PN-ABR-050

96992

LOCAL DEVELOPMENT II
URBAN PROJECT

Submitted to

USAID / CAIRO

Submitted by

WILBUR SMITH ASSOCIATES

in association with

PUBLIC ADMINISTRATION SERVICE

DEVELOPMENT CONSULTING OFFICE

DELOITTE AND TOUCHE

ENGINEERING AND GEOLOGICAL CONSULTING OFFICE

LD - II

URBAN PROJECT

ISSUES AND ECONOMICS OF ROAD MAINTENANCE IN EGYPT

Table of Contents

				Page No.
Abstract				
I.	Introduction			1
II.	Key Road Maintenance Issues			2
	1.	Causes of Road Deterioration		2
	2.	Requirements for Restoration		3
		i.	Technical	3
		ii.	Institutional	3
		iii.	Financial	4
III.	Road Maintenance Cost Savings Benefits			5
	1.	Road Provider Benefits: Government Cost Savings		5
		i.	Routine and Preventive Maintenance	5
		ii	Rehabilitative Maintenance	6
		iii.	Cost Savings	7
	2.	Road User Benefits: General Public Cost Savings		8
		i.	Vehicle Operating Costs	9
		ii.	Other User Costs	9
IV.	Suez Case Study			10
	1.	Basic VOC		10
	2.	The Effects of Road Roughness		10
	3.	Road Maintenance Cost Savings		11
V.	Conclusion			17

List of Tables

		Page No.
Table 1	VKT and VOC Comparisons	12
Table 2	The Effects of Road Roughness on VOC	13
Table 3	Additional VOC Incurred With Little or No Road Maintenance	14
Table 4	Financial Costs and Economic Benefits	15
Table 5	Cost per Vehicle: Road Maintenance vs. Little or No Road Maintenance	16

List of Figures

		Page No.
Figure 1	Effect of Preventive Maintenance	6
Figure 2	Effect of Rehabilitation	7
Figure 3	Cost of Road Maintenance	8
Figure 4	Additional VOC Incurred on Poorly Maintained Roads	9

I. Introduction

From the rural roads of Upper Egypt to the busy highways of large urban cities in Lower Egypt, roads and streets are vital to the country's economic and political stability. The country's agriculture, commerce, and tourism and recreation industries are all dependent on good roads. To facilitate the continuation and growth in these industries a great deal of time, effort and funds have been invested in developing the essential transportation component of Egypt's infrastructure.

The purpose of this study is to address the benefits derived from the preservation of the established road network. The paper begins by addressing the causes of road deterioration and the requirements for restoration. The benefits are then categorized as the cost savings derived through road maintenance by the institutions that provide for roads, e.g. the Government of Egypt; and by the people who use the roads, e.g. the general public and local businesses. The paper then concludes with an illustrative example of the benefits that a proposed road maintenance project in Suez would confer on the community.

The most important concept resulting from the study is that roads are a capital asset with definite economic value that will be lost if roads are not adequately maintained. In addition, a greater effort needs to be made to maintain the highways, roads and streets in Egypt.

Key Road Maintenance Issues

Since the dilemma of road deterioration and the requirements for restoration are faced by all governments world-wide, there is a wealth of information available with which to address the problems. In this section, a good portion of the discussion is drawn from a 1988 World Bank Policy Study: Road Deterioration in Developing Countries, Causes and Remedies. In this paper, a concise overview of the causes of road deterioration that are applicable to Egypt is presented, as well as the categorization of the requirements necessary to ameliorate the situation.

1. Causes of Road Deterioration

What causes road deterioration ? A combination of road use, environmental erosion and an inefficient management of both materials and financial resources lead to the deterioration of roads. In Egypt many roads are deficient, either functionally, structurally or in terms of safety. Specifically, the factors that lead to poor road conditions are:

- Heavier traffic volume than initially expected;
- Axle loadings exceeding pavement design;
- Dirt, dust and other debris accumulation;
- Lack of commitment to maintain roads;
- Priority of financial and material resources given to new road construction;
- Road breakage and damage arising from utility and new building construction; and
- Rapid road expansion that stretches road maintenance department resources.

These factors all contribute to the reduction in the condition of roads from the initial "good" condition to that of "fair" and "poor". The following explanations of street and road conditions are used in this report.

Good: Paved streets substantially free of defects and requiring only routine maintenance. Unpaved streets needing only routine grading and spot repairs.

Fair: Paved streets having significant defects requiring extensive maintenance. Unpaved streets needing extensive spot repairs and reshaping.

Poor: Paved streets having extensive defects and requiring immediate rehabilitation or reconstruction. Unpaved streets needing reconstruction.

2. Requirements for Restoration

What is required to restore the existing deficient roads ? There is no simple solution that can be broadly implemented to ameliorate the present condition of Egypt's deteriorating road system. Instead a reevaluation of the current technical, institutional and financial requirements for road maintenance is required.

i. Technical Requirements

Road investment strategies must be tailored to specific circumstances. A set of guidelines needs to be adopted in determining which roads to pave, how to allocate funds, and how to preserve good roads. These include:

a. Prioritizing paving activities to roads with heavy traffic volume. This will lower vehicle operating costs and travel time.
b. Allocating maintenance funds to ensure the least negative impact on vehicle operating costs and future road repair.
c. Conducting minor road repairs and regularly clearing debris. This will prevent good roads from falling into a state of disrepair.
d. Supervising changes in road conditions. Closely monitor an inventory of the road network and individual road conditions.

ii. Institutional Requirements

The organization, staffing and activities of the institutions that administer roads must be improved. A clearer organizational structure and objective must be established for these agencies. Simply, the institutions must:

a. Reevaluate their ability to effectively allocate funds, e.g. astute decisions must be made on new construction projects versus road maintenance. By the same token, purchasing decisions on new heavy equipment should be evaluated versus the needed servicing of existing equipment.

b. Introduce mechanisms to increase the internal accountability for personnel performance and for resource use, e.g. the use of performance standards for various maintenance tasks.

c. Provide incentives for good performance in the agency and by the contractors it engages. Because of deficient salary scales and promotion systems it is often difficult to retain a competent, hard working staff.

iii. Financial Requirements

Before an effective and efficient financial strategy can be implemented to restore roads, the total cost required to repair and maintain roads must be formulated. Then a cohesive strategy can begin. Specifically:

a. Evaluate current funding available for all road activities, including both road maintenance and road construction.

b. Prioritize road maintenance and road repairs, taking into account the road's level of use, the road's age, and the available funding.

c. Revise road user charges, or impose new ones to help alleviate budgetary constraints.

III. Road Maintenance Cost Savings Benefits

Well maintained roads result in cost savings to both the government.that provides for roads and the people who use the roads. This concept is addressed conceptually as well as graphically in this section.

1. Road Provider Benefits: Government Cost Savings

The government's objective concerning roads is to supply safe and efficient transportation at the lowest possible cost. Since this is a continual process that is expected to improve over time, the government must maintain the existing road network in addition to any construction of new roads for the network to improve as a whole.

The most cost effective way to maintain roads is through continual preventive maintenance and timely road rehabilitation. The combination of these will largely reduce or prevent the need for the more costly road reconstruction. The prevailing academic research concludes that the cost of restoring poorly maintained, deteriorated roads is three to five times greater than the cost for normal maintenance. <1>

i. Routine and Preventive Maintenance

The objective of preventive maintenance is to perform small and quick road maintenance repair, especially on good roads, to ensure that these roads continue to remain in good condition. By doing so, the need for the more costly large rehabilitation and reconstruction projects will be greatly reduced. Specifically, the type of light road maintenance to be done is:

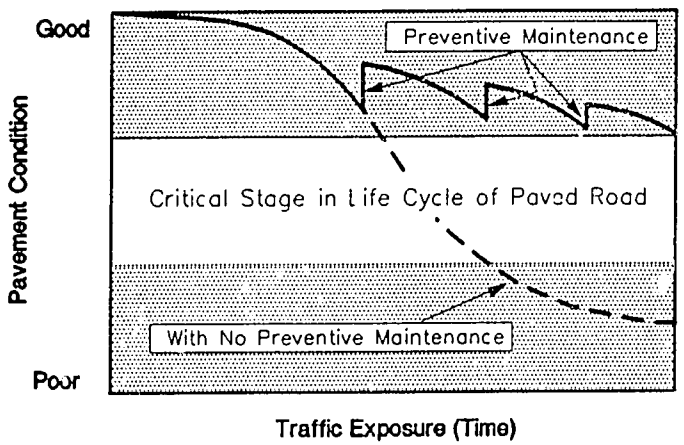
a. Clearing road and footpath debris, e.g. sand, dirt and garbage.
b. Conducting minor road repair, e.g. fix small potholes, depressions, upheavals, curb and median crumbling, footpath cracks and missing tiles.
c. Repairing large potholes and lay short asphalt overlays. Road deterioration accelerates with time. Paved roads undergo little visible deterioration during the initial phase of the roads' life cycle. This stage lasts up to two-thirds of the roads' life cycle. Followed by a stage of increasingly rapid deterioration.

During this initial stage, any sand, dirt or other debris that collect on streets can be easily removed with little or no cost involved. In addition, small pavement defects can be quickly corrected. The key to this aspect of preventive

road maintenance is the simple allocation of available resources to ensure that the work is done. Without such maintenance, roads can quickly become covered with debris or plagued with minor potholes and depressions to the point where access is greatly inhibited. And, as access is inhibited road users stop driving on the road. This leads to greater congestion on other roads. In effect, this otherwise good road gradually ceases to exist.

Below, in figure 1, is a graph demonstrating how a road's pavement condition sharply declines in the later stages of its life cycle, and how the simple preventive road maintenance discussed above can ameliorate this deterioration.

Figure 1
Effect of Preventive Maintenance



The vertical axis denotes the road condition and the horizontal axis represents time. As the road is exposed to more traffic, the pavement condition will fall. When the road condition begins to fall drastically, it enters the "Critical Stage" of its life cycle. A major objective of an institution's road maintenance program is to perform the required preventive maintenance and deter a road rom entering this critical stage for as long as possible. Nevertheless, as a road ages it will eventually enter this critical stage and require rejuvenation.

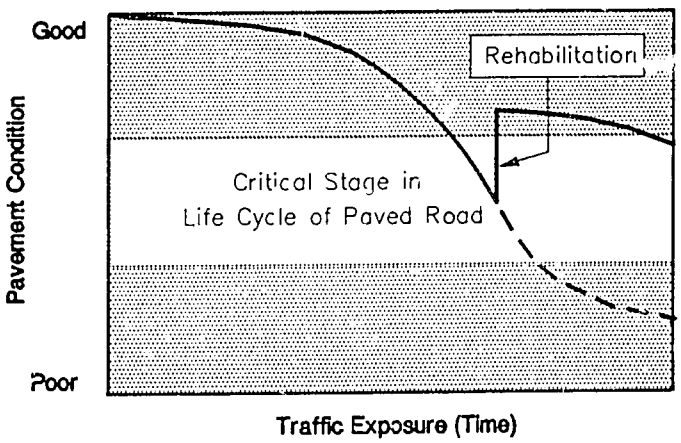
ii. Rehabilitative Maintenance

Older roads in fair condition will require more attention than good roads, for they are farther along the pavement's life cycle. Since their deterioration is progressing rapidly at this point, it is necessary to conduct any minor road rejuvenation required such as

resurfacing and/or strengthening in a timely manner. Neglect of such activities will result in the need for the more costly reconstruction to prevent the roads from declining to a state of virtual uselessness due to their poor condition.

Similar to the graph above, the one below in Figure 2 demonstrates how timely resurfacing and/or strengthening of paved roads can renew a road pavement's life cycle. In Egypt, such types of rehabilitation will typically be required once every eight-to-twelve years on roads with medium-to-heavy traffic volumes. Since each road's requirements vary according to the various causes of road deterioration (see II.1), many lightly traveled roads will forego rehabilitation until the fifteenth-to-twentieth year. Nevertheless, all roads must be supervised closely to ensure that they receive the needed rehabilitation to avoid the more costly reconstruction.

Figure 2
Effect of Rehabilitation



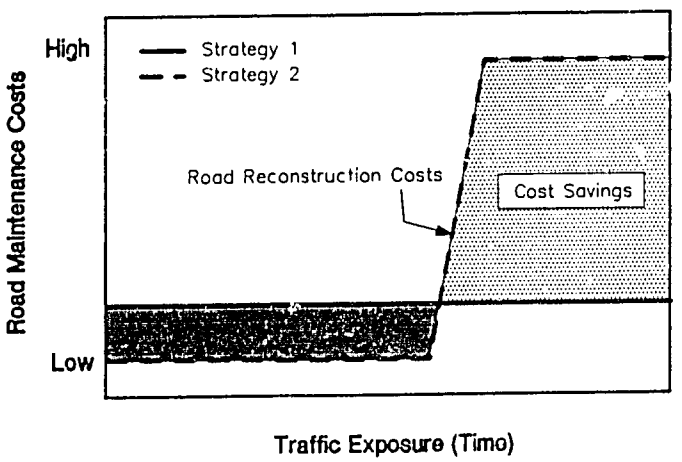
iii. Cost Savings

To fully realize the cost saving enjoyed by government agencies through road maintenance it is necessary to understand the "Concept of Capital." Specifically, that the existing roads have definite economic value that can be preserved through proper maintenance, but will loose economic value if left to deteriorate without proper maintenance. To demonstrate this concept several cost benefit analyses have been conducted to quantitatively explain the cost savings enjoyed through good road maintenance.

To maintain roads money will be spent. It can be spent in small amounts spread out over time, or in large amounts at later dates. Compared to reconstruction the cost of preventive maintenance is negligible. Road reconstruction is defined as major road rejuvenation requiring the excavation of the existing road structure, the placement of new base course, and the laying of new asphalt. The ensuing reconstruction costs, are three-to-five times greater than those of resurfacing or rehabilitation.

Past cost-benefit studies have continually documented that by far the least costly method of performing maintenance is to do so through a continual road maintenance strategy. This concept is shown graphically in Figure 3.

Figure 3
Cost of Road Maintenance



The vertical axis represents the cost incurred for road maintenance, and the horizontal axis denotes time. Strategy 1 shows the continual expenditures made on routine preventive road maintenance, resurfacing and strengthening as required. Strategy 2 plots the ad-hoc expenditures made on roads for reconstruction due to a lack of any regular road maintenance.

As can be seen, despite the greater initial outlay of funds to maintain roads in the early years, strategy 1 is clearly less costly over time.

2. Road User Benefits: General Public Cost Savings

The other component of road transportation costs are those costs incurred by road users. These costs are comprised of the vehicle operating costs (VOC), and the costs associated with the time spent traveling.

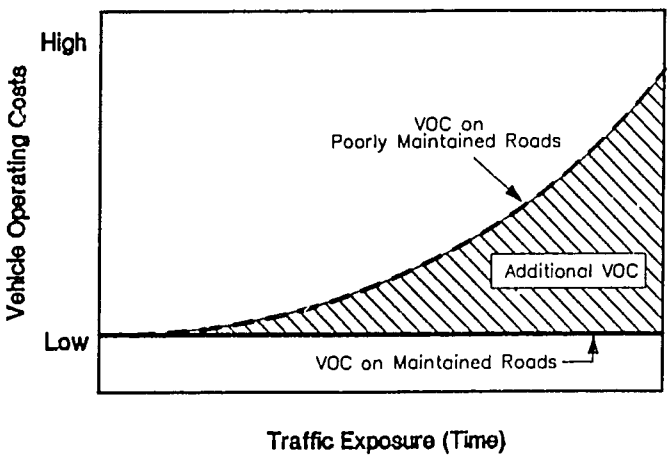
i. Vehicle Operating Costs

Of all the road transportation costs, VOC comprise the largest amount. VOC are those costs associated with tire wear, oil, gasoline and motor vehicle maintenance and repair. These costs comprise 75-95 percent of the total transport costs on all but the most lightly traveled roads.<2>

There has been an exhaustive amount of research done on VOC. All of which indicate that a small percentage increase in VOC arises from a decrease in a road's condition. Nevertheless, this results in a huge overall cost increase to the combined road users because of the large volume of vehicle kilometers traveled (VKT) on the roads. On heavily travelled roads the costs of such wear and tear is enormous. The graph below, Figure 4, shows how good road maintenance limits VOC to a steady level over time. The cost is relatively low when compared to the costs of a strategy of little or no road maintenance in which poorly maintained roads become rougher and/or lose their accessibility. This results in more wear and tear on motor vehicles, greater fuel consumption, and more traffic congestion.

Figure 4

Additional VOC Incurred on Poorly Maintained Roads



ii. Other User Costs The additional costs of passenger time, vehicle accidents, and truck cargo inventory costs also rise drastically on poorly maintained roads. Though difficult to quantify, the costs associated with each is easy to conceptualize. Longer cargo travel times, for example, result in higher commodity prices when they finally reach their destination. Similarly, poor road conditions lead to more vehicle accidents which result in property damage and human injury.

IV. Suez Case Study

The Suez economic cost-benefit analysis evaluated the benefits that a proposed road maintenance project would confer on the community. <3> These Community benefits were considered to be the reduced vehicle operating costs incurred by the people who use the Suez roads. To determine these benefits the current road network was compared in a future environment of well maintained roads versus an environment of poorly maintained roads.

In the study, it was decided to initially attempt to demonstrate the economic benefit of road maintenance using easily definable, conservative parameters without conducting an exhaustive study. Therefor, the nature of the report was to address the major and easily quantifiable VOC costs in a very conservative manner. For this reason, the more detailed cost savings associated with passenger time, truck cargo inventory savings and vehicle accidents were considered beyond the scope of the study and were not included in the analysis.

Specifically, the study adopted an abbreviated form of the prevailing methodology of assigning VOC per vehicle kilometer traveled (VKT). These costs were evaluated and summarized according to vehicle type and road condition.

1. Basic VOC

The estimated annual cost of operating vehicles in Suez was developed through hybrid vehicles whose characteristics approximate those of the current Suez fleet, together with their average per mile VOC. The categories were the (1.) passenger car, (2.) mini-bus and taxi, (3.) light truck, and (4.) heavy truck. The per kilometer VOC were developed based on the Federal Highway Association (FHWA) consumption factors <4> adjusted for the Suez environment. The per kilometer VOC were then applied to the estimated annual vehicle kilometers traveled (VKT) to determine the total annual VOC. The annual VKT estimates were developed through consultant traffic counts conducted in May 1990.

The current estimated VKT and VOC on Suez roads are broken down and analyzed in Table 1. Note that the relatively high VOC per vehicle for mini-buses and taxis is due to the high level of annual VKT by the vehicle class.

2. The Effects of Road Roughness

The effect of bad roads is quantitatively assessable and standardized with the International Roughness Index (IRI). This index uses "roughness," a measure of road surface irregularities,

to evaluate the effect of road condition on VOC. <5> Table 2 shows the increase in these VOC on different road conditions by vehicle type. These costs are direct out of pocket costs to the driver who operates and maintains the vehicle, such as blow-outs, front-end alignments, shock absorbers and traffic accidents - not to mention increase in travel time.

By applying the additional VOC factors to the existing Suez road network, the additional VOC of traveling on inadequately maintained roads was determined. Table 3 shows the resulting VOC. Note that the adjustment factors are not very high. Nevertheless, when these factors are applied to the VKT on the Suez road network, the additional cost of travel on the neglected roads rises dramatically.

3. Road Maintenance Cost Savings

The economic benefits derived through road maintenance by pursuing the recommended policy over one of disregarding maintenance are significant. Table 4 compares the costs of the road maintenance program to that of the VOC savings (referred to as VOC Benefits) and the reduction in road rejuvenation costs (Road Rejuvenation Benefits). The total economic savings are LE 310,094,640. This is primarily due to the high cost of operating all the cars, mini-buses, taxis, and small and large trucks on the Suez road network.

What may be regarded as most pertinent to the institution that administers roads, the Suez Roads Directorate, is the fact that the road maintenance program is estimated to save LE 100,594 annually in reconstruction costs; nearly a quarter of the annual proposed program cost. This will result in a savings of the LE 2,011,880 over the 20 year analysis period.

Finally, Table 5 compares the average cost per registered Suez vehicle of the proposed road maintenance program to that of the additional VOC incurred if little or no road maintenance were conducted. The table shows that the average annual cost of the proposed program translates to LE 31 per vehicle, and LE 617 over 20 years. Conversely, the additional operating cost per vehicle on inadequately maintained roads starts at LE 60 and rises to a dramatic LE 2,195 in year 20. The total additional cost per vehicle to drive on the neglected roads over the 20 year period would be LE 22,334.

Clearly this demonstrates the necessity to maintain roads. In addition, it shows that it is more cost effective for the road user (vehicle owner) to pay higher user taxes on roads than to not pay taxes and suffer the consequences of high VOC.

Table 1
VKT and VOC Comparisons
Suez Governorate Road Maintenance Study

Annual VKT:	Car	Mini-bus & Taxi	Light Truck	Heavy Truck
VKT (km 1,000)	90,269	168,210	15,079	10,663
Vehicles	7,500	3,700	1,900	1,100
VKT per Vehicle	12,036	45,462	7,936	9,694

Annual VOC:	Car	Mini-bus & Taxi	Light Truck	Heavy Truck
VOC (LE 1,000)	43,876	116,664	32,185	40,335
Vehicles	7,500	3,700	1,900	1,100
VOC per Vehicle	5,850	31,531	16,939	36,668

Annual VOC per VKT:	Car	Mini-bus & Taxi	Light Truck	Heavy Truck
VOC (LE 1,000)	43,876	116,664	32,185	40,335
VKT (km 1,000)	90,269	168,210	15,079	10,663
VOC per Kilometer	0.49	0.69	2.13	3.78

Source: Compiled from Consultant observations and FHWA Vehicle Operating Costs, Pavement Type and Condition Factors, 1982, adjusted for Suez.

Table 2
The Effects of Road Roughness on VOC
(Index of VOC: good = 100, at 2.3 IRI)

	Road Condition		
Vehicle Class	Fair (1)	Poor (2)	Unpaved (3)
Small Car	106	114–26	108–26
Bus/Taxi	106	114–26	108–26
Light Truck	112	124–38	114–38
Heavy Truck	114	129–46	117–44

(1) IRI 4.6
(2) IRI 6.9 to 9.2
(3) IRI 5.0 to 9.0

Source: From application of the VOC submodel of the Highway Design and Maintenance Standards Model (HDM-III). For the Costa Rican Context, see Bhandari and others (1987).

Table 3
Additional VOC Incurred With No Road Maintenance
Suez Governorate Road Maintenance Study

	Vehicle Operating Costs (1,000 LE)								
	Cars		Mini-Bus & Taxi		Light Truck		Heavy Truck		Total
Year	Adj Factor	VOC	Adj Factor	VOC	Adj Factor	VOC	Adj Factor	VOC	Additional VOC
1	1.003	110	1.003	292	1.003	80	1.009	363	845
2	1.006	270	1.006	718	1.006	205	1.018	729	1,922
3	1.010	458	1.010	1,217	1.020	644	1.030	1,210	3,529
4	1.015	665	1.015	1,768	1.060	1,931	1.040	1,613	5,977
5	1.020	889	1.020	2,363	1.040	1,287	1.060	2,420	6,959
6	1.026	1,127	1.026	2,996	1.060	1,931	1.070	2,823	8,877
7	1.031	1,377	1.031	3,660	1.060	1,931	1.080	3,227	10,195
8	1.037	1,638	1.037	4,354	1.070	2,253	1.080	3,227	11,472
9	1.043	1,908	1.043	5,074	1.080	2,575	1.090	3,630	13,187
10	1.050	2,189	1.050	5,819	1.090	2,897	1.091	3,672	14,577
11	1.056	2,477	1.056	6,587	1.100	3,219	1.100	4,041	16,324
12	1.063	2,774	1.063	7,376	1.120	3,862	1.109	4,411	18,423
13	1.070	3,078	1.070	8,185	1.120	3,862	1.119	4,780	19,905
14	1.077	3,389	1.077	9,012	1.130	4,184	1.140	5,647	22,232
15	1.085	3,708	1.085	9,858	1.130	4,184	1.137	5,519	23,269
16	1.092	4,032	1.092	10,721	1.130	4,184	1.146	5,889	24,826
17	1.099	4,363	1.099	11,600	1.130	4,184	1.155	6,259	26,406
18	1.107	4,699	1.107	12,495	1.124	3,983	1.164	6,629	27,806
19	1.115	5,041	1.115	13,405	1.140	4,506	1.174	7,000	29,952
20	1.123	5,389	1.123	14,329	1.143	4,592	1.170	6,857	31,167
Totals		49,581		131,829		56,494		79,946	317,850

Source: Consultant calculations

Table 4
Financial Costs & Economic Benefits
Suez Governorate Road Maintenance Study

Year	Costs: Road Maintenance Program (1)	Benefits: VOC Savings (2)	Benefits: Road Rejuvenation Savings (3)	Total Savings
1	438,362	845,000	100,594	507,232
2	438,362	1,922,000	100,594	1,584,232
3	438,362	3,529,000	100,594	3,191,232
4	438,362	5,977,000	100,594	5,639,232
5	438,362	6,959,000	100,594	6,621,232
6	438,362	8,877,000	100,594	8,539,232
7	438,362	10,195,000	100,594	9,857,232
8	438,362	11,472,000	100,594	11,134,232
9	438,362	13,187,000	100,594	12,849,232
10	438,362	14,577,000	100,594	14,239,232
11	438,362	16,324,000	100,594	15,986,232
12	438,362	18,423,000	100,594	18,085,232
13	438,362	19,905,000	100,594	19,567,232
14	438,362	22,232,000	100,594	21,894,232
15	438,362	23,269,000	100,594	22,931,232
16	438,362	24,826,000	100,594	24,488,232
17	438,362	26,406,000	100,594	26,068,232
18	438,362	27,806,000	100,594	27,468,232
19	438,362	29,952,000	100,594	29,614,232
20	438,362	31,167,000	100,594	30,829,232
Totals	8,767,240	317,850,000	2,011,880	311,094,640

(1) Annual Costs of proposed road maintenance program.
(2) Table 4-3.
(3) Reconstruction cost savings arising from good road conditions.

Table 5
Cost Per Vehicle (LE)
Road Maintenance vs. Little or No Road Maintenance
Suez Governorate Road Maintenance Study

Road Maintenance	Year 1	Year 20	Total
Program Costs (1)	438,362	438,362	8,767,240
Vehicles (2)	14,200	14,200	14,200
Program Costs per Vehicle	31	31	617

No Road Maintenance	Year 1	Year 20	Total
Additional VOC (3)	845,000	31,167,000	317,850,000
Vehicles (2)	14,200	14,200	14,200
Additional VOC per Vehicle	60	2,195	22,384

(1) Annual costs of proposed road maintenance program.
(2) Total Suez registered vehicles, Suez Safety Directorate Traffic Section and Consultant observations.
(3) Table 4-3.

V. Conclusion

This study, has reached similar conclusions to the majority of studies conducted worldwide in that it has found the financial savings of a good road maintenance program far outweigh the costs. These savings are those enjoyed by both the institutions that administer roads as well as the people who use the roads. In short, roads are a capital asset with definite economic value that will be lost if roads are not adequately maintained. The Government of Egypt and the local governorates, therefor, have a choice: invest the necessary funds now to repair and improve the existing road network, or pay a far greater amount latter to rebuild a defunct transportation system. To succeed, the government must conscientiously address the causes of road deterioration and implement the necessary technical, institutional and financial requirements. By doing so, a better road network will facilitate an improved business environment for the many industries that are dependent on the transportation infrastructure.

Footnotes

<1> Road Deterioration in Developing Countries, A World Bank Study, 1988; The International Bank for Reconstruction and Development (IBRD), p 1.

<2> Ibid., p 45.

<3> Suez report

<4> See FHWA Vehicle Operating Costs, Fuel Consumption and Pavement Type and Condition Factors, 1982.

<5> Ibid., IBRD p 12.