Road Deterioration in Developing Countries: Financial Requirements

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This paper is part of a major policy study by the World Bank. It contains rough estimates of the aggregate cost of rehabilitating and maintaining the main road networks of 85 developing countries. The estimates use information on the condition of the network in each country, norms on economically justified maintenance standards, and uniform unit costs of rehabilitation and maintenance works by geographic region. Totals are given by region of the rehabilitation backlog—more than $40 billion, not counting bridges and all minor roads—and future annual maintenance needed to prevent the backlog (totaling $4 to $5 billion per year) from growing. The 85 countries are classified according to the burden of rehabilitation and maintenance needs relative to gross national product (GNP) and the adjustment required from present levels of expenditure on roads, including new construction. The results show a varied picture: good in much of East Asia, bad in much of South Asia and Africa. Indeed many African countries will need to make a major effort over at least a decade, with both large increases in total roads funding and a radical shift from new construction to rehabilitation and maintenance, to prevent their networks from deteriorating further, let alone restore them to an economically warranted condition. Options for finding the funds needed are reviewed.

Studies conducted by the World Bank on the road networks of Costa Rica, Chile, and Mali are reported in the paper by Bhandari et al. in this Record. They have shown that additional expenditures on rehabilitation and maintenance (R&M) can yield high returns. In both Costa Rica and Chile traffic volumes on most of the network are sufficient to justify high standards of maintenance, warranting approximately a doubling of the R&M budget in Costa Rica from what it was at the time of the study and an increase of about 40 percent (which was recently adopted) in Chile. Even in the case of Mali, where very low traffic volumes do not justify high levels of maintenance for most roads, the present low level of maintenance expenditures would nonetheless need to be doubled to provide the minimal level that is economically warranted.

In this paper these questions are addressed: What is the scale of financing required for road rehabilitation and maintenance throughout the developing world and how does it compare with present levels of road expenditures? What are the differences among countries? To answer these questions on a global scale a more simplified model is used, in reality amounting to some rules of thumb on economic levels of expenditure based on the case studies. No great degree of accuracy can be claimed, but the aggregate results are consistent with the findings of the more detailed studies, and they shed useful light on the relative severity of the maintenance problem in different regions and types of countries. The focus is limited to the main networks (see Faiz and Harral, "State of the Road Networks in Developing Countries and a Country Typology of Response Measures," in this Record).

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BASIS FOR THE PROJECTIONS

The Model

In the absence of detailed knowledge of traffic flows on the different road networks, the model requires as inputs only knowledge of the current breakdown of road condition into good, fair, and poor. It then uses standard assumptions derived from the results of the case studies on road life-cycle deterioration (varying by climatic zone) and economically justified amounts of rehabilitation (adjusted as a function of per capita income to reflect lower traffic volumes in the case of the poorer countries of sub-Saharan Africa) to predict the quantities of R&M needed. These quantities are then multiplied by average unit costs (varying by region) to arrive at financial requirements, broken down into rehabilitation, periodic maintenance (i.e., overlays for paved roads and regraveling for gravel roads), and routine maintenance.

Drawing on the case studies of Chile, Costa Rica, and Mali, it can be assumed that in countries that are neither exceptionally wet nor exceptionally dry, a newly constructed or rehabilitated paved road deteriorates slowly until after about 11 years when it makes the transition from good to fair condition. In the "fair" state an overlay will restore the pavement to as-new condition. If nothing is done, the road continues to deteriorate until about 7 years after the good-to-fair transition. Eighteen years after original construction (or the last overlay or rehabilitation), the road makes the transition from fair to poor. From this point on it will require rehabilitation to restore it to good condition.

The standard operation to restore a paved road in fair condition to its original condition is to apply a thin asphalt concrete overlay. In reality roads with heavy traffic will warrant thicker overlays and roads with light traffic will require perhaps no more than a surface dressing, but the thin overlay is an acceptable average in terms of cost and its contribution to the strength of the pavement.

Pavements deteriorate more quickly in wet climates and more slowly in dry climates. The values used in the model are as follows:

	Annual Rainfall (mm)	*Good-to-Fair Interval (yr)*	*Fair-to-Poor Interval (yr)*
Wet	Over 2,000	9	5
Moderate	600–2,000	11	7
Dry	Under 600	12	9

The cycle for unpaved roads is modeled somewhat similarly. All roads need regraveling on average about every 7 years. Every unpaved road is assumed to pass from good to fair condition 6 years after it is constructed. If funds are available, it is regraveled a year later; otherwise it remains fair for 4 years and passes to poor 10 years after construction (or last regraveling or rehabilitation).

The only parts of a network that should be in poor condition are those that carry insufficient traffic to warrant rehabilitation. The threshold for paved roads is generally about 200 vehicles per day and 150 vehicles per day for unpaved roads. As for routine maintenance, including patching, the case studies show that it is economically justified on the entire network in virtually all circumstances. The rehabilitation backlog can now be defined as all roads in poor condition with traffic exceeding the economic thresholds. Extrapolating from the few countries for which the relevant traffic data are available, in all except a few countries 100 percent of poor paved roads and 80 percent of poor unpaved roads carry sufficient traffic to warrant rehabilitation.

The exceptions are in sub-Saharan Africa where roads are known to have been paved at low traffic volumes and the main network includes many unpaved roads carrying only a few vehicles per day. Using findings from Mali and Niger, it is estimated that the share of poor roads with sufficient traffic to warrant rehabilitation is a linear function of GNP per head. For paved roads, interpolate between 0 percent at $0 per head to 100 percent at $500 per head; for unpaved roads the corresponding values are 0 percent at $150 per head and 80 percent at $500 per head.

Because few if any countries will be able to eliminate their backlog immediately, road sections now in fair condition will deteriorate to poor in the time that it takes to rehabilitate what is already poor, unless they are overlaid or regraveled. There is no information on the age distribution of roads now in fair condition (typically those built or last restored to good condition in the later 1960s or early 1970s), thus it is assumed to be uniform. Until about 1991, the annual periodic maintenance requirement will therefore be one-fifth, one-seventh, or one-ninth (depending on the climate) of the paved roads now in fair condition and one-sixth of the unpaved roads in fair condition. This level of effort will need to be sustained for the corresponding number of years until the entire length now in fair condition has been treated.

At the same time, road sections now in good condition will be deteriorating to fair. Most of these sections would have been built or last restored in the late 1970s. In the majority of countries the annual good-to-fair contingent will be less than the fair-to-poor contingent while the surge from the 1960s boom passes through. Where it is greater, that quantity should determine the annual periodic maintenance requirement because anything less will allow the fair contingent to build up.

The estimate of the periodic maintenance requirement is therefore the greater of the annual good-to-fair and the fair-to-poor contingents. Where no information is available on the age distribution of the good roads (as is the case for all unpaved roads), it is assumed to be uniform, and the good-to-fair contingent is calculated as the 1984–1985 good length divided by the good-to-fair length given previously. For most countries the number of paved roads constructed between 1975 and 1979 and 1980 and 1984 is known. In the immediate future, no roads constructed in the 1980–1984 period will make the transition to fair, whereas those constructed between 1975 and 1979 are twice as likely to deteriorate to fair as the average of all combined, which the model takes into account.

The unit costs for each operation are given in Table 1. They were compiled by World Bank staff between 1983 and 1985 and updated to January 1985. The estimates for paved road rehabilitation do not include widening and minor alignment improvements that in practice are often carried out at the same time. Such capacity increases on existing paved roads normally are good investments and yield high economic returns. In most countries, therefore, it would be justified to spend at least 20 to 30 percent more than the strict rehabilitation amounts that emerge from this analysis.

It should be noted that according to this model (e.g., Mali) much of that portion of the road network in lower-income sub-Saharan Africa that has deteriorated to poor condition would not be rehabilitated because the low traffic volumes do not warrant the high expenditures necessary for such extensive restoration. In some cases there was not adequate economic justification for the original investments; in other cases low-cost roads were constructed for compelling social reasons, for example, to facilitate food movement in periods of famine. Improvements were undertaken that were not well-founded, such as paving unpaved roads in order to reduce maintenance requirements in the short run without adequate consideration of the large longer-term requirements.

More generally, few planners foresaw the economic decline of sub-Saharan Africa, and roads that were justified under forecasts of moderate traffic growth are no longer sustainable in the present prolonged period of traffic decline. Specifically, inferring present and future traffic as a function of per capita incomes, in the lowest income countries it is estimated that only 15 percent of the paved roads in poor condition would be rehabilitated, rising to 100 percent in countries with incomes of $500 or more. The remaining roads in poor condition would receive only higher levels of routine maintenance, which would not be adequate to restore normally accepted engineering standards but would result in some improvement over current conditions.

Because the requirements to restore the network to appropriate economic standards (the backlog) are very large in relation to available resources in most countries, it is necessary to postulate alternative targets. Three scenarios have been examined:

1. Clear the backlog of rehabilitation in 5 years or less,
2. Clear the backlog in 10 years, and
3. Keep the network in its present condition.

The costs to users of driving on roads in fair and poor condition during the 5- or 10-year catch-up period will certainly be

TABLE 1 UNIT COSTS OF MAINTENANCE AND REHABILITATION ($/km)

Routine Maintenance, All Regions			Periodic Maintenance		Rehabilitation	
Road Condition	Paved	Unpaved	Region	Paved	Unpaved	Paved	Unpaved
Good	450		ESA	40,000	10,000	180,000	45,000
Fair	500	1,000	WA	40,000	10,000	170,000	45,000
Poor	550		EAP	30,000	10,000	120,000	45,000
			SA	30,000	10,000	120,000	45,000
			EMENA	40,000	10,000	150,000	45,000
			LAC	40,000	10,000	130,000	45,000

NOTE: ESA = Eastern and Southern Africa; WA = Western Africa; EAP = East Asia and Pacific; SA = South Asia; EMENA = Europe, Middle East, and North Africa; and LAC = Latin America and Caribbean.

substantial. Here, however, the focus is solely on the financial requirements for the infrastructure—agency costs as described by Bhandari et al. elsewhere in this Record.

The Existing Backlog

On these assumptions the current backlog of rehabilitation for the main road networks is valued at approximately $41 billion (Table 2). Had these needs been met on a more timely basis, the cost would have been only about $10 to $12 billion. There would have been interest on the earlier outlays, but it would have been far more than offset by user cost savings.

These costs exclude bridges and the large tertiary and lower-order networks (for which data are unavailable). A speculative estimate for these components would be on the order of $15 to $25 billion additional, but under current circumstances only a part of this would be likely to meet the test of economic priorities. Similarly they exclude $3 billion for rehabilitation of main roads in the lowest income countries of Africa that would not, according to this analysis, be economically warranted.

Deterioration During 1986–1990

The current backlog is only a snapshot of present circumstances. Roads will continue to deteriorate. Many countries that added substantially to their networks in earlier years now find large portions of their network in fair condition. Unless overlaid or regraveled, such roads will deteriorate into poor condition over the next 5 to 9 years, after which they will require rehabilitation costing three to five times more. The cost of routine and periodic maintenance needed to prevent the parts of the network now in good and fair condition from deteriorating further during 1986–1990 is about $4.6 billion/year (Table 3). Provided these needs are met on a timely basis, requirements would then taper off after 1991, as the present surge of roads in fair condition passed. After allowing for this tapering, requirements to meet new deterioration expected over the 10-year period (1986–1995) would total about $43 billion.

This is clearly a lower limit, for it is unlikely that all needs will be met during the surge in the years immediately ahead. If, for example, 20 percent of the roads now in fair condition were allowed to deteriorate to the point where they require rehabilitation, the costs would increase by about $20 billion.

TABLE 2 EXISTING MAINTENANCE BACKLOG ($ billion; 1984 dollars)

	Rehabilitation		
Region	Paved	Unpaved	Total
Eastern and Southern Africa	1.3	0.7	2.0
Western Africa	1.8	0.8	2.6
East Asia and Pacific	7.2	1.6	8.7
South Asia	7.4	0.8	8.3
Europe, Middle East, and North Africa	8.1	0.8	8.9
Latin America and Caribbean	7.6	2.8	10.4
Total	33.4	7.6	41.0
Percentage of total	82	18	100

NOTE: Row and column totals vary due to rounding.

TABLE 3 ANNUAL MAINTENANCE NEEDED TO FORESTALL DETERIORATION 1986–1990 ($ billion; 1984 dollars)

		Periodic		
Region	Routine	Paved	Unpaved	Total
Eastern and Southern Africa	0.2	0.1	0.1	0.4
Western Africa	0.1	0.1	0.1	0.3
East Asia and Pacific	0.3	0.7	0.2	1.2
South Asia	0.1	0.3	0.04	0.5
Europe, Middle East, and North Africa	0.2	0.5	0.1	0.8
Latin America and Caribbean	0.4	0.6	0.3	1.3
Total	1.3	2.5	0.8	4.6
Percentage of total	28	54	17	100

NOTE: Row and column totals vary due to rounding.

Annual Financing Needs

The annual R&M requirement is whatever fraction of the backlog each government decides to catch up on every year plus that required to meet future deterioration. Considering that all governments will aim to clear their backlogs in 5 or 10 years, the minimum needed over the next years is about $9 billion/year for the 10-year scenario ($4.6 billion for maintenance and $4.1 billion for rehabilitation), or $13 billion/year over 5 years ($4.6 billion plus $8.2 billion).

The breakdown of these totals by geographic region is given in Table 4, which also indicates the amount of foreign exchange required. The foreign exchange shares were estimated on the basis of recent World Bank appraisal reports. They are highest (70 percent) for overlays and rehabilitation of paved roads in

TABLE 4 ANNUAL R&M FINANCING REQUIREMENTS ($ billion)

Region	Total Cost, Target Year		Foreign Exchange, Target Year	
	10	5	10	5
Eastern and Southern Africa	0.6	0.8	0.3	0.4
Western Africa	0.6	0.9	0.3	0.5
East Asia and Pacific	2.1	3.0	0.8	1.2
South Asia	1.3	2.2	0.6	0.9
Europe, Middle East, and North Africa	1.7	2.6	0.8	1.3
Latin America and Caribbean	2.4	3.4	1.1	1.6
Total	8.7	12.8	3.9	5.8

NOTE: Row and column totals vary due to rounding.

low-income countries and lowest (30 percent) for routine maintenance in middle-income countries. For China and India, a uniform rate of 30 percent is used to reflect their policy of relying as much as possible on domestic resources. Thus the foreign exchange required for all 85 countries combined amounts to $4 to $6 billion/year for 5 to 10 years. Sub-Saharan Africa would require between $0.7 and $0.9 billion/year.

To give a sense of proportion, these sums are equivalent to four- to seven-tenths of one percent of the combined GNPs of the 85 countries studied. For the median country the value is somewhat higher—0.8 to 1.0 percent of GNP (because the needs happen to be proportionately greater in small countries). Another indicator of proportions is expenditure per kilometer. Averaged over paved and unpaved networks, the R&M requirement is $4,800 to $7,000/km.

The most important comparison is with present expenditures. This, however, is complicated by two limitations: data on present roads expenditure are available for only 66 of the 88 networks (85 countries plus 3 federal networks), and the breakdown among new construction, rehabilitation, and maintenance is known for only 18 of those 66. Among the 66, expenditures on roads in 1983–1985 averaged 0.7 percent of GNP; and among the 18, the split between new construction and R&M was on average approximately 50/50. In the African countries where it is known, the share of rehabilitation and maintenance ranged between 20 and 60 percent; in Europe, the Middle East, North Africa, and Latin America it was between 50 and 85 percent. Data are insufficient for generalizations about East Asia and South Asia. Applying these proportions to the 85 countries, total roads spending in 1984 is estimated at about $13 billion, of which about $6.5 billion was for R&M.

If this is correct, R&M allocations in aggregate would need to be increased by 33 to 100 percent from present levels to meet the target range of $9 to $13 billion. How much of an increase, if any, is required in total road budgets (rather than just R&M) will depend on how much new construction is retained. If it were eliminated entirely, no increase would be needed on a global basis, but if new construction continues at its present level (based on the preceding reasoning it is estimated to be about $6.5 billion per year), the overall increase will need to be 20 to 50 percent.

Country Differences

Nevertheless, these global abstractions are not what count for highway directors and budget decision makers around the world; circumstances are different in each country. The rough estimates presented here suggest that R&M requirements range from country to country from 0.1 percent of GNP to more than 5 percent and from 15 percent of present roads spending to more than 500 percent. The comparison with GNP indicates the relative burden of maintenance requirements, whereas the comparison with present total roads expenditures indicates the relative adjustment called for. If countries can then be classified according to whether they are about average, low, or high by each of these two measures, nine groupings emerge. Singling out only the four combinations of low and high values, those in the low-burden/low-adjustment category are in the best position, whereas those in the high-burden/high-adjustment category are in the worst position and are most in need. Furthermore, the countries in the low-burden/high-adjustment category are doing the least to meet their road needs in relation to their incomes and are well placed to solve their financial problems. In contrast, countries in the high-burden/low-adjustment category are, by these criteria, most deserving of external assistance because, in relation to their income, they are already making major efforts.

The data in Tables 6–8 show the countries classified using these criteria. The division relative to GNP is in three equal-sized groups, whereas the division relative to present roads expenditures is on a different basis, but one that yields groups of almost equal size. The "low-adjustment" countries are those that could clear their backlog while forestalling further deterioration in 5 years or less with no increase in their present budget and retaining at least 20 percent for new construction. Twenty-six countries are in this group (3 out of every 10 World Bank borrowers), which includes representatives of every region. It is striking that the low-burden/low-adjustment subgroup includes the entire East Asia region except Thailand (which is just outside the region). Also noteworthy are the three African countries that make up the deserving high-burden/low-adjustment subgroup: Lesotho, Malawi, and Niger.

The moderate-adjustment countries are defined as those that, while falling below the aforementioned threshold, can clear their backlog in 10 years if they increase their budget by as much as 50 percent; reallocate radically from new construction (bringing its share down to as little as one-fifth of the total, the same limit as set for the first group); and sustain that effort for an entire decade. Thirty-four countries are in this group (4 of 10 World Bank borrowers), which includes several major borrowers in Europe, North Africa, and Latin America, including Brazil and Mexico, as well as the Indian national highway network. With an 80/20 split between R&M and new construction, the median country in this group would need a 10 percent budget increase to clear its backlog in 10 years. If instead it chose to clear its backlog in 5 years with the same R&M and new construction split, it would need to raise its roads budget 70 to 80 percent.

The remaining 25 countries together with the India states networks require larger financial efforts. The 19 members of the high-burden/high-adjustment subgroup—14 in sub-Saharan Africa, 2 in South Asia, and 3 in Latin America and the

TABLE 5 ROAD USER TAXES: THEIR STRUCTURE AND CONTRIBUTION TO GOVERNMENT REVENUES IN SELECTED COUNTRIES

Country	Year	Taxes on Vehicle Acquisition: Import	Purchase	Registn	Annual Taxes on Ownership: Cars	Other Veh.	Drivers' Licenses	Taxes on Use: Fuel & Oil: Gas.	Diesel	Tires, spare parts	Tolls & road transp.	Total	Total RUC as % of: Expenditures on Roads	Total Govt. Rev's.	Taxes on Incomes, Profits & Cap. Gains as % of Total Rev's.
		(as percent of total road user charge revenues)													
ESA															
Kenya	81	22	15	..	7		1	55		..	..	100	138	12	29
Madagascar	81	35		..	6		..	59		..	..	100	..	16	16
Mauritius	81	20	..	1	12		..	45	12	9	..	100	1,700	13	18
Rwanda	84	18	..	1	13		..	41		12	12	100			
Somalia	79	NA	..	4	NA		..	49	51	..	..	100*	[305]	[11[b]]	6
Sudan	81	27	..	..	2		..	33		21	4	100	269	8[c]	16[d]
Uganda	84	NA	..	..	NA		..	81		..	19	100*	[411]	[12]	7
Zimbabwe	83/4	34					..	58	9	..	..	100	345	14	42
WA															
Cameroon	78	57	..	..	2		..	28		12	..	100	273	14	14
Sierra Leone	79	35	..	..	11		..	54		..	..	100	200	7	24
AEP															
Indonesia	85/6	11	9	14	12		..	50	1	[e]	3	100	110	5-6[f]	74
Korea	83	NA	12	4	16		..	30	23	..	15	100*			
Phillipines	81	NA	NA	..	13		..	87		..	..	100*	[116]	[15]	22
Thailand	79	NA	26	..	10		..	63		1	..	100*	[174]	[14]	18
SA															
India	80/1	13			18		..	45		12	12	100	197	15	18
Pakistan	84/5	25		2	5	6	..	41	10	10	1	100	292	11	15
EMENA															
Oman	83	36	..	17	..		2	45		..	..	100	100	10	26
Turkey	83	60			4		..	35		[e]	1	100			
Yemen AR	82	55	20	0	7		2	16		..	..	100	103	12	12
LAC															
Argentina	83	11			14		..	56	13	6	..	100	137	6	4
Brazil	83	NA	NA	..	22		..	65		..	12	100*		[4[g]]	15
Chile	84	35	..	6	..		..	55		..	4	100	326	14	11
Dominica	80/1	39			13		..	37		12	..	100	..	15	17
Haiti	80	25	..	..	9		1	56		8	..	100			
Peru	80	27	..		4		..	66		..	4	100	156	5	27
Industrialized countries															
Australia	77/8	NA	NA	33	4		..	58		..	4	100*			
Canada	77	NA	NA		29			71		..	..	100*			
FR Germany	78	NA	NA		24		..	76		..	..	100*			
Gt. Britain	78	..	14		23		..	50	13	..	..	100*	[285]	[8]	40
New Zealand	78/9	12	29	7	..	8		44		..	..	100	204	9	65
USA	78	28					..	72		[d]	1	100			

NA = not available (thought to be significant)
.. = no information (thought to be zero or insignificant)
* = total thought to be incomplete
[ ]= incomplete

a) 1980 data
b) 1979 RUC as % of 1978 total revenues
c) 1981 RUC as % of 1982 total revenues
d) 1982 data
e) included with taxes on vehicle acquisition
f) estimate
g) RUC exclude VAT

Sources:
Developing countries: World Bank appraisal reports and IMF Government Finance Statistics Yearbook.
Industrialized countries: Australian Bureau of Transport Economics, "Road Financing in Selected Countries," Occasional Paper 49, Canberra 1982.

TABLE 6 COUNTRIES ABLE TO ELIMINATE MAINTENANCE AND REHABILITATION BACKLOG IN 5 YEARS OR LESS WITHOUT RAISING PRESENT ROADS BUDGET

Low Percentage of GNP Required[a] (N = 13)	Moderate Percentage of GNP Required (N = 10)	High Percentage of GNP Required (N = 3)
Nigeria	Rwanda	Lesotho
Korea	Burundi	Malawi
Papua New Guinea	Cameroon	Niger
Indonesia	Ivory Coast	
China	Nepal	
Philippines	Yemen People's Democratic Republic	
Malaysia[b]	Turkey	
Yemen Arab Republic	Oman	
Hungary	Honduras	
Romania[b]	Paraguay	
Dominican Republic		
Ecuador		

NOTE: New construction not less than 20 percent of total.

[a]A low percentage of GNP for the 5-year target is ≤ 0.8 percent and high ≥ 1.6 percent. The corresponding thresholds for the 10-year target are 0.6 and 1.3 percent.

[b]Expenditure data not available. Classified by analogy on basis of condition data and institutional capabilities.

TABLE 7 COUNTRIES WITH MODERATE FINANCING PROBLEMS

Low Percentage of GNP Required (N = 4)	Moderate Percentage of GNP Required (N = 16)	High Percentage of GNP Required (N = 6)
Zimbabwe	Kenya[a]	Botswana
Sudan[a]	Mauritius[a]	Swaziland
Thailand	Mali	Somalia[a]
India National	Guinea	Togo
Bangladesh[a]	Benin	Central African Republic
Egypt	Burkina	Costa Rica
Syria[a]	Congo[a]	
Algeria[a]	Tunisia	
Mexico[a]	Morocco	
Argentina	Cyprus	
Chile	Guatemala	
Brazil	Uruguay	
	Peru[a]	
	Haiti[a]	
	Panama[a]	
	Barbados[a]	

NOTE: Able to clear backlog in 10 years by increasing roads budget by up to 50 percent and cutting new construction to 20 percent of new total.

[a]Expenditure data not available. Classified by analogy on basis of condition data and institutional capabilities.

Caribbean—face particularly daunting prospects. The African countries are already spending a relatively large share of GNP on roads, but until recently have been allocating the lion's share to expanding their still rudimentary networks. Even doubling their roads budget and cutting new construction back to 20 percent of the new total, almost all these countries would still not be able to clear their backlog of economically warranted rehabilitation in 10 years. Indeed, the median country in this group would need to triple its budget (with an 80/20 split) to do so. It would be a commendable achievement just to stabilize the most essential network and prevent further deterioration. For most African countries this will require a budget equivalent to 0.8 to 1.4 percent of GNP. The consequences of missing even this target is that in several countries the length of paved road in poor condition could easily double by 1990 from what it was at the end of 1984, and in a few years 100 percent of unpaved roads would be in poor condition.

It is perhaps surprising to find such higher-income countries as Yugoslavia and Portugal in the low-burden/high-adjustment subgroup. In the case of Yugoslavia, the explanation is that maintenance budget increases have fallen far short of rapid inflation several years in a row. A fourfold increase in the total roads budget appears needed just to clear the backlog in 5 years, but even then Yugoslavia's spending on roads would still be below the world average as a percentage of GNP. Portugal and Pakistan are in a similar, though not quite so extreme, situation.

TABLE 8 COUNTRIES WITH SEVERE FINANCING PROBLEMS

Low Percentage of GNP Required (N = 4)	Moderate Percentage of GNP Required (N = 3)	High Percentage of GNP Required (N = 19)
Ethiopia[a]	Tanzania	Madagascar
India States	Uganda[a]	Zaire
Portugal	Pakistan	Djibouti
Yugoslavia		Zambia
		Comoros
		Sierra Leone
		Mauritania
		Senegal
		The Gambia
		Liberia
		Equatorial Guinea[a]
		Chad[a]
		Guinea-Bissau[a]
		Ghana[a]
		Burma
		Sri Lanka
		Bolivia
		Belize
		Jamaica

NOTE: Unable to clear backlog in 10 years even with 50 percent increase in roads budget and restriction of new construction to 20 percent of new total.

[a]Expenditure data not available. Classified by analogy on basis of condition data and institutional capabilities.

India and China present a particular dilemma as to priorities between restoration and new construction. India's existing network is large but technically and economically obsolete. Replacement rather than restoration is probably the best solution. China is in reality worse off than India because of the sparseness and low standards of its network in relation to present and potential demands. Relief of capacity constraints will generate high-priority claims in these countries in the years ahead; the financing needs will be particularly large.

Options for Finding the Money

Several options are available for raising the additional financing needed. Several levels of government can take action. Any strategy to deal with the maintenance crisis should be a package of measures, including some or all of the following.

1. *Use the existing road maintenance budget more productively.* Most maintenance departments have substantial scope for raising the productive efficiency of the men, machines, and materials at their disposal. In "Organization and Management of Road Maintenance in Developing Countries" elsewhere in this Record, a number of recommendations are made on institutional and managerial options. They bear primarily on work carried out by government force account (direct labor); that is, most if not all of routine maintenance ($1.3 billion out of the annual requirement of $4.6 billion estimated) and that part of periodic maintenance not contracted out (some part of the remaining $3.3 billion per year). The relevant level for decision making is the maintenance department, although several institutional changes suggested will require higher-level approval.

2. *Devise a more cost-effective mix of maintenance and rehabilitation activities.* Bhandari et al., in a paper in this Record, summarize recent insights into efficient choices among alternative R&M operations for roads of various pavement types, surface conditions and traffic levels, and priorities among such road categories within a constrained budget. Particular attention should be directed to the ratio of extra road-user costs to each dollar in the agency's budget saved by successive cutbacks from the economic optimum. Decision making will be a joint effort by the maintenance department and the road authority's planning department.

3. *Reallocate from new construction.* The economic return on marginal increases in road maintenance budgets is often very high—more than 100 percent is not uncommon. And yet they are sometimes squeezed out by new construction projects with rates of return of 10 to 20 percent, or even lower. The massive reallocation from new construction that appears warranted in many countries calls for a substantial effort to improve the technical quality and hence credibility of such economic evaluations if they are to prevail against the strong political pressures normally favoring new works. The administrative separation of maintenance in the current budget from new construction in the capital budget may also have to be overcome. Furthermore, in countries heavily dependent on external concessionary financing, donors' bias toward new construction also has to be addressed.

4. *Reallocate from rail and elsewhere in transport.* Many developing countries could fund proportionally large increases in road maintenance by modest cuts in subsidies and capital grants for railways and other transport modes.

5. *Give transport a larger share of the total budget.* Transport's share of government spending in developing countries was cut substantially during the recession of the early 1980s. The average amount given by the International Monetary Fund *(1)* covering current and capital expenditures combined as a percentage of central government outlays, dropped steadily from nearly 9 percent in 1977 to below 6 percent in 1982; it rose slightly in 1983. As growth resumes, planning and finance ministries should reexamine the share they are now allocating

to transport, particularly in sub-Saharan Africa, where, as Faiz and Harral point out in a paper in this Record, the low density of population entails road requirements per $ million of GNP well above the average.

6. *Increase road-user charges and taxes.* If a bigger piece of the pie is infeasible, how about a larger pie? Road users in most developing countries already pay, in aggregate, taxes and duties on fuel, vehicles, and parts that substantially exceed government spending on roads (Table 5); nonetheless taxes on private automobiles are a cost-effective and rational substitute for a progressive income tax. Any additional charge on road users has the potential, if properly used for improving road conditions, to lower rather than raise vehicle operating costs—the obverse of the agency cost/user cost trade-off mentioned previously. Furthermore, almost everywhere heavy trucks are charged less than the variable cost of the road damage they cause. Governments could raise revenue while encouraging a shift to less-damaging axle configurations if they increased license fees, particularly for the worst offenders.

7. *Earmark road-user taxes for a road maintenance fund.* To protect a finance ministry's flexibility to manage a country's fiscal affairs, the World Bank generally discourages earmarking of taxes for specific expenditures (dedicated revenues). An exception may well be warranted, however, when the normal annual budget-setting mechanism consistently fails to vote adequate funds for road maintenance or funds voted fail to get through, and when a road fund could be relied on to deliver on both counts. One option would be a temporary surcharge on fuel taxes earmarked for road rehabilitation. A "sunset" provision is advisable under which the justification for the fund is reviewed every 5 years.

CONCLUSIONS

The intent of this paper has been to show that the financial requirements for road rehabilitation and maintenance are indeed large and urgent; $9 to $13 billion/year will be required over the next 5 to 10 years, equivalent in the median country to 0.8 to 1.0 percent of GNP. Among the 85 countries reviewed, some $30 billion could have been saved if roads had received periodic maintenance before they deteriorated to a state in which they required rehabilitation. The vehicle wear and tear suffered by road users, though not calculated, has probably been several times greater.

The needs are urgent; a "baby boom" of roads built in the 1960s and early 1970s are now approaching the transition from fair to poor condition. If only one-fifth of these roads are not serviced in time, road departments will sooner or later have to bear an extra $20 billion or more in rehabilitation costs. Aggregate spending on roads in 1984, estimated at about $13 billion, was barely adequate to cover these needs, even if it had been heavily concentrated on rehabilitation and maintenance; it was not—about one-half was spent on new construction.

The severity of the situation varies among countries; 3 out of 10 can eliminate their rehabilitation backlog in 5 years or less while forestalling further deterioration without an increase in their roads budget. However, some of these countries will need to reallocate substantially from new construction to R&M. East Asian countries are prominent in this group. Another 4 out of 10 countries can eliminate their backlog within 10 years by increasing their roads budget by as much as 50 percent and allocating no more than one-fifth of it to new construction. This group includes the majority of World Bank borrowers in Latin America, the Middle East, and North Africa, as well as several countries in sub-Saharan Africa.

The core of the problem is the 26 countries, which, even if they could make the latter adjustment and sustain it over a decade, could not restore their networks to an economically sound condition. Of this number 16 are in sub-Saharan Africa. There are many options appropriate to the various levels of government for finding the money needed; seven are identified in this paper.

REFERENCE

1. *Government Finance Statistics Yearbook.* International Monetary Fund, Washington, D.C., 1985, p. 54.

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