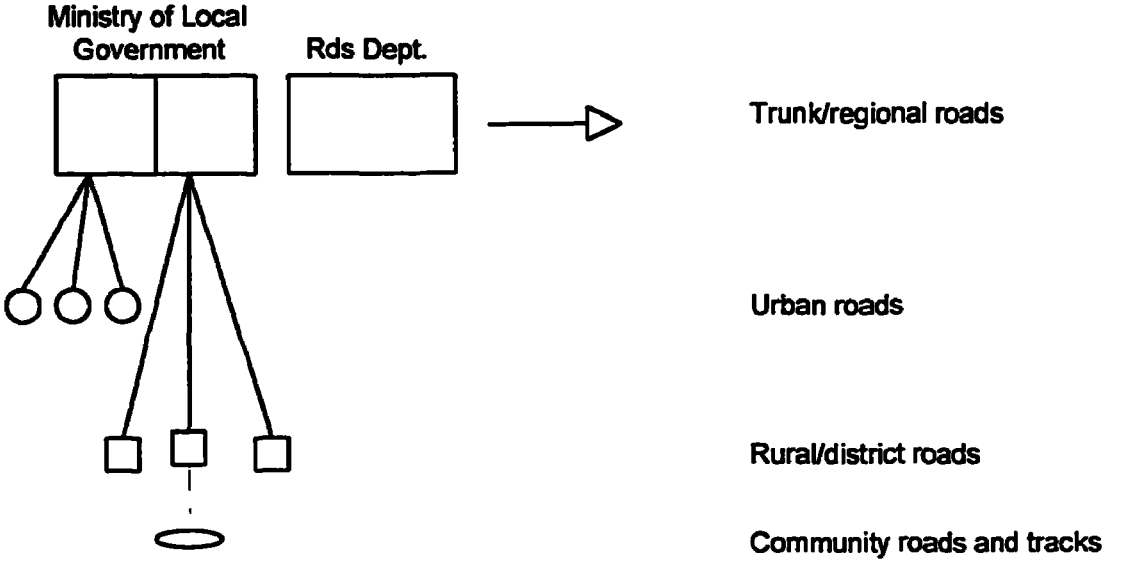
and eighty-four rural district councils (31,989 km). These are clearly very small networks with an average length of only about 353 km. For purposes of administration, district councils report to the Prime Minister's Office, which is responsible for all matters pertaining to local governments. Finally, the 28,011 km main road network, comprising 10,300 km of trunk roads and 17,711 km of regional roads, is managed by the Department of Roads (and Aerodromes) which forms part of the Ministry of Works, Communications and Transport. There are several important international transit routes in Tanzania which are managed as part of the overall trunk road network.

Figure 8.2 Diagram Illustrating Two-Tier Organizational Structure



The organizational structure in Zambia is similar, although the road network is much smaller. The official unclassified network is a mere 5,714 km, although it is thought that the actual unclassified network may be between 20,000 km and 30,000 km. These roads are managed by the Game Department and by local village councils. The 19,600 km district road network is managed by eight urban districts (3,625 km) and fourty-eight rural district councils (15,980 km), which operate under the overall jurisdiction of the Ministry of Local Government (MLG). Again, these are very small road networks with an average length of only about 350 km. Finally, the 20,783 km main road network, which includes 3,119 km of international trunk roads, is managed by the Roads Department under the Ministry of Works. The trunk road network serving interregional transport needs is managed through nine Provincial Roads Department offices. International trunk roads, which are considered a particularly important part of the Zambian road network, are managed directly from Roads Department headquarters.

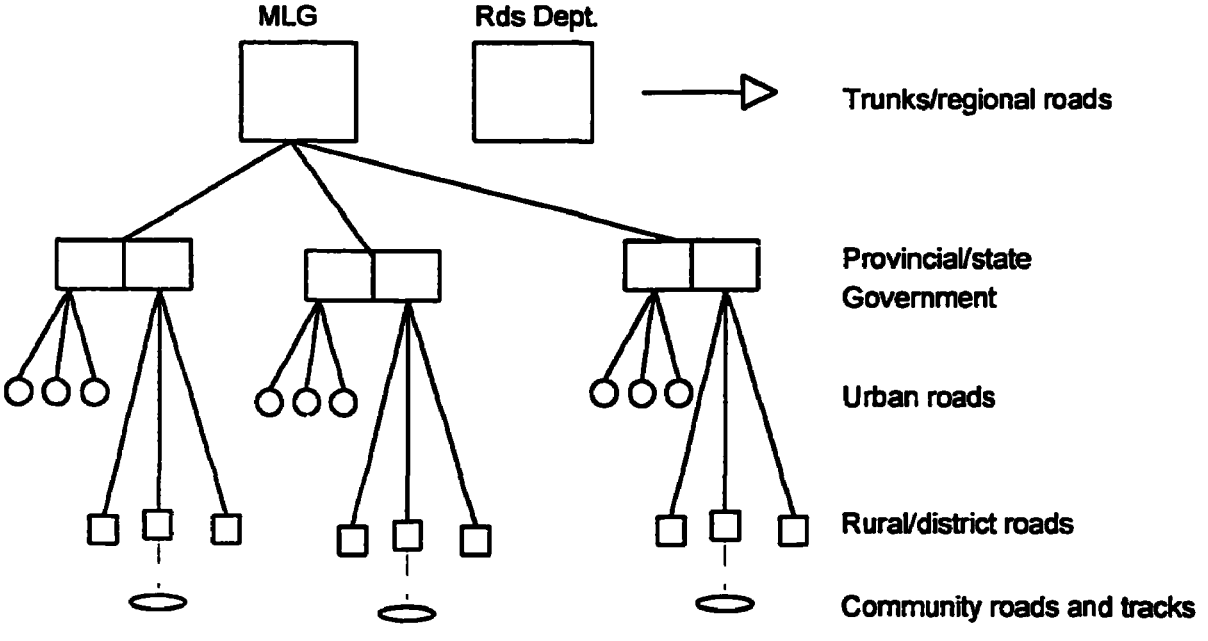
There are two points worth noting about the above management arrangements. First, district council road networks are very small, and it is almost impossible for them to establish a free-standing road agency with the technical capacity to manage these small road networks. As a result, most district road networks, particularly in rural areas, are badly managed and poorly maintained. The governments in both Tanzania and Zambia are therefore in the process of improving arrangements for channeling funds to district councils and strengthening the management of district roads. In the case of rural district roads in Zambia, the government is also providing technical assistance to district councils through a newly established Feeder Roads Section in the MLG. The technical assistance helps the rural districts prepare their road

programs and provides training and advice to support the implementation of approved programs. Second, the separation of responsibility for main roads from that for rural roads–the former being under Ministry of Works and the latter under the MLG–has not proved particularly effective. As a result, Tanzania is proposing to transfer overall responsibility for rural roads to the Ministry of Works, and Zambia is considering what to do with the MLG's Feeder Roads Section in the longer term.

8.2.3 Three-Tier Systems

Three-tier systems add a third layer to the management structure, usually by adding provincial or state governments to the model (see Figure 8.3). The hierarchy thus follows from the central, to the provincial (state), to the local governments. These countries also tend to have large unclassified road networks which they leave in the hands of local communities. The model suits larger countries like Nigeria and Madagascar. Both countries are roughly the same size as Tanzania and Zambia.

Figure 8.3 Diagram Illustrating Three-Tier Organizational Structure



Nigeria has a clear three-tier structure. Responsibility for the rural road network, of 108,700 km, and the urban network, of 21,875 km, is assigned to over 600 local government authorities (effectively rural and urban government agencies). Because of the recent proliferation of local government authorities in Nigeria (in 1976 there were only 301), the average length of their road networks — about 218 km — is even smaller than the district councils in Tanzania and Zambia. The second tier consists of state road networks. It comprises about 30,500 km of roads which are managed by 20 state governments. The average length, 1,525 km, is quite small, but is large enough to support a viable road maintenance organization. Finally, there are 28,600 km of main roads, including 1,150 km of tolled roads, that are managed by the Federal Highway Department, which forms part of the Federal Ministry of Works and Housing. However, although tolls are collected over part of the federal highway network, these roads are not managed as toll roads. The toll revenue is simply treated as general tax revenue.

Madagascar also has a fairly clear three-tier structure, although it also has a network of about 15,000 km of unclassified roads and tracks which are left in the hands of local communities. The classified network starts at the first level, with about 13,000 km of rural access roads which are managed by 110 local government departments. These networks, with an average length of less than 120 km, are even smaller than those in Nigeria. The second tier comprises the provincial road networks. It consists of about 11,000 km of roads which are managed by six provincial governments.[36] The average length, 1,800 km, is larger than that in Nigeria and large enough to support a viable maintenance organization. Finally, there are 10,150 km of main roads (including 1,507 km of urban roads) which are managed by the Ministry of Public Works.

The surprising thing about these examples is the small size of the first tier road networks. At this small scale, it is difficult to carry out maintenance efficiently. The same problems arise in three-tier systems when central government responsibilities are divided between the ministry of works and another ministry dealing with local government. Where feasible, central government responsibility for roads should fall under one ministry. Finally, it is also surprising that Nigeria does not operate its tolled roads on an autonomous basis to strengthen performance and improve managerial accountability.

8.3 MANAGING ROAD TRAFFIC

The concern here is with responsibility for those characteristics which interact with the road network and affect the management and financing of roads. The assignment of some responsibilities is fairly obvious, since they are widely recognized as an intimate part of the overall road management function. Road signs and signals fall into this category (they are, in any case, usually specified under international agreements), as do road design standards. These are clearly a central government responsibility and will usually be delegated to the agency responsible for managing the main road network (in Zambia, they have been delegated to the National Roads Board). The agency with prime responsibility may nevertheless delegate some of these responsibilities to lower level road agencies (e.g., for road signing in urban areas).

At the other extreme, it is clear that control of parking, particularly on-street parking, and management of urban road congestion should be assigned to the agencies responsible for managing the urban road networks. The two issues are closely linked, tied to the issue of urban road safety (particularly pedestrian-vehicle conflict), and are essentially local in nature. They are therefore generally dealt with most effectively at the local government level in conjunction with local level policing. Traffic regulations, particularly those dealing with the routing of heavy vehicles in cities, are also largely a local matter. They either form part of local level traffic management or, in the case of heavy vehicles, are intimately related to control of vehicle impacts and construction of local relief roads and urban by-pass schemes. Although the broad framework for these regulations should be set at the central government level, their detailed application needs to be delegated to the agencies responsible for managing the urban road networks.

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[36] New legislation is under consideration which provides for the creation of twenty-two to thirty-two new regional organizations to replace the six provincial authorities.

More problematic are the questions of vehicle weights and dimensions, vehicle safety, vehicle emissions, and the environmental impacts associated with new road schemes. Overweight vehicles damage the road pavement and increase road maintenance costs, while permissible vehicle dimensions affect road design standards and hence construction and maintenance costs. All road agencies therefore have a vested interest in seeing that these regulations are well designed and consistently enforced. Axle-weight regulations are the most important, but the most difficult to enforce. The regulations are promulgated by the central government, following consultation with concerned road agencies, while enforcement is generally left to the police. Reviews of past enforcement efforts have pointed to three areas of weakness: lack of clearly assigned responsibilities, weak enforcement agencies, and resistance by the road transport industry. Part of the solution thus lies in assigning responsibility more clearly to the agency managing the main road network. The key nevertheless lies in winning the support of the road transport industry. Without their support, most initiatives will fail. That is why the recent initiative in Zambia involving the appointment of voluntary road traffic commissioners to supervise weigh-bridges warrants serious consideration (Chapter 6, Box 6.2). Tanzania is also considering using the private sector to help enforce axle-weight regulations.

Regulations governing vehicle safety and vehicle emissions are usually administered in conjunction with the issuing of vehicle licenses. In some countries this is done by central government (e.g., Tanzania), while in others it is handled by local governments (e.g., Zambia and Mozambique). Administration is generally done by the transport ministry (licensing branch) or by the local tax office. Since about half of the vehicles in Africa are unlicensed and uninsured, vehicle safety and emissions regulations, where they exist, are not effective. Road agencies have a clear interest in vehicle safety since it affects the usage of the road network and has an important impact on road safety, for which most road agencies also have some responsibility. It may therefore be worthwhile to assign responsibility for regulating vehicle safety to the agencies responsible for managing the road network and, since this involves vehicle inspection, to also assign them responsibility for administering vehicle emissions regulations. However, it is only worth doing this if the agencies have the skills and resources to carry out the inspections properly.

Finally, there is the important question of assigning responsibility for dealing with the environmental impacts associated with new road schemes.[37] Such schemes can have major environmental impacts. They may inadvertently result in damage to ecologically sensitive areas, destroy property, displace people, or disrupt established settlement patterns, particularly in urban areas. The road agency should, at least in principle, be assigned the responsibility of ensuring that adverse environmental impacts are minimized and that remaining impacts are considered acceptable. The usual way of doing this is by ensuring that major road schemes are subjected to some form of environmental assessment process involving public consultation.[38] The responsibilities assigned to a road agency should thus include the need to undertake

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37 Responsibility for the environmental impacts associated with new road schemes is not the same as responsibility for dealing with the environmental impacts associated with road traffic. Road agencies have little control over the latter impacts, which are mainly affected by the tax structure (which influences the size of vehicles, their age, the type of fuel used, etc.), vehicle emission regulations and inspection procedures, and the quality of imported and locally refined fuel. These responsibilities are normally assigned to the ministries of environment, energy, and finance.

38 A study of the circumstances which might make it desirable to discuss the impacts of major road schemes in the context of a public inquiry is currently being carried out in Tanzania.

environmental impact studies for major road schemes and to use them as the basis for undertaking public consultations.

8.4 THE BASIC ORGANIZATIONAL MODEL

The above discussion leads to the following suggestions for strengthening organizational arrangements:

(i) It is best to leave community roads under the jurisdiction of village councils and other local government bodies.

(ii) Since local communities usually lack the financial and technical capacity to manage their road networks, a higher level road agency (perhaps at the regional or provincial level) should be contracted to provide them with technical advice and act as a channel for transferring financial resources. Local communities should be encouraged to undertake most work on a self-help basis, and outside financial support should be confined to meeting the costs of bought-out materials.

(iii) Rural roads have special characteristics and require special attention. A single-tier systems requires a separate Feeder Roads Department. In two and three-tier systems management should be handed over to local government agencies at the provincial or district levels, while keeping management coordinated at the central government level by having a single ministry responsible for roads. Central government also needs to provide funds and technical assistance.

(iv) Since most rural district councils are small and have limited technical and financial capacity, they should be encouraged to manage their road networks under contract or by combining with other rural district councils to form a larger operating unit with sufficient scale economies to make sound management feasible (perhaps combining them on a provincial basis). A formal arrangement should also be put in place to ensure that rural district councils have access to technical support services.

(v) Roads in villages can be managed by the main road agency, while those in larger urban areas should eventually be managed by the municipality or town council. Some support may be required in the interim to help them develop the required managerial capacity. This could come from the main road agency or a special urban roads department at the central government level.

(vi) International transit routes are important in some countries and often deserve special treatment. They may either be managed by a dedicated section of the main road agency or, where traffic volumes are high enough, could even be operated as toll roads.

(vii) There is little point in having toll roads unless the revenues are spent on roads and the arrangement is used to improve performance and strengthen accountability. Such roads should ideally be operated on an autonomous basis, either by the main road agency, under a management contract, or under a private sector concession agreement.

(viii) The main road agency should be assigned all regulatory responsibilities affecting the entire road network (e.g., design standards and signs and signals), even though it may delegate some of these to other road agencies or other competent bodies.

(ix) Urban road agencies should be assigned those responsibilities which have significant urban impacts (e.g., control of parking and congestion and routing of heavy vehicles).

(x) The main road agency should be assigned responsibility for enforcing axle-weight regulations. This should ideally be done in conjunction (and with the cooperation of) the road transport industry. The main road agency could also carry out vehicle safety and vehicle emission inspections, provided they have the skills and resources to do them properly.

(xi) All road agencies should be made responsible for examining the potential environmental impacts of new road schemes and should be required to satisfy the public that adverse impacts have been minimized and that remaining impacts are acceptable.

9 INTRODUCING SOUND BUSINESS PRACTICES

Public sector agencies tend to function most efficiently when they are faced with some form of competition or a competition surrogate. Competition creates market discipline, which is the primary factor that motivates managers to cut waste, improve performance, and allocate resources efficiently. Previous chapters have suggested ways of creating such discipline by introducing an explicit road tariff (to encourage users to demand value for money), linking revenues and expenditures (to create a hard budget constraint), and involving users in management of roads. Another option is to unbundle services and contract them out. These strategies strengthen market discipline and provide managers with the incentive to operate efficiently. The corollary is that managers need to work within an organization which can respond to market discipline. They need a clear and unambiguous corporate mission, competent staff, a sound management structure, appropriate management systems, and sufficient autonomy to enable them to run the agency efficiently. These topics are examined below.

9.1 DEFINING THE MISSION

The first task is to state clearly the role of the road agency: what is it supposed to be doing? It is surprising how few road agencies have any vision or mission statement to guide their operations. The Ghana Highway Authority has one of the clearest: "The vision of the Ghana Highway Authority is to ensure that Ghana has a smooth, economic, efficient, safe, and reliable trunk road network linking national, regional, and district capitals and other major towns in Ghana to themselves and to major towns in neighboring countries. The network also forms the main routes for internal distribution, defense, export, and import in harmony with other modes of transportation." From this vision statement they have derived a simple mission statement: "To provide a safe and reliable trunk road network that should facilitate socioeconomic development in the country." Malawi has a similar mission statement: "The main objective of the Ministry of Works is to have a viable network of roads to enable the transfer of goods both within and outside the country."

However, most governments currently supplement these vision statements with a statement of national policy regarding civil service reform — and the associated policy of reducing the size of the civil service — development of the local construction industry, use of local consultants, and involvement of private sector financing under concession agreements. An increasing number of governments also have policies to encourage the use of labor-based work methods, particularly in rural areas. These policies, though not necessarily included in the road agency's mission statement, still have to be taken into account because they affect the size of the road agency, number of regular staff required, and type of skills they need. Although it varies significantly between countries, road agencies are being increasingly urged, as part of overall government policy, to:

- Do less construction and maintenance work in-house and more under contract with the private sector,
- Hand over government plant and equipment to autonomous plant pools or private sector agencies and hire it back only when required,

- Encourage private sector interests to construct and operate toll roads under concession agreements or to take over, rehabilitate, and operate existing roads on a similar basis,

- Do more work using labor-based work methods, and

- Reduce staff numbers as part of civil service reform.

There are some caveats. First, you cannot hand over work to the private sector unless private contractors already exist. Most countries therefore combine contracting out with initiatives to develop the local construction and consulting industry (see Box 9.1). Second, you cannot prepare bid documents, award contracts, and supervise implementation of civil works with staff accustomed only to force account work. Nor can you easily manage all contractual work through local consultants. It may be feasible at the local level (i.e., for urban and rural district roads), where a consortium of consultants and contractors could manage the road network on an agency basis, but not at the national level. Some staff in the main road agency must know something about contracting arrangements, contract law, and arbitration procedures, even if only to be able to advise local authorities about them.

Third, labor-based work methods will only work when road agency staff are familiar with them, government procurement and payment methods have been adapted to favor small-scale, labor-based contractors, and small-scale contractors have access to training in labor-based work methods. Finally, there are limits to how far one can go with contracting out, particularly at the national level. The main road agency is often the only source of training in labor-based work methods and, since staff rarely join the road agency from senior positions in the construction industry, may provide the only source of training for road agency staff in road construction methods. In Botswana, Ghana, and Zimbabwe, in-house construction units are seen as important training grounds for small-scale contractors and in-house staff. These caveats have to be taken into account when translating the mission statement into country-specific actions on the ground.

In keeping with the above mission statements and overall government policies, most road agencies are evolving into white-collar agencies which concentrate on planning, training, contract supervision, and the monitoring and control of works. This generally means they end up with a mission where they:

- Do most design work using consultants,
- Do all periodic maintenance under contract,
- Do most routine maintenance under contract,
- Do all new construction and road improvements under contract.

The larger road agencies may also operate one or two mobile maintenance units (one for emergency works and the other for training), an in-house construction unit for training purposes, and a labor-based training program for small-scale contractors linked to on-site programs of road construction, rehabilitation, and maintenance.

Box 9.1 Developing Domestic Contractors for Road Maintenance

A number of initiatives have recently been taken to develop the capacity of local contractors. They have concentrated on: (i) providing preparatory training, (ii) providing hands-on training, (iii) providing access to plant and equipment, (iv) assisting road agencies to acquire the skills to supervise contracts, and (v) simplifying government procurement procedures.

Preparatory training. Seminars have been organized, or are under preparation, in Burundi, Ghana, Tanzania, and Zaire to teach contractors how to manage small civil works contracts. The most comprehensive seminar program for contractors is in Tanzania. It offers training for administrative managers, engineers, site superintendents, and technicians. The owners and managers of the firms have also asked to participate in the training so that they can understand what is being taught to their staff.

Hands-On training. Potential contractors have been permitted to work on small projects to gain practical contract experience. In Ghana, sections involving 5 km of road rehabilitation have been used as training works for implementing labor-based work methods (contract value around $50,000). Similarly, in Guinea Bissau, the International Labor Organization (ILO) has organized 3 km training sections for labor-based rehabilitation of feeder roads. In Uganda, contractors have been trained on 10 to 15 km road sections under contracts amounting to about $100,000. In Kenya, contractors have been progressively trained to bid for road rehabilitation works. The first time unit prices were fixed by the road agency. The second time contractors were allowed to bid on the same rates but with a plus or minus factor. Now they have to compute their unit prices themselves. Current contracts amount to about $500,000 each. In Tanzania, training works for equipment-based road rehabilitation are 30 to 70 km in length and are estimated at $1 to $2 million per contract.

Availability of plant and equipment. These initiatives have focused on helping contractors get better access to plant and equipment. A plant pool has been in operation in Ghana for years and has helped to develop domestic road contractors. In Uganda, rented equipment belonging to the Ministry of Works was made available to contractors, but it was not sufficient. Contractors therefore decided to buy additional machinery and share it from a pool. Renting equipment to contractors is being considered by the ministries of works in Burundi, Guinea, Tanzania, and Zaire. The Integrated Roads Project in Tanzania is providing contractors with access to foreign currency to enable them to buy equipment and spares.

Contract supervision. Most road agencies have a limited capacity to supervise contracts and several initiatives are under way to strengthen this capacity. Burundi, Guinea, Guinea-Bissau, Tanzania, and Zaire are all building or strengthening control units in the road agency in order to adequately supervise contracted road works. In each case, foreign expertise is involved in preparing sample documents for preparation, procurement, and supervision, staffing the unit during the initial years, and training civil servants in this new activity.

Simplifying procurement procedures. Simplification of procurement procedures is an essential component of efforts to do more work under contract and develop the local construction industry. In Ghana, a comprehensive review of conditions of contracts for ICB and LCB has been carried out under the Road Rehabilitation and Maintenance Project. Proposals for changes have been prepared and accepted. New conditions of contracts are being implemented. If implemented earlier, some specific clauses, such as provision for compensation for delayed payments, might have prevented some contractors from going bankrupt, although there is no substitute for prompt payment. In Chad, Guinea Bissau, and Tanzania, governments have decided to reshape and simplify the regulations for procurement and contract administration to make them easier for contractors.

Source: J-M Lantran.

Finally, the mission statement has to be operationalized by translating it into a specific set of objectives (e.g., *pot-holes on arterial roads will normally be repaired within one week of being reported*) and service standards, which define the thresholds that trigger action on these objectives (e.g., *a pothole is defined as localized, severe raveling extending to greater than the full depth of the surfacing*).

9.2 HUMAN RESOURCE REQUIREMENTS

Once the road agency has defined its mission, it can turn its attention to the number and type of staff needed to discharge this mission. The above mission could clearly be handled by fewer staff, but they need different qualifications. The regular staff could be quite small and could be supported by lengthman subcontractors for most routine maintenance work, small-scale, labor-based contractors for the rehabilitation and periodic maintenance of gravel roads, and regular contractors for the patching, periodic maintenance, and rehabilitation of paved roads (see Table 9.1).

For a road network of about 20,000 km (5,000 km paved), it would require about 800 to 1,000 regular staff (fourty to fifty engineers, about 100 technicians, administrators and foremen, 500 to 600 supervisors, and about 100 laborers). It would also require about 5,000 to 6,000 lengthman subcontractors and, with road maintenance fully-funded, more than 2,000 additional staff would be involved in contract rehabilitation and maintenance work. It is significant that the Department of Feeder Roads in Ghana, which used to manage a 22,000 km road network with 2,000 staff, now does so with 700, including about fourty engineers. By these standards, virtually every road agency included in Table 3.2 is over-staffed.

Table 9.1 Estimated Number of Staff Required to Operate a Medium-Sized Road Agency

Function[a]	*Managerial/ professional*	*Technical/ administrative/ foreman*	*Charge-hand/ supervisor*	*Laborer/ lengthman*
Management	5	10	-	-
Other HQ staff	15	25	-	-
Regional offices	20	50	500	-
Road management system	3	10	10	-
Mobile maintenance unit[b]	2	6	12	120
Labor-based training unit[c]	2	5	25	-
Total	47	106	547	120

a. 20,000 km road network managed through ten regional offices.
b. Mainly for emergency maintenance and training in-house staff.
c. Provides training in labor-based construction, rehabilitation, and maintenance.

The above reduction in size needs to be accompanied by a significant improvement in the terms and conditions of employment, particularly for older staff with experience and for the chief executive officer (CEO) and directors. In general, as Chapter three points out, current salaries for engineers and technicians now need to be increased by about two and a half times to make them competitive with the private sector. In some countries — notably Rwanda, Uganda, Tanzania and Zambia — they need to be increased by more, as do the salaries of the CEO and directors. Allowances also need to be revised. There was a time when road agency staff enjoyed all sorts of perks which made up for lower salaries. Inflation has eroded these fringe benefits and private sector employers now offer better bonuses, housing allowances and car allowances. Salaries for laborers tend to be less out of line with the private sector, but also require adjustment.

At first glance, the above downsizing will create a large number of redundancies. However, restructuring and downsizing can normally be handled in the following way: (i) a large number of existing laborers can be converted into lengthman subcontractors, (ii) with road maintenance fully-funded, road contractors would start recruiting new staff and this would create new jobs for road agency staff, (iii) daylighting by technical staff is now so widespread that many would join their other employers on a full-time basis, and (iv) the remaining displaced staff would have to be offered a redundancy package. The Ghana and Sierra Leone Highway Authorities managed to reduce their staff from 8,400 to 4,700 and from 10,000 to 1,400, respectively through voluntary retirement and by converting staff into petty contractors. The road agency in Senegal has dramatically reduced its staff by offering redundancy packages (up to two years salary). Other countries, notably the UK, managed to reduce the number of engineers and technicians by negotiating their transfer to private sector consultants in conjunction with the transfer of agreed design and supervision work. Downsizing is not only necessary, its feasible.

A smaller road agency must also address its skill-mix requirements. The agency will be smaller, more commercial, and more of a planner, facilitator, and paymaster. It will thus need more managers, more staff with financial backgrounds, and more engineers with experience in contract management, contract law, and arbitration procedures. With an increased focus on labor-based work methods, it will also need staff who know when such techniques are suitable and must be in a position to provide training to small-scale contractors doing labor-based work. These changes require new personnel policies and revised training programs. They also call for a new look at technical assistance programs. With a clear mission and competent, well-paid staff, there should be no need for long-term expatriates in line management positions. Technical assistance can instead be refocused to meet clearly identified skill needs.

9.3 MANAGEMENT STRUCTURE

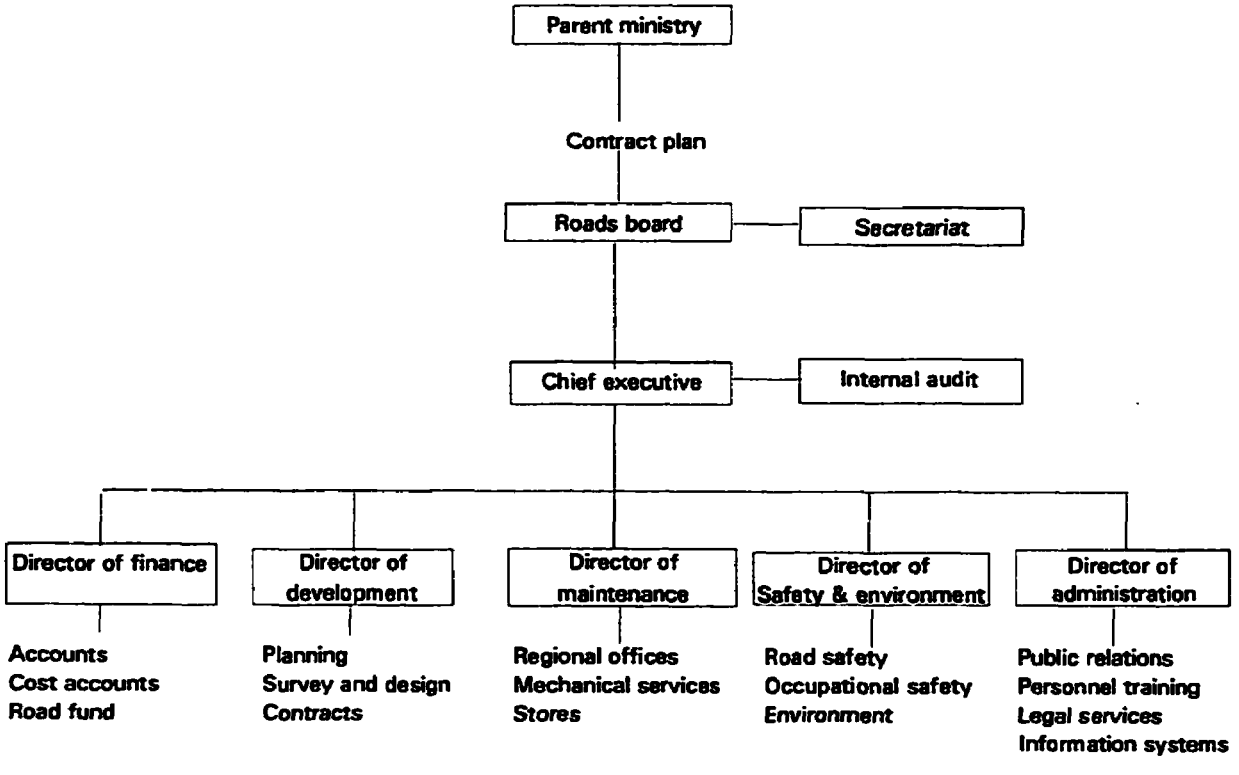
Chapter 3 pointed out that most road agencies have management structures which date back to the time when the Ministry of Public Works spent about as much time on roads as it did on maintenance of public buildings and procurement of government vehicles. That is no longer the case. Roads departments now typically account for over 70 percent of the ministry's total expenditures and are responsible for managing more assets than either the railways or national airline. The head of the roads department is nevertheless appointed at a level which corresponds to that of chief civil engineer in the railways and chief mechanical engineer in the airline. Furthermore, the organization chart of a typical central government road agency exhibits four structural weaknesses: (i) it is missing a layer of management, (ii) several important functions do not report to the director of roads and are shared with other departments (e.g., personnel, finance, and training), (iii) the director of roads rarely reports directly to the permanent secretary (in contrast to the railways and airline which report directly to the PS of works or transport), and (iv) the structure is usually overly centralized.

Some road agencies have already been restructured to create a more commercially oriented management structure along the lines illustrated in Figure 9.1. The highway authorities in both Ghana and Sierra Leone have established the post of CEO and created a new layer of line managers appointed at roughly the same level as the former director of roads. The GHA has

three line managers (deputy CEOs) responsible for administration, development, and maintenance, while SLRA has a deputy CEO and five directors responsible for equipment and supplies, development, administration, maintenance, and feeder roads. The CEO and his deputy in Sierra Leone are appointed by the president on the advice of the minister of works, while line managers are appointed by the board. Tanzania is proposing a similar form of restructuring involving the creation of a separate department of Public Roads (instead of the current Department of Roads and Aerodromes), headed by a commissioner and four directors responsible for development, road maintenance, feeder roads, and administration. The growing importance of financing arrangements, combined with a move toward commercial accounting systems, suggests one line manager should be responsible for accounting and finance.

The above restructuring has also addressed the issues of shared services and confused reporting arrangements. Nonroad activities have been removed (e.g., responsibility for aerodromes in Tanzania), and the road agencies have been given their own support services (e.g., administration and accounting). Reporting arrangements have also been simplified and made more direct. Regional engineers report directly to the CEO (in Tanzania they reported to the PS, and Madagascar has a similar arrangement), and the CEO reports through the board to the PS. Similar reforms have also taken place with regard to urban and rural roads. In Ghana, the departments responsible for urban roads and feeder roads report directly to the Ministry of Roads and Highways in the same way as the GHA. Likewise in Zambia, where rural roads are dealt with through a feeder roads section in the Ministry of Local Government, the departmental head now reports directly to the PS.

Figure 9.1 Proposed Management Structure for a Large Road Agency



The GHA has taken the process of restructuring one stage further. It noticed that there were a large number of job grades and that grades were not related to the size of the division or needs of the task. There was also too much layering. They therefore prepared new job descriptions based on current functional needs, designed a new organizational structure for each division based on the new job descriptions, reduced layering by grouping staff into three broad categories (senior management, middle management, and operating staff), introduced a new reward and career system, and reviewed and revised the disciplinary code. Other road agencies are beginning to do the same.

The regional structure of the road agency is also important, particularly in large countries where centralized agencies remain too remote from their constituents. Several countries are attempting to address this issue by decentralizing operations to regional offices. Under such arrangements, most planning and execution is done at the regional level, while the headquarters staff coordinate regional programs, operate the management information system and provide other central support services. In the case of main roads, the headquarters staff may also deal with trunk roads (Tanzania), or international transit corridors (Zambia). Up to 80 percent of the staff may thus be placed in regional offices. In Ghana, 90 percent of the feeder roads staff work in the regions. Tanzania has also appointed regional roads boards to decentralize the management of roads to the local level and improve coordination between trunk, regional, and district road programs.

9.4 MANAGEMENT INFORMATION SYSTEMS

Management cannot plan, deploy, and control resources without effective management information. The road agency's parent ministry and constituents likewise need transparent information to judge whether the road agency is using resources efficiently. The management information system consists of a set of established and documented procedures which can be used to generate and evaluate alternative ways of operating, maintaining, improving, and extending the road network. It will generally show the condition of the road network, its utilization (traffic volumes and loading), and the impact of potential future management interventions. This information can then be used to generate information on the physical and financial performance of the road network (see Box 9.2).

The management information system provides a framework for making decisions on a number of issues, usually handled by different divisions within the road agency. They include decisions on:

- Routine and periodic maintenance of gravel roads, paved roads, and bridges,
- Rehabilitation of pavements and bridges,
- Upgrading gravel roads to paved standard,
- Improving the geometric characteristics, or capacity, of roads,
- Setting charges for the use of roads and bridges.

Each of the above activities are interdependent with regard to the road agency's budget constraint. Resources have to be allocated between competing programs to optimize expenditures, and user charges must be set to generate the resources required to finance them.

The management information system should thus provide the basis for allocating resources in a manner which achieves best overall road conditions.

The management information system will usually comprise data collection, storage and analysis, estimated traffic, predicted future road conditions, and the impact of alternative management strategies. The system need not–and should not–be too complicated. Africa is littered with the relics of failed management information systems which were poorly designed and overly complicated (see Box 9.3). The key guiding principle is that the system should be affordable, suit the decisionmaking needs of the road agency, be compatible with the scarce manpower resources needed to operate it, and be capable of being incrementally upgraded when resources permit. Most road agencies in Africa will start with a centralized, manual system with four modules: (i) traffic information (classified counts with some axle-weight data), (ii) a survey database (periodic, visual road condition survey data), (iii) road planning (upgrading and new roads), and (iv) maintenance management (using engineering judgment and standard unit costs). This roughly corresponds to the current system used by the Ministry of Works in Tanzania. It is about as simple as you can get, although some road agencies, as presently staffed, will not even be able to manage this level of sophistication. For a 20,000 km road network (5,000 km paved), the system would require about two to three traffic count teams, two road inspection teams, and at least one engineer and one technician to operate the system. Traffic counting and inspection could be done by consultants. The engineer and technician should ideally be in-house staff.

The next level of sophistication is probably to computerize the system and make it accessible to regional engineers. The system in Zimbabwe has currently reached this stage. The survey database might then be extended (to include surface roughness and pavement strength), and the pavement management system might be strengthened by basing it on an analytical model, like HDM III. However, this takes more resources, requires continuity among the staff operating the system, and should only be attempted when there are sufficient trained staff and other resources to operate the upgraded system. Further sophistication can then follow, perhaps along the lines being pursued in Botswana, although that level of sophistication lies well in the future for most African countries (see Box 9.4).

Box 9.2 Key Indices for Measuring Road Agency Performance

(1) Finance:
- Ratio of actual to required maintenance expenditures
- Ratio of new investment to total road expenditures
- Routine and periodic maintenance expenditures per km

(2) Condition of network:
- **Condition of pavement**
  percentage length in good, fair, poor condition by road type and class in terms of specific physical measures, such as roughness or condition ratings, or in terms of visual assessment,
  km backlog of rehabilitation and resurfacing,
- **Condition of bridges**
  number of bridges in terms of structurally and functionally sound, structurally deficient, or functionally deficient

(3) Utilization and management of network:
- **Traffic flow**
  km of road by range of average annual daily traffic according to functional class and road width
- **Vehicle size and weight**
  single and tandem axle load limits
  average gross vehicle weight per heavy vehicle
  average equivalent standard axle per heavy vehicle
- **Safety**
  total accidents, fatalities
  accidents or fatalities per road km, per vehicle, per vehicle-km

(4) Administration and productivity:
- **Staffing**
  by function (e.g., administration, planning, design, maintenance, or construction), age profile, number of expatriates, and vacancies
- **Annual salary range**
  highest versus lowest paid
- **Labor intensity**
  staffing ratios: ratio of administrative to technical staff, ratio of skilled to unskilled workers, ratio of permanent to temporary staff
  total staff and engineers per lane-km (for all activities and separately for maintenance)
- **Equipment**
  availability and utilization of equipment (by major categories and types of equipment and hours or mileage worked)
  age (by major types of equipment)
- **Average construction cost**
  per km (two-lane road) by terrain (flat, hilly, mountainous).
- **Percent maintenance by contract**
  routine
  periodic

Source: W.D.O, Paterson.

Box 9.3 Problems Implementing Road Management Systems

A recent study has reviewed projects dealing with the development of road management systems (RMSs) to identify why they encountered problems during implementation and what might be done to overcome these problems. The following factors were identified as important contributory factors:

Design problems
- Inappropriate and unrealistic terms of reference.
- Consultants lacking sufficient qualified staff.

Client attitudes
- Lack of commitment, often because the RMS had been imposed by donors as a loan condition.
- Expectation of high-tech solutions when simple common sense solutions were more appropriate.
- Greater than expected resistance to change.

Cultural problems
- Problems of introducing Western management practices, including incentives, into cultures that were gerontocracies, where interethnic problems existed, or where nepotism and favoritism were prevalent.
- Traditional behavior where excuses had to be found to avoid blaming individuals.

Economic and financial problems
- Weak local economies and *foreign exchange* shortages preventing the purchase of inputs needed to support the system.
- Local funds sufficient to pay for little more than staff salaries, with the result that little road maintenance could actually be carried out.

Staff problems
- Shortage of experienced local staff.
- Operational requirements prevented local staff from being released for training.
- Over-ambitious training programs with poorly prepared instructors.
- Insufficient follow-up training and updating.

Hardware and software problems
- Focus on procurement of new equipment, rather than systems needed for maintenance and repair.
- Deficient computer facilities and unsuitable hardware.
- Inadequate data.
- Systems too complicated to be sustainable with local staff and other resources.

In all the cases reviewed, the RMS was judged unsuccessful. All systems ceased to function effectively within a short time of the consultants departing. Failure was not due to any inherent faults in the RMS, but because institutional and managerial shortcomings in the road agency were not recognized and corrected before implementation. The study concluded that, for successful operation, systems need: (i) agreement on objectives and methods of implementation, (ii) qualified staff who are well motivated and properly supervised, and (iii) an integral training and upgrading program. More specifically, the provision of an RMS needs to be considered within the general context of the road agency's institutional structure. It was thus recommended that the following factors be borne in mind when specifying and selecting an RMS:

- Obtain genuine government commitment before proceeding.
- Identify system users and the outputs they require to support informed management decisions.
- Identify the policy framework and the road agency's technical and institutional capacity to operate the RMS; if the appraisal indicates that the institutional capacity does not exist, proceed no further.
- If the appraisal indicates that an RMS is needed and can be supported, agree on objectives for the system, design it (based on an analysis of costs and benefits of each component), and prepare a procurement plan.
- Identify data and models required to produce these outputs.
- Identify appropriate software.
- Identify hardware and operating systems needed to support the RMS.

It typically takes five to ten years to institutionalize management systems in industrialized countries. It takes at least as long in a developing country.

Source: R. Robinson.

Box 9.4 The Road Management System (RMS) in Botswana

The RMS currently under development in Botswana consists of a central database linked to subsystems covering data collection, planning, and management. The role of each subsystem is summarized below.

(1) Central database (CDB) contains validated summary data generated by the other subsystems. To allow rapid export and import of data to and from the other subsystems, it uses a Fourth Generation Language database management system. The other subsystems use the same database system.

(2) Pavement management subsystem (PMS) determines the type, and optimum timing and level of maintenance required, given prevailing road conditions. It provides information on: (i) optimum maintenance requirements, (ii) the short and long-term consequences of restricted maintenance funding, (iii) pavements with the highest priority when maintenance funds are limited, (iv) the best maintenance strategy for each road link, and (v) the impact of past maintenance strategies on overall road conditions.

- At the network level, the PMS identifies and ranks pavements for improvement, prepares network level budgets, produces long-range budget forecasts, assesses network level pavement conditions, and forecasts future pavement conditions.
- At the project level, the PMS assesses causes of road deterioration, specifies alternative pavement interventions, assesses the benefits of alternative pavement interventions using life cycle costing, and selects and displays preferred solutions.

The support system for the PMS includes data collection, data analysis (using HDM III), optimization (using appropriate criteria), and preparation of an implementation program.

(3) Maintenance management subsystem (MMS) is not yet operational. Its aim will be to specify, for the selected maintenance strategy: (i) *performance standards* describing the procedures to be followed, resources required (in terms of people, equipment, and materials), and rate of production to be achieved, (ii) *budget requirements* (in terms of people, equipment, and materials) to accomplish the planned maintenance program, (iii) *schedule* of activities within the program to ensure resources are used efficiently, and (iv) a *management information reporting* system to provide the basis for regular management reports. The MMS will eventually include a road inventory, inspection reports, assessment of maintenance needs, costs of proposed works, priorities, implementation plans, and arrangements for monitoring results. It will help to improve the planning and scheduling of work, establish standards (optimum standards being set by the PMS), guide management decisions (optimum timing also being determined by the PMS), and support preparation of accurate budgets.

(4) Bridge management subsystem (BMS) is not yet operational. Its aim will be to provide a rational basis for managing bridge structures. It will eventually cover: (i) the allocation of funds for construction, replacement, rehabilitation, and maintenance, (ii) the identification of bridges requiring remedial action, (iii) the selection and prioritization of selected bridge works, (iv) the identification and prioritization of urgent remedial works, (v) the identification of the best bridge maintenance strategies, and (vi) the monitoring and evaluation of bridge conditions on an ongoing basis.

(5) Traffic subsystem (TSS) provides a variety of statistics on the road network, including traffic volume and loading by vehicle type by road link, total distance traveled, and growth rate by vehicle type by road link.

(6) Cost accounting subsystem (CASE) is not yet operational. It aims to provide accurate cost accounting data for purposes of: (i) establishing budgets and standard costs for road maintenance operations, (ii) tracking and accounting for *actual* costs of operations by activity and cost center, and (iii) monitoring performance and assessing productivity by cost center.

(7) Geographic information subsystem (GIS) allows visual presentation and production of maps of the road network. The subsystem can be configured to display and plot data for any link in the road network, such as road classification, average road condition, and traffic flows.

Resource requirements are: (i) two to three full-time traffic census teams, (ii) two road inspection teams (a technician and surveyor), and (iii) two engineers, a systems analyst, and a technician to operate the RMS.

Source: M.I. Pinard.

9.5 FINANCIAL ACCOUNTING SYSTEMS

The financial accounting system should be designed to complement and support the management information system. It should present a clear picture of the road agency's overall financial health and be capable of producing the financial data needed to plan expenditures, compare alternative strategies, monitor implementation, and account for the way funds are used. Standard government accounts, which focus almost exclusively on cash expenditures, cannot do this. A number of road agencies, notably in New Zealand and parts of Australia, are therefore restructuring their accounting systems to provide a better basis for informed management decisions. They are generally moving toward regular commercial accounting systems, including a standard *income statement*, *balance sheet* and *sources and application of funds statement.*

Many of the benefits of commercial accounting can be achieved with simpler reforms. The most important involve: (i) preparing an income statement which matches revenues and expenditures, (ii) accounting for all the assets owned directly by the road agency (i.e., excluding the capital invested in roads), (iii) recording, in a simple and transparent fashion, the financial condition of the road network, and (iv) producing better information on costs to support the above road management systems.

The SLRA produces some of the best road agency accounts in the world. To start with, they simply produced an *income statement* and a *statement of affairs*. The income statement recorded their income (income from the Road Fund, proceeds from sale of contract documents, and government grants), together with the expenditures associated with the operation and maintenance of the road network. The expenditures included *all* expenditures on roads and excluded expenditures associated with other responsibilities handled by the Ministry of Works. The statement of affairs was a modest document which simply listed the fixed assets owned by the SLRA (vehicles, plant and equipment, and office equipment), money owed to the Authority (debtors), cash in hand, and money owed by the Authority (creditors). These reforms require little more than better book keeping arrangements. The next step involved turning the statement of affairs into a regular *balance sheet* and adding a *cash flow statement* to the financial accounts. The cash flow statement is a simplified sources and application of funds statement. Their accounts for the year ending 30 June 1993 are illustrated in Table 9.2.

These financial reforms can have a major impact on managerial behavior. They provide managers with a better record of what is happening to the business; motivate them to make an effort to locate all their assets[39], value them, and record their value; encourage an *asset-management* culture; and take a first step toward fully costing the overhead and administrative costs of operating and maintaining the road network. Financial reform is thus intimately related to managerial accountability. Without proper accounts, managers cannot be fully accountable.

The next reform focuses on creating a financial statement which accounts for the capital invested in roads, the impact on this of new investment, and shortfalls in regular road maintenance. It has two parts. The first provides an estimate of the total book value of the road network at the end of the fiscal year. It can either be estimated in great detail, as was done in

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[39] When the Ministry of Works in New Zealand was commercialized and required to prepare regular commercial accounts, it was astonished to learn how much land and other assets it owned and how much these assets were worth.

Table 9.2 Financial Satements for the Sierrra Leone Roads Authority, Year Ending 30 June, 1993

(millions of leones)

I. Income and Expenditure Statement

Income for road repairs (fuel levy and government grants)		1,757.3
Expenditure on roads		(761.5)
Surplus on road repairs		995.8
Administrative expenses		(122.0)
Other income (sale of contract documents)		1.6
Grant income (Government of Japan grant)		283.3
Surplus of income over expenditure (after charging depreciation and audit fees)		1,158.7
Taxation		-
Accumulated surplus		1,158.7

II. Balance Sheet

Fixed assets		
Tangible assets (land, buildings, plant, vehicles, and furniture and equipment)		233.5
Intangible assets		209.4
Current assets		
Stocks	476.7	
Debtors	6.2	
Cash and bank balances	811.7	
Sub-Total	1,294.6	
Creditors: Amounts falling due within one year	(21.3)	
Net current asset		1,273.3
Total asset less current liabilities		1,716.2
Creditors: Amounts falling due after one year		(526.1)
Total assets		1,190.1
Reserves		
Capital reserve		31.5
Accumulated surplus		1,158.7
Total Reserves		1,190.1

III. Cash flow statement

Net cash inflow from operating activities (including depreciation)		707.5
Investing acitivities		
Payment to acquire fixed assets	(242.0)	
Value of assets taken over on vesting day	(2.0)	
Payment on behalf of Freetown Infrastructure Rehabilitation project	(209.4)	
Net cash outflow for investment activities		(453.4)
Net cash inflow before financing		254.1
Financing		
IDA advances	526.1	
Assets introduced by Department of Works	31.5	
Net cash inflow from financing		557.6
Increase in cash		811.7

Hungary,[40] or on an approximate basis. The latter method is acceptable when the results are to be used for illustrative purposes only. It is done by multiplying the length of each type of road by its estimated replacement cost, adding any required inflation adjustment to bring book values to their current replacement cost, and adding to this to any new investment completed during the year. This gives the total book value at the end of the year, valued at current replacement costs. The second part of the statement measures the erosion of capital. It is made up of four items: (i) the rehabilitation backlog at the beginning of the fiscal year (the length of road classified as being in *poor* condition, multiplied by the average costs of rehabilitating such roads), (ii) the amount of rehabilitation completed during the year, (iii) the shortfall in regular recurrent maintenance during the year (routine and periodic maintenance), and (iv) the additional costs of future road rehabilitation caused by shortfalls in recurrent maintenance (chapter two section 2.2, suggests that cuts in road maintenance increase the future cash costs of rehabilitation by a factor of two to three). Every four to five years, the estimated rehabilitation backlog should be replaced by a new estimate, based on a new road condition survey. The sum of these items provides an estimate of the current rehabilitation backlog. Finally, the above figures can be used to estimate the current value of the road network and the erosion of capital as a percent of current book values. A prototype road asset statement is shown in Table 9.3.

Table 9.3 Prototype Road Asset Statement for a Road Agency
(millions of dollars)

	December 31 1990	December 31 1991
Fixed assets		
Total book value at beginning of year[a]	2,030.00	2,035.70
Adjustment for Inflation	0	0
New works completed during the year[b]	5.70	3.90
Total book value at end of year	2,035.70	2,039.60
Erosion of capital:		
Rehabilitation backlog at beginning of year[c]	(670.00)	(714.31)
Rehabilitation completed during the year	14.95	6.94
Shortfall in recurrent maintenance[d]	(29.63)	(26.59)
Additional rehabilitation costs[e]	(29.63)	(26.59)
Rehabilitation backlog at end of year	(714.31)	(760.55)
Current value of the road network	**1,321.39**	**1,279.05**
Overall erosion of capital (percent)	**35**	**37**

a. Book values are calculated using the following replacement costs per km: paved, $250,000, gravel, $50,000, and earth, $20,000.
b. Investment in new roads and upgrading existing roads.
c. Calculated for all roads in poor condition using the following costs per km for rehabilitation: paved roads, $230,000, gravel, $36,000.
d. Required maintenance expenditures based on the following values per km: paved, $4,000, gravel, $1,000, and earth, $400. Shortfall is the difference between actual maintenance expenditures (from income and expenditure statement) and required maintenance expenditures.
e. A rough estimate based on figures given in chapter two, section 2.2. The rehabilitation backlog should be updated every four to five years, based on road condition surveys.

[40] Highway Department, 1988.

Box 9.5 Establishing a Commercial Cost Accounting System for Roads: Botswana

The Roads Department (RD) in Botswana is in the process of installing a maintenance management system (MMS) as part of its overall management information system. To be effective, the MMS needs to utilize accurate cost accounting data, which can be used to estimate costs, plan future work programs, monitor implementation, and provide accurate information on overall financial performance. Although most periodic maintenance and 60 percent of routine maintenance are contracted out to the private sector, the design of all maintenance programs and the remaining 40 percent of routine maintenance continue to be done in-house, and the RD wishes to quantify the effectiveness of its in-house work and develop guidelines to increase efficiency.

The cost accounting system is being designed to achieve the following goals and objectives: (i) establish comprehensive routine maintenance budgets and job standard costs which can be compared to actual costs; (ii) establish performance standards by work activity and cost center to determine productivity and efficiency with which available resources are utilized; (iii) track and account for actual direct and indirect unit costs of operations by activity, cost center (location), and road link; and (iv) monitor performance and record progress on implementation by activity and cost center.

A database is being established, with an associated computerized coding system, to account for all anticipated inputs as follows:

Cost centers and responsibility centers. Each cost item will be coded according to its location.
Work activities. Work activities will be coded, based on an updated version of the current list of thirty-four work activities, to specify type of maintenance (routine, periodic, spot, emergency) and type of road (paved, gravel, earth).
Personnel. All personnel (industrial Class personnel, casual labor, and professional staff) will be coded by compensation level, including allowances.
Plant and equipment. This is currently supplied free by the central transport organization, but will be coded by type and fee structure (fee levels being based on recommendations included in a recent road maintenance study) to avoid biasing costs in favor of equipment-based work.
Materials and supplies. All materials and supplies used during the execution of work will be separately coded.
Overheads. These include headquarters and other indirect costs.

Sources for the above data include the *work activity weekly reports*, for quantities of labor, plant and equipment, and materials, and the *standard cost report*, for standard costs of each item and for overheads. The major outputs from the system will consist of weekly, monthly, quarterly, and annual cost summaries on the following topics:

- Comparison of budgeted unit cost with actual unit costs by cost and responsibility center;
- Comparison of budgeted unit costs with actual unit costs for each specific work item (labor, plant and equipment, materials and supplies, and overheads);
- Budgeted unit costs by work activity and type of road surface;
- Annual plans and budgets based on actual resource requirements and standard input costs.

It is estimated that the above cost-accounting system could be operated alongside the existing management information system without any increase in staff, but would require one additional computer plus suitable software. A consultant would also be needed for three to four months to set up the system and train staff. Although the design of the system in Botswana is unique, many of the elements can be used as the basis for setting up similar cost accounting systems in other countries. In most cases, the road agency will need to recruit a cost-accounting clerk and procure computer hardware and software to support the system, since many countries do not have access to the level of resources currently available in Botswana.

Source: C. McKudu.

The third reform focuses on the development of a better costing system. This is usually done by setting up some form of cost accounting system, as is currently under consideration in Botswana (see Box 9.5). Cost accounts show how resources are used, for what purpose, and how well they serve that purpose. In particular, they show how financial performance varies over time, between different parts of the road agency, and between work done in-house and under contract. Cost accounts provide the basic raw materials needed to operate a maintenance

management system effectively. The maintenance management system defines the amount of work required, while the cost accounting system estimates what it will cost and whether it will be cheaper to do work in-house or under contract. The system must nevertheless be kept simple and compatible with existing financial reporting systems and capable of being operated within existing staffing and other resource constraints.

9.6 STRENGTHENING MANAGERIAL ACCOUNTABILITY

Accountability requires clear management objectives, monitorable targets, a regular reporting system, systematic auditing, and effective oversight arrangements. It also requires autonomy. Managers cannot be held accountable unless they have sufficient freedom to sign and award contracts, offer reasonable terms and conditions of employment, and operate without outside interference. The first step required to strengthen managerial accountability is thus to specify clear objectives and, based on these, to set monitorable targets. It is desirable to do this in the form of a written document to avoid later disagreements and to share it with others. It is usually done by preparing a *corporate plan* and using it as the basis for negotiating a *performance contract* with the parent ministry (see Box 9.6). The GHA prepares a three-year rolling corporate plan and uses the first year of the plan to draw up a draft performance contract. The contract spells out the government's goals for the GHA, strategies for achieving them, and procedures for implementation, monitoring, and control. Monitoring is usually done in terms of the indicators outlined in Box 9.2.

Box 9.6 Basic Principles Governing the Preparation of Contract Plans

The contract plan should be developed jointly by the road agency and government, and formally ratified by both. It is primarily an implementing document, not a planning document, and will usually be based on the road agency's corporate plan, or similar statement of corporate intentions. It should be in the form of a clear, written document ratifying and committing both the road agency and the government to the road agency's objectives and policy choices defined in its corporate plan. It should clarify the authority to make decisions, clearly specify those areas where government review or approval is necessary, and set down the road agency's performance goals (in terms of road conditions, staff productivity, and financial targets). The performance goals should be simple, mutually consistent, and restricted to those items which define the direction of development and measure the performance of senior management. The contract plan should also include a statement of related government commitment, which may include budgetary support, regulatory changes, and potential changes in labor laws and procedures.

Source: L. Thompson.

Reporting systems are also an important tool for strengthening managerial accountability and should be produced on a regular basis using the sort of indicators included in the above performance contract. It is surprising how few road agencies produce such reports. Most simply produce *ad hoc* reports when preparing donor-financed road projects. The SLRA produces some of the best reports. It prepares a detailed annual budget (so do other road agencies), an annual statement of accounts audited by an independent auditor, and an annual report. The annual report includes information on the proceedings and policies of the SLRA, the audited accounts, report of the auditor, and any other information requested by the parent ministry. All road agencies should be required to regularly produce such reports.

Effective auditing is also an important tool for strengthening managerial accountability. Most auditing is done by the government audit office, which checks to ensure that budget

allocations have not been exceeded and that funds have been handled according to government guidelines. This does not go far enough. Staff in the auditor general's office lack institutional independence and the audit usually falls short of the rigorous auditing needed to account for the large sums of money associated with a fully-funded road maintenance program. Some road agencies have therefore opted for an independent audit by a member of the Institute of Chartered Accountants (as is done in Sierra Leone). Other countries have gone even further and are introducing independent technical *and* financial audits. Kenya is doing so on the rural access roads and minor roads program (using an international auditing firm working in association with a local engineering consultant), Burkina Faso has started doing so on their road maintenance program (using a local engineer, supervised by an expatriate engineer, to carry out the technical audit), and Senegal is carrying out an independent technical and financial audit of their entire road maintenance program (using expatriate engineers to carry out the technical audit).

Oversight arrangements can also strengthen accountability. The roads boards in Sierra Leone, South Africa, Tanzania, and Zambia (together with the board of the GHA, which is due to be reinstated) and the various roads committees which operate at the local government level make an important contribution to strengthening accountability, as do the boards and committees which oversee the road funds in Benin, CAR, Mozambique, and Rwanda. Such oversight arrangements should be encouraged and strengthened.

Finally, there is the question of autonomy. For over twenty years the World Bank has been urging governments to grant more autonomy to the managers of parastatals. The objective was to reduce political interference in management decisions, develop a more commercial managerial outlook, reduce overstaffing, and strengthen accountability. The same rationale applies to road agencies. Road managers will not behave commercially until the road agency is more autonomous and managers are held accountable for their performance. This has been done in Sierra Leone and Zaire with good results and is about to be reintroduced in Ghana. Greater autonomy is normally one of the cornerstones of a more commercial approach to management.

PART III

Finale

10 CONCLUSIONS

The replacement costs of the road network in SSA is about $150 billion, and it requires annual expenditures on routine and periodic maintenance of $1.5 to $2.0 billion to keep these roads in stable, long-term condition. During the past twenty years, African countries have spent nothing like this amount, and about $43 billion, amounting to nearly a third of the capital invested in Africa's roads, has been eroded because of lack of maintenance. Restoring only those roads which are economically justified and preventing further deterioration will require annual expenditures of about $1.5 billion over the next ten years. Cutting back on maintenance is self defeating. A dollar reduction in road maintenance expenditures *increases* vehicle operating costs by about $2.0 to $3.0. In Tanzania, the annual economic costs of poor road maintenance have been estimated to be between $100 and $150 million. In Kenya it is estimated that the annual $40 million shortfall in road maintenance expenditures adds about $150 million per year to vehicle operating costs. That is a high price to pay for poor road maintenance policies.

The main problems affecting road maintenance are institutional and financial. They relate to the institutional framework within which roads are managed, an inadequate and erratic flow of funds, poor terms and conditions of employment, lack of clearly defined responsibilities, ineffective management structures, weak management systems, and lack of managerial accountability. Roads are managed like a bureaucracy, not like a business. These are the root causes of poor road maintenance policies. Road managers are faced with a biased incentive system and that, in turn, leads to undue emphasis on force account work, ineffective use of plant and equipment, and lack of interest in labor-based work methods. Managers simply do not have the funds or the incentives to use resources efficiently, and nor are they penalized for poor performance.

10.1 GENERAL CONCLUSIONS

Solving these problems requires fundamental changes in the way governments manage and finance their road networks. The key concept which has emerged from the RMI program is *commercialization*: bring roads into the market place, put them on a *fee-for-service* basis, and manage them like any other business enterprise. However, since roads are a public monopoly and their ownership is likely to remain in government hands for some time, commercialization requires complementary reforms in four other important areas. These are referred to as the four basic building blocks: (i) involve road users in management of roads to win public support for more road funding, to control potential monopoly power, and to constrain road spending to what is affordable, (ii) secure an adequate and stable source of funds and introduce secure arrangements for channeling these funds to the respective road agencies, (iii) establish a clear organizational structure defining who is responsible for what, both for roads and road traffic, and (iv) strengthen the management of roads by providing effective systems and procedures and strengthening managerial accountability.

These building blocks represent the core of the required reforms. They are interdependent and should ideally be implemented together. Without all four, the reforms may only achieve part of their objective. You cannot solve the financing problem without the strong

support of road users. And you cannot win the support of road users without taking steps to ensure that resources are used efficiently. And you cannot improve resource use unless you control monopoly power, constrain road spending to what is affordable, and increase managerial accountability. And you cannot hold managers accountable unless they have clearly defined responsibilities.

The first reform focuses on winning the support of road users. They are the people who use the road network and also pay for it, whether through taxes or user charges. Major policy reforms in the road sector are unlikely to succeed without their active support. Given that current allocations for road maintenance are erratic and well below the levels needed to keep the road network in stable, long-term condition, the first building block involves winning public support for more road funding, taking steps to ensure that road agencies do not operate as public monopolies, and do not spend more on roads than the country can afford. This is an essential precondition for getting road users to willingly pay for roads on a fee-for-service basis. It is fundamental at the central government level, where most road maintenance funds are managed, and is also desirable at the regional, provincial, district and community levels.

The preferred method of involving road users at the central, regional and provincial levels is by involving them in road management boards. At least eight countries in Africa now have roads boards which operate at the national level and, in one case, also at the regional level. The oldest are the South African Roads Board (originally established in 1935) and the Board of the Ghana Highway Authority (established in 1974, but suspended by the military government in 1981). Other boards are of more recent origin and were established during the late 1980s and early 1990s. Most of these boards have members representing organizations like the chamber of commerce, farmer's organizations, the road transport industry, and the engineering profession. The most effective have independent chairmen and allow the organizations represented on the board to nominate their own representatives. Some boards manage the road fund, while others have wider responsibilities and oversee management and financing as a whole. Both Ghana (until it was suspended) and Sierra Leone have semi-autonomous executive boards which have powers to hire and fire staff, sign contracts, and otherwise operate according to sound commercial principles.

The second building block concentrates on establishing an adequate and stable flow of funds, usually by introducing an explicit road tariff to manage demand and generate the revenues needed to support the operation and maintenance of roads. Without an adequate flow of funds, none of the reforms will be sustainable. All governments in Africa are seriously short of fiscal revenues. Budget allocations for road maintenance rarely exceed 30 percent of requirements, and it is simply not feasible for governments to increase these allocations under present fiscal conditions. Improved revenue mobilization is essential. However, if road user charges are increased, there is no guarantee that the additional revenues will be allocated to roads. Traditional earmarking is not a viable solution. It has adverse impacts on the management of the government's overall budget and is rarely sustainable. An added concern is that current financing mechanisms do little to strengthen market discipline, either by managing demand or by improving the efficiency of the road agency.

Several African countries are addressing this issue by introducing an explicit road tariff consisting of vehicle license fees (or a heavy vehicle license fee), a fuel levy, and (where

relevant) international transit fees. The fuel levy is ideally specified as a discrete amount, (e.g., 30 shillings per liter) to avoid the appearance of being part of the government's general tax revenues, and is either levied in addition to all preexisting taxes or is partly additional and partly replaces existing fuel taxes. Ideally, the tariff should be set by the Ministry of Finance on the recommendation of the roads board and should be collected independently from government sales and excise taxes.

In the best examples (CAR, Ghana, and Zambia), the fuel levy is collected by the oil companies and deposited directly into the road fund. This prevents the proceeds from being siphoned off and spent on other public programs. The intention is to: (i) create a clear market signal to encourage road users to demand value for money from road spending, and (ii) link revenues and expenditures to impose a hard budget constraint on the road agency, so that more road spending means a higher tariff, while a lower tariff means less road spending. The tariff is generally set to eventually cover all costs of maintaining main roads and part of the costs of maintaining urban and rural roads. The remaining costs of maintaining urban and rural roads are financed through local taxes. The local taxes may consist of land-value increment taxes (e.g., betterment taxes or frontage fees), local property taxes, or other local taxes. Most of the countries with road funds have agreed procedures for allocating funds between different road agencies. Some use simple formulas (Ghana and Mozambique), others use formulas which are modified in relation to needs (Tanzania and Zambia), while others base them on a complex assessment of needs (South Africa).

A recent review of road funds in Africa suggest that there are several factors which contribute to successful operation. They include:

- *Collecting the revenues.* The road tariff should be collected and deposited directly into the road fund without having to pass through the Ministry of Finance account.

- *Road fund management.* The fund should be managed by a board which includes road user representatives.

- *Setting the tariff level.* There should be a formal mechanism for varying the level of the road tariff.

- *Allocation of funds.* There should be a simple and consistent procedure for allocating funds between the different agencies entitled to draw from the fund.

- *Audit arrangements.* The Fund should be audited by independent auditors, and the works financed through the road fund should be subjected to a full financial and selective technical audit.

The third reform focuses on establishing a consistent organizational structure for managing different parts of the road network and dealing with road traffic. In other words, it focuses on establishing who is responsible for what. This requires two things. First, clear assignment of responsibility among different government departments and different levels of government, and second, clear assignment of responsibility to the individual road agencies. The arrangement needs to be based on an accurate road inventory, functional classification of roads,

designation of appropriate road agencies, formal assignment of responsibility to each road agency, and clarification of the relationship between each road agency and the parent ministry. Responsibilities to be assigned include those for the operation, maintenance, improvement, and development of the road network as well as those for traffic management, road accidents caused by the road agency's own negligence, and the adverse environmental impacts associated with roads and road traffic.

At the community level, where roads are generally managed by village councils, higher level road agencies may provide technical advice but usually leave most of the work to be done by the local communities on a self-help basis. Financial support from the center is generally limited to meeting the costs of bought-out materials. Rural roads under the jurisdiction of the central government are generally managed by central government feeder roads departments. Those under the jurisdiction of local governments are generally managed by district councils. Since district councils have limited technical and financial capacity, they are usually encouraged to have their roads managed under contract or to merge with other district councils to create sufficient scale economies to enable the combined network to be managed by a larger road agency. Urban roads are usually managed by urban district councils, while the main trunk road network is generally managed by a central government road agency. International transit routes are critical for Africa and sometimes deserve special treatment. They may either be managed by a dedicated section in the main road agency, as is effectively done in Zambia, or as separate toll roads, as is done in South Africa.

Responsibility for the regulation of road traffic is generally assigned to the main road agency, although it may choose to delegate some of these functions to other agencies or to the private sector. Urban road agencies are normally assigned responsibility for activities which have significant impacts in urban areas (e.g., controlling parking and routing of heavy vehicles in urban areas), while the main road agency is normally responsible for enforcing axle-weight regulations. Axle-weight enforcement should ideally be done in conjunction with the private sector, as is done in Zambia. It is often desirable to make the main road agency responsible for carrying out vehicle safety inspections and vehicle emissions tests, provided they have the capacity to do it effectively (again, these functions may be delegated to the private sector). Finally, all road agencies should be responsible for examining the potential environmental impacts of new road schemes and should be required to satisfy the public that adverse impacts have been minimized and remaining impacts are acceptable.

The final building block focuses on creating a more businesslike road agency. Once road users are involved in the management of roads, they generally press for the introduction of sound business practices to ensure that their constituents get value for money. They expect clear management objectives, competitive terms and conditions of employment, consolidated budgets, commercial costing systems, and effective management information systems. The most important issue requiring attention is the wide gap between the terms and conditions of employment in the public and private sectors, and the impact that this has on staffing and staff morale. An engineer in the private sector in Cameroon normally receives a total remuneration package more than twice as large as his public sector counterpart (the ratio is five in Tanzania and nearly nine in Zambia). As a result, several road agencies have lost most of their technical staff or are being managed by expatriates who are paid international salaries by multilateral and bilateral donors. You cannot manage a road agency on a sustainable basis with expatriates or

with demoralized local staff who spend most of their time daylighting to supplement their incomes. Any serious reform program must address these issues. Tanzania is now trying to define a competitive remuneration package for road agency staff which can be provided within existing civil service regulations.

Once staff are adequately paid, other reforms should concentrate on giving each road agency a clear mission and effective management structures, including appropriate management information systems; good accounting systems; and more managerial autonomy, enabling managers to act commercially. The Ghana Highway Authority has made great progress in this direction by streamlining staffing and disciplinary procedures and introducing a road management system. It has also developed a corporate plan which forms the basis of an annual contract plan between the Authority and the government. These reforms improve market discipline, provide managers with the freedom to operate commercially, and strengthen managerial accountability. They also encourage a more objective approach to setting priorities, comparing in-house to contract work, and evaluating labor-based work methods. Finally, auditing procedures also need to be improved to ensure that the public gets value for money from road spending. The aim is to ensure that funds allocated for roads are spent on road works and that the work is carried out according to specification. Where possible, both financial and technical audits should be carried out by independent auditors. Technical and financial audits are now being used on the rural access roads program in Kenya and on the road maintenance programs in Burkina Faso and Senegal. The technical audit usually covers all contract work as well as work done though force account on a sample basis.

10.2 ROLE OF THE DONOR COMMUNITY

The donor community has a particularly important role to play in facilitating these reforms. Their assistance strategies can either support the reform process by providing well targeted aid or can undermine it by providing contradictory aid which primarily serves their own narrow national interests. Therefore, one of the most important things that the donor community can do is to refuse to provide any assistance to the road sector without a clear government commitment to introduce sustainable road maintenance policies. There is no point rehabilitating roads which will be never maintained. Doing so merely reinforces the cycle of rehabilitation, lack of maintenance, and further requests for rehabilitation. To break the cycle, the donor community has to insist on a clear government commitment to reform, a time-table for implementing it, and some up-front actions demonstrating a serious intention to reform.

To be effective, the donor community needs to act in a coordinated way. This requires consultation and basic agreement on the underlying rules of the game. In that regard, the SSATP as a whole and the RMI in particular have been highly effective instruments for building consensus among donors. However, these programs are transitory in nature and will eventually have to be replaced by a more permanent, formal arrangement. The rules of the game also need to be formalized. The Donors Code of Conduct, prepared by the EEC, provides, a sound basis for doing so as long as all key donors agree to sign it. Although the Code lacks specificity, it shows the determination and commitment of the donor community, and the general agreements set out in the Code will be bolstered by the more specific reforms set out in this report.

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ANNEX 1. IMPACT OF ROAD MAINTENANCE ON VEHICLE OPERATING COSTS

by W.D.O. Paterson

The following example analyzes the impact of road maintenance on vehicle operating costs (VOCs), using data for Nigeria and the World Bank's Highway Design and Maintenance model, HDM III. The analysis was carried out for roads in both fair and poor condition, for traffic volumes of 500 and 1,000 veh/day annual average daily traffic (AADT) growing at 3 percent per year. Seventy percent of the traffic consists of trucks. The cases examined included a base case and 16 possible maintenance interventions, including: (i) patching of potholes; (ii) surface treated reconstruction with and without patching of potholes (i.e., flexible pavement with a crushed stone base and double surface treatment); and (iii) asphalt concrete overlays with and without patching of potholes. Five interventions were finally selected for detailed analysis. These interventions were either on or close to the "economic efficiency frontier", which represents the highest net present value (NPV) of benefits determined for each corresponding level of road agency expenditures. They consisted of:

- P100 Patching of potholes only.
- RY07 Surface treated reconstruction initiated when surface roughness reaches 7 IRI (m/km), with patching of potholes.
- RN07 Surface treated reconstruction initiated when surface roughness reaches 7 IRI (m/km), without patching of potholes.
- OY50 Asphalt-concrete overlay, initiated when surface roughness reaches 5 IRI, with patching of potholes.
- ON50 Asphalt-concrete overlay, initiated when surface roughness reaches 5 IRI, without patching of potholes.

These five interventions were compared against a base intervention case in which no maintenance at all was done to the pavement. For this example, the deteriorated asset was still considered to be a paved road so its value was assessed relative to the cost of restoring it to full paved road quality and functionality after the analysis period. A null case, which effectively abandons the road to disintegrate to a gravel or earth road without full reconstruction was also analyzed, but is not presented in detail here.

Modified Analysis. For this analysis, some modifications were made to the traditional HDM-III analysis to introduce refinements which are important when evaluating cost recovery and comparing the costs and effectiveness of dissimilar strategies. These modifications are summarized below and are to be incorporated in future versions of the model.

Relative Residual Value. When comparing dissimilar alternative maintenance strategies over a finite evaluation period (in this case 20 years), it is important to take account of the condition of the road pavement at the end of the analysis period because this may vary depending on whether a treatment would be made just within or beyond the analyzed period. The analysis thus included a method for estimating the residual or salvage value of the pavement at the end of the analysis period. The Relative Residual Value (RRV) was defined as the net added structural cost of upgrading the pavement from its initial as-new structural

capacity to the final effective structural capacity, which is the final pavement capacity reduced by an amount related to the final damage state. The three elements used to derive the residual value included: (i) the condition or *integrity* of the pavement, defined by the damage or sum of cracking and potholing areas; (ii) the effective structural capacity defined by the resultant thickness of the pavement, reduced in proportion to the final amount of damage; and (iii) the pavement value in its final state relative to its initial new state. The definition of a relative value is a general approach, which avoids the difficulty of assessing the initial construction value and utilizes costs that are consistent with the same unit costs used for the rehabilitation and reconstruction analyses.

Reconstruction Cost. The cost of pavement reconstruction typically varies with the existing condition of the pavement and the target design life adopted for the new pavement. The reconstruction cost should thus be higher when the road is in very poor condition (11 m/km IRI), than when it is in fair/poor condition (7 m/km IRI). Typically, the costs would also include sideworks (repairing drainage etc.) which would vary with the level of routine maintenance applied and would be higher for deferred (worse condition) interventions. Reconstruction costs therefore vary widely and typically range from $90,000 to $250,000 per km for a 2-lane road. As a conservative approach, a flat unit cost of reconstruction of $93,470 per km was adopted as an adjustment to the Nigerian data. In a more rigorous adjustment, the increases would be higher for higher damage levels (more potholing, less patching) and for higher roughness levels (more shape correction and leveling needed), but these refinements would not have affected the particular strategies analyzed here and so were not added in this exercise.

Adjusting Maintenance Strategy Costs. These two sets of adjustments were applied to the HDM-III generated results for the above maintenance strategies. No changes were made to either the physical estimates (pavement condition, maintenance quantities or traffic quantities) or the vehicle operating costs. Adjusted estimates were made for the agency financial costs (undiscounted and discounted at 12 percent), and the net present value (NPV at 12 percent discount rate). In the case of the base and P100 strategies, the cost of reinstating the pavement at the end of the 20-year analysis period to its original capacity is added.

Interpretation of Adjusted NPVs. The adjusted NPVs consist of the original NPV, less the discounted additional cost of reconstruction, plus the PV of the Relative Residual Value. Since the RRV of the Base or Null Strategy (routine maintenance only without patching) is negative (there being a net loss in the final badly deteriorated condition relative to the initial as-new condition), there was a need to consider the most relevant definition of a base strategy. This could be either:

(a) Assume full loss of the functionality of the pavement asset, with reversion to indeterminate gravel/earth state (which would therefore exclude reconstruction at any time); or

(b) Assume that the initial functionality of the asset would have to be restored, so that full reconstruction to original paved standard is required after the analysis period.

It was decided to define the Base case as (b), relating values to the intended functionality of the asset which in this case is that of a paved road. Additionally, in order to demonstrate the loss of value associated with complete neglect, the Null case was defined as (a) above, so the

Null case was typically of lower maintenance cost but also negative NPV when compared with the base case.

Comparison of Maintenance Strategies based on Annualized Costs. In a normal economic life-cycle analysis, the predicted agency costs are presented as either the PV of the cost stream or as an annualized cost, utilizing the applicable discount rate. The results from the above analysis are summarized in Table A.1 using annualized maintenance costs. This shows first that patching is more beneficial and cost-effective than not patching. The effect is strongest comparing the pothole patching (P100) with the base strategy, showing that the annualized maintenance cost including the patching is actually *lower* than the cost excluding the patching, *and* gains user benefits, because the pavement has to be restored eventually to regain functionality. The effects are also evident with the reconstruction (RY07 v. RN07), and overlay (OY50 V. ON50) strategies. For fair condition roads undertaking reconstruction at 7 IRI roughness provides significant benefits over patching only, with an incremental B/C ratio of 4 to 7.7. However, intervening with an overlay at 5 IRI is the most beneficial giving an additional 4.7 to 17.6 incremental B/C ratio. On poor condition roads, overlay strategies are very much more beneficial than reconstruction strategies because the reconstruction is required immediately and costs more than staging the restoration with overlays.

Comparison of Maintenance Strategies based on Average Costs. When considering cost recovery of road expenditures as a basis for road user charges, the applicable maintenance cost to be determined is an undiscounted average of the overall maintenance strategy cost because the distribution of pavement ages in a road network can be assumed uniform. For example, in each year some part of the network will be requiring treatment intervention, and typically a similar length will be handled each year. The results using average maintenance costs are shown in Table A.2. These show an even stronger preference for overlay strategies over deferred reconstruction strategies for both fair and poor condition roads, both in substantially lower average costs and in higher benefit/cost ratios. These results apply when road ages are uniformly distributed throughout the network, so that roughly the same amount of maintenance is each year applied to successive segments of the network, i.e. the road network is in a state of stable equilibrium.

Table A1.1 Impact of Alternative Maintenance Strategies Using Annualized Benefits and Costs ($s)

Strategy	*Base*	*P100*	*RY07*	*RN07*	*OY50*	*ON50*
Road in Fair condition; traffic volume 500 veh/day AADT:						
Increased maintenance	633	546	1,799	2,370	2,868	2,866
VOC savings	0	3,310	8,259	9,348	13,259	13,228
Benefit/cost ratio	-	6.1	4.6	3.9	4.6	4.6
NPV, mill @ 12 percent	-6.2	27.0	62.8	67.8	99.8	99.4
Incremental B/C ratio	-	6.1	4.0	3.3	4.7	4.7
Rank, by inc. B/C ratio		1	2	-	3	-
Road in Fair condition, traffic volume 1,000 veh/day AADT:						
Increased maintenance	633	606	3,011	4,677	3,399	3,520
VOC savings	0	13,371	31,976	36,141	40,418	40,947
Benefit/cost ratio	-	22.1	10.6	7.7	11.9	11.6
NPV, mill @ 12 percent	-6.2	125.2	283.7	307.9	361.0	364.8
Incremental B/C ratio	-	22.1	7.7	5.6	21.8	17.6
Rank, by inc. B/C ratio		1	2	-	3	-
Road in Poor condition, traffic volume 500 veh/day AADT:						
Increased maintenance	633	568	9,278	9,276	5,978	5,977
VOC savings	0	2,291	31,507	31,477	27,872	27,872
Benefit/cost ratio	-	4.0	3.4	3.4	4.7	4.7
NPV, mill @ 12 percent	-6.2	16.8	216.3	216.0	211.1	211.1
Incremental B/C ratio	-	4.0	1.1	1.1	4.7	4.7
Rank, by inc. B/C ratio		1	3	-	-	2
Road in Poor condition, traffic volume, 1,000 veh/day AADT:						
Increased maintenance	633	628	9,295	9,268	6,254	6,252
VOC savings	0	6,039	66,680	66,171	60,886	60,866
Benefit/cost ratio	-	9.6	7.2	7.1	9.7	9.7
NPV, mill @ 12 percent	-6.2	53.1	561.6	556.9	532.6	532.4
Incremental B/C ratio	-	9.6	1.9	1.8	9.7	9.7
Rank, by inc. B/C ratio		1	3	-	2	-

Table A1.2 Impact of Alternative Maintenance Strategies Using Average Annual Benefits and Costs ($s)

Strategy	*Base*	*P100*	*RY07*	*RN07*	*OY50*	*ON50*
Road in Fair condition; traffic volume 500 veh/dayAADT:						
Increased maintenance	3,000	2,473	2,202	2,214	1,034	1,029
VOC savings	0	3,310	8,259	9,348	13,259	13,228
Benefit/cost ratio	-	1.3	3.8	4.2	12.8	12.9
NPV, mill @ 12 percent	-6.2	27	62.8	67.8	99.8	99.4
Road in Fair condition, traffic volume 1,000 veh/day AADT:						
Increased maintenance	3,000	2,559	3,414	5,298	1,183	1,340
VOC savings	0	13,371	31,976	36,141	40,418	40,947
Benefit/cost ratio	-	5.2	9.4	6.8	34.2	30.6
NPV, mill @ 12 percent	-6.2	125.2	283.7	307.9	361.0	364.8
Road in Poor condition, traffic volume 500 veh/day AADT:						
Increased maintenance	3,000	2,486	6,117	6,110	4,290	4,288
VOC savings	0	2,291	31,507	31,477	27,872	27,872
Benefit/cost ratio	-	0.9	5.2	5.2	6.5	6.5
NPV, mill @ 12 percent	-6.2	16.8	216.3	216.0	211.1	211.1
Road in Poor condition, traffic volume 1,000 veh/day AADT:						
Increased maintenance	3,000	2,572	6,186	6,074	4,548	4,544
VOC savings	0	6,039	66,680	66,171	60,886	60,866
Benefit/cost ratio	-	2.3	10.8	10.9	13.4	13.4
NPV, mill @ 12 percent	-6.2	53.1	561.6	556.9	532.6	532.4

ANNEX 2. THE INVERSE ELASTICITY RULE

This Annex presents a simple exposition of the inverse elasticity rule as it might be used to determine an optimal set of road user charges. The question is how to mobilize a given amount of revenue from each group of road users (car, bus, truck) in a way which minimizes overall loss of welfare by all user groups. Heuristically, this involves minimizing the overall loss of welfare suffered by all road users by equalizing the dead-weight loss per dollar of revenue raised from each user group.

The rule will be illustrated in terms of a simple example which assumes that short-run marginal costs of road use (SRMCs) are constant (i.e., there is no congestion), cross-price elasticities are small enough to be ignored (i.e., the travel demand for each user group is independent of the other user groups), and that relevant elasticities are compensated demand elasticities. The example is illustrated in Figure A2.1. When the price of road use is raised from P (where it is equal to vehicle operating costs plus the SRMCs of road use) to P', the dead-weight loss per dollar of revenue raised, S, is equal to the triangular dead-weight loss area ABC divided by the additional net revenue raised, DCAE. In other words:

$$S = -\tfrac{1}{2}(\Delta P \cdot \Delta N)/(\Delta P \cdot N') = -\tfrac{1}{2}\Delta N/N' ,$$
$$\text{where } \Delta P = (P' - P),\ \Delta N = (N - N').$$

Since the compensated own-price point elasticity of demand e^A evaluated at point A is defined to be:

$$(\Delta N/N')/(\Delta P/P')$$

S can be rewritten as:

$$S = -\tfrac{1}{2}e^A(\Delta P/P')$$

The overall loss of welfare is minimized by equalizing S across all user groups:

$$S = e_1^A T_1 = e_2^A T_2 = \ldots = e_n^A T_n \qquad (1)$$

where S represents the welfare gain associated with relaxation of the revenue constraint,
1, 2 ... n represent the different user groups, and
$T_1, T_2 \ldots T_n$ represent the relative mark-up of price over the final gross price, $(\Delta P_i/P_i')$.

This is the familiar inverse elasticity rule. The ratio of the relative mark-up of user group 1 over user group 2, T_1/T_2, is inversely proportional to the ratio of their respective own-price elasticities of demand, e_2^A/e_1^A. The solution is illustrated in Figure A2.2. Note that with a constant demand elasticity, the lines representing group 1, group 2, and group n are straight; otherwise they are curved.

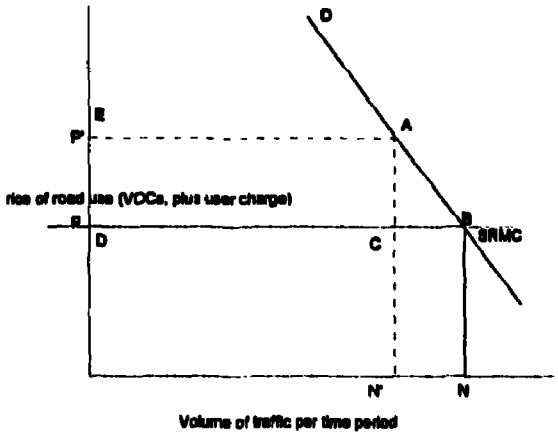

Figure A2.1 Loss of consumer surplus when price is raised

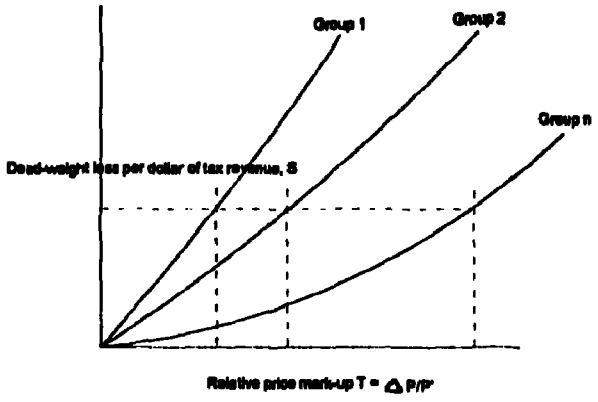

Figure A2.2 Equalizing the dead-weight loss per dollar of revenue raised

The revenue generated by the above mark-ups is:

$$R = T_1P_1'N_1' + T_2P_2'N_2' + \ldots T_nP_n'N_n'$$

$$= \Delta P_1N_1' + \Delta P_2N_2' + \ldots + \Delta P_nN_n' \qquad (2)$$

where $N'_1 \ldots N'_n$ represents the volume of each type of traffic at the final traffic levels; and $\Delta P_i = P_i\cdot[T_i/(1 - T_i)]$, $i = 1,\ldots,n$.

Since the values of P, e^A, and R are known, the only unknowns are the values of N' and T. These are estimated from equations (1) and (2) using trial and error[41] or a simple numerical algorithm.

Empirical estimates of the price elasticity of demand for transport generally ignore income effects. When the income effect is thought to be important, the compensated demand elasticity should be used. It is equal to the ordinary demand elasticity plus the proportion of the household budget spent on transport multiplied by the income elasticity of demand for transport. When the cross-price elasticities of demand between the different user groups are significant, the relevant cross-price elasticities should be subtracted: $e^A = (e_{11}^A - e_{21}^A)$.

In practice, empirical estimates of the price elasticity of demand by different road users are subject to wide margins of error (see Oum, et al, 1990). Recent estimates vary from: 0.10 to 1.1.0 for a car; 0.10 to 1.30 for a bus; to 0.70 to 1.10 for a truck. This reflects the fact that demand elasiticites depend on market conditions, which vary widely throughout the road network. It is therefore unwise to use *average* or *typical* demand elasticities to estimate road user charges. Instead, it is better to use uniform mark-ups (i.e., to assume

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41 Choose a starting value for S and solve equation (1) for T_i. Estimate $\Delta P_i = P_i\cdot[T_i/(1 - T_i)]$. Assume N_i' is approximately equal to N_i. Calculate the implied value of R from equation (2) and compare it with the actual value of R. If the implied value is less than the actual value, choose a higher value for S and repeat the calculation. The values converge after about three to five iterations. Finally, check whether ΔP_i is large enough to make N_i' significantly lower than N_i. If so, replace N_i with a new estimate of N_i' and repeat the above calculations.

demand elasticities are equal) and only to use differential mark-ups when accurate and consistent country-specific values are available.

Finally, when roads are congested and SRMCs are not constant, the analysis has to include the supply elasticities and this adds greatly to the complexity of the analysis.

ANNEX 3. ESTIMATING ROAD USER CHARGES: A WORKED EXAMPLE

This annex takes a hypothetical road network and, using the pricing and cost recovery policies developed in Chapter 7, estimates the user charges required to ensure that: (i) the costs of operating and maintaining the main road network are fully-funded, and (ii) the grants made to road agencies managing urban and rural roads are sufficient to ensure their maintenance programs are also fully-funded, and (iii) sufficient funds are available to finance investment in main roads, support investment in urban and rural roads, and meet debt service obligations.

The hypothetical road network consists of 28,000 km of trunk roads managed by the main road agency (3,000 km are paved), 3,000 km of urban roads managed by the municipalities and 27,000 km of rural roads managed by rural district councils (see Table A3.1). Traffic volumes are modest and vary from an average of 600 vpd on paved roads, to 300 vpd on gravel roads, and 50 vpd on earth roads and gravel roads in rural areas. The vehicle fleet consists of 200,000 vehicles (see Table A3.2). Twenty percent consist of trucks and buses and these vehicles account for nearly 27 percent of annual veh-km. Average annual distances traveled vary from about 35,000 km for light vehicles, to 50,000 km for most trucks and buses, to 70,000 km for articulated trucks.

There are four main steps to the analysis:

(i) Estimate the costs of operating and maintaining the entire road network on a sustainable basis. Actual expenditures may be lower than this since maintenance may be underfunded and the road agency may be accumulating a large backlog of deferred maintenance.

(ii) Using the above costs, prepare an outline financing table showing all costs which have to be met through user charges. The table will include the entire costs of the trunk road network and part of the costs associated with urban and rural district roads.

(iii) Estimate the amount of traffic expected to use the road network during the year for which costs are being estimated.

(iv) Estimate the variable costs attributable to each type of traffic and then set the level of the fuel levy, together with license fees and (where relevant) heavy vehicle license fees to ensure: (a) each type of traffic covers its variable costs, and (b) all vehicles in total generate sufficient revenues to cover all the costs included in the outline financing table.

The first task, item (i) above, should be carried out using either the *short analysis*, or the *formal analysis* described in Box A3.1. This example uses the short analysis, based on the cost matrices included in Annex 4. The results of the analysis are summarized in Table A3.1. The only parameters needed for this analysis are: (i) length of the road network, by type of road; (ii) average daily traffic volumes; and (iii) observed unit maintenance costs, which are used to adjust the cost figures set out in Annex 4. In this example, the figures from Annex 4 have been used without adjustment.

Box A3.1 Methods for Estimating Road Maintenance Requirements

Data collection: From traffic count data, classify the road network in AADT ranges (preferably 50, 300, 1000, 3000, etc.) and estimate the vehicle-km-traveled (VKT) for each vehicle class and each traffic volume class. Using a 5 percent sample of roads in each traffic class, determine the representative pavement strength (in pavement structural numbers) and traffic loading (Equivalent standard axles lane-yr, using average ESAs for each vehicle class). The percentage lengths in good, fair, and poor condition should also be observed. If there are relevant regional differences in costs or pavement performance, the sample should be uniformly distributed across the regions. The unit costs of resurfacing, rehabilitation, and reconstruction (reseal, thin overlays, thick overlays, etc.) should be determined with and without taxes, and the periodicity of application, if any, should be noted according to region.

Short analysis: The short method avoids direct analysis and instead makes adjustments to general figures generated using the HDM III model with data from a selection of developing countries (see annex 4). Determine a cost factor by comparing the observed unit maintenance treatment costs with the values in annex 4, Table A4.1. Also use this table to determine the applicable loading category from the loading characteristics (ESA/lane-yr) for each traffic volume class. Estimate the uncorrected optimal maintenance costs from annex 4, Table A4.2 for the relevant loading profile and pavement SNC, then adjust using the above unit maintenance cost factor. Multiply the adjusted estimated maintenance cost by the road length for each traffic volume category to obtain the estimated total network maintenance costs.

- Maintenance requirements are equal to total network maintenance costs.
- Shortfall is equal to estimated maintenance requirements minus the available budget.
- Backlog is the sum of estimated rehabilitation costs for all road lengths in poor condition.

Formal analysis: Calibrate the HDM-III to local conditions and prepare collected data as inputs, defining a series of maintenance strategies sufficient to define an optimal NPV. Only the representative values of SNC and ESA/lane-yr are used for each traffic volume class. Apply end-of-period adjustments to ensure that a full life-cycle is considered by the HDM-III. Run the analysis three times: (a) with full traffic as measured; (b) with no loading, but with all vehicles, by setting the load (or ESA) input to a negligible value; and (c) with no traffic (HDM requires a minimum of one vehicle per class for computational logic in this zero traffic case). Select the optimal maintenance treatment from the (smoothed) maximum NPV in economic terms under each of the full traffic, nonload, and nontraffic run-cases. Determine the average maintenance requirements from the undiscounted, predicted maintenance costs of the optimal treatment for each road traffic class and run-case. The shortfall is determined using the full-traffic predicted maintenance costs for the optimal treatment in each case, multiplied by the road length in each traffic class. The backlog is the product of the average optimal treatment cost (for poor condition) and road length in poor condition summed for all traffic classes

Source: W.D.O. Paterson.

The second task is to prepare the outline financing table. This is shown in Table A3.3. In addition to routine and periodic maintenance (from Table A3.1) this table also includes: (i) the costs of policing and administration (both of which are properly attributable to road users), (ii) interest charges on projects financed through loans, (iii) grants to local authorities to support operation and maintenance of urban and rural district roads (the grants have been set to cover all variable costs which amount to between 60 and 70 percent of total urban and rural road expenditures), (iv) all investment in trunk roads and 50 percent of investment in urban and rural roads (it is assumed there is a 50 percent cost-sharing formula for the latter roads), and (v) debt service repayments. The total costs to be recovered from road users amount to $100.6 million, comprising variable costs of $55.9 million (SRMCs without congestion) and fixed costs of $24.0 million (main roads only). The balance of the fixed costs, amounting to $10.6 million, would be financed by the respective district councils (from property taxes and other local revenues). Variable costs are made up of costs which vary with traffic (variable road maintenance costs and variable road operating costs) and those which vary with traffic loading (variable periodic maintenance). The costs which vary with traffic amount to $37.7 million (including policing and administration), while those which vary with traffic loading amount to $18.2 million.

The third task is to estimate the amount of traffic using the road network. This has been done in Table A3.2. It requires a knowledge of the vehicle fleet (i.e., number of vehicles operating over the road network), together with the average annual mileage traveled by each type of vehicle. Factors like axle-weights and fuel consumption are available from standard tables or manufacturers specifications.

The final task is to estimate variable costs for each type of vehicle. This calculation is illustrated in Table A3.4. The footnotes explain how vehicle-related costs (column 1) and axle-related costs (column 2) were calculated. These are then added to give the total variable costs attributable to each type of vehicle (column 3). The fuel levy is calculated in column 4 and, in this example, has been set at $0.09 per liter. It has been assumed that there are an existing set of license fees set at nominal levels, varying from $20 per year for a car, to $100 per year for heavy single-axle trucks and buses, to $300 p.a. for an articulated truck (column 5). Clearly, without a heavy-vehicle license fee, articulated trucks would not cover variable road costs and would make no contribution to fixed costs. The table has therefore introduced a heavy vehicle license fee for the three heaviest vehicle classes and has set the charge at $375 per equivalent standard axles (ESALs) per year. This results in supplementary license fees of $218, $975, and $2,550 per year for the three heaviest types of vehicle. The combined effect of the regular license and heavy vehicle license is shown in column 7.

The final matrix of charges ensures that all heavy vehicles cover their variable road costs, without involving extensive over-charging of light vehicles. The total revenue generated, $102.4 million, is sufficient to cover the total required revenues, $100.6 million, shown in Table A3.3. Most revenue comes from the fuel levy, $82.9 million (over 80 percent). Regular license fees contribute relatively little, $6.0 million (just under 6 percent), while the heavy vehicle license fee — which, in this example, is only collected from 16,000 vehicles (i.e., 8 percent of the vehicle stock) — brings in $13.5 million.

Table A3.1 Costs of Maintaining the Road Network on a Sustainable Basis

			Routine maintenance (millions of dollars)			Periodic maintenance		
	Length (km)	*AADT*	*Variable*	*Fixed*	*Total*	*Variable*	*Fixed*	*Total*
Main Roads								
Paved	3,000	600	0.90	5.10	6.00	2.83	3.34	6.16
Gravel	10,000	300	10.74	1.40	12.14	11.26	8.23	19.49
Earth	15,000	50	8.04	1.50	9.54	--	--	0.00
Total	**28,000**		**19.68**	**8.00**	**27.68**	**14.09**	**11.57**	**25.65**
Urban Roads								
Paved	500	600	0.15	0.85	1.00	0.47	0.56	1.03
Gravel	2,500	300	2.69	0.35	3.04	2.82	2.06	4.87
Earth	--	--	--	--	0.00	--	--	0.00
Total	**3,000**		**2.84**	**1.20**	**4.04**	**3.29**	**2.61**	**5.90**
Rural Roads								
Paved	--	--	--	--	0.0	--	--	0.00
Gravel	5,000	50	2.68	0.50	3.18	0.82	4.12	4.94
Earth	22,000	50	11.79	2.20	13.99	--	--	0.00
Total	**27,000**		**14.47**	**2.70**	**17.17**	**0.82**	**4.12**	**4.94**

--: Not Applicable

Source: Paved roads: routine maintenance, Table A4.1
Paved roads: periodic maintenance, Table A4.2, for a road with a structural number of three, using the mid-point between 300 vpd and 1,000 vpd.
Gravel and earth roads: periodic and routine maintenance, Table A4.3

Table A3.2 Characteristics of Vehicle Using the Road Network
(Individual Units)

Vehicle type and payload (tons)	*Number of vehicles*	*Mileage per year*	*Axle-weight (ESALs)*	*ESAL-km (mill)*	*Veh-km (mill)*	*Fuel use (l/km)*
Car gasoline	50,000	35,000	0.0001	0	1,750	0.08
Car diesel	70,000	35,000	0.0001	0	2,450	0.07
Utility (0.8)	40,000	35,000	0.0080	11	1,400	0.09
Light truck (2.0)	20,000	50,000	0.0920	92	1,000	0.15
Medium truck (5.0)	7,000	50,000	0.5800	203	350	0.20
Heavy single-axle truck (12.0)	7,000	50,000	2.6000	910	350	0.93
Articulated truck (25.0)	2,000	70,000	6.8000	952	140	0.49
Bus	4,000	50,000	0.4900	98	200	0.36
Total	**200,000**			**2,267**	**7,640**	

Table A3.3 Annual Expenditures on Road Subdivided into Main Cost Components (millions of dollars)

	Total annual expenditure	*Variable costs*	*Fixed costs*	*Financed by district council*
Recurrent costs				
Main roads				
Policing[a]	0.70	0.21	0.49	-
Administration[b]	2.44	0.49	1.95	-
Interest charges[c]	2.00	0.00	2.00	-
Routine maintenance	27.68	19.68	8.00	-
Periodic maintenance	25.65	14.09	11.57	-
Subtotal	58.47	34.47	24.01	-
Urban roads				
Grants for maintenance[d]				
Routine		2.84	1.20	
Periodic		3.29	2.61	
Subtotal	6.13	6.13	3.81	(3.81)
Rural roads				
Grants for maintenance[d]				
Routine		14.47	2.70	
Periodic		0.82	4.12	
Subtotal	15.29	15.29	6.82	(6.82)
Total recurrent costs	***79.89***	***55.89***	***34.64***	***(10.63)***
Investment[e]				
Main roads	8.50	-	-	-
Debt service/repayment	2.83	-	-	-
Grants for urban roads[f]	2.50	-	-	(2.50)
Grants for rural roads[f]	6.90	-	-	(6.90)
Total investment	***20.73***	-	-	***(9.40)***
Total funds required	***100.62***			

- Not Applicable
a. An estimated 70 percent of these costs are fixed.
b. Fixed costs include expenditures on buildings and 70 percent of headquarter salaries.
c. Interest charges on road loans.
d. Maintenance grants are set to cover all variable road maintenance costs.
e. Although an estimated 10 percent of investment is usually incurred on behalf of heavier vehicles and 5 percent on behalf of large vehicles, no distinction has been made in the financing table.
f. Grants for investments in urban and rural roads have been set at 50 percent of total investment costs.

Table A3.4 User Charges Required to Cover Variable and Fixed Costs of Road Use

	Variable costs of road use			*Required user charge*				
	Vehicle related[a] (c/veh-k) (1)	*Axle related*[b] c/ESAL-km (2)	*Total Var. costs* (c/km) (3)	*Fuel levy @ 9 c/l charge*[c] (c/km) (4)	*Standard license fee*[d] ($ p.a.) (5)	*Heavy vehicle license*[d] ($ p.a.) (6)	*Total license charge*[e] (c/km) (7)	*Total user charge* (c/km) (8)
Car gasoline	0.49	0.00	0.49	0.72	20	-	0.06	0.78
Car diesel	0.49	0.00	0.49	0.59	20	-	0.06	0.64
Utility	0.49	0.01	0.50	0.81	25	-	0.07	0.88
Light truck	0.49	0.07	0.57	1.35	30	-	0.06	1.41
Medium truck	0.49	0.47	0.96	1.80	45	218	0.53	2.33
Heavy single-axle truck	0.49	2.09	2.58	3.51	100	975	2.15	5.66
Articulated truck	0.49	5.46	5.95	4.38	300	2,550	4.07	8.45
Bus	0.49	0.39	0.89	3.21	100	-	0.20	3.41
Total	**37.69**	**18.20**	**55.89**	**82.92**	**6.02**	**13.45**	**19.46**	**102.38**

-: Not applicable

a. Values consist of total vehicle-related variable costs, $37.69 million, divided by total veh-km (from Table A3.2).

b. Values consist of total weight-related variable costs, $18.20 million, divided by total ESAL-km (from Table A3.2), multiplied by the number of ESALs for each vehicle type divided by veh-km for each type of vehicle.

c. Values consist of the fuel levy (specified in a cell elsewhere on the spreadsheet), multiplied by rate of fuel consumption (from Table A3.2). The column total multiplies each cell by the distance traveled by each vehicle type.

d. Total are the sum of each cell multiplied by the respective number of vehicles.

e. Values consist of the annual license fee multiplied by the respective number of vehicles (from Table A3.2) and divided by the veh-km for each type of vehicle.

ANNEX 4. TABLES FOR ESTIMATING OPTIMAL MAINTENANCE REQUIREMENTS

This annex presents data for estimating optimal road maintenance requirements. The analysis was undertaken by W.D.O. Paterson and R. Archando-Callao using data from a selection of developing countries without any extremes of climate. Table A4.1 presents data on maintenance costs, and traffic loading. Table A4.2 then uses this data to estimate the average annual pavement maintenance costs (including routine maintenance) and usage costs for paved roads under optimal maintenance strategies for a variety of loading conditions. Routine maintenance costs can be estimated separately using the formula included in the first part of Table A4.1.

Table A4.3 provides similar figures for unpaved roads. They show costs of maintaining both gravel and earth roads and have been estimated for the sorts of traffic volumes likely to be encountered in Africa.

Table A4.1 Basic Data Required to Estimate Road Use Costs

Maintenance Costs:

Treatment	*Unit*	*Code*	*Economic*	*Financial*
Routine maintenance	$/km-yr	-	1,450 + 0.43 T	1,700 + 0.5 T
Reseal	$/km	RExx	19,400	22,400
Thin overlay, 40mm	$/km	OSyy	47,600	56,000
Thick overlay, 80mm	$/km	ODyy	76,200	90,000
Reconstruction (+2 SNC)	$/km	RCyy	238,000	280,000
Unpaved blading	$/km/blading	-	75	80
Regravelling	$/m^3	-	6.00	7.00

Pavement

Modified structural number (SNC)	2	3	5	8
Asphalt surfacing thickness, mm	20	40	50	100
Subgrade in situ CBR, %	8	8	8	8

Traffic Loading:

	Units	*Light*	*Moderate*	*Heavy*	*High*
Truck					
Nominal axleload limit (tons)	-	8.2	8.2	11	8.2
Presence of overloading	-	no	yes	yes	yes
Compliant axle load limit (tons)	-	8.2	11	13	11
300 veh/day	MESA/L-yr	0.007	0.014	0.028	0.070
	ESA/Hveh	(0.63)	(1.25)	(2.50)	(1.25)
1,000 veh/day	MESA/L-yr	0.026	0.053	0.104	0.250
	ESA/Hveh	(0.72)	(1.45)	(2.90)	(1.45)
3,000 veh/day	MESA/L-yr	0.129	0.258	0.129	0.576
	ESA/Hveh	(1.17)	(2.35)	(4.70)	(2.35)
6,000 veh day	MESA/L-yr	0.50	1.00	2.00	-
	ESA/Hveh	(1.52)	(3.05)	(6.10)	-
10,000 veh/day	MESA/L-yr	0.87	1.74	3.48	-
	ESA/Hveh	(1.59)	(3.18)	(6.36)	-

Notes: -: Not applicable
xx = percentage area with surface distress; yy = intervention roughness in m/km IRI x 10;
ESA = equivalent 80kN single axle loadings; M = million; L = lane;
Hveh = heavy vehicle, average for all vehicles (laden and unladen) of GVW 3.5t or more;
T = annual average daily traffic volume (veh/d).

Table A4.2 Average Annual Maintenance Costs and Usage Costs for Paved Roads under Optimal Maintenance Strategies

(Average annual costs, $/km-yr)

SNC[a]	AADT	ESA/LY million	Optimal maint.	Total	No traffic	Vehicles	Loading	Variable c/veh-km	Vehicle c/veh-km	Loading c/ESA-km
				Costs for moderate traffic loading with normal truck composition (20%)						
8	10,000	1.740	OD30	7658	3806	3216	636	0.106	0.088	0.018
8	6,000	1.000	OD30	6804	3155	3217	432	0.167	0.147	0.022
8	3,000	0.260	OD30	6180	2955	2647	578	0.295	0.242	0.111
5	10,000	1.740	OD30	9953	3921	3365	2667	0.165	0.092	0.077
5	6,000	1.000	OD30	8042	3270	3038	1734	0.218	0.139	0.087
5	3,000	0.260	OS35	6242	3211	2391	640	0.277	0.218	0.123
5	1,000	0.053	OD70	3524	3062	145	317	0.127	0.040	0.299
5	300	0.014	OD70	2939	2562	128	249	0.344	0.117	0.889
3	3,000	0.260	OS35	7988	3212	2648	2128	0.436	0.242	0.409
3	1,000	0.053	OD50	5004	3062	379	1563	0.532	0.104	1.475
3	300	0.014	OD70	3104	2562	206	336	0.495	0.188	1.200
2	3,000	0.260	OD35	9558	3272	3323	2963	0.574	0.303	0.570
2	1,000	0.053	OS40	5975	3122	1336	1517	0.782	0.366	1.431
2	300	0.014	OD70	3560	2622	290	648	0.857	0.265	2.314
				Costs for moderate traffic loading with high truck composition (70%)						
8	3,000	1.000	OD30	6604	2955	2647	1002	0.333	0.242	0.050
8	1,000	0.250	OS30	5073	2806	63	2204	0.621	0.017	0.441
8	300	0.070	P100	2795	2306	59	430	0.447	0.054	0.307
5	3,000	1.000	OD30	8944	3211	2391	3342	0.524	0.218	0.167
5	1,000	0.250	OS35	5481	3062	145	2274	0.663	0.040	0.455
5	300	0.070	OD70	3007	2562	128	317	0.406	0.117	0.226
3	3,000	1.000	OD30	10320	3212	2648	4460	0.649	0.242	0.223
3	1,000	0.250	OS35	7045	3062	379	3604	1.091	0.104	0.721
3	300	0.070	OD50	4508	2562	206	1740	1.777	0.188	1.243
2	1,000	0.250	OS35	8848	3122	1336	4390	1.569	0.366	0.878
2	300	0.070	OD60	5039	2622	290	2127	2.207	0.265	1.519
				Costs for heavy traffic loading with normal truck omposition (20%)						
8	6,000	1.960	OD30	7520	3155	3217	1148	0.199	0.147	0.029
5	3,000	0.500	OS35	6351	3211	2391	749	0.287	0.218	0.075
3	1,000	0.101	OD50	5355	3062	379	1914	0.628	0.104	0.948
2	300	0.026	OD60	4263	2622	290	1351	1.499	0.265	2.598
				Costs for light traffic loading with normal truck composition (20%)						
8	6,000	0.500	OD30	6586	3155	3217	214	0.157	0.147	0.021
5	3,000	0.130	OD35	6207	3211	2391	605	0.274	0.218	0.233
3	1,000	0.025	OD50	4750	3062	379	1309	0.462	0.104	2.618
2	300	0.013	OD70	3380	2622	290	468	0.692	0.265	1.800

Note: For traffic loading, see Table A4.1

a. Modified structural number

Source: Analysis of data in Table A4.1 using the HDM-III model

Table A4.3 Average Annual Maintenance and Road Usage Costs for Unpaved Roads

	Gravel Surface						*Earth*		
	300 veh/day			50 veh/day			50		
	M[a]	F[a]	V[a]	M	F	V	M	F	V
Average annual Maintenance costs (undiscounted financial costs)									
Blading (@$88/km/blading)	12	0	1074	6	0	536	6	0	536
Other routine (@$/km-yr)	1	140	0	1	100	0	1	100	0
Regravelling (@$7/cu. m)	0.25	823	1126	0.11	823	164	0	0	0
Total costs	na	963	2200	na	923	700	na	100	536
Average user costs									
Cost by element (cents/veh-km)	na	0.88	2.01	na	5.06	3.84	na	0.55	2.94
Total usage cost (cents/veh-km)	na	na	2.89	na		8.90	na	na	3.49

na = not applicable

a. M = Maintenance frequency treatments per year; F = Fixed costs ($/km/yr); V = Variable costs ($/km yr).

Source: HDM-III analysis.

APPENDICES

Appendix 1 Road Network Length Classification, Density and Replacement Values

Country	Area Thousand Km2	1992 Population million 1/	Total Vehicle Fleet	1992 GNP Per Capita (US$) 2/	1992 Total GNP (US$m)2/	CLASSIFICATION OF THE NETWORK: Total Network Length (KM)	Main Network Length (KM)	Main Paved Length (KM)	Main Unpaved Length (KM)	Rural Network Length (KM)	Urban Network Length (KM)	RATIOS: Total Length Per Thousand Km2	Total Length Per Million Population	Total Length Per Thousand Vehicle	Total Length Per Million US$ GNP	REPLACEMENT VALUES: Main Network US $ Million 9/	Rural Network US $ Million 10/
ANGOLA	1247	9.73	57,030			21,780	15,811	7,942	7,869	4,518	1,451	17	2,238	382		2,742	226
BENIN	113	5.0	31,250	410	2,058	15,682	3,425	1,195	2,230	10,457	1,800	139	3,110	502	8	860	523
BOTSWANA	582	1.4	81,260	2,790	3,797	30,367	17,867	2,831	15,036	11,000	1,500	52	22,329	374	8	1,835	550
BURKINA	274	9.5	32,000	290	2,908	13,538	8,739	1,506	7,233	4,378	421	49	1,420	423	5	843	219
BURUNDI	28	5.8	13,500	210	1,193	6,466	4,099	1,011	3,088	2,189	178	231	1,111	479	5	452	109
CAMEROON	475	12.2	110,000	820	10,003	54,102	33,000	3,670	29,330	18,000	3,102	69	2,695	300	3	3,160	900
CAPE VERDE	4	0.4	11,180	850	330	1,214	1,095	679	416		119	274	2,815	98	3	220	
C.A.R.	623	3.2	23,135	410	1,307	24,441	9,300	440	8,860	14,400	741	39	7,720	1,056	19	738	720
CHAD	1,284	6.0	14,000	220	1,307	28,717	3,800	300	3,500	24,000	917	22	4,805	2,051	22	479	1,200
COMOROS	2	0.5	4,500	510	262	795	735	467	268		60	398	1,559	177	3	145	
CONGO	342	2.4	46,000	1,030	2,502	11,504	10,800	1,245	9,555	200	504	34	4,738	250	5	915	10
COTE D'IVOIRE	322	12.8	235,447	670	8,665	48,443	14,976	3,976	11,000	30,224	3,243	150	3,773	206	6	2,355	1,511
DJIBOUTI	22	0.5	20,000			3,429	1,577	857	720	1,668	184	156	7,374	171		296	83
EQUAT. GUINEA	28	0.4	7,500	330	146	1,690	1,090	447	643	450	150	60	3,867	225	12	181	23
ETHIOPIA	1,222	54.8	59,328	110	6,206	32,339	14,020	4,115	9,905	15,000	3,319	26	590	545	5	2,354	750
GABON	268	1.2	27,000	4,450	5,341	7,976	5,300	700	4,600	2,400	276	30	6,641	295	1	474	120
GAMBIA	11	0.9	5,900	390	367	2,492	1,310	510	800	1,080	102	227	2,682	422	7	193	54
GHANA	239	15.8	130,000	450	7,066	38,731	14,100	5,458	8,642	21,830	2,801	162	2,448	298	5	2,497	1,092
GUINEA	246	6.0	24,000	510	3,103	19,426	14,000	1,382	12,618	4,500	926	79	3,212	809	6	1,208	225
GUINEA-BISSAU	36	1.0	5,000	210	217	4,143	2,577	485	2,092	1,404	162	115	4,054	829	19	266	70
KENYA	580	25.8	337,000	330	8,453	154,490	63,324	8,615	54,709	87,276	3,890	109	2,451	188	7	5,862	4,364
LESOTHO	30	1.9	21,600	590	1,090	5,425	2,346	600	1,746	2,904	175	181	2,917	251	5	281	145
LIBERIA 3/	111	2.7	18,074	450	1,224	8,142	,945	557	3,388	3,615	582	73	2,994	450	7	454	181
MADAGASCAR	587	12.4	47,714	230	2,809	29,147	14,640	4,540	10,100	13,000	1,507	50	2,354	611	10	2,017	650
MALAWI	118	9.1	31,000	210	1,896	12,561	9,963	2,520	7,443	2,000	598	106	1,383	405	7	1,152	100
MALI	1,240	9.0	32,000	300	2,730	29,400	13,004	2,404	10,600	15,496	900	24	3,281	919	11	1,356	775
MAURITANIA	1,026	2.1	17,200	530	1,109	8,214	2,100	1,500	600	5,700	414	8	3,945	478	7	509	285
MAURITIUS	2	1.1	44,958	2,700	2,965	2,091	1,800	1,620	180		291	1,046	1,903	47	1	487	
MOZAMBIQUE	802	16.6	45,000	60	1,034	32,042	13,308	4,600	8,708	16,923	1,811	40	1,934	712	31	2,898	846
NIGER	1,267	8.2	31,708	300	2,466	19,701	6,694	2,768	3,926	12,306	701	16	2,411	621	8	1,064	615
NIGERIA 4,5/	924	101.9	302,572	320	32,944	189,675	59,100	33,430	25,670	108,700	21,875	205	1,862	627	6	15,356	7,935
RWANDA	26	7.3	17,135	250	1,813	12,985	5,845	971	4,874	6,640	500	499	1,776	758	7	611	332
SENEGAL	197	7.8	116,000	780	6,124	15,459	10,277	3,777	6,500	3,738	1,444	78	1,971	133	3	1,630	187
SIERRA LEONE	72	4.4	52,000	170	726	11,699	7,085	1,262	5,823	4,254	360	162	2,687	225	16	697	213
SOMALIA 3/	638	8.3	26,700	120	996	22,545	7,112	2,460	4,652	14,191	1,242	35	2,716	844	23	1,158	710
SOUTH AFRICA 6/	1,221	39.8	5,030,743	2,670	106,167	356,002	62,053	57,034	5,019	233,949	60,000	292	8,953	71	3	30,437	11,697
SUDAN 7/	2,506	26.6	117,000	420	11,167	22,952	8,094	2,245	5,849	11,816	3,042	9	863	196	2	1,614	591
SWAZILAND	17	0.9	28,840	1,080	930	2,913	2,757	689	2,068	64	92	171	3,387	101	3	299	3
TANZANIA	945	26.0	100,000	110	2,561	64,007	28,011	3,349	24,662	31,989	4,007	30	1,079	280	11	3,072	1,999
TOGO	57	3.9	4,225	400	1,575	5,747	2,293	1,580	713	3,000	454	101	1,474	1,360	4	544	150
UGANDA	236	17.5	50,000	170	2,949	30,968	8,068	2,095	5,973	22,200	700	131	1,772	619	11	997	1,110
ZAIRE	2,345	39.8	180,000	220	8,755	155,509	60,900	2,800	58,100	87,000	7,609	66	3,908	864	18	5,507	4,350
ZAMBIA	753	8.6	102,500	290	2,580	40,388	20,783	6,396	14,387	15,980	3,625	54	4,702	394	16	3,225	799
ZIMBABWE 8/	391	10.4	415,000	570	5,896	91,078	18,434	8,261	10,173	67,357	5,287	233	8,798	219	15	3,896	4,546
TOTAL	23,459	542	8,106,999	494	267,736	1,690,415	609,557	195,289	414,268	937,796	143,062	72	3,122	209	6	105,301	47,970

NOTES:

1/ Source of population data: The World Bank Atlas 1994

2/ Source of GNP data: World Development Report 1993 and World Tables 1993

3/ GNP in 1990

4/ 12,500 Km of the Rural Roads are Paved

5/ Main network includes main roads under local government jurisdiction

6/ Main roads are primary and secondary roads. They include 1,953 km of freeway standard and 1,759 km of dual carriageway under both Department of Transport and provincial authorities.

7/ GNP in 1987

8/ 5,889 Km of the Rural Roads are Paved

9/ Replacement value is calculated with $500,000 for freeways and dual carriageways, $250,000 for main paved, $50,000 for main unpaved network and $250,000 for urban roads.

10/ Replacement value is calculated with $50,000 for rural network

Appendix 2 Road Condition by Category

Estimated Physical Condition of Roads, 1989

Country	Total Length (km)	Main Length (km)	Main Paved Network Condition				Main Unpaved Network Condition				Rural Network Length (km)
			Length (km)	Good	Fair	Poor	Length (km)	Good	Fair	Poor	
				percent				percent			
Angola	21,780	15,811	7,942	n.a.	n.a.	n.a.	7,869	n.a.	n.a.	n.a.	4,518
Benin	15,682	3,425	1,195	13	59	28	2,230	10	40	50	10,457
Botswana	33,264	17,867	2,831	94	4	2	15,036	45	19	36	11,000
Burkina Faso	13,538	8,739	1,506	70	12	18	7,233	16	55	29	4,378
Burundi	6,466	4,099	1,011	75	19	6	2,156	37	53	10	2,189
Cameroon	54,102	33,000	3,670	25	60	15	29,330	n.a.	n.a.	n.a.	18,000
Cape Verde	1,214	1,095	679	14	59	27	416	0	20	80	n.a.
C.A.R.	24,441	9,300	440	30	35	35	8,860	68	16	16	14,400
Chad	28,717	3,800	300	0	10	90	3,500	0	0	100	24,000
Comoros	795	735	467	43	53	4	268	25	38	37	n.a.
Congo	11,504	10,800	1,245	50	12	38	9,555	38	27	35	200
Côte d'Ivoire	48,443	14,976	3,976	75	25	0	11,000	34	65	1	30,224
Djibouti	3,429	1,577	857	51	38	11	720	51	38	11	1,668
Equat. Guinea	1,690	1,090	447	27	50	23	643	30	42	0	450
Ethiopia	32,339	14,020	4,115	47	42	11	9,905	47	31	22	15,000
Gabon	7,976	5,300	700	30	30	40	4,600	32	30	38	2,400
Gambia	2,492	1,310	510	22	46	32	800	32	39	29	1,080
Ghana	38,731	14,100	5,458	28	21	51	8,642	32	36	32	21,830
Guinea	19,426	14,000	1,382	50	0	50	12,618	0	0	100	4,500
Guinea-Bissau	4,143	2,577	485	39	26	35	2,092	6	6	88	1,404
Kenya	154,490	63,324	8,615	32	39	28	54,709	66	15	19	87,276
Lesotho	5,425	2,346	600	53	29	18	1,746	16	57	27	2,904
Liberia	8,142	3,945	557	85	13	2	3,388	15	75	10	3,615
Madagascar	29,147	14,640	4,540	56	27	17	10,100	27	30	43	13,000
Malawi	13,361	9,963	2,520	56	38	6	7,443	8	76	16	2,000
Mali	29,400	13,004	2,404	70	14	16	10,600	10	24	66	15,496
Mauritania	8,214	2,100	1,500	58	30	12	600	16	33	51	5,700
Mauritius	2,091	1,800	1,620	95	5	0	180	90	5	5	n.a.
Mozambique	32,042	13,308	4,600	19	49	32	8,708	3	17	80	16,923
Niger	19,701	6,694	2,768	67	5	28	3,926	0	10	90	12,306
Nigeria[a]	189,675	59,100	33,430	34	32	34	25,670	24	17	59	108,700
Rwanda	12,985	5,845	971	41	41	18	4,874	19	46	35	6,640
Senegal	15,459	10,277	3,777	28	32	40	6,500	7	21	72	3,738
Sierra Leone	11,699	7,085	1,262	62	9	29	5,823	8	37	55	4,254
Somalia	22,545	7,112	2,460	52	33	15	4,652	4	10	86	14,191
South Africa	356,002	62,053	57,034	n.a.	n.a.	5	5,019	n.a.	n.a.	20	233,949
Sudan	22,952	8,094	2,245	27	43	30	5,849	20	20	60	11,816
Swaziland	2,913	2,757	689	35	35	30	2,068	60	37	3	64
Tanzania	64,007	28,011	3,349	39	39	22	24,662	18	44	38	31,989
Togo	5,747	2,293	1,580	75	14	11	713	31	36	33	3,000
Uganda	30,968	8,068	2,095	10	63	27	5,973	0	73	27	22,200
Zaire	155,509	60,900	2,800	20	40	40	58,100	44	29	27	87,000
Zambia	40,388	20,783	6,396	40	30	30	14,387	30	35	35	15,980
Zimbabwe[b]	100,078	18,434	8,261	70	27	3	10,173	50	30	20	67,357

a. Main network includes the main roads under local governments. 12,500 km of rural roads are paved
b. 5,889 km of rural roads are paved

Appendix 3 Population, Vehicles, Accidents and Casualties in Selected Countries, Cities, and Urban Areas

Country	City	Year	Population	Vehicles	Total accidents	Casualty accidents	Deaths	Total injuries	Total casualties	Casualties /accidents	Severity Index
1. Population, vehicles, accidents, and casualties in selected countries											
Benin		1992	5,042,000	31,250		2,212	349	1,985	349		
Botswana		1991	1,319,000	81,260	8,376		333		333	0.0	
Burkina Faso		1983	6,751,000	17,829		924	45	879	924		20.5
Cape Verde		1991	380,000	11,180	1,610	211	47	818	47	0.0	
C.A.R.		1991	3,100,000	23,135		633	45	810	45		
Cameroon		1992	12,245,000	110,000			1,028		1,028		
Côte d'Ivoire		1982	8,954,000	255,206	4,600	3,936	690	9,250	9,940	2.2	14.4
Djibouti		1991	400,000	20,000		234	44	342	44		
Ethiopia		1990	52,800,000	59,328		4,578	1,169	3,409	1,169		4.5
Ghana		1984	12,200,000	63,000	7,346		705	6,977	7,682	1.0	10.9
Guinea		1992	6,048,000	24,000		7,542	423	3,906	423		
Kenya		1990	24,328,000	337,000		10,308	1,856	17,074	1,856		10.0
Lesotho		1992	1,860,000	21,600		2,196	326	1,495	326		6.9
Liberia		1981	1,909,000	18,074			97	1,676	1,773		18.3
Madagascar		1991	12 384,000	83,800		722	26	962	26		
Mali[a]		1973	6,043,000	19,075			117	670	787		6.7
Malawi		1991	8,800,000	31,000		3,256	1,117	2,730	1,117		
Mauritius		1991	1,099,000	44,958		2,600	163	3,716	163		
Morocco		1991	25,668,000	702,869		36,433	2,140	10,024	2,140		
Nigeria[a]		1983	89,022,000	650,000	37,109		10,462	28,866	39,328	1.1	3.8
Rwanda		1990	6,921,000	17,135		2,817	331	2,486	331		
Senggal[c]		1985	6,565,000	106,023	13,960	6,051	483	7,720	8,203	0.6	17.0
Sierra Leone		1978	3,222,000	33,292	3,273		357	3,923	4,280	1.3	12.0
South Africa		1991	38,900,000	5,030,743	91,428		11,069	136,446	11,069	0.1	
Swaziland		1991	800,000	28,840		3,360	232	1,455	232		
Tanzania		1992	25,965,000	100,000		11,862	1,367	11,406	1,367		
Togo		1988	3,377,000	4,225		818	190	2,043	190		8.1
Uganda		1992	17,475,000	50,000			660		660		9.5
Zambia		1991	8,300,000	102,500		3,283	869	4,519	869		
Zimbabwe		1992	10,352,000	415,000			1,066				
2. Population, accidents and casualties in selected cities											
Cameroon[d]	Yaounde	1979	786,000		4,204		46	1,180	1,226	0.3	3.8
Cote d'Ivoire[d]	Abdijan	198[illegible]	1,421,000		1,513		56	1,973	2,029	1.3	2.8
Ethiopia	Addis	1974	1,153,000				124	531	655		18.9
Ghana	Accra	1985	885,000		2,637		146	1,760	1,906	0.7	7.7
Kenya	Nairobi	1984	1,108,000		4,608		281	2,399	2,680	0.6	10.5
Kenya	Mombasa	1985	419,000		710		91	479	570	0.8	16.0
Nigeria	Lagos	1978	3,517,000		4,478		927	2,352	3,279	0.7	28.3
Sierra Leone	Freetown	1984	444,000		1,590		47	1,356	1,403	0.9	3.3
Sudan	Khartou	1984	1,761,000		2,746		246	2,100	2,346	0.9	10.5
Zimbabwe	Harare	1984	948,000		8,133		156	2,746	2,902	0.4	5.4
3. Population, accidents and casualties in selected urban area											
Cameroon[e]		1980	3,744,000		9,488		151	2,860	3,011	0.3	19.9
Cote d'Ivoire[e]		1982	4,180,000		2,315		202	2,478	2,680	1.2	13.3
Kenya[f]		1985	2,059,000		5,955		539	4,009	4,548	0.8	8.4
Morocco		1987	10,565,000		20,746		832	24,303	25,135	1.2	30.2
Senegal[e]		1984	2,363,000		12,973		188	4,464	4,652	0.4	24.7
Togo[e]		1984	686,000				83	1,490	1,573		19.0

NOTES: Blank spaces mean data is not available

a. Vehicle fleet 1980
b. Vehicle fleet 1979
c. Vehicle data do not include motorcycles
d. City popluation estimates for 1983
e. Urban population estimate for 1983
f. Data for 7 largest urban areas

Source : Barrett R., National, Urban and City Road Safety Comparisons, Second Road Safety Congress Addis Ababa, October 16-20 1989

Appendix 4 Vehicles, Accidents and Casualty Rates in Selected Countries, Cities, and Urban Areas

Country	City	Year	Population	Vehicles /10,000 Population	Accidents /100,000 Population	Fatalities /100,000 Population	Casualities /100,000 Population
1. Vehicle, accident, and casualty rates in selected countries							
Benin		1992	5,042,000	62		1	1
Botswana		1991	1,319,000	616	1,031	3	3
Burkina Faso		1983	6,751,000	26		0	1
Cape Verde		1991	380,000	294	1,440	1	1
C.A.R.		1991	3,100,000	75		0	0
Cameroon		1992	12,245,000	90		1	1
Côte d'Ivoire		1982	8,954,000	285	180	1	11
Djibouti		1991	400,000	500		1	1
Ethiopia		1990	52,800,000	11		0	0
Ghana		1984	12,200,000	52	1,166	1	6
Guinea		1992	6,048,000	40		1	1
Kenya		1990	24,328,000	139		1	1
Lesotho		1992	1,860,000	116		2	2
Liberia		1981	1,909,000	95		1	9
Madagascar		1991	12,384,000	68			0
Mali[a]		1973	6,043,000	32		0	1
Malawi		1991	8,800,000	35		1	1
Mauritius		1991	1,099,000	409		1	1
Morocco		1991	25,668,000	274		1	1
Nigeria[b]		1983	89,022,000	73	571	1	4
Rwanda		1990	6,921,000	25		0	0
Senegal[c]		1985	6,565,000	161	1,317	1	12
Sierra Leone		1978	3,222,000	103	983	1	13
South Africa		1991	38,900,000	1,293	182	3	3
Swasiland		1991	800,000	361		3	3
Tanzania		1992	25,965,000	39		1	1
Togo		1988	3,377,000	13		1	1
Uganda		1992	17,475,000	29		0	0
Zambia		1991	8,300,000	123		1	1
Zimbabwe		1992	10,352,000	401		1	0
2. Accident and casualty rates in selected cities							
Cameroon[d]	Yaounde	1979	786,000		535	6	156
Cote d'Ivoire[d]	Abdijan	1982	1,421,000		106	4	143
Ethiopia	Addis	1974	1,153,000			11	57
Ghana	Accra	1985	885,000		298	16	215
Kenya	Nairobi	1984	1,108,000		416	25	242
Kenya	Mombasa	1985	419,000		169	22	136
Nigeria	Lagos	1978	3,517,000		127	26	93
Sierra Leone	Freetown	1984	444,000		358	11	316
Sudan	Khartou	1984	1,761,000		156	14	133
Zimbabwe	Harare	1984	948,000		858	16	306
3. Accident and casualty rates in selected urban area							
Cameroon[e]		1980	3,744,000		253	4	80
Cote d'Ivoire[e]		1982	4,180,000		55	5	64
Kenya[f]		1985	2,059,000		289	26	221
Morocco		1987	10,565,000		196	8	238
Senegal[e]		1984	2,363,000		549	8	197
Togo[e]		1984	686,000			12	229

a. Vehicle fleet 1980
b. Vehicle fleet 1979
c. Vehicle data do not include motorcycles
d. City population estimates for 1983
e. Urban population estimates for 1983
f. Data for 7 largest urban areas

Source: Barrett R., National, Urban and City Road Safety Comparisons, Second Road Safety Congress Addis Ababa, October 16-20 1989

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