How much should Developing Countries spend on Road Maintenance?

Briefing Note

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December 2013

EXECUTIVE SUMMARY

This Briefing Note recommends that national funding of the maintenance of the classified road network for most economically developing countries should fall between about **0.2% and more than 1% of GDP,** to hold the infrastructure assets in a stable condition. This does ***not*** include the additional allocations required for tackling any backlog of maintenance, rehabilitation or network improvements. Total road sector infrastructure allocation needs can be expected to be in the region of 3 – 5% of GDP. The requirements should be developed for each country based on careful consideration of the network development, conditions and a range of other local factors.

Because of the demonstrably higher economic and social benefits attributable to road maintenance, over network rehabilitation or upgrading, highest priority should be given to allocating available funds to routine and periodic maintenance of the existing network.

A rationale transport network target for 2030 could be:

Proposed Rural Transport SDG target - Reducing by 90% the number of people without access to maintained all-weather roads or adequate transport (road or waterborne) services by 2030. Access being defined as living within 2km or 30 minutes walking distance.

'All weather' could be defined as being 'Constructed to an appropriate engineered standard, passable by the local means of transport for 98% of the year, and with all justifiable routine and periodic maintenance requirements met.'

1. INTRODUCTION

The question in the title of this Briefing Note has been challenging engineers (both civil and mechanical), managers, economists, accountants and politicians for decades. A constraint has been that these key stakeholders rarely collectively consult on the issue. Furthermore there has been insufficient research and comprehensive record keeping on the issue to provide sound guidance for these various stakeholders.

Furthermore, the complexities of road maintenance, implementation options and costing in an economically developing country environment mean that the answer will be similar to "How long is a piece of string?". An appropriate response may be "As much as required!"

There are so many factors influencing the maintenance requirements of any road, that it is impossible to quote a single, all-encompassing figure, or "rule of thumb", as many people unfortunately attempt to do.

In terms of resources, the maintenance needs of a particular road will depend on a wide range of factors, including, but not restricted to:

- Road Width
- Surface type
- Alignment and cross section characteristics
- Pavement (if any) and foundation characteristics
- Drainage regime
- Traffic characteristics and loading
- Climate: rainfall and temperature characteristics
- Quality of construction
- Maintenance regime……..

The costs of maintenance will likewise also depend on a range of factors, including:

- Organisational arrangements (e.g. contracting, force account etc.)
- Management regime
- Logistics of the network
- Technologies adopted: labour, intermediate equipment or heavy plant methods mix
- Availability of materials (local and imported) and their costs
- Market or established manpower costs
- Equipment and vehicles costs and costing method ……..

The topic is also clouded by the fact that markets in developing countries are rarely 'perfect' and that there is often scant attention paid to issues of the realistic costing of the key components of finance, depreciation (amortisation), especially of equipment and overheads. Finance and depreciation costs are particularly problematic to assess in a developing country environment due to local market characteristics. Further guidance on costing can be found in Further References 1) and 2).

It is therefore clear that global single figure maintenance costs cannot be sensibly quoted and it is prudent to quote likely ranges and refine assessments according to careful consideration of the local factors and operational environment.

This Briefing note investigates the issue from three different angles:

- Resource requirements
- Asset Management and Cost experiences
- GDP guidance.

2. LITERATURE REVIEW

Evidence of maintenance costs in developing and emerging economies has been gathered from the reference documents quoted.

2.1 Resource Requirements

There are limited reference documents on the resource requirements for the maintenance of rural roads under various ranges of circumstances. One problem is that few networks are in a fully 'maintainable' condition, where resource inputs are continued at a relatively stable level. Poor condition roads will naturally have higher input requirements.

Labour based routine maintenance of gravel roads in East Africa in the 1970s to the 1990s enabled experience to be gained on required length-person labour inputs: **Ministry of Public Works, Roads Department, Kenya, 1992, Road Maintenance Manual**, and **Ministry of Works, 1997, Labour Based Roadworks Road Maintenance Technical Manual.**

Successful labour based routine maintenance was establish on the basis of length-person allocation which translated into manpower inputs of between 40 and 125 person days per km per year depending on rainfall, traffic and surface condition.

Detailed cost analysis of the Zimbabwe DDF routine maintenance system of the 25,000km network of low volume gravel roads (Further Reference 3)), showed that a maintenance unit comprising one agricultural tractor, a towed grader, trailer bowser and drags with a mobile labour team could successfully (routine) maintain an network of 120 – 160km of gravel roads with a variable workforce of up to 17 persons. The tractor towed graders typically achieved about 3 light towed gradings on the whole network each year.

Routine maintenance resource requirements are fairly similar for earth and gravel surfaced roads; principally involving surface reshaping, drainage and vegetation control.

Where a gravel surface is provided, the resource requirements are substantially more for the required periodic maintenance; depending on a range of factors that influence the re-gravelling cycle to replace material lost from the surface due to traffic and weather.

Maintenance requirements for paved roads vary enormously, depending on surface type and quality of construction and other factors mentioned in the Introduction. In the early life of a paved road, routine maintenance resource requirements should be less than for unpaved roads. However, surface patching and crack/joint sealing requirements may develop and periodic maintenance (such as resealing a bitumen surface) can require very substantial resources to be allocated.

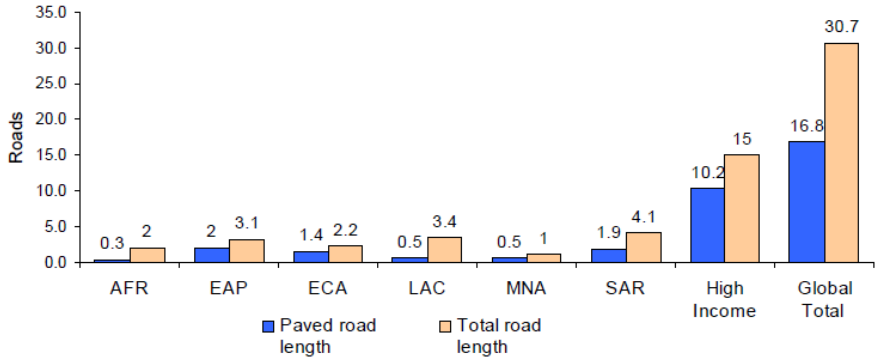
The resource requirements for paved roads will vary considerably according to the factors discussed in the Introduction. Further research is required on Low Volume Road (LVR) resource requirements in a stable environment.

2.2 Asset Management and Cost experiences

The International Bank for Reconstruction and Development / The World Bank, 2008, Safe, Clean, and Affordable Transport for Development. The World Bank Group's Transport Business Strategy for 2008-2012.

The developing world's transport infrastructure represents an enormous asset. The value of the road network alone in the Bank Group's regions of operation is of the order of US$2 trillion. The length of the classified road network assets are summarised in Figure 4.1 from that publication.

Figure 4-1. Length of the road network, by region, 2005



Note: Road lengths are in millions of kilometers.
See Annex D for listing of World Bank regions.
Source: International Road Federation Statistics 2005 and World Bank analysis.

Comment: The network length documented by the World Bank is 30.7 million km in 2005 giving an average asset value of about US$65,000 per network km in 2005 prices.

1995, Heggie, Ian, Management and Financing of Roads, An Agenda for Reform, WORLD BANK TECHNICAL PAPER NUMBER 275

"By the end of the 1980s, there were nearly two million km of roads in *(Sub Saharan Africa)* SSA, including 610,000 km of main roads, 938,000 km of rural roads, and 143,000 km of urban roads. These roads are some of the region's largest assets. Their replacement costs amount to over $150 billion, and required annual expenditures on routine and periodic maintenance to keep them in stable long-term condition are between $1.5 and $2.0 billion."

Comment: This publication estimates the average asset value of about US$80,000 per network km in 'end of 1980s' prices. It can be expected that the unit asset value costs per km would be higher for SSA than other regions due to a number of factors. The assessed maintenance requirements amount to 1 to 1.3% of the asset or replacement value per year.

Further Reference 4) assessed road maintenance needs. These were calculated, in rough estimates, to be 2% of the replacement cost of the capital stock for road networks. This percentage was not intended to represent an optimum for maintenance expenditures but was broadly seen as being the minimum annual average expenditure on maintenance, below which the network's functionality will be threatened.

Further Reference 6) suggests that adequate road maintenance requires an investment of 2.5 percent of the asset value per year.

Sally Burningham and Natalya Stankevich, 2005, Why road maintenance is important and how to get it done, The World Bank, Washington, DC Transport Note No. TRN-4.

"Where no maintenance program is in place, cost calculations do not have to be precise at the beginning. The main point is to get started. If calculations of road maintenance need using sophisticated road management systems or complicated formulas seem overwhelming, start with

simple rules of thumb. Thus, for a road network in reasonable condition, assume costs of about US$500 per kilometre per year for routine maintenance at the municipal level and US$500–US$750 per kilometre per year for maintenance at the national level."

Comment: this is probably based on year 2000 costs, as the following table. Furthermore, these guideline figures look quite low compared to the figures presented in the table.

Table 1: Maintenance costs for two-lane roads, all regions, 2000 (US dollars per kilometer)

Work class	Work type	Predominant work activity	Minimum	Maximum	Mean
Routine	Routine maintenance	Unsealed 2L Highway	277	1,740	989
		Bituminous 2L Highway	656	5,580	2,199
Periodic	Grading	Light Grading	51	205	110
		Heavy Grading	323	876	522
	Gravel resurfacing	Regravelling	1,997	65,038	15,326
	Bituminous pavement	Fog Seal	2,805	15,783	8,946
	Unsealed	Unsealed Preventive Treatment	2,009	6,965	4,266
	Surface treatment Resurfacing	Slurry Seal or Cape Seal	4,452	27,520	9,780
		Single Surface Treatment	5,295	38,607	18,937
		Double Surface Treatment	10,684	45,277	27,039
	Asphalt mix	Asphalt Overlay < 40 mm	12,878	82,320	38,095
	Resurfacing	Asphalt Overlay 40 to 59 mm	21,021	126,131	68,713

Source: World Bank ROCKS website.

*Comment: These are year 2000 data. It is necessary to inflate them to current day prices to provide guidance on benchmark current costs. Using US Domestic Crude oil prices inflation in crude oil prices (which would influence fuel, bitumen costs and energy costs in equipment manufacture) the price has risen from US$27 (2000) to US$87 (2013); a rise of over **200%**. Another indicator benchmark would be the US Consumer Prices index which rose from 168.8 in January 2000 to 233.1 in November 2013; a more modest increase of **38%**. It can be expected that developing country road works cost increases to 2013 would be somewhere between these percentages.*

From Table 1 the problem of local factors influencing costs is clearly illustrated in the range of data for re-gravelling costs: US$1,997 to US$65,038 per km; the latter figure being 32 times higher than the lower.

This highlights the need to collect and monitor local asset and maintenance component costs.

Table 2: Unit costs for maintenance of a two-lane road, Lao PDR, 2003			
Surface/Type of maintenance	**Work type**	**Description**	**Financial unit cost (US dollars)**
Paved/ routine maintenance	Routine maintenance off carriageway	Grass Cutting, ditch cleaning, culvert cleaning, slopes, etc.	195 per km
	Crack sealing	Bituminous sealing of cracks wider than 3 mm.	1.5 per m^2
	Patching	Patching of potholes by filling with base material and patch with surface dressing	5.8 per m^2
	Edge Repair	Repair of pavement edges	2.2 per m^2
Paved/ periodic maintenance	Surface dressing	Resurfacing the pavement surface with a single bituminous surface dressing	1.5 per m^2 ~12,500 per km
	Spot rehabilitation	New single surface treatment by scarifying the old surface	~25,000 per km
	Overlay	Resurfacing and reshaping the surface with 30 mm asphalt concrete overlay	6.6 per m^2
	Reconstruction	Reconstruction of the whole pavement structure including new sandy subbase, gravel base and a double bituminous surface dressing	~120,000 per km ~21 per m^2
Unpaved/ routine maintenance	Routine maintenance	Grass cutting, ditch cleaning, culvert cleaning	180 per km
	Grading	Reshaping and leveling of the pavement surface	125 per km
Unpaved/ periodic maintenance	Spot regravelling	Spot regravelling in affected areas	5.8 per m^3
	Regravelling including scarifying and reshaping	Regravelling of the pavement surface by applying 150 mm gravel including scarifying and reshaping the road surface	8.0 per m^3 ~7,750 per km
	Rehabilitation	Same as for paved roads except bitumen works	~15,000 per km
	Upgrade	Upgrade the pavement to sealed standard with new sub-base, base and surface dressing	~170,000 per km

Source: Ministry of Communication, Transport, Post and Construction of the Lao People's Democratic Republic 2003.

Further Reference 3) included a detailed cost analysis of the established labour and tractor based routine maintenance system for unpaved rural roads. The costing included full finance, depreciation and overhead costs, which are often not fully incorporated in assessments. The total inclusive costs were assessed to be US$260/km/year in 1997 prices. This would translate into about US$500 – 750/km/year in current prices.

The Zimbabwe DDF system described in Further Reference 3) was set up under a parastatal force account framework. A similar area based tractor and labour routine maintenance system has been set up in Mozambique under a small scale contractor framework (Further Reference 4)). However, comparative costs have not yet been developed. Unpublished documentation indicates that the unit costs or routine maintenance per km are higher than the Zimbabwe experience. Further research and analysis is required.

Ian Heggie I and Piers Vickers, 1998, Commercial Management and Financing of Roads, World Bank Technical Paper No 409

"Poor road maintenance also raises the long-term costs of maintaining the road network. Maintaining a paved road for 15 years costs about $60,000 per km. If the road is allowed to deteriorate over the 15-year period, it will cost about $200,000 per km to rehabilitate it. In other words, rehabilitating paved roads every 10 to 20 years is more than three times as expensive, in cash terms, as maintaining them on a regular basis, and 35 percent more expensive in terms of net present value discounted at 12 percent per year."

The HDM-4 model can be an important tool in assessing performance and whole life costs of paved roads. Unfortunately, it is very data hungry and requires calibration to the local road and environment. However, **Richard Robinson, 2008, Restructuring Road Institutions, Finance and Management, Volume 1: Concepts and Principles**, illustrated that by use of HDM-4 the influence of the range of factors on the performance and maintenance costs of paved roads can be shown to vary by a factor of more than 10.

2.3 GDP Guidance

GDP guidance provides an outline approach to assessing the overall adequacy of maintenance funding allocations. However, there can be issues of whether the allocated funding is actually spent on actual maintenance works, or is diverted to backlog rehabilitation, upgrading or other purposes. The approach assesses the allocation of funding compared to the national GDP as a percentage.

World Bank, 1981, The Road Maintenance Problem and International Assistance

"It is clear that highway maintenance is, in general, a much more serious burden in Africa south of the Sahara, than in most other parts of the world. Rough calculations for a broad range of developing countries, half of them in that region and half distributed over all continents, show that barely adequate maintenance of national road networks would require more than twice as high a proportion of government revenues in African countries as elsewhere: a median of some 3.3 percent (range: 2.5 percent to 5 percent) of the total in Africa, while only 1.6 percent (range: 0.5 percent to 3.0 percent) is required elsewhere. If the burden is measured as a proportion of gross domestic product (GDP), the difference is even greater: a median of 0.7 percent (range 0.3 percent to 1.4 percent) for the African countries, while the proportion is only 0.22 percent (range: 0.1 percent to 0.5 percent for the others."

Comment: This indicates that road maintenance funding should be in the range 0.1% to 1.4% of GDP, and more than 0.3% in Sub-Saharan Africa. It is important to consider the wide range of local factors in developing assessments of road maintenance funding needs.

1991, John Riverson, Juan Gaviria, and Sydney Thriscutt, Rural Roads in Sub-Saharan Africa, Lessons from World Bank Experience, WORLD BANK TECHNICAL PAPER NUMBER 141

"The funding needs to rehabilitate rural roads in SSA are enormous, and a range of estimates has been made. The highest estimate calls for US$2.5 billion per year for a ten-fold increase in the rural road network. On the other hand, a 1988 Bank study estimated that US$350 million per year are required considering that half of the rural road network in SSA (350,000 km) requires substantial rehabilitation. In addition to the latter, annual outlays of US$400 million for maintenance and US$20 million for institutional building would be needed to keep up the present network. The total annual requirements of US$770 million would amount to about 0.5 per cent of the region's GNP. For agricultural production to rise, the rural road network would need to be extended commensurate at least with the expected rate of growth of marketed agriculture and use of modern inputs. The need for network expansion can therefore be estimated on an average annual growth of 3 percent, for a total annual outlay of about US$920 million a year or 0.6 percent of regional GNP."

"There are no firm guidelines presently available for splitting expenditures between new construction, rehabilitation and maintenance for rural roads cannot, as yet, be analyzed as it can for

main roads. A recent review of main roads in SSA, concluded that in a stable main road network, 65 per cent of expenditure should be for maintenance, 15 per cent for rehabilitation, and no more than 20 per cent for new construction and improvement."

Comment: This indicates that for Sub-Saharan Africa, approximately 0.25% of GNP is required for ongoing maintenance, a further 0.25% of GNP is required to tackle the maintenance backlog, and about 0.6% of GNP required for network improvement.

Ian Heggie I and Piers Vickers, 1998, Commercial Management and Financing of Roads, World Bank Technical Paper No 409

"The economic costs of poor road maintenance are borne primarily by road users. When a road is allowed to deteriorate from good to poor condition, each dollar saved on road maintenance increases VOCs by between $2 and $3.3 Far from saving money, cutting back on road maintenance increases the cost of road transport and raises the net cost to the economy as a whole.

It is estimated that the extra costs of insufficient maintenance in Africa amounts to about $1.2 billion per year, or 0.85 percent of regional GDP. In Latin American and the Caribbean equivalent figures were estimated at $1.7 billion per year in 1992, amounting to 1.4 percent of individual countries' GDP. The Ministry of Surface Transport in India has estimated that $4 billion of the roughly $39 billion in annual VOCs could be saved through proper road maintenance— more than twice total annual expenditures on capital and maintenance works on national and state roads (Indian Ministry of Surface Transport 1996)."

Comment: These figures seem to relate only to Vehicle Operating Costs (VOCs), whereas the deficient maintenance also builds up a substantial additional cost liability or asset devaluation for the road owner. The figures suggest that network road maintenance expenditure should be in the region of 0.4 – 0.7% of GDP.

Stephen Brushett, 2005, Lead Transport Specialist, World Bank, Washington, D.C, EXPERIENCE IN REFORMS OF ROAD MAINTENANCE FINANCING AND MANAGEMENT IN SUB-SAHARAN AFRICA, Transport and Communications Bulletin for Asia and the Pacific No. 75.

"Fay and Yepes (2003) estimate that needed yearly infrastructure expenditure in developing countries is around US$ 233 billion with a similar amount required for maintenance, approximating about 5.5 per cent of GDP in total. On average, roads are projected to require about 19 per cent of all infrastructure investment needs, or up to 1 per cent of GDP, to which allowance for current maintenance has to be added. For sub-Saharan Africa the numbers will be generally higher in view of past underinvestment and the accumulation of arrears on maintenance. For example, recent World Bank reports cite annual road sector expenditure as a percentage of GDP amounting to 2.2 to 2.5 per cent in Malawi (World Bank 2001) and 1.9 per cent in Zambia (World Bank 1997) in neither case was this regarded as sufficient to meet all needs.

At this time it could fairly be stated that road maintenance in sub-Saharan Africa was as problematic as in any region. Heggie (2003) estimated that less than half of the required expenditure to prevent further deterioration was being met and that the required increases were on average 0.85 per cent of GDP."

Comment: This seems to suggest that network road maintenance expenditure should be in the region of more than 1% of GDP.

3. CONCLUSIONS AND RECOMMENDATIONS

This Briefing Note concludes that there is a wide range of factors that influence road maintenance needs and costs in developing and emerging economies. These factors and range of costs make it impossible to provide global 'rule of thumb' recommendations on cost per km needs. A more appropriate approach is to suggest a range of sensible values, and highlight the influential factors.

The currently available evidence does not provide convincing corroboration of the influence of various influential factors on the actual resources and cost requirements for road maintenance in the range of circumstances encountered.

There is no substitution for gathering and compiling local costs and data so that adequate maintenance funding and implementation can be justified. These of course need to be regularly updated and adapted to changing circumstances.

However, overall guidance can be provided in broad ranges of funding, from various sources. These can be used as a starting point to refining local needs in current prices.

In broad terms it appears that national funding of the maintenance of the classified road network for most economically developing countries should fall between **0.2% and more than 1% of GDP**. This does ***not*** include the additional allocations required for tackling any backlog of maintenance, rehabilitation or network improvements.

Because of the demonstrably higher economic and social benefits attributable to road maintenance, over network rehabilitation or upgrading, highest priority should be given to allocating funds to routine and periodic maintenance of the existing network.

In terms of resource requirements, labour inputs per km for routine maintenance can vary between about 40 and 125 person days per km per year for unpaved roads. The manpower inputs can be reduced with the support of low capital, intermediate equipment. The optimal mix of labour, intermediate equipment and heavy plant will depend on local labour costs, and the local cost and availability of finance for equipment procurement, and the local market characteristics.

Costs for road maintenance vary substantially and can be expected to be in the following current price ranges:

- Routine maintenance of earth and gravel roads: US$500 – 3,000/network km/year
- Periodic maintenance re-gravelling of gravel roads: US$500 – 15,000/network km/year
- Routine maintenance of sealed/paved roads: US$500 – 8,000/network km/year
- Periodic maintenance of sealed/paved roads: US$500 – 8,000/network km/year

In terms of current asset replacement value (CAV), annual maintenance costs can be expected to be in the range from about 2% per annum for a basic access; principally earth road, to about 15% per annum for a gravel road with high surface material loss rates. Satisfactory maintenance of well-constructed paved roads should be possible from about 2% of the CAV.

It is recommended that more research is required into the need for and performance of road maintenance, and costs in the range of circumstances and environments encountered. Options of

technology mix (labour, intermediate equipment and heavy plant), operational arrangements (contract, force account, community involvement etc.), paving materials and types beyond the main existing knowledge sets for gravel and bitumen seals etc. need to be investigated and the knowledge compiled into usable and accessible format.

Further research is required particularly on the arrangements and true costs of the different organisational options of contracting, force account and community participation approaches for maintenance of Low Volume rural Roads (LVR), to include all true supervisory, overhead, finance, technology options and depreciation costs in limited market conditions.

It is recommended that this knowledge and good practice are made freely available through an international, adequately funded, and fully participatory sector forum for the benefit of all sector stakeholders and decision makers.

A rationale transport network target for 2030 could be:

Proposed Rural Transport SDG target - Reducing by 90% the number of people without access to maintained all-weather roads or adequate transport (road or waterborne) services by 2030. Access being defined as living within 2km or 30 minutes walking distance.

'All weather' could be defined as being 'Constructed to an appropriate engineered standard, passable by the local means of transport for 98% of the year, and with all justifiable routine and periodic maintenance requirements met.'

Further References

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6) Ed Connerley and Larry Schroeder, 1996, Rural Transport Planning, Approach Paper, SSATP Working Paper No 19.