

# A DECISION SUPPORT TOOL FOR UPGRADING FARM ROADS, LOCATING LOADING ZONES AND ESTABLISHING CANE EXTRACTION PROFILES

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## Abstract

Previous research has shown that on-farm road infrastructures in South Africa may currently be sub-optimal as a result of excessive C-class roads (tractor roads) and insufficient B-class roads (truck roads). This paper reports on the development of a user friendly Decision Support Programme (DSP) that will assist extension officers, growers and estate managers to quantify and correct their road infrastructures. The DSP is programmed in Excel and includes menus, navigation bars and a help facility. By specifying a road's current traffic profile, the system will determine whether, and up to where, a road needs to be upgraded. Likewise, the system will also calculate if more loading zones on an existing road are necessary. The construction of new roads and loading zones on a farm may significantly change the farm's extraction profile. It is shown that the DSP could be used to optimally allocate fields to certain loading zones. All results are quantified in economic terms, include a comprehensive capital budget and the DSP allows for hardcopy reports to be generated.

*Keywords:* cane extraction, farm roads, on-farm transport, loading zones, economics

## Introduction

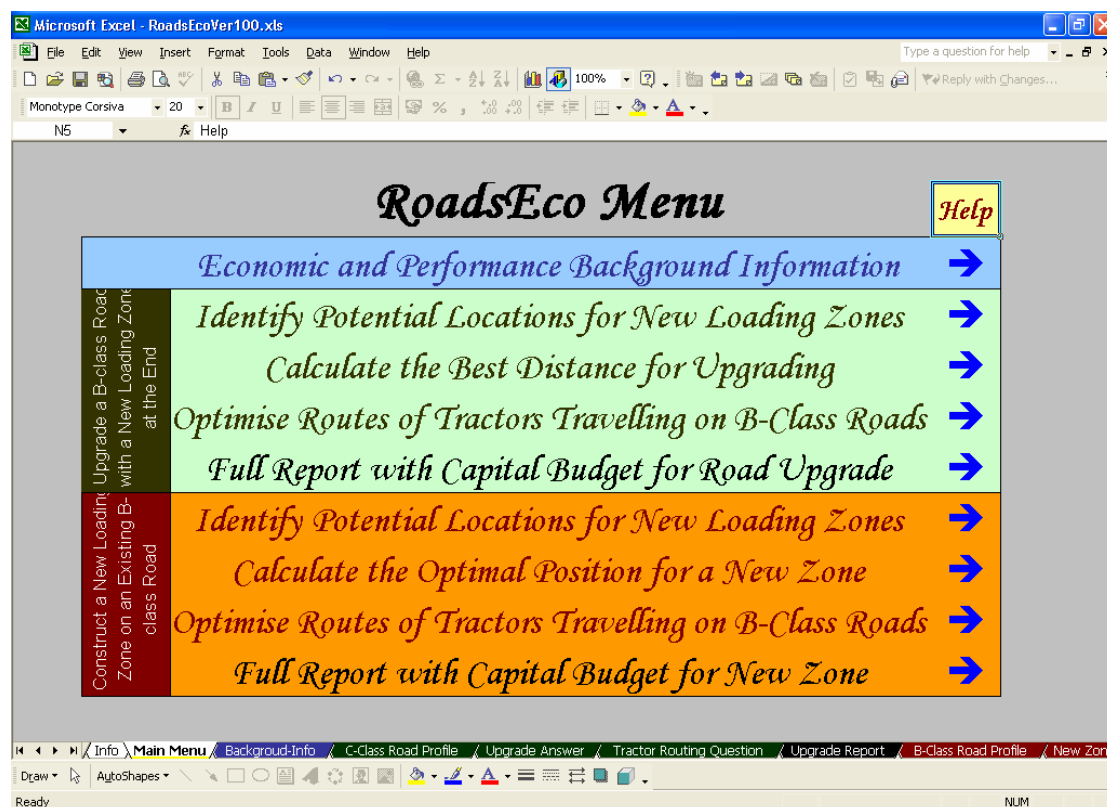
A typical sugarcane harvesting system allows for infield vehicles to transport cane from the field to easily accessible loading zones. Long distance truck-trailer vehicles then transport the cane from the loading zone to the mill. Because of this, farms in South Africa typically have a dense network of low cost tractor-trailer roads, also known as C-Class roads, and a considerably sparser road network for long distance trucks. Truck roads, known as B-Class roads, are built at high costs and often include hardened surfaces. However, tractor-trailer transportation may incur costs of between six and to nine times that of truck transportation. Research conducted in forestry and sugar (Lusso, 2005; Bezuidenhout *et al*, 2004) illustrated that road infrastructures in South Africa may currently be sub-optimal and a set of mathematical optimisation formulae were derived to optimise sugarcane farm road and loading zone infrastructures.

Compared to the previous rule of thumb for choosing a loading zone location (Meyer, 1998), the new optimisation formulas by Bezuidenhout *et al*. (2004) are relatively complex, require more input variables and demand a higher degree of mathematical proficiency. As a result, a user-friendly MS Excel-based Decision Support Programme (DSP) called RoadsEco was developed. The main objective of this paper is to demonstrate the use of this DSP. An additional specific objective was to assess issues regarding vehicle running costs and utilisation.

## A Demonstration of the RoadEco DSP

### General DSP description

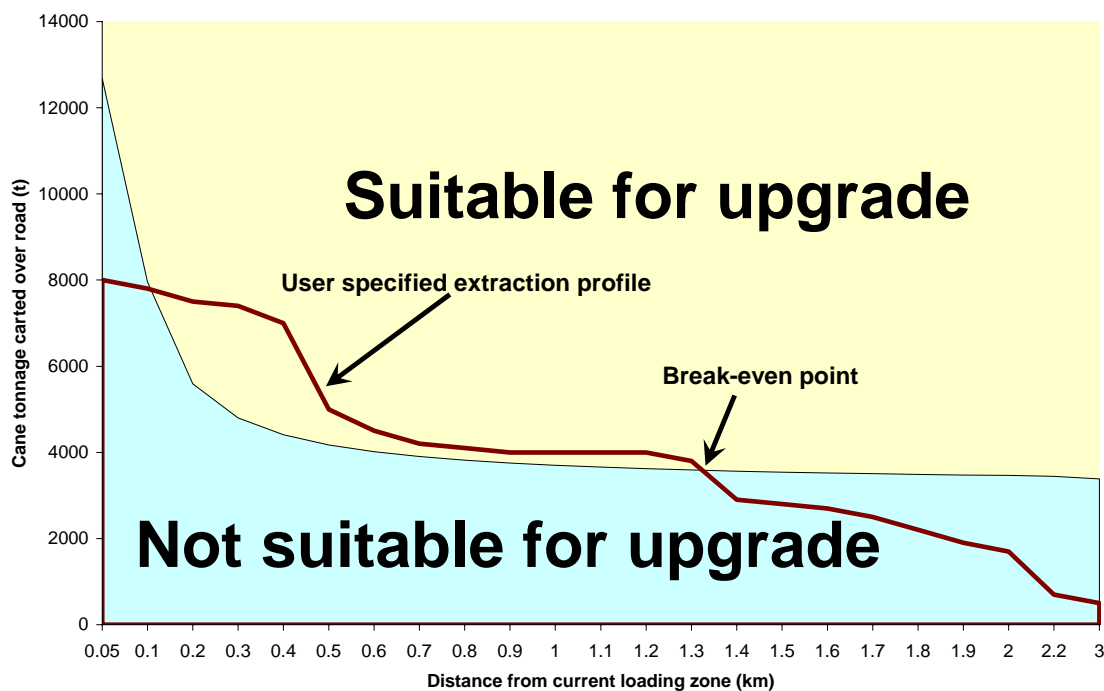
Figure 1 illustrates the main menu of the RoadsEco (ver 1.00) DSP. The system allows a user to (1) specify economic and other background information, (2) investigate the feasibility to upgrade a C-class road to a B-class road and (3) investigate whether an additional loading zone on a B-class road is economically feasible. The system also has a comprehensive help facility that works sequentially through an example. Detailed reports can be generated once a calculation has been completed.



**Figure 1. The main menu screen of the RoadsEco (ver 100) road optimisation decision support tool.**

### Deciding on a road upgrade

For illustrative purposes, the following description will explain how the DSP is used to determine if a C-class road should be upgraded to B-class status. A similar procedure is followed to decide whether an existing B-class road needs an additional loading zone. The system uses the economic and background information to calculate a threshold distance vs. cane tonnage curve (Bezuidenhout *et al.*, 2004). This curve is illustrated in Figure 2 (light blue) and indicates the threshold where a road upgrade can economically be justified. It can be seen that road upgrades are not easily justified if the respective road segment is relatively short or if a small quantity of cane travels over the road during extraction. A description of the road's actual extraction profile (red line in Figure 2) is provided by the user and superimposed over the threshold curve. This gives a clear indication up to which point the road upgrade can be justified (break-even point in Figure 2).



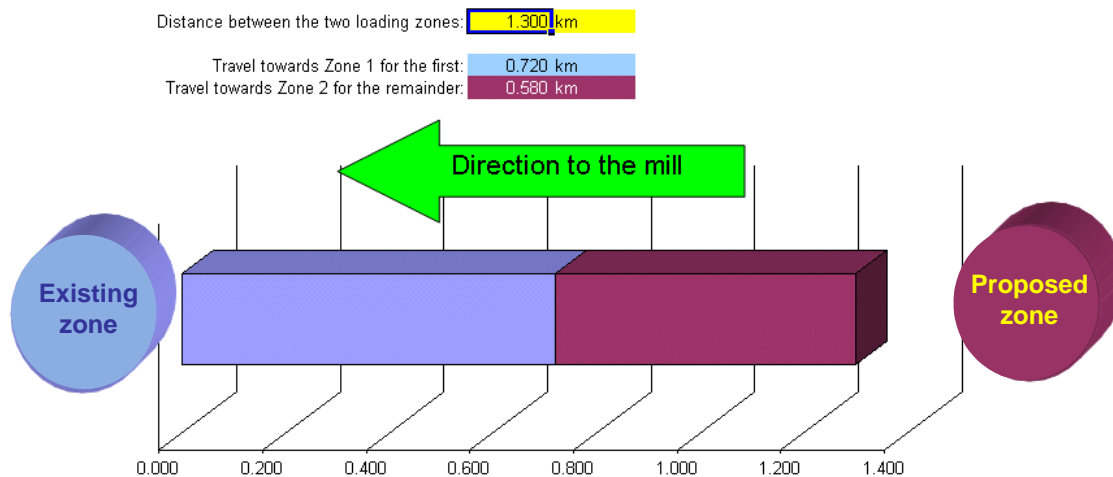
**Figure 2. A user-specified cane extraction profile over the distance of a road (red/dark line) and a threshold curve (blue/shaded area) indicating where a road upgrade will be economically feasible.**

The example shown in Figure 2 suggests that the C-class road should be upgraded at any point between 0.12 and 1.3 km from the current loading zone. The furthest point (1.3 km) will be the most feasible point.

#### *Allocating farm segments to loading zones*

An additional facility in the DSP assists users to decide which cane fields are to be serviced by which loading zones. Figure 3 illustrates this decision, indicating in purple where it will be economically more feasible for tractor-trailers to cart cane “upstream” to a zone located further away from the mill. The cane extraction profile of a farm determines the infrastructure required and in some cases changes to the infrastructure, such as building a new B-class road may drastically influence the current extraction profile. It may therefore be important to iteratively calculate the most feasible point for upgrading a road, then revise the extraction profile, which will in turn again influence the road’s extraction profile. It is therefore strongly advised that users repeat these procedures until they are satisfied with the decision.

*This Calculation helps you determine at which loading zone a tractor should deliver cane. This is only meant for tractors traveling on B-Class roads.*



**Figure 3. A screen from the RoadEco DSP indicating at which point tractor-trailers should rather deliver cane to a closer located upstream loading zone, as opposed to always carting cane down stream.**

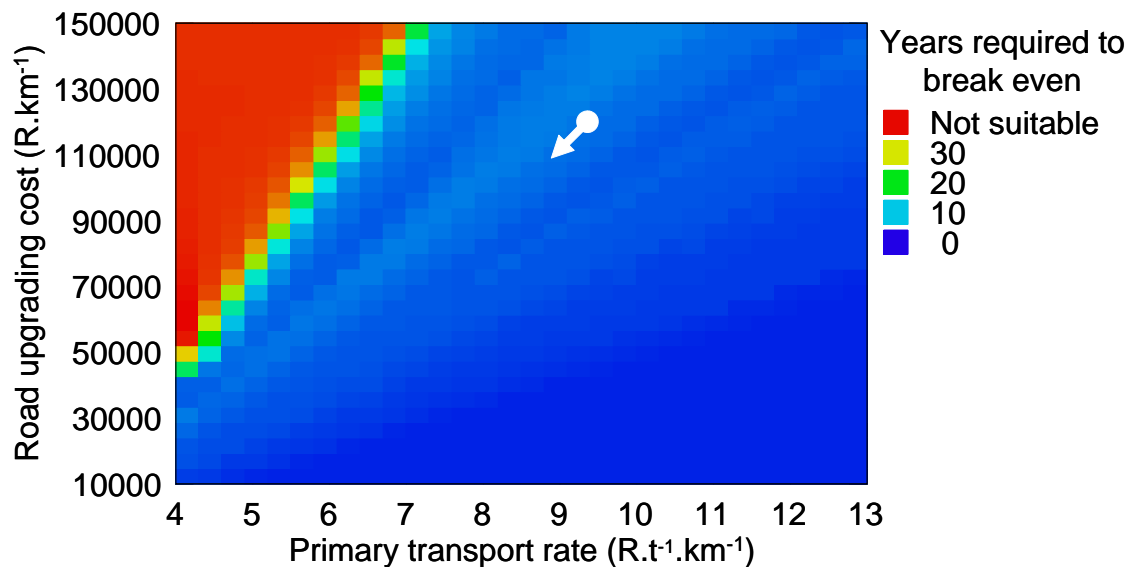
The RoadEco DSP enables the user to generate a comprehensive cost analyses and capital budget report according to Bezuidenhout *et al.* (2004). Appendix A contains an example of such a report. The report includes information on capital depreciation and estimates on cost savings and cash flow. The comprehensive capital budget economic analyses are not considered during the previously described decision making process. Growers may, therefore, decide to revise some of the initial recommendations based on other issues, such as cash flow or return on capital expectations.

### Vehicle utilisation issues

Tractor-trailer cost plays an important role in the above-mentioned decisions. This cost is made up of two components, *viz.* running costs and fixed costs. Fixed costs are largely determined by a vehicle's utilisation, which will be influenced if the road infrastructure changes. Generally, high tractor-trailer costs will encourage road upgrading, which in turn will reduce tractor-trailer utilisation and hence increase the associated fixed costs. This recursive event can only be addressed if vehicle utilisation is increased accordingly. Bezuidenhout *et al.* (2004) assumed road upgrading costs of R117 000 km<sup>-1</sup>, which is a relatively high contractor quoted rate. A reduction in on-farm tractor-trailer utilisation could be addressed by using these vehicles during road and loading zone construction. Although it may be expected that construction will take place over a longer time, this may be a feasible solution towards addressing vehicle utilisation, as well as cash flow requirements. Road construction, however, does not only include tractor-trailers, but also other equipment, which also need to be included into the economics before a decision is made.

Figure 4 compares different road upgrading scenarios for the same example as illustrated in Figure 1. In this case it was assumed that a road segment of 1.3 km will be upgraded. This was carried out under different road construction and primary transport cost scenarios. A colour scale indicates the number of years under each scenario required to recover all costs associated with the road upgrade. It is evident that low upgrading costs could easily justify the upgrade. High upgrading costs with low primary transport costs, however, produced unsuitable conditions for road upgrading. The white dot in Figure 4 indicates the scenario

under contractor quoted rates (Upgrading cost = R117 000 km<sup>-1</sup> and Primary transport cost = R9.27 t<sup>-1</sup>.km<sup>-1</sup>). Should a grower decide to construct the road using his own equipment and vehicles, then, as indicated by the arrow in Figure 4, it could be expected that vehicle utilisation and road construction costs would be reduced. This assumption is based on the fact that self constructed roads would be cheaper and that vehicle utilisation would be higher during construction (for example, during the off-season). Figure 4 indicates little risk for this decision to become economically unsuitable.



**Figure 4. A mosaic plot of the number of years required to pay for a specific road upgrade under different upgrading cost and primary transport rate scenarios. The white arrow indicates a specific scenario and the direction of new scenarios if a grower decides to upgrade the road without the help of contractors.**

### Conclusions and Discussion

The decision to upgrade a road to allow heavier vehicle access into remote corners of a farm remains complex. New loading zones may result in significant changes to a farm's cane extraction profile. In addition, shorter tractor-trailer lead distances may affect vehicle utilisation and may even cause some vehicles to become redundant. The RoadEco Decision Support Program assists growers to quantify and evaluate different road infrastructure proposals. The system, however, does not automatically solve the problem and users may need to iterate several times between different scenarios before the required criteria are met. Several other issues, such as cash flow and return on investments may also influence a user's decision. Once again, the RoadEco DSP provides suitable answers concerning these issues, but leaves the decision on the suitable solution to the user.

RoadOpt is user-friendly and takes care of complex calculations while prompting the user for the least number of input parameters. However, users who do not use it as an iterative exploration tool should be aware of the consequences. The DSP is freely available from the authors.

### Acknowledgement

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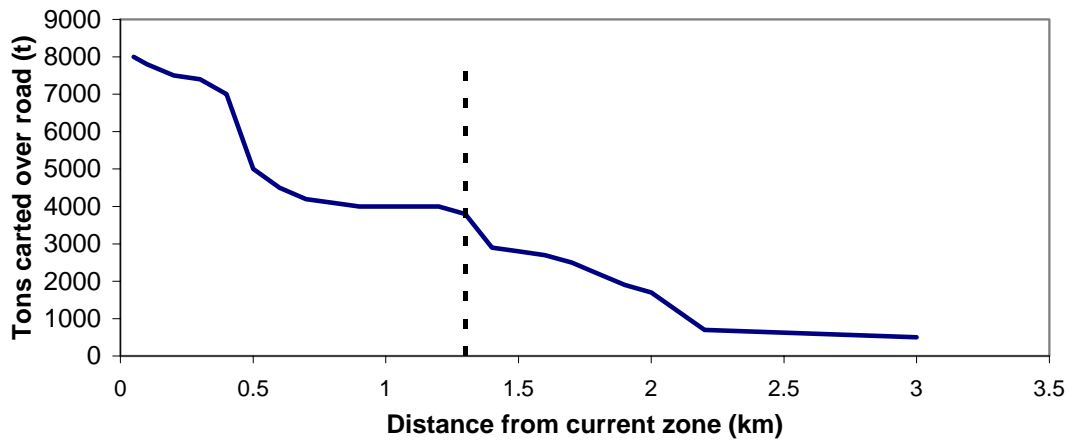
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APPENDIX A

# RoadsEco - Road Upgrade Recommendation

Demonstration Farm ABC

December 23, 2004



The recommendation is that the specified C-class road is upgraded up to a distance of 1.300 km from the current loading zone. The first 0.720 km on this road should be served by the old loading zone, while the remaining 0.580 should be served by the new loading zone.

CAPITAL COSTS		Rand
Road construction costs		156000
Loading zone construction costs		13500
<b>TOTAL CAPITAL:</b>		<b>169500</b>

Capital depreciation	Year 1	50%	-84750
	Year 2	30%	-50850
	Year 3	20%	-33900

COST SAVINGS (R/an)		
Profit losses due to reduced area under cane (R/an)		-3763
Profit gains due to transport savings:		
Tons delivered to old zone before upgrade:	8000	
New tons to be delivered at old zone:	3800	
Tons to be delivered at new zone:	4200	
Tons carted upstream to new zone:	400	
Short haul savings on cane beyond the 1.300 km mark (R/an)		36635
Additional long haul on cane beyond the 1.300 km mark (R/an)		-3952
Approx. short haul savings on cane traveling upstream (R/an)		2136
Additional long haul on cane traveling upstream (R/an)		-416
<b>TOTAL ANNUAL COST SAVING:</b>		<b>30640</b>

*This investment will be paid off within 7 years*



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## *RoadsEco - Capital Budget*

Year	Capital Investment (R)	Depreciation of Capital (R/an)	Total Annual Cost Saving (R/an)	Change in Taxable Income (R/an)	Change in Taxation (R/an)	Change in Net Cash Flow (R/an)	Present Value of Change in Net Cash Flow (R/an)	Percentage of Investment Returned (%)
2004	169500		30640	30640	12256	-151116	-151116	<b>11%</b>
2005		-84750	30640	-54110	-21644	52284	48864	<b>40%</b>
2006		-50850	30640	-20210	-8084	38724	33823	<b>60%</b>
2007		-33900	30640	-3260	-1304	31944	26076	<b>75%</b>
2008			30640	30640	12256	18384	15007	<b>84%</b>
2009			30640	30640	12256	18384	14025	<b>92%</b>
2010			30640	30640	12256	18384	13108	<b>100%</b>
2011			30640	30640	12256	18384	12250	<b>107%</b>