# Agriculture and rural roads – synergies and opportunities


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## Abstract

Although developed for the agriculture sector, the two-axle tractor has found proven, low-cost and beneficial applications in the African rural roads sector, particularly for maintenance operations. The challenges in the road sector and advantages of tractor applications are discussed. The synergies and potential for cross-sector cooperation are explored and recommendations made for improved awareness and performance to contribute to rural development and community wellbeing.


## Background

Over 80 percent of the approximately 2 million kilometres of public roads in sub-Saharan Africa (SSA) are unpaved (earth or gravel surface) and generally receive little or no maintenance (Petts & Gongera, 2018). Despite improvements in the management and financing of SSA's main roads in recent years, minor roads continue to receive insufficient maintenance and transport access for rural communities is generally poor. Local authorities responsible for the roads suffer from under-funding and insufficient capacity to arrange adequate maintenance of these important infrastructure assets. Rural communities endure poor access, which impedes rural social, agricultural and economic development (Cook *et al*, 2017).

## Analysing the problem

Analysis of the road-sector problem indicates a range of issues, including inappropriate institutional and operational arrangements, funding and capacity constraints, and the use of expensive, unsustainable technologies based on developed economy models (Petts, 1997).

Main road construction sites can benefit from high utilisation and focussed, close support to justify high-capital, dedicated-function, heavy civil-engineering equipment applications. By contrast, heavy equipment-based methods are not suited to the maintenance of most rural roads in emerging nations. These routes are anyway usually relatively narrow compared with main roads. However, the principal disadvantage is the enormous capital investment cost of heavy equipment operations. They also involve very high equipment finance (real or opportunity), operating, maintenance and mobilisation costs, usually necessitating the use of low-bed transporters to move them between dispersed work sites. These equipment items also require specialist operational and support skills and resources. With relatively low fleet numbers normally encountered in-country, there are serious support and spares issues. Since most unpaved road maintenance and rehabilitation equipment tasks fundamentally require no more than 100 hp (75 kW), the use of modern heavy equipment is an extremely expensive, inflexible and (fortunately) avoidable luxury (Petts, 2012). Until 1955, the most powerful Caterpillar motor grader was 100 hp (75 kW) – quite sufficient for most construction and maintenance grading work.

Skilled and unskilled labour wage rates in SSA are a fraction of the economically developed country wage rates, for which heavy equipment is primarily designed. Furthermore, market rates for credit/finance in SSA are typically in the range 20–40 percent per annum, and loan availability is limited, with restrictive payback terms. Therefore, the opportunity cost of capital is very high. This suggests that an alternative low-capital approach is required.

## The agricultural tractor solution

Agricultural tractor-based technology offers a *proven* low purchase and operating cost road maintenance alternative (Gongera & Petts, 2003), with typical total

cost savings of more than 50 percent. Not only are towed graders manufactured in the region (Zimbabwe, for more than 50 years; Kenya and South Africa), there is a wide range of other road construction and maintenance activities that the agricultural tractor can power (see Table 1) to offer a total road rehabilitation and maintenance package based on the use of tractors, locally manufactured attachments and local labour.

With a global manufacturing ratio of agricultural tractors to motor graders of approximately 200:1, the spares supply and rural support for tractors will always be superior. The towed items and attachments are also generally easily repairable in local workshops with basic metal cutting, welding and hydraulic component skills.

Regarding the key road maintenance activities of road surface grading (Petts, 2012), the power requirement for light (routine) grading is about 70 hp (52 kW) in conjunction with a 2-tonne towed grader (Figure 1). For heavy (periodic) grading, which involves recovery of lost camber on earth and gravel roads, or reshaping of the coarse material of stone macadam surfaces, the power requirement is about 100 hp (75 kW) with a towed grader of 4–5 tonnes weight (Figure 2).

**Figure 1. Mann light (2 t) towed grader**
(Photo: Intech; reproduced with permission of Intech Associates)

**Table 1. Potential agricultural tractor applications in the rural economy**

| Sector | Operations |
|---|---|
| Agriculture | 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) |
| Forestry | Winching, loading, hauling, poling, sawing, access roads |
| Roads (paved and unpaved) | Gravel haulage, water collection haulage and distribution, personnel transport, bridge and 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 and haulage (towed scraper), excavation (back hoe/ripper/scarifier/ compressor and pneumatic tools), loading (front shovel), grass and 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) |
| Agro-processors | Threshing, hulling, milling, haulage |
| Municipal (non-road) | Garbage skips, water haulage, night-soil disposal |
| Water sector (non-road) | Pipeline excavation, pipe laying, cranage, loading, earth-dam construction, irrigation channel construction, water pumping, water haulage, borehole drilling |
| Building contractors | Materials haulage, excavation (back hoe/ripper/scarifier/compressor and pneumatic tools), loading (front shovel) |
| Mining/quarrying | Stone crushing (from Power Take Off), loading, access roads, materials haulage |
| Transporters | Loading, short haulage (goods, materials and personnel) |
| Plant hire companies | Hire to others for all the applications in this table |
| Research/ academic/ technical institutions | Demonstration<br>Training |
| NGOs | Any of the above operations |

Source: Petts (2012) (reproduced with permission from the author).

**Figure 2. Rogue heavy (5 t) towed grader**
(Photo: Intech; reproduced with permission of Intech Associates)

Previous research (Hancox & Petts, 1999) showed that agriculture-focussed use of tractors was often constrained by the levels of annual utilisation achieved by individual tractor owners, which can be typically much less than 500 hours per tractor per year. At these levels of utilisation, the market will usually not bear the true full costs of investment, ownership and operation of the equipment. At market hire rates, the owners will often find themselves descending into a downward spiral of insufficient income to cover the costs of preventive maintenance and proper repairs, and funds for acquiring an eventual replacement of the machinery.

This is a crucial factor which prevails in many developing countries and results in the general poor and aged condition, and unreliability, of individually owned tractors. The problem of low utilisation is closely related to not achieving continuity of work throughout the year. This under-utilisation is caused by tractors being used mainly in small-scale agriculture, undertaking primary cultivation and transport, which only provides a narrow window of opportunity for work during each cropping season. After this the tractor is substantially under-utilised until the next peak demand. Therefore, it is necessary to consider a cross-sector approach to tractor-based contracting to obtain a balanced workload for the tractor throughout the year.

## Tractor multi-sector potential

Fortunately, the versatility and the multi-role capability of the basic agricultural tractor provides existing tractor owners with a clear competitive advantage over owners using equipment with only a single role capability, such as trucks or heavy civil-engineering equipment. Tractors can move freely between different business sectors, and to the remotest locations, undertaking a range of activities from land preparation, harvesting, processing, transport, road construction and maintenance, earth-dam construction and forestry (Table 1). Such versatility reduces the risks for tractor owners because they are not dependent upon one client and can maximise tractor utilisation throughout the year, and hence their profit.

In many emerging countries, the use of agricultural tractors has been developing steadily due to the fact that most SSA economies are agriculture-based and they are graduating from labour-based tillage to basic mechanised technology. The two-axle agricultural tractor has been the dominant motorised power source. As a result, the basic skills for minor repair and maintenance have been developed in rural locations and passed on through practical hands-on use during the various agricultural activities. This is not applicable with heavy mechanised earth-moving equipment that requires sophisticated tools, well-equipped and specialised workshops to carry out basic repair and maintenance, with agents usually based only in logistically remote, very large urban centres. Agricultural tractors are versatile, multi-purpose and relatively simple to maintain and repair, making them cost-effective and appropriate in a resource-constrained environment with limited technical backup and scarce and expensive financial support.

In general, the agricultural sector demand for tractors is concentrated pre-rains in land preparation, and post-rains harvesting, transporting and processing. Rain-season demand is generally light; yet this is the time of highest demand for road-sector light grading. This is when there is moisture in the road surface materials to assist reconsolidation without the need for expensive watering and compaction equipment. Heavy rehabilitation grading – which requires both watering and compaction (which also can be achieved using tractor-towed water bowsers and rollers) – can be achieved throughout the year. These synergies are there to be utilised to the benefit of all parties.

## Cross-sector cooperation and initiatives required

Regarding cross-sector operations, even though the economic and business environment in many developing countries is now becoming more conducive to the development of a tractor-based contracting sub-sector, the recognition of such a sub-sector will still need policy support and programme intervention (FAO, 2018). This is required to create an enabling environment and steer present and new tractor owners into seeking out and exploiting all the contracting opportunities that are now becoming available.

With improved cross-sector awareness and cooperation, rural tractor utilisation would be raised, benefitting 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.

Under an Africa Community Access Partnership (AFCAP) initiative, proven tractor technology is currently being promoted through a national demonstration and training initiative in Zambia (Petts & Gongera, 2019). Both the private and public sectors are being involved. Potential to replace expensive and problematic motor grader road maintenance operations is also being explored in The Gambia, Kenya, Mozambique and Namibia.

For the higher-traffic, bitumen paved road networks there is also potential to introduce low-cost tractor- and emulsion-based surface rehabilitation techniques. These are proven and have been used, for example, in the UK for many years.

As with any new approach, it will be necessary to test, pilot and evaluate systems in the local conditions before wider application. 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 and knowledge widely disseminated.

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

The benefits of data recording and analysis are generally not widely appreciated, especially in the public sector. Often, key knowledge such as national equipment fleet numbers, age, condition and real costs are lacking. Improved data management practices would bring benefits to policy making, planning and efficiency.

The roads and agriculture sectors tend to work in isolation. Awareness, dialogue and cooperation between these two key rural operations need to be vastly improved.

We can anticipate advantages from reduced carbon footprint from tractor applications and the improved cross-sector cooperation and roll-out of more efficient road transport management and agricultural production. There will also be important rural economic and social development, and poverty reduction benefits.

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**Further reading and resources:** http://www.research4cap.org/SitePages/Rural%20access%20library.aspx and www.fao.org

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