Gongera. Oct 2017).

It is important to note that the logistics and seasonality of unpaved road maintenance grading is completely different to intense and concentrated construction site activity. The influential cost factors are accordingly distinctively dissimilar.

The time value of money and the more onerous investment, operating and maintenance costs of a motor grader, favours the lower capital cost of the tractor. To demonstrate 10%, 20%, and 30% discount rates were used in the Discounted Cash Flow (DCF) lifecycle costing.

In practice a motor grader would be intended to be used for both light and heavy grading in an annual road maintenance cycle. The tractor could also be used for a range of productive activities throughout the year. The analysis focussed on the periods of feasible efficient routine light grading and made a range of assumptions to pro-rata performance and costs to a one year analysis basis. The economic analysis assumptions for the various Discounted Cash Flow (DCF) and results are contained in the Equipment Report (Petts and Gongera. Oct 2017). Two main scenarios were analysed; that of high utilisation (1,000 hours per year) and low utilisation (500 hours per year). The low utilisation is the order of current usage of the Chongwe motorgrader and typical road maintenance motorgrader utilisation experience elsewhere (Petts & Jones, 1991). Results in parenthesis in the tables are uneconomic.

**Table 6**

#### Summary findings for light grading (maintenance) comparison Motorgrader V's Tractor Towed Grader - HIGH UTILISATION

Net Present Value of Investment	DCF 10%	DCF 20%	DCF 30%
Motor Grader	\$ 166,234.77	\$ 17,273.67	\$ (53,242.39)
Tractor & Towed Grader	\$ 683,177.62	\$ 463,290.01	\$ 347,784.25

  

Internal Rate of Return	DCF 10%	DCF 20%	DCF 30%
Motor Grader	22%	22%	Uneconomic
Tractor & Towed Grader	1000%	1000%	1000%

  

Payback Years	DCF 10%	DCF 20%	DCF 30%
Motor Grader	7	12	Never
Tractor & Towed Grader	1	1	1

Table 7

**Summary findings for light grading (maintenance) comparison  
Motorgrader V's Tractor Towed Grader - LOW UTILISATION**

Net Present Value of Investment	DCF 10%	DCF 20%	DCF 30%
Motor Grader	\$ (2,348.00)	\$ (93,902.03)	\$ (136,851.53)
Tractor & Towed Grader	\$ 340,212.81	\$ 224,547.55	\$ 163,862.01

  

Internal Rate of Return	DCF 10%	DCF 20%	DCF 30%
Motor Grader	Uneconomic	Uneconomic	Uneconomic
Tractor & Towed Grader	1000%	1000%	1000%

  

Payback Years	DCF 10%	DCF 20%	DCF 30%
Motor Grader	Never	Never	Never
Tractor & Towed Grader	1	1	1

From the economic analysis, the following conclusions are drawn:

- Net Present Value of the Tractor and Towed grader is always positive and repays even with 30% discount rate within a year, even at low utilisation.
- The Motor Grader will only pay itself back at low discount rates and high utilisation. At low utilisation rates, the Motor Grader is uneconomic.
- The Motor Grader breaks even at discount rates of 22%, so it is not worth investing unless cheap finance is available and high utilisation can be assured.
- The difference in Net Present Value of the investments for high utilisation scenarios, even at African discount rates, is over US\$400,000.
- The potential attraction of the tractor technology to the MSME sector is clear if contractors are allowed and encouraged to be involved in rural road maintenance, as the capital investments are substantially lower, payback period is short and there is potential for cross sector earnings, compared to heavy equipment approaches.

The economic analysis compares the two technologies at equivalent utilisation and discount rates for a specific activity. In reality, the potential economic advantages of the tractor technology approach are substantially greater for the following reasons:

- The flexibility of the agricultural tractor as the low cost mobile power source with many rural activity applications and opportunities for other economic development in the roads, agriculture, water and other rural sectors are additional economic benefits to be added to the return on investment for the Tractor.
- For any level of funding in a resource constrained environment, more tractor based operational units can be procured than heavy equipment based.
- The multi-tasking potential of the tractor technology, synergies with the agricultural sector and private sector involvement potential will mean that in the future higher actual tractor utilisation and much lower unit costs will create greater economic returns on tractor investments than heavy equipment options. Dialogue is proposed with the Zambia National Farmers Union (ZNFU) to explore this potential in detail.



- The potential for the tractor attachments to be made in Zambia and feasible tractor assembly in Zambia would enhance the economic benefits of the tractor technology approach.
- Global production of agricultural tractors is about 100 times that of motorgraders. So, that spares supply and local mechanical support will always be logistically superior and cheaper than for motorgraders.
- The feasibility of delivering more road maintenance at lower unit costs using the tractor technology should realise further socio-economic benefits as a result of improved all-season rural access, lowering of user transport costs and stimulation of other investments in the rural areas.

At the time of the DTU equipment economic analysis in 2017, the Zambian Kwacha was trading at about 9 to the US\$, whereas now the rate is 18.6. It has therefore lost about 50% of its value! With nearly all equipment imported it is now ever more important to adopt low capital technologies in Zambia, where they are proven to be capable of delivering the same quality of work, at much lower cost, and with the potential affordable use by local MSMEs.

## 16. THE GLOBAL CONTEXT

Sustainable Mobility for All (SuM4All) is an umbrella platform that brings together 55 public and private organizations and companies with a shared ambition to transform the future of mobility. Its unique value lies in bringing key influential actors to work together. It serves as the principal platform for international cooperation on sustainable mobility, a centre of excellence, and a repository of policy, knowledge and resource on sustainable mobility. Its mission is to play a leading role in the ongoing transformation of the global mobility system, and support countries in their transition towards sustainable mobility. In their recent report: Global Roadmap of Action, Towards Sustainable Mobility (Sum4ALL, 2019) the following guidance is made with relevance to Asset Management of rural road networks:

*“Four policy measures that address asset management aim to maintain and restore transport infrastructure and ensure that transport systems meet their performance requirements over their life span, and across types of infrastructure for all modes of transport.*

*Asset management is supported by the “development of asset management plans and standards”, that will preserve, maintain, and manage transport infrastructure; and “establishing reliable approaches to feeder road asset management,” **that focus on feeder road maintenance as one of the main bottlenecks for achieving universal rural access.** Such policy measures promote an approach in which communities are involved in routine maintenance where feasible.*

*The main policy goals these measures address are efficiency and universal rural access. Local governments, maintenance contractors, and communities, play the largest role in the delivery of asset management policies.*

The substantially lower capital and operating costs of tractor-based road maintenance, the substantially easier technical support and management needs of the technology, and the potential to involve local enterprises and communities, make this approach a future vital component of rural road asset management for sustainable mobility and poverty reduction.

## 17. DISSEMINATION AND UPTAKE OF KNOWLEDGE

Because of the Covid-19 situation, it will not be possible to arrange the study tour or in country Final Workshop in the current project closure period. These project components have therefore been cancelled, unless a project extension can be arranged.

The training material produced by the Consultant can be used in awareness creation programmes. A recent briefing PPT was provided for the purpose of augmenting the previously provided materials (Annex 4).

## 18. MEDIA PRODUCTIONS FOR TRAINING & AWARENESS CREATION

To enhance the electronic and course materials produced in Phase 1 of the Project, it was agreed to develop a series of video and PowerPoint documents under Phase 2 to enhance training and awareness creation activities. Due to the Covid-19 situation, these were prepared in Zambia, Zimbabwe and UK using new and existing visual materials.

Video presentations for both light routine maintenance grading and heavy rehabilitation grading activities have been produced to demonstrate effectiveness of the tractor technology.

Separate videos for the daily checks on the light and heavy tractors and towed graders have also been prepared.

An audio PowerPoint introducing the tractor technology roadworks has also been produced for decision makers' awareness and general training.

## 19. PROJECT CLOSURE WORKSHOP

The original plan was to hold a project review in Lusaka; to be attended by the various project stakeholders. The onset of the global Covid-19 pandemic meant that this would not be possible. Therefore, it was agreed to hold a virtual workshop using Zoom<sup>2</sup>.

A Zoom Project Closure Workshop was arranged for Friday 21<sup>st</sup> August 2020. The original programme envisaged an all-day event. However, this had to be compressed when it was found to be necessary to treat the RDA offices in the afternoon against possible Coronavirus contamination.

Despite these drawbacks the workshop went ahead with key stakeholders contributing to the presentations and discussions, or by participating.

All of the views expressed were positive towards the impact of the project. However, it was broadly appreciated that considerable further work is still required regarding awareness creation, confidence building and mobilising support for the national roll-out of the demonstrated tractor roadworks technology.

Annex 7 in Volume 2 contains the virtual workshop programme and some of the presentations.

The workshop recommendations for follow up included:

- National road maintenance policy to be updated taking account of the Tractor technology DTU project knowledge and experiences.
- Road Network Asset Management Tools to be developed and applied:
  - Rational Maintenance System for Rural Roads
  - Inventory and Condition data system
  - Planning and Budgeting Asset Management System
  - Works Reporting System
  - Appropriate Micro Small and Medium Enterprise (MSME) Contract documentation for LVR maintenance works using tractor technology,
  - An Equipment Cost model for MSMEs and Road Authorities.
- Maintenance Funds allocation to be based on data justifying performance, economic & social benefits and maintenance needs.
- Continue to support RDA, NCC, NRFA, MoLG and Chongwe Council in the Demonstration and Training operations, in the 'roll out' of the techniques to a national upscaling.

---

<sup>2</sup> Zoom is a videotelephony and online chat service through a cloud-based peer-to-peer software platform and is used for teleconferencing, telecommuting, distance education, and social relations.

- Support the IRCP project in the introduction of local MSME routine maintenance operations,
- Support the continued operation of DTU Coordination Committee.
- Support members of the National Association of Medium and Small Scale Contractors and Zambian Association of Women in Construction to develop capacity to effectively compete for and carry out road maintenance contracts, using tractor technology.
- Support University of Zambia Engineering and Agricultural Schools to mainstream the proven tractor technology roadworks in curricula.
- A Pilot Tractor Technology works Unit to be established in Chongwe Municipal Council, to compliment the established NCC training initiatives.

These recommendations were endorsed 100% in the workshop feedback received. Regarding most of the suggestions, outline proposals have already been prepared.

Regarding the last Pilot Works Unit suggestion, the following initiative could be envisaged:

The Tractor-based road works Demonstration-Training Unit ReCAP Project in Zambia (RECAP Project Reference: ZAM2059B), is now drawing to a close, due to the closure of the ReCAP programme. However, at the Project Closure workshop on 21 August 2020, the stakeholder participants endorsed a proposal to set up a Pilot Tractor Technology Works Unit in Chongwe district (the location of the NCC field training for the project), to act as a national model for managing road maintenance works using tractor technology.

The unit would manage approximately 200km of the approximately 400km municipality unpaved road network. It would have the following roles:

- To manage the selected Works Unit network using only the unit's tractor-based equipment.
- Rehabilitate the roads to a maintainable condition using one 100hp 4WD tractor and heavy towed grader, towed bowser and roller (no expensive gravelling would be arranged, thus demonstrating the suitability of very-low-cost maintained earth road running surface for the levels of traffic experienced).
- Establish effective routine maintenance on the rehabilitated roads using a 70hp 2WD tractor and light towed grader and towed drags.
- Maintain vegetation control, drainage system and erosion control with a small labour workforce with handtools; transported between sites in a general-purpose towed trailer.
- Act as a model unit for contractors (particularly (MSMEs), local consultants, and other stakeholders and decision makers to visit, and to establish confidence in the systems across the rural road sector.
- Collect, compile and disseminate benchmark performance and cost data for use by NRFA, RDA, MOLG and other councils to plan and implement their own tractor-based road maintenance.
- Establish pilot management systems and tools for review and refinement before incorporating in a new national Road Maintenance Policy, and for wider roll-out; particularly:
  - A Rational Maintenance System for Rural Roads
  - Inventory and Condition data system
  - Planning and Budgeting Asset Management System
  - Works Reporting System
  - Appropriate Micro Small and Medium Enterprise (MSME) Contract documentation for LVR maintenance works using tractor technology,
- Feed equipment use data into a pilot Equipment Cost model for MSMEs and Road Authorities.
- Allow verification of financial and economic assessment and justification of the tractor-based road maintenance system.
- Allow engineering and agricultural college and university students, and sector professionals to gain field experience in the technology. The proximity to Lusaka would facilitate this important role.
- Feed practical network experiences into NCC training courses.

Discussions are being held between NRFA and RDA regarding the possibility to fund this initiative.

The unit could either be force account with Chongwe Council management, or by a Small Scale Contractor with a local Consultant supervising.

The following workshop comments are of specific relevance to the endeavours to actively follow up on the DTU initiative:

- Board members of RDA have made a resolution " to compel the Research and Development (R&D) Unit of RDA that all research findings should be incorporated into solicitation documentation so that it is implemented. It is stressed that the tractor technology output will be part of the research that will be incorporated.
- The IRCP representative requested closer cooperation with the R&D Unit to facilitate uptake of the tractor technology.
- The Chilanga Council Engineer Sophie requested more evidence-based data under works conditions to support the tractor technology compared to the traditional heavy equipment method, to facilitate general confidence building.
- The issue of NCC course fees was raised and the issue of Contractors' confidence to invest in the training without immediate works payback possibilities. It was agreed that the stakeholders would consider possibilities to subsidise the course fees in the short term until the national roll-out is established.

During the Workshop, the NFRA representative confirmed that the additional amounts had been paid out to the DTU project NCC accounts. NCC confirmed the received amounts:

- training (ZMK 233,000)
- equipment protection shed (ZMK 180,000)
- road maintenance operations (ZMK 460,000).

Feedback from the Workshop participants was very positive and endorsed the proposed project follow up actions. The summary of the feedback is provided in Annex 7 of Volume 2 of this Report.

## 20. UNRESOLVED ISSUES

Discussions were held with the RDA and NCC personnel to update on the agreed Action List of items to be addressed to ensure satisfactory preparations for, and implementation of, the demonstration and training activities. The updated status of the Action List items is contained in Annex 5.

With respect to the Consultant's contract, now coming to a close, the following items should be re-scheduled:

- Study Tour
- Comprehensive economic evaluation based on actual works performance
- Agreement on follow up actions.

## 21. LESSONS LEARNED

The project has involved cooperation of a number of Zambian stakeholder organisations. There has been an understandable challenge in coordinating the inputs and cooperation of the various parties. These challenges should be appreciated in planning future projects of this multi-disciplinary and multi-sector nature.

Despite the foregoing, the wide range of stakeholders in the project Coordination Committee allowed significant awareness creation and positive contributions to the project process.

The well-researched equipment recommendations of the Consultant were not followed in the equipment procurement. This resulted in delays and additional unbudgeted costs to the project operations. It is recommended that future project monitoring should be more pro-active, with pressure applied as necessary to keep parties to agreed responsibilities.

The tractor technology road maintenance approaches were taken up enthusiastically by the NCC local trainers and the ease of skill acquisition and application was evident from the demonstration and training activities.

## 22. RECOMMENDATIONS FOR FOLLOW UP

This has been a capacity building project that seeks to introduce a proven, cost-effective and sustainable approach to rural road maintenance by using tractor-based technologies already successfully applied in a number of countries in the region.

This project follows the successful completion and endorsement of a scoping study in 2016 and Phase 1 and 2 implementation of the Establishment of a Demonstration and Training Unit (DTU) in Chongwe Municipal Council; east of Lusaka, Zambia. The initiative has been directed by the Zambian Road Development Agency (RDA) with training provided by the National Council of Construction of Zambia (NCC). Local counterpart funding is being provided by the Zambia National Road Fund Agency (NFRFA).

The Project has successfully established training and demonstration of cost-effective tractor technology methods for routine and periodic maintenance, as well as rehabilitation of unpaved rural roads. The techniques offer cost savings of more than 50% or more over 'traditional' heavy equipment methods and are suitable for either local authority or local private sector MSME<sup>3</sup> implementation. The capital requirements to set up tractor-based maintenance units are less than 30% of the cost of heavy equipment units for comparable workloads.

Following the successful Phase 1 and 2 implementation, there is an identified need for further support to facilitate the national roll out of these techniques with the local Zambian partners and the World Bank IRCP project<sup>4</sup>.

The activities recommended to be provided by the Consultant over an extension period should include support for the follow up suggested by the Project Closure Workshop in Section 19 of this Report.

---

<sup>3</sup> MSME Micro Small and Medium Enterprise

<sup>4</sup> IRCP Improved Rural Connectivity Project

## REFERENCES

- Archondo-Callao Rodrigo S. (1999), Unpaved Roads Roughness Estimation by Subjective Evaluation. World Bank Infrastructure Note RT2.
- Asco for RDA, Zambia (2014), Final Report, Construction Supervision Services Rehabilitation of Feeder Roads in Eastern Province, Chipata/Katete Districts.
- Burrow M, Petts R, Snaith M, Ghataora G, & Evdorides M. (2015). What is the evidence supporting the technology selection for low-volume, rural roads in low-income countries and what evidence is there to support the sustainability of different rural road technologies? A Systematic Review, for EPI and DFID.
- Civil Design Solutions.(2019). Economic Growth through Effective Road Asset Management (GEM), Rural Road Asset Management Practitioners' Guideline, Project No. 10636A GEN2018A, London: ReCAP for DFID.
- Paul Collier, Martina Kirchberger, Måns Söderbom (2015), The Cost of Road Infrastructure in Low and Middle Income Countries, World Bank Group.
- Cook J, Petts, R. C. & Rolt J. (2013). Low Volume Rural Road Surfacing and Pavements, A Guide to Good Practice, AFCAP and DFID, 134 pages.
- Cook J, Petts R C, Visser C, & Yiu A. (2017), The Contribution of Rural Transport to Achieve the Sustainable Development Goals.
- Gongera K. and Petts R. C. (2003). A tractor and labour based routine maintenance system for rural roads, Institution of Agricultural Engineers, LCS Working Paper No 5, DFID, Landwards, 2000 & IRF 2001.
- Gongera K. (2012). Road Maintenance Management in Inhambane Province Mozambique, AFCAP Practitioners Conference.
- Gongera K. and Petts R. C. (2015). Agricultural Tractor Based Solutions for Rural Access and Development, T2 Conference, Bulawayo, May 2015.
- Gongera and Petts (2017), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Chongwe District Road Inventory & Condition Report.
- Gongera and Petts, (February 2020), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia, Bi-monthly Progress Report 2.
- Gongera and Petts, (April 2020), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia, Bi-monthly Progress Report 3.
- Hancox W and Petts R. C. (1999), Guidelines for the development of Small Scale Tractor-based Enterprises in the Rural and Transport Sectors.
- Intech Associates (1990), Minor Road Programme Master Plan, for MOPW, Kenya.
- Intech Associates (1991), Preliminary 10 Year Plan for labour based maintenance of the Classified Road Network, for MOPW, Kenya.
- Intech Associates (1993), Roads 2000, A programme for labour and tractor based maintenance of the Classified Road network, Pilot Project, Final Report, for MPWH, Kenya.
- KPMG (2019), 2019 Budget Highlights, Zambia.
- Larcher P. (1999), A Model for a Contractor Support Agency, MART WP14.
- Ministry of Transport, Works, Supply and Communications Ministry of Local Government and Housing, 2015, Local Road Authorities Procedures Manual.
- Mouter N (2018), A critical assessment of discounting policies for transport Cost-Benefit Analysis in five European practices, European Journal of Transport and Infrastructure Research.
- O'Neill P, Petts R. C. & Beusch A. (2010), Improved Asset Management – Climbing out of the Road Sector Pothole!
- Petts R. C. & Jones T. E. (1991). Towed Graders and Tractor based Maintenance of Low Volume Roads, Fifth International Conference on Low Volume Roads, USA.
- Petts R. C. (1992). Roads 2000, a programme for labour and tractor based maintenance of the classified road network, paper for the RMI road maintenance policy seminar, Nairobi 2 - 5 June 1992.

- Petts R. C. (1994). International Road Maintenance Handbooks (4 Volumes), For TRL, ODA and PIARC World Road Association.
- Petts R. C. (1995-1997) Agricultural Tractors in Roadworks”, and other MART Working Papers.
- Petts R. C. (1998). Seminars Report on Tractor Based Enterprises for the Roads and Other Sectors in Ghana, for RIO.
- Petts R. C. & Cutler M. (2006). Tractor solutions for Rural Roads & Agriculture, PIARC – CIGR International Seminar on Maintenance of Rural Roads, Rabat, Morocco.
- Petts R. C. (2010). Handbook of Intermediate Technology Roadworks Equipment.
- Petts R. C. & Gongera K. (2016), Scoping Study for Establishment of Pilot Project to implement tractor-based road maintenance approaches in Zambia, for AfCAP.
- Petts, Gongera and Goma (2017), Introduction of tractor based rural road maintenance approaches in Zambia.
- Petts & Gongera (2017), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Report 1 – Inception.
- Petts, Gongera and Petts (2017), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Equipment Evaluation Report.
- Petts and Gongera (2018), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Training Material Review.
- Petts and Gongera (2018), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Project Implementation Plan.
- Petts and Gongera (May 2018), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia. Phase 1 Final Report
- Petts & Gongera, (2018), Improved Rural Road Network Asset Management through Appropriate Technology, SARF Conference, Durban RSA.
- Petts and Gongera, (Sept 2019), DTU Review Visit and Phase 2 Commencement Report.
- Petts and Gongera, (November 2019), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia, DTU Base Set-Up Report (2 Volumes).
- Petts and Gongera, (December 2019), Establishment of Tractor-based road works Demonstration-Training Unit in Zambia, Bi-monthly Progress Report 1.
- Petts R C (2020), Agriculture and rural roads – synergies and opportunities, Published article for the Tropical Agriculture Association, UK.
- RDA (2014), Road Maintenance Strategy 2015 -2024 (draft).
- Sum4ALL (2019), Global Roadmap of Action, Towards Sustainable Mobility.
- Cesar Queiroz (2012) Monitoring Road Works Contracts and Unit Costs in Sub-Saharan Africa for Enhanced Governance.
- World Bank (2017), Zambia: Improved Rural Connectivity Project-SUF, Project Appraisal Document.
- World Road Association (PIARC), (1994), International Road Maintenance Handbooks.
- World Road Association (PIARC), (2000), Save Your Country’s Roads.