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VEHICLE OPERATING COSTS

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C O N T E N T S

T A B L E S

PREFACE

Investment on road improvements is justified exclusively by savings in vehicle operating costs. Therefore, road planners frequently need information on variations in vehicle operating costs in response to changes in road characteristics such as surface smoothness, gradient, curvature, etc.

Vehicle operating costs earlier compiled by various agencies were based on studies carried out in other countries. Over the years, the National Transport Research Centre has carried out studies on fuel consumption and vehicle operating speeds. The present study utilizes the result of these studies and thus relates to vehicles and road conditions in the country.

There are, however, still a number of variables for which local data is not available, such as variations in response to gradient, curvature, roughness etc. The values of such factors have been taken from the Ministry of Communications study of 1977 which in turn utilizes results of Kenya and Yugoslavia studies.

The earlier studies provided costs for two types of roads, viz. improved and un-improved. In the present case, costs have been compiled for three categories of roads viz. improved, un-improved and shingle which have been specifically defined according to degree of roughness, curvature, gradient. More detailed cost estimates can be compiled for any other combination of physical characteristics.

Besides, earlier studies provided values for speed levels ranging from 16 Km to 96 Km per hour with class intervals of 8 Km. This was based on conversion of speed from miles to kilometers which was a reflection of the time when metric system was newly adopted. However, as the metric system is now well understood, values have been expressed for speeds in kilometers ranging from 30 to 90 with class interval of 10 Km.

Tabulations were assisted by Mr. S. A. Rehman, Transport Economist, Ministry of Communications. His contribution is gratefully acknowledged.

References are given at the end of the report.

Islamabad,
January, 1985.

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VEHICLE OPERATING COSTS

CHAPTER I

INTRODUCTION

Need for the Study

The increase in the number of motor vehicles all over the world over the last few decades has led to greater demand for more and better roads requiring more and more resources. This has brought into sharp focus the need for proper appraisal of investments on construction and improvement of roads.

Expenditure on road improvements are justified exclusively by savings in vehicle operating costs. The questions that usually arise are: whether cost of improvement of a surface, elevation, curvature, reducing distance would be paid off by savings in vehicle operating costs? To answer such questions, road planners need information not only of vehicle operating costs as such but on variations in vehicle operating costs in response to changes in road characteristics such as surface smoothness, elevation, curvature, distance, etc.

On the other hand, vehicle operating costs are maintained, if any, by road users according to main cost components like price of the vehicle and parts, fuel, oil, tyres, wages and salaries of crews etc. The relating of vehicle operating cost components to different road characteristics requires considerable research and experimentation.

Earlier Work

Among numerous experts, notable work in this field has recently been done by Winfrey (1963 & 1969) and De Weille (1966).

Winfrey

Winfrey provided a substantial amount of data from different sources and methodology for Economic Analysis of Highways. His work has been extensively used by others and is still quoted by many as the basic source.

De Weille

De Weille's work, "Quantification of Road User Savings", published as a World Bank Staff Occasional Paper Number Two, (1966) by virtue of its wider circulation among professional circles in member countries, under the auspices of the World Bank, became a better known reference and set the pattern for similar work in other countries.

De Weille provided estimates of physical quantities of different cost components (fuel consumption, oil consumption, tyre wear and tear, maintenance (labour and parts), deprecation, interest and crew wages) for three categories of cars (European, American and average) and four categories of goods vehicles (1 ton, 3.5 ton, 15 ton and 18 tons) according to different speed levels and road characteristics such as,surface smoothness, curvature, rise, fall, etc.

By multiplying physical quantities with prices, vehicle operating costs can be estimated for given speed and road conditions for any country. The difference in costs for any existing and improved road conditions would constitute savings due to such improvement.

The job of the road palnner is thus simplified. He will have to determine existing speeds and road characteristics and those expected after improvement, determine physical quantities of cost components and calculate respective costs before and after improvement.

As the physical inputs are more or less stable over places in the short and medium run, the estimation of costs over time and places by simply multiplying the quantities with prices has become feasible.

Non Transferability of Results

However, the main draw back in De Weille's report is that vehicles considered therein are specific to U.S. conditions at that time. All vehicles have petrol engines except the heaviest truck of 18 ton capacity which has a diesel engine. In today's conditions, most of the goods vehicles except small pick-ups, would have diesel engines which are more efficient and give more mileage. The vehicles used in De Weille's report are hardly comparable to our country where the goods vehicle are of relatively smaller size, mostly 9 ton pay load. In the developing countries, the conditions of roads would also be different from those of USA and Europe.

Studies in other countries

In view of the differences in vehicle types, road conditions and prices, there is need for determining vehicle operating costs for individual countries. The need for more reliable estimates is still greater for developing countries due to relatively scarce resources and larger expenditure on development of roads. Accordingly, a number of vehicle operating cost studies have been carried out in the recent past in several countries including Brazil, Yugoslavia, Kenya and India.

Kenya

The Kenya Road Transport Cost Study (1975) carried out by the Transport and Road Research Laboratory of UK has developed a system of equations for each of the cost components leading to formulation of comprehensive road investment model. However, the transfer of these equations to other countries would be limited due to differences in vehicles and road conditions.

In view of the above, there is need for determining vehicle operating costs specific to types of vehicles and road conditions in each country. Various countries have estimated such vehicle operating costs for the appraisal of their road and transport projects.

Studies in Pakistan - Burns (1968)

In Pakistan, vehicle operating costs were earlier prepared by Burns (1968) for the Transport Planning Cell, Planning and Development Department of the then Government of West Pakistan. He considered economic costs of three types of vehicles, (Opel Rekord Car, Bedford Diesel Truck with 6 ton pay load and Bedford Diesel Bus 49 seater). Costs were estimated at three different foreign exchange rates for four speed levels and for paved, gravel and earth roads. Noor Mohammad and Mohammad Ishaq (1972) also prepared Bus and Truck Operating Costs at different speeds on paved gravel and earth roads for the Transport Planning Cell of West Pakistan.

Ministry of Communications (1977)

More comprehensive estimates of road user costs for 1977 were prepared by the Ministry of Communications (Central Roads Organization) (1978) for use by the World Bank Third Highway Project Consultants in Pakistan for feasibility studies of various highway sections. These estimates provided financial and economic costs for improved and un-improved roads for four main categories of vehicles Car (Toyota), Wagon (Ford Transit), Bus and Truck (Both Bedford) at speeds ranging from 24 to 96 Km per hour with class interval of 8 Km. The data on physical quantities of various cost components was obtained from various sources including studies in other countries and surveys carried out specifically for estimating vehicle operating costs.

National Highways Board (1982)

The 1977 cost estimates of the Ministry of Communications were updated by the National Highways Board in 1982. However, only financial costs were updated and not the economic costs which are more essential for the appraisal of road projects.

Both the above studies prepared by the Ministry of Communications (1977) and National Highways Board (1982) are based on data which has mostly been drawn from foreign studies particularly, Kenya and Yugoslavia studies. The parameters of such foreign studies are also not directly applicable to particular conditions in other countries. For example our trucks and buses would be hardly found in any other country.

NTRC Studies

In view of the need for specific data for Pakistan, the National Transport Research Centre has carried out a few basic studies such as Highway Speed Survey (1980) Fuel Consumption Study (1981). These have been used for estimating vehicle operating costs in the present study. Other data used in earlier studies has also been made use of. Much of the basic data still comes from studies in other countries. There is still need for verification and updating of primary data which should continue.

CHAPTER II

VARIABLES

This chapter describes main variables of the study including vehicles, roads, prices and physical quantities of cost components - fuel, oil, tyres, maintenance, depreciation, interest etc., methods of estimation, sources, scope and limitations of data, etc.

Representative Vehicles

The representative vehicles used in this study and their physical characteristics such as gross weight, number of axles, tyres etc are given table 1 below.

Table 1: Physical Characteristics of representative Vehicles

Sl. No.	Type of Vehicle & Make		Gross Weight Tonnes	No. of Axles	No. of Tyres Excl.spare
1	2		3	4	5
1.	Car 1000-1300 cc	- Toyota	1.0	2	4
2.	Wagon/Mini Bus	- Ford Transit	2.7	2	4
3.	Bus - 52 seater	- Bedford	10.0	2	6
4.	Truck	- Bedford	14.0	2	6

Road Types

Three types of roads have been considered for estimating vehicle operating costs, viz. improved, un-improved and shingle. These categories are defined on the basis of gradient, curvature and roughness as in table 2 below.

Table 2: Specifications of Road Types

Type of Road	Gradient m/Km	Curvature Degrees/Km	Roughness m/Km
1	2	3	4
Improved	10	100	1.5
Un-Improved	20	200	3.5
Shingle	20	200	5.5

Costs and Prices

Prices of vehicles, petrol, oil, tyres and labour have been estimated in financial and economic terms. Financial costs (prices) include taxes while economic costs exclude taxes. The data relates to January, 1985. Details are given in table 3 below.

Table 3: Prices of Vehicle Operating Cost Components

Sl. No.	Cost Component	Prices (Rs.) Financial (Including taxes)	Economic (Excluding taxes)
1	2	3	4
1.	Cost of Vehicle(Excluding Tyres)		
	a. Car	152,950	55,730
	b. Wagon	159,750	55,595
	c. Bus	369,425	225,256
	d. Truck	344,211	230,800
2.	Fuel and Oil (Rs/Litre)		
	a. Petrol	7.02	5.37
	b. Diesel	4.25	3.32
	c. Engine Oil	13.50	11.50
3.	Tyres		
	a. Car	1210	854
	b. Wagon	1450	881
	c. Bus	2225	1392
	d. Truck	2827	1600
4.	Labour Maintenance Rs/Hr	10	10

Fuel Consumption

Fuel consumption which is the most obvious item of vehicle operating costs, can be measured precisely and has been investigated exhaustively. The main determinents are; speed of vehicle, rate of rise and fall, curvature of the road, roughness of surface...

Estimates of fuel consumption made in different countries relate to their vehicle fleet which are different from Pakistan and are therefore not directly applicable to our conditions. For example, none of the vehicles considered in the De Weille Report are used in Pakistan. Perhaps most of them would be out of date in US as well particularly after the fuel crisis. Similarly, goods vehicles used in the Kenya Study were mostly three axle vehicles as against much smaller two axle vehicles in Pakistan.

In view of the above, there was need for determination of fuel consumption by main vehicles used in Pakistan for estimation of vehicle operating costs. Accordingly, fuel consumption tests were carried out by NTRC on most commonly used vehicles in Pakistan. The detailed results have been published separately.

Based on the results of the above study, fuel consumption at speeds ranging from 30 to 90 Km per hour is given in table 4 below.

Table 4: Fuel Consumption on Level tangent paved road (Litres per 1000 Km)

Type of Vehicle and Make	Speed Km/Hr						
	30	40	50	60	70	80	90
Car - Toyota	68	62	70	79	91	111	139
Wagon - Ford Transit	87	75	67	75	86	98	106
Bus - Bedford NJM	237	193	164	201	303	323	336
Truck - Bedford CJQ	394	253	126	196	226	393	-

Source: National Transport Research Centre, "Fuel Consumption Study," July, 1981.

It would be seen from the above table that optimum speeds at which fuel consumption is lowest are 40 Km per hour for cars, 50 Km per hour for wagon, buses and trucks. These values are significantly different from those of the Ministry of Communications which give minimum consumption at 32 Km/hr for all categories of vehicles.

The absolute values of fuel consumption in our study are less than the Ministry of Communications figures for speed levels upto 80 Km per hour for cars, and for all speed levels for wagons. In the case of buses and trucks the values are comparable at low and high speeds. In the middle range our figures are lower than those of the Ministry of Communications (1977). As our estimates are based on precise measurements of fuel consumption on controlled sections, these are more reliable and have been adopted.

Besides speed, fuel consumption is influenced by surface smoothness, rate of rise and fall, curvature, speed cycle changes etc. The effects of these factors on fuel consumption are given in tables 5 to 10 which show correction factors over fuel consumption on level tangent road. These have been adopted from the Ministry of Communications Report as our tests covered only the basic estimates for level tangent roads.

Table 5: Fuel Correction for Rate of Rise

Add Litres per 1000 Km to table 4

Rate of Rise Meteres/Km	Car	Wagon	Bus & Truck
10	17.22	31.39	49.29
20	34.43	62.77	98.58
30	51.65	94.15	147.87
40	68.86	125.54	197.16
50	86.08	156.92	246.45
60	103.29	188.31	295.74
70	120.51	129.69	345.03
80	137.72	251.08	394.33
90	146.33	266.77	418.97

Source: Ministry of Communications, 1977 (Kenya Study)

Table 6: Fuel Correction for Rate of Fall

Subtract litres per 1000 Km from Table 4

Rate of Fall Meters/Km	Car	Wagon	Bus & Truck
10	9.22	13.79	20.72
20	18.45	27.58	41.45
30	27.67	41.38	62.17
40	36.89	55.17	82.90
50	46.12	68.96	103.62
60	55.34	82.75	124.34
70	64.56	96.54	145.07
80	70.79	110.33	165.79
85	78.40	117.23	176.76

Source: Ministry of Communications, 1977 (Kenya Study).

Table 7: Fuel Correction for Curvature

Percent Increase on Consumption in Table 4

Speed Km per Hour	Degree of Curvature (Degrees per 100 Meters)								
	10	20	30	40	50	60	70	80	90
A. CAR									
30									3
40						2	5	6	13
50				3	6	10	15	26	44
60			4	6	9	22	36	50	
70	2	3	8	14	28	41			
80	3	5	14	22	47				
90	4	9	24	38					
B. MINI BUS									
30									7
40							4	6	25
50				2	3	6	12	16	
60			2	5	8	17	30		
70		3	5	12	26				
80	1	5	14	20					
90	2	6	22						
96	3								
C. BUS & TRUCK									
30		1	1	1	1	1	1	5	6
40		1	1	1	2	2	10	15	21
50		1	2	4	8	14	25	38	73
60	1	2	6	12	20	37	46		
70	2	5	14	33	51				
80	4	10	28						
90	6	16							
96	7								

Source: Ministry of Communications, 1977.

Table 8: Fuel Correction for Road Roughness

Add Litres per 1000 Km for All Speeds

Roughness metres per Kilometre	Vehicle Type		
	Car	Minibus	Bus & Truck
1.0	-	-	-
1.5	1.83	1.78	2.46
2.0	2.44	2.38	3.28
2.5	3.05	2.97	4.10
3.0	3.66	3.57	4.92
3.5	4.27	4.16	5.74
4.0	4.88	4.75	6.55
4.5	5.49	5.35	7.37
5.0	6.10	5.94	8.19
5.5	6.71	6.53	0.01
6.0	7.32	7.13	9.83
6.5	7.93	7.72	10.65
7.0	8.54	8.32	11.47
7.5	9.15	8.91	12.29

Source: Ministry of Communications, 1977 (Kenya Study).

Table 9: Fuel Correction for Traffic Congestion

Percent increase on Consumption Table 4

Average Highway Speed KPH	Average Operating Speed K.p.i.						
	40	50	60	70	80	88	96
Cars and Mini Bus							
50	2						
60	13	9					
70	23	18	10	5			
80	37	30	20	10	4		
90	53	42	30	20	12	5	
Buses and Trucks							
60	6	6					
70	17	16	10	4			
80	35	33	26	18	9		
90	64	60	50	41	29	18	

Source: Ministry of Communications, 1977.

Table 10: Fuel Correction for Speed-Cycle Changes

Add Litres per Speed change to table 4

Speed reduced to and returned from K.P.H.	Initial Operating Speed K.P.H.							
	20	30	40	50	60	70	80	90
CAR								
Stop	.01	.01	.02	.03	.04	.04	.05	.06
10	.01	.01	.01	.02	.03	.03	.04	.04
20		.01	.01	.01	.02	.03	.04	.04
30				.01	.02	.03	.03	.04
40					.02	.03	.03	.04
50					.01	.02	.03	.03
60					.01	.01	.02	.03
70							.01	.02
80								.01
90								-
Minibus								
Stop	.04	.06	.08	.11	.15	.18	.22	.25
10	.03	.05	.07	.10	.14	.18	.20	.24
20	.02	.03	.06	.08	.12	.16	.18	.21
30			.03	.05	.10	.14	.16	.19
40				.03	.08	.12	.15	.17
50					.05	.10	.13	.15
60						.07	.10	.13
70							.05	.09
80								.06
Bus & Truck								
Stop	.05	.08	.11	.14	.20	.25	.28	.33
10	.03	.06	.10	.13	.18	.23	.27	.31
20	.02	.04	.07	.10	.16	.21	.24	.28
30			.03	.07	.13	.18	.21	.25
40				.04	.10	.16	.19	.23
50					.07	.14	.17	.20
60						.09	.13	.16
70							.07	.12
80								.08

Source: Ministry of Communications, 1977.

Engine Oil

This is by far the least important in the make up of vehicle operating costs. Little research has been done on the subject partly because of relatively low importance and partly because of the technical difficulty of establishing how engine oil consumption varies with speed. Table 11 shows engine oil consumption according to speed. The data is based on values used by the Ministry of Communications (1977)

Table 11: Engine Oil Consumption

Litres per 1000 Km

Type of Vehicle	Speed Km/Hr						
	30	40	50	60	70	80	90
Car	1.44	1.44	1.44	1.44	1.44	1.20	1.20
Mini Bus	2.16	2.16	2.16	2.16	2.16	1.80	2.16
Bus & Truck	6.22	5.80	5.53	4.86	3.86	3.56	3.80

Source: Ministry of Communications, 1977 (Kenya Study).

Tyre Wear

Tyre wear is an important component of vehicle operating costs particularly for heavier vehicles. Nevertheless most vehicle operators are content to reckon average life of the tyre irrespective of speed and type of road surface. The determination of tyre wear for different road conditions needs considerable research. Numerous surveys and studies have been carried out from time to time by manufacturers, users, highway agencies and other researchers. Though precise relationships are difficult to determine, various studies have indicated dependence on road roughness, vehicle speed, speed changes, curvature, temperature etc. The vehicle operating cost studies carried out in different countries have, on the basis of surveys and studies and using data available from different sources, developed tables of tyre wear according to speed, road roughness, curvature etc.

Table 12 gives tyre wear according to road roughness and speed for each vehicle type. The tyre wear is expressed as percent of one tyre. Further variations according to curvature and congestion are given in table 13 and 14. The variations have been measured in terms of percentage increase over basic table 10. The data used by the Ministry of Communications which in turn is based on the Kenya and Yogoslavia studies has been used in the study.

As would be seen from table 12 to 14 tyre wear increases with speed and roughness.

Table 12: Tyre Wear according to road roughness

Number of tyres per 1000 Km

Roughness metres per K. M.	Speed K. P. H.						
	30	40	50	60	70	80	90
CARS							
1.5	.009	.012	.016	.022	.026	.030	.037
2.0	.010	.014	.018	.024	.028	.033	.037
2.5	.019	.025	.036	.046	.053	.062	.079
3.0	.028	.037	.050	.063	.076	.091	.116
3.5	.037	.049	.065	.089	.100	.120	.153
4.0	.046	.060	.081	.103	.124	.149	.190
4.5	.055	.073	.097	.124	.149	.178	.227
5.0	.064	.085	.113	.143	.173	.207	.264
5.5	.073	.097	.129	.164	.197	.236	.300
6.0	.082	.109	.145	.184	.222	.265	.338
6.5	.091	.121	.160	.204	.246	.294	.375
7.0	.100	.132	.176	.224	.270	.323	.411
7.5	.109	.144	.192	.245	.294	.352	.449
MINIBUSES							
1.5	.011	.014	.019	.024	.029	.035	.045
2.0	.011	.016	.021	.026	.032	.039	.050
2.5	.022	.029	.040	.050	.060	.073	.093
3.0	.032	.043	.069	.073	.088	.107	.136
3.5	.041	.056	.077	.097	.117	.142	.179
4.0	.052	.070	.096	.120	.145	.176	.222
4.5	.062	.084	.114	.143	.173	.210	.265
5.0	.072	.097	.133	.167	.201	.244	.308
5.5	.082	.111	.152	.190	.229	.279	.352
6.0	.092	.125	.170	.214	.258	.313	.395
6.5	.102	.138	.189	.237	.286	.347	.439
7.0	.113	.152	.208	.261	.314	.381	.482
7.5	.122	.165	.226	.284	.342	.415	.525
BUSES AND TRUCKS							
1.5	.031	.044	.061	.078	.097	.120	.163
2.0	.033	.046	.063	.082	.102	.126	.172
2.5	.035	.049	.068	.087	.108	.133	.183
3.0	.037	.052	.072	.092	.114	.140	.193
3.5	.039	.054	.075	.096	.119	.147	.202
4.0	.040	.056	.079	.101	.125	.154	.212
4.5	.041	.059	.082	.106	.130	.160	.221
5.0	.043	.061	.086	.110	.135	.167	.230
5.5	.045	.064	.090	.115	.140	.174	.236
6.0	.047	.066	.092	.117	.146	.180	.246
6.5	.048	.068	.096	.122	.151	.187	.255
7.0	.050	.071	.098	.126	.157	.193	.264
7.5	.052	.074	.102	.130	.162	.200	.274

Source: Ministry of Communications, 1977 (Kenya Study).

Table 13: Tyre Wear due to Curvature

Percent increase on Table 12 for all vehicle types

Speed K.P.H.	Degree of curvature (Degrees per Km)								
	100	200	300	400	500	600	700	800	900
30					10	28	47	75	141
40				10	40	80	120	180	280
50	27	45	68	118	188	270	423	663	
60	38	66	113	197	291	413	638		
70	49	107	185	282	428	710			
80	70	150	280	440	730				
90	112	272	563						

Source: Ministry of Communications, 1977.

Table 14: Tyre wear due to traffic congestion

Percent increase on Table 12

Average Highway Speed k.p.h.	Average operating speed k.p.h.						
	40	50	60	70	80	90	100
Cars and Mini Bus							
50	26						
60	79	46	20				
70	118	76	45	15			
80	166	112	75	33	12		
90	209	201	143	85	53	28	8
Buses and Trucks							
50	23						
60	72	42	21				
70	111	71	45	15			
80	158	109	73	35	14		
90	201	201	144	97	64	40	20

Source: Ministry of Communications, 1977.

Maintenance

Maintenance is related to road roughness and is divided into two categories - labour and parts. Labour is measured in hours and parts as percentage of value of new vehicle.

Table 15 and 16 give values of labour hours and parts respectively according to roughness for different types of vehicles as used by the Ministry of Communications (1977).

Table 15: Maintenance Labour Hours per 1000 Km

Road Roughness - meters per Km	Vehicle Type			
	Car	Mini-Bus	Bus	Truck
1.0	1.99	16.44	18.43	18.65
1.5	2.59	17.04	19.58	19.74
2.0	3.19	17.65	20.71	20.82
2.5	3.79	18.25	21.86	21.92
3.0	4.39	18.86	23.00	23.00
3.5	4.99	19.47	24.14	24.09
4.0	5.59	20.07	25.28	25.18
4.5	6.19	20.67	26.43	26.27
5.0	6.79	21.28	27.58	27.35
5.5	7.38	21.89	28.72	28.44
6.0	7.98	22.49	29.86	29.53
6.5	8.58	23.10	31.01	30.62
7.0	9.18	23.70	32.15	31.70
7.5	9.78	24.31	33.29	32.79

Source: Ministry of Communications (1977).

Table 16: Maintenance parts as % of the cost of a new Vehicle per 1000 Km

Road Roghness - meters per Km	Vehicle Type			
	Car	Mini-Bus	Bus	Truck
1.0	.0261	.0560	.0560	.0491
1.5	.0261	.0612	.0980	.0941
2.0	.0688	.1167	.1400	.1392
2.5	.1095	.1724	.1820	.1843
3.0	.1930	.2280	.2240	.2280
3.5	.2764	.2835	.2660	.2745
4.0	.3599	.3391	.3080	.3196
4.5	.4433	.3947	.3500	.3647
5.0	.5267	.4503	.3920	.4098
5.5	.6102	.5059	.4340	.4458
6.0	.6936	.5615	.4760	.5000
6.5	.7771	.6170	.5180	.5450
7.0	.8695	.6726	.5600	.5901
7.5	.9440	.7282	.6020	.6352

Source: Ministry of Communications (1977).

Depreciation

Physical measurement of depreciation is very difficult to make. There is no mechanical device to measure the same. It has to be estimated on certain assumptions.

Depreciation should cover the value of the vehicle less residual value at the end of the useful life, less cost of tyres which have been taken into account separately. The residual value has been ignored in this exercise as of insignificant value.

If the life of a vehicle is taken in terms of distance, depreciation per kilometer will be the same at all speeds. If, however, life is taken in years and operating hours are assumed to be fixed, increase in speed will result in higher kilometrage and less depreciation per unit of distance.

In practice, depreciation depends partly on time and partly on usage. Increase in speed due to improvement of road would increase usage (annual and life time mileage) and reduce life of the vehicle but both proportionately less than speed.

In quantitative terms, it is assumed that 1% increase in speed would result in .66% increase in annual kilometrage but decrease in the life of the vehicle and increase in life time kilometrage would be at half the rate of increase in annual kilometrage. Taking average life and kilometrage used by the Ministry of Communications (1977) as mid values - 60 Km per hour speed, estimates of annual and life time kilometrage and life in years have been made for speed levels ranging from 30 to 90 Km per hour for each type of vehicle in table 17.

Table 17: Usage and Life of Vehicles according to Speed

Type of Vehicle	Description	Unit	Speed Km/Hr 30	40	50	60	70	80	90
Car	Annual usage	000 Km	8.6	10.3	11.8	13.3	14.8	16.2	17.5
	Life time usage	000 Km	130	141	151	160	169	177	184
	Life	Years	15.1	13.7	12.8	12.0	11.4	10.9	10.5
Wagon	Annual usage	000 Km	32.2	38.3	44.5	50.0	55.0	60.2	65.2
	Total usage	000 Km	324	353	378	400	422	442	460
	Life	Years	10.0	9.1	8.5	8.0	7.7	7.3	7.0
Bus	Annual usage	000 Km	40.3	48.3	55.6	62.5	68.8	75.2	81.4
	Life time usage	000 Km	354	386	413	438	462	483	503
	Life	Years	8.8	8.0	7.4	7.0	6.7	6.4	6.2
Truck	Annual usage	000 Km	25.8	30.9	35.6	40.0	44.4	48.6	52.6
	Life time usage	000 Km	324	353	378	400	422	442	460
	Life	Years	12.5	11.4	10.6	10.0	9.5	9.1	8.7

Given the relationships between speed, life and kilometrage in table 17, depreciation per distance unit can be calculated by dividing the value of vehicle by life in years and annual kilometrage which is the same thing as life time kilometrage. Accordingly, depreciation for each vehicle type according to speed has been calculated in table 18 by dividing value by life time mileage. The valuesare as percent of cost of new vehicle per 1000 Km.

Table 18: Depreciation as % cost of New Vehicle (without tyres)

Per 1000 Km

Type of Vehicle	Speed Km/Hr 30	40	50	60	70	80	90
Car	.77	.71	.66	.62	.59	.56	.54
Wagon	.31	.28	.26	.25	.24	.23	.22
Bus	.28	.26	.24	.23	.22	.21	.20
Truck	.31	.28	.26	.25	.24	.23	.22

As would be evident from the foregoing, depreciation is related to speed irrespective of the type of road. It is assumed that as speed on different types of roads varies, variation in depreciation according to speed would take into account type of road indirectly. However, it does not seem logical that at a given speed, depreciation on different types of roads should be the same. For every speed level there will be more wear and tear and therefore higher depreciation on an un-improved road than on an improved road. However, due to lack of data, it has not been possible to determine variations according to type of road. This limitation may be kept in view while using the data. As this is an important aspect in appraisal of road and transport projects, further research on determination of wear and tear on improved and un-improved roads is strongly recommended.

Interest

Interest constitutes cost of capital invested on the vehicle which is assumed to be proportionate to age. The vehicles on road vary in age. Given a constant size of the fleet, average age of the fleet would be equal to sum of the ages of vehicles divided by the number of vehicles. For example, average age of a fleet of 5 vehicles would be $1+2+3+4+5 = 15 \div 5 = 3$ and not half the life of the vehicle, $5 \div 2 = 2.5$. Dividing the maximum age by 2 would give lower figure. As the stock of vehicle is growing, particularly

in developing countries, vehicles in lower age groups would be relatively more. To account for the same the average age of vehicle has been taken as half of maximum age instead of dividing the sum of ages by the number.

Using the interest rate of 12% p.a. recommended for appraisal of transport projects, and capital value as half of the cost of new vehicle, annual interest costs were obtained and divided by annual kilometrage for each speed level to get interest costs per 1000 Km as in table 19.

Table 19: Interest Cost as % of Cost of New Vehicle Per 1000 Km

Type of Vehicle	Speed Km/Hr						
	30	40	50	60	70	80	90
Car	.70	.58	.51	.45	.41	.37	.34
Wagon (Minibus)	.19	.16	.13	.12	.11	.10	.09
Bus	.15	.12	.11	.10	.09	.08	.07
Truck	.23	.19	.17	.15	.14	.12	.11

Time Cost

Time costs in terms of distance units (per Km) are inversly related to speed of the vehicle and have been arrived at by dividing hourly earnings by speed.

Time is divided into two categories - working and non-working. Working time is valued equal to earnings and non-working time at 1/3rd of working time. Working time usually covers time of crew members and travel for business. All other time is regarded as non-working.

According to the survey of Domestic Toursim in Pakistan (1982) 19.5% of trips by road are for business and the rest for other purpose. The same ratio has been used for cars, wagons and buses for estimating time value of vehicle occupants.

The earnings of crew members are based on estimates of their wages and commission. The earnings of passengers are calculated at per capita GDP for 1983-84 which was Rs. 4530 per annum. In the case of cars, earnings of main occupantare assumed at Rs. 3000/- per month and of other occupants at half of this amount. Occupancy has been taken at 75% of capacity for each vehicle.

On the above lines, time costs per hour for different vehicle types work out as in table 20. Dividing the same by speed, time costs per Km have been obtained in table 21.

Table 20: Hourly costs for Different type of Vehicles

Type of Vehicle	Type of Occupant	Earnings	Proportion of Time		Hourly Cost (Rs.)
			Working	Non-Working	
1	2	3	4	5	6
Car	Main Occupant	Rs. 3000 PM	20	80	7.00
	Other	Rs. 1500 PM	20	80	7.00
					14.00
Wagon	Driver	Rs. 1400 PM	100	-	7.50
	Conductor	Rs. 1200 PM	100	-	6.00
	Passengers(8)	Rs. 4530 PA	20	80	7.05
					20.55
Bus	Driver	Rs. 2000 PM	100	-	10.00
	Conductor	Rs. 1500 PM	100	-	7.50
	Passenger(30)	Rs. 4530 PA	20	80	26.42
					43.92
Truck	Driver	Rs. 2000 PM	100	-	10.00
	Conductor	Rs. 1500 PM	100	-	7.50
					17.50

Table 21: Time Costs

Rs/m 1000 Km

Type of Vehicle	Speed Km/Hr						
	30	40	50	60	70	80	90
Car	470	350	280	230	200	180	160
Wagon	690	510	410	340	290	260	230
Bus	460	100	880	730	630	550	490
Truck	580	580	350	290	250	220	190

CHAPTER III

VEHICLE OPERATING COSTS

On the basis of physical quantities of cost inputs given in Chapter II, vehicle operating costs have been calculated for four types of vehicles - car, wagon, bus and truck, three types of roads - shingle, un-improved and improved and at speeds ranging from 30 to 90 Km per hour with class interval of 10 Km. Costs have been calculated in financial and economic terms i.e. including and excluding taxes.

Summary of results showing financial and economic costs for each vehicle and road type and speed levels indicated above are given in table 22 and 23 and accompanying graphs respectively. Details giving quantities of individual cost components, and financial and economic costs thereof are provided for each vehicle type, road category and speed levels in table 24 to 35 respectively.

TABLE 22 : SUMMARY OF ROAD VEHICLE OPERATING COSTS
(FINANCIAL COSTS)

RS.PER 1000 KM

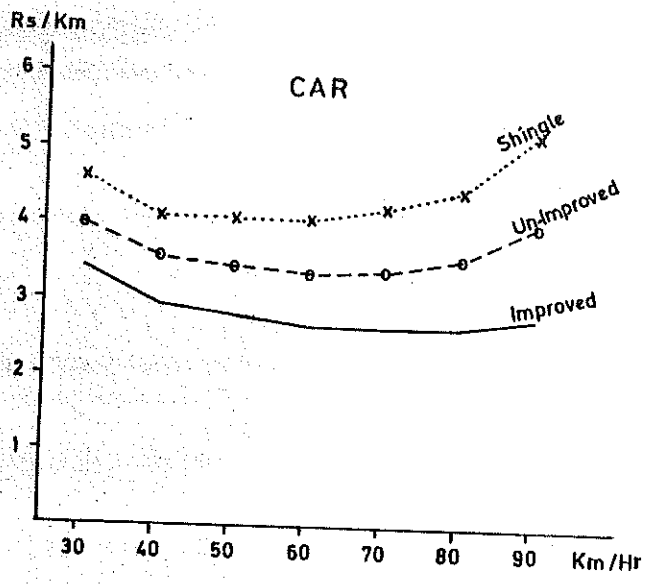
Type of Vehicle	Speed Km/Hrs	Road Type		
		Improved	Un-Improved	Shingle
Car	30	3425.61	4004.26	4619.25
	40	2984.78	3581.34	4113.11
	50	2809.04	3438.51	4093.01
	60	2676.43	3357.98	4055.99
	70	2647.28	3401.72	4195.30
	80	2682.50	3546.15	4445.78
	90	2830.90	4018.57	5226.87
Mini Bus	30	2312.74	2879.14	3328.08
	40	1991.70	2574.05	3043.36
	50	1790.87	2441.37	2976.9
	60	1735.98	2444.48	3051.02
	70	1716.27	2539.09	3258.33
	80	1728.62	2695.59	3570.38
	90	1760.78	3129.65	4442.38
Bus	30	4986.51	5904.03	7023.32
	40	4278.04	5198.14	6284.06
	50	3873.75	4841.58	6040.97
	60	3895.58	4907.26	6106.64
	70	4241.23	5394.24	6613.65
	80	4328.73	5643.29	6840.56
	90	4600.06	6633.64	7497.18
Truck	30	5015.18	5953.32	6608.30
	40	4206.07	5148.87	5810.20
	50	3813.29	4812.13	5512.35
	60	3743.85	4695.13	5423.66
	70	3764.50	4941.62	5740.02
	80	4585.75	5895.22	6875.92

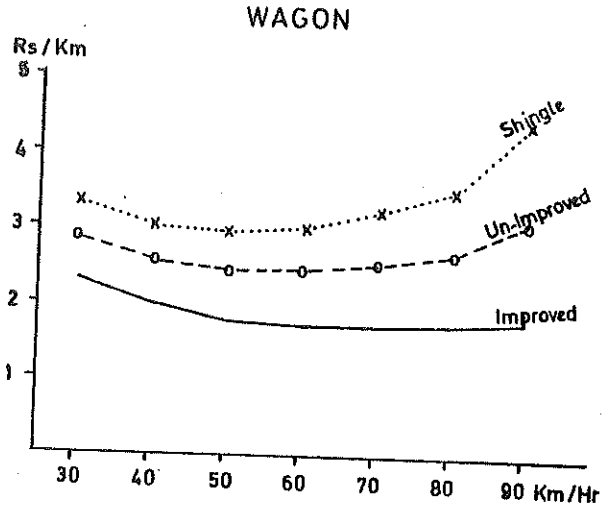
TABLE 23 : SUMMARY OF ROAD VEHICLE OPERATING COSTS
(ECONOMIC COSTS)

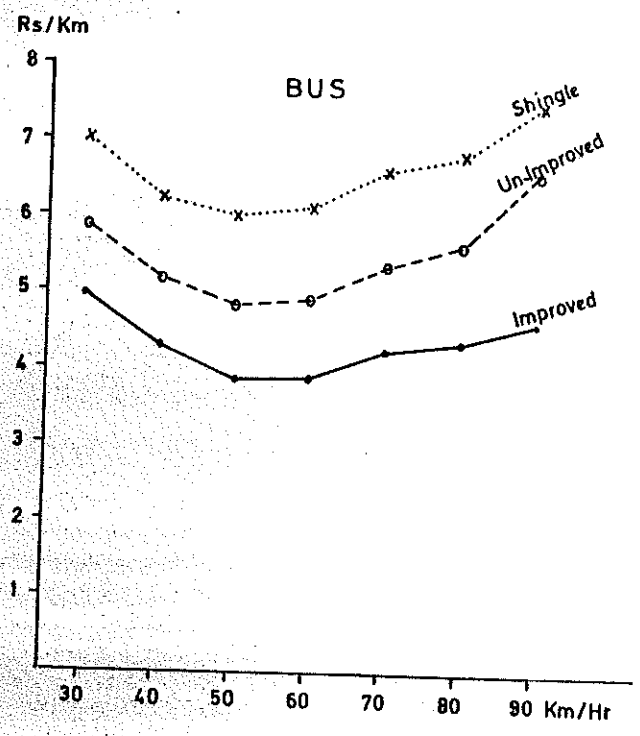
RS.PER 1000 KM

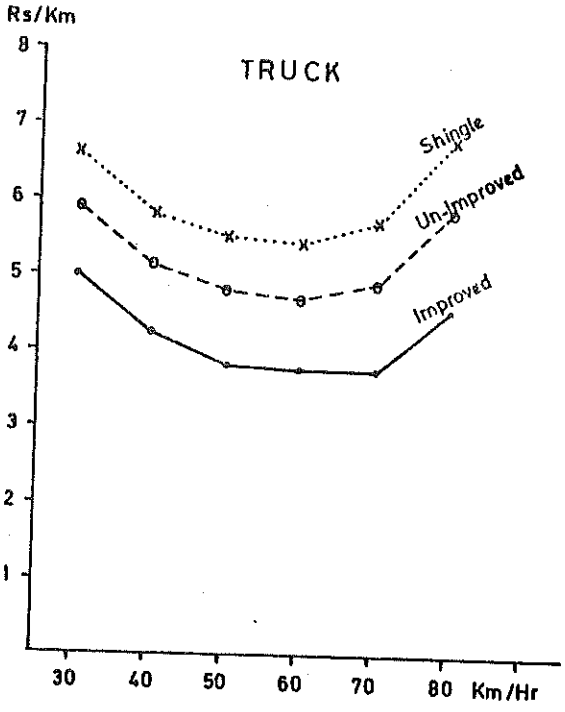
Type of Vehicle	Speed Km/Hrs	Road Type		
		Improved	Un-Improved	Shingle
Car	30	1821.39	2114.31	2368.47
	40	1566.04	1872.02	2137.64
	50	1487.75	1816.54	2112.21
	60	1435.47	1805.25	2127.40
	70	1448.36	1865.73	2259.55
	80	1512.34	2005.92	2473.19
	90	1649.36	2375.52	3062.16
Mini Bus	30	1605.88	1892.29	2084.85
	40	1356.22	1652.32	1856.48
	50	1209.78	1547.29	1791.86
	60	1163.14	1535.89	1823.60
	70	1147.36	1591.22	1947.65
	80	1160.45	1693.08	2143.76
	90	1184.39	1961.49	2678.27
Bus	30	3918.48	4536.05	5245.86
	40	3313.04	3931.93	4620.85
	50	2972.01	3620.57	4380.48
	60	2941.93	3618.15	4378.07
	70	3188.96	3958.29	4730.74
	80	3231.76	4121.56	4867.56
	90	3394.33	4668.21	5280.58
Truck	30	3831.02	4502.20	4952.21
	40	3217.31	3887.01	4343.45
	50	2755.05	3559.06	4034.66
	60	2697.61	3431.10	3922.74
	70	2767.33	3596.74	4107.55
	80	3373.74	4240.70	4907.37

VEHICLE OPERATING COSTS INCLUDING TAXES (FINANCIAL COSTS) ACCODING TO SPEED AND TYPE OF ROAD

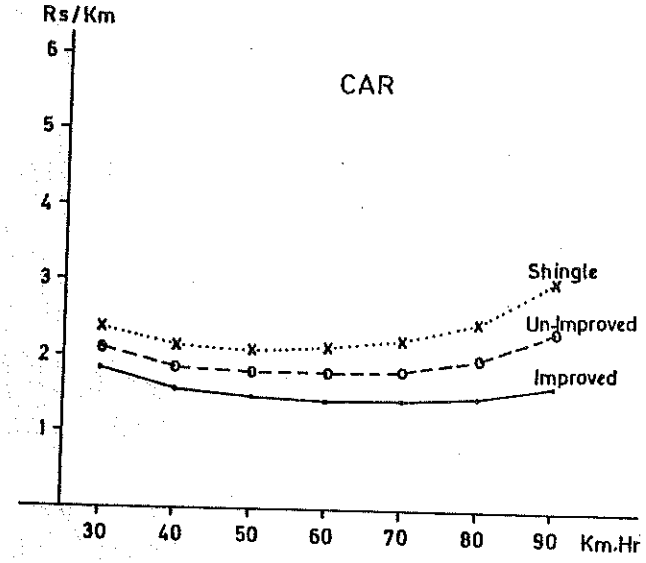


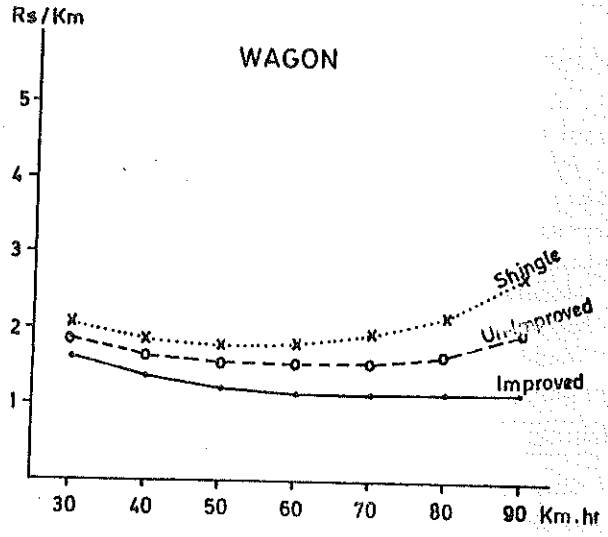


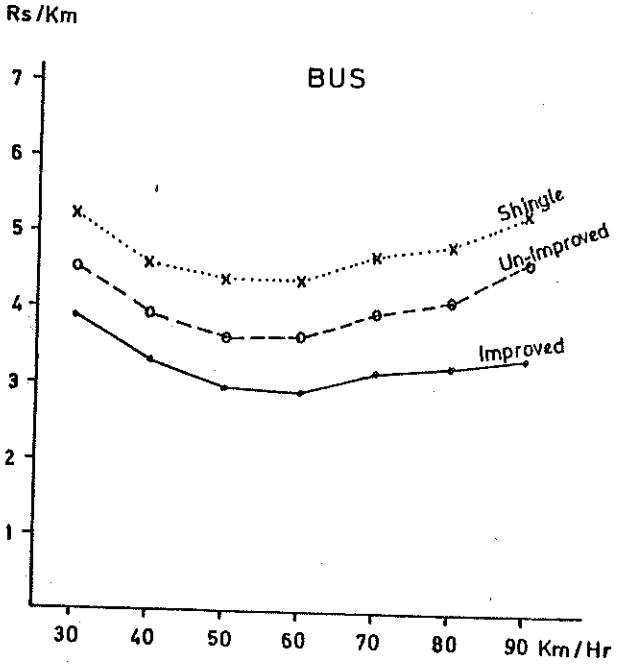




VEHICLE OPERATING COSTS EXCLUDING TAXES (ECONOMIC COSTS) ACCORDING TO SPEED AND TYPE OF ROAD







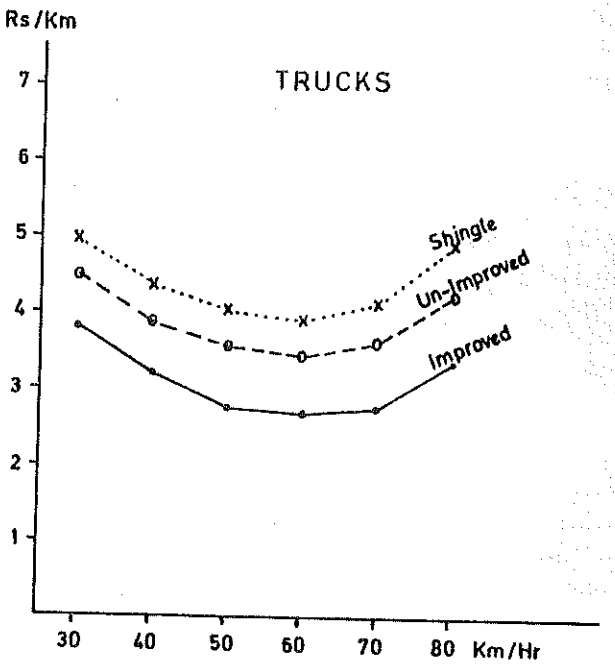


TABLE 24: VEHICLE OPERATING COSTS ON IMPROVED ROADS FOR CARS PER 1000 KM

Description	Unit	Speed Km/Hr 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	87.05	80.05	89.05	98.05	111.87	133.38	163.61
Engine Oil	Litres	1.44	1.44	1.44	1.44	1.44	1.20	1.20
Tyre Wear	Tyre	0.009	0.012	0.024	0.030	0.039	0.051	0.078
Depreciation	% Veh.	0.77	0.71	0.66	0.62	0.59	0.56	0.54
Interest	% Veh.	0.70	0.58	0.51	0.45	0.41	0.37	0.34
Maintenance								
- Labour	Hrs.	2.59	2.59	2.59	2.59	2.59	2.59	2.59
- Parts	% Veh.	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	611.09	561.95	625.13	688.31	785.33	936.33	1148.54
Engine Oil	Rs.	19.44	19.44	19.44	19.44	19.44	16.20	16.20
Tyre Wear	Rs.	10.89	14.52	29.04	36.30	47.19	61.71	94.38
Depreciation	Rs.	1177.72	1085.94	1009.47	948.29	802.40	866.52	825.93
Interest	Rs.	1070.65	887.11	780.14	688.27	627.10	565.92	520.03
Maintenance								
- Labour	Rs.	25.90	25.90	25.90	25.90	25.90	25.90	25.90
- Parts	Rs.	39.92	39.92	39.92	39.92	39.92	39.92	39.92
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
Total	Rs.	3425.61	2984.78	2809.04	2676.43	2547.28	2692.50	2830.90
ECONOMIC COSTS								
Fuel Consumption	Rs.	467.46	429.87	478.20	526.53	600.74	716.25	878.88
Engine Oil	Rs.	16.56	16.56	16.56	16.56	16.56	13.80	13.80
Tyre Wear	Rs.	7.69	10.25	20.50	25.62	33.31	43.55	66.11
Depreciation	Rs.	429.12	395.68	367.82	345.53	328.81	312.09	300.94
Interest	Rs.	390.11	323.23	284.22	250.78	228.49	206.20	189.48
Maintenance								
- Labour	Rs.	25.90	25.90	25.90	25.90	25.90	25.90	25.90
- Parts	Rs.	14.55	14.55	14.55	14.55	14.55	14.55	14.55
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
Total	Rs.	1821.39	1566.04	1487.75	1435.47	1448.36	1512.34	1649.36

TABLE 25: VEHICLE OPERATING COSTS ON IMPROVED ROADS FOR MINI BUSES PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	120.17	108.17	100.17	108.17	119.17	132.23	141.29
Engine Oil	Litres	2.16	2.16	2.16	2.16	2.16	1.80	2.16
Tyre Wear	Tyre	0.011	0.015	0.024	0.033	0.043	0.060	0.075
Depreciation	% Veh.	0.31	0.28	0.26	0.25	0.24	0.23	0.22
Interest	% Veh.	0.19	0.16	0.13	0.12	0.11	0.10	0.09
Maintenance								
- Labour	Hrs.	17.04	17.04	17.04	17.04	17.04	17.04	17.04
- Parts	% Veh.	0.0612	0.0612	0.0612	0.0612	0.0612	0.0612	0.0612
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	510.72	459.72	425.72	459.72	506.47	561.98	600.48
Engine Oil	Rs.	29.16	29.16	29.16	29.16	29.16	24.30	29.16
Tyre Wear	Rs.	15.95	21.75	34.80	47.85	62.35	87.00	137.75
Depreciation	Rs.	495.22	447.30	415.35	399.38	384.40	367.42	351.45
Interest	Rs.	303.52	255.60	207.67	191.70	175.72	159.75	143.77
Maintenance								
- Labour	Rs.	170.40	170.40	170.40	170.40	170.40	170.40	170.40
- Parts	Rs.	97.77	97.77	97.77	97.77	97.77	97.77	97.77
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
Total	Rs.	2312.74	1991.70	1790.87	1735.98	1716.27	1728.62	1760.78
ECONOMIC COSTS								
Fuel Consumption	Rs.	398.96	359.12	332.56	359.12	395.64	439.00	469.08
Engine Oil	Rs.	24.84	24.84	24.84	24.84	24.84	20.70	24.84
Tyre Wear	Rs.	9.69	13.22	21.14	29.07	37.88	52.86	83.70
Depreciation	Rs.	172.34	155.67	144.55	138.98	133.43	127.87	122.31
Interest	Rs.	105.63	88.95	72.27	66.71	61.15	55.60	50.04
Maintenance								
- Labour	Rs.	170.40	170.40	170.40	170.40	170.40	170.40	170.40
- Parts	Rs.	34.02	34.02	34.02	34.02	34.02	34.02	34.02
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
Total	Rs.	1605.88	1356.22	1209.78	1163.14	1147.36	1160.45	1184.39

TABLE 26: VEHICLE OPERATING COSTS ON IMPROVED ROADS FOR BUSES PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	288.75	244.75	215.75	254.76	360.81	387.67	407.91
Engine Oil	Litres	6.22	5.80	5.53	4.86	3.86	3.56	3.80
Tyre Wear	Tyre	0.031	0.044	0.077	0.108	0.145	0.204	0.346
Depreciation	% Veh.	0.28	0.26	0.24	0.23	0.22	0.21	0.20
Interest	% Veh.	0.15	0.12	0.11	0.10	0.09	0.08	0.07
Maintenance								
- Labour	Hrs.	19.58	19.58	19.58	19.58	19.58	19.58	19.58
- Parts	% Veh.	0.0980	0.0980	0.0980	0.0980	0.0980	0.0980	0.0980
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	1227.19	1040.19	916.94	1082.73	1533.44	1647.60	1733.62
Engine Oil	Rs.	83.97	78.30	74.66	65.61	52.11	48.06	51.30
Tyre Wear	Rs.	68.98	97.90	171.32	240.30	322.63	453.90	769.85
Depreciation	Rs.	1034.39	960.50	866.62	849.68	812.73	775.79	738.85
Interest	Rs.	554.14	443.31	406.37	369.42	332.48	295.54	258.60
Maintenance								
- Labour	Rs.	195.80	195.80	195.80	195.80	195.80	195.80	195.80
- Parts	Rs.	362.04	362.04	362.04	362.04	362.04	362.04	362.04
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
Total	Rs.	4986.51	4278.04	3873.75	3895.58	4241.23	4328.73	4600.06
ECONOMIC COSTS								
Fuel Consumption	Rs.	958.65	812.57	716.29	845.80	1197.89	1287.06	1354.26
Engine Oil	Rs.	71.53	66.70	63.60	55.89	44.39	40.94	43.70
Tyre Wear	Rs.	43.15	61.25	107.18	150.34	201.84	283.97	481.63
Depreciation	Rs.	630.72	585.67	540.61	518.09	495.56	473.04	450.51
Interest	Rs.	337.88	270.30	247.78	225.26	202.73	180.20	157.68
Maintenance								
- Labour	Rs.	195.80	195.80	195.80	195.80	195.80	195.80	195.80
- Parts	Rs.	220.75	220.75	220.75	220.75	220.75	220.75	220.75
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
Total	Rs.	3918.48	3313.04	2972.01	2941.93	3188.96	3231.76	3394.33

TABLE 27: VEHICLE OPERATING COSTS ON IMPROVED ROADS FOR TRUCKS PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80
PHYSICAL FACTORS							
Fuel Consumption	Litres	445.74	304.75	277.75	249.71	282.27	460.47
Engine Oil	Litres	6.22	5.80	5.53	4.86	3.86	3.56
Tyre Wear	Tyre	0.031	0.044	0.077	0.108	0.145	0.204
Depreciation	% Veh.	0.31	0.28	0.26	0.25	0.24	0.23
Interest	% Veh.	0.23	0.19	0.17	0.16	0.15	0.14
Maintenance							
- Labour	Hrs.	18.65	18.65	18.65	18.65	18.65	18.65
- Parts	% Veh.	0.0941	0.0941	0.0941	0.0941	0.0941	0.0941
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
FINANCIAL COSTS							
Fuel Consumption	Rs.	1894.44	1295.19	1180.44	1061.27	1199.65	1957.00
Engine Oil	Rs.	83.97	78.30	74.66	65.61	52.11	48.06
Tyre Wear	Rs.	87.64	124.39	217.68	305.32	409.92	576.71
Depreciation	Rs.	1067.05	963.79	894.95	960.52	826.10	791.68
Interest	Rs.	791.68	654.00	585.16	550.73	516.32	481.90
Maintenance							
- Labour	Rs.	186.50	186.50	186.50	186.50	186.50	186.50
- Parts	Rs.	323.90	323.90	323.90	323.90	323.90	323.90
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
Total	Rs.	5015.18	4206.07	3813.29	3743.85	3764.50	4585.75
ECONOMIC COSTS							
Fuel Consumption	Rs.	1479.89	1011.77	922.13	829.04	937.14	1528.76
Engine Oil	Rs.	71.53	66.70	63.60	55.89	44.39	40.94
Tyre Wear	Rs.	49.60	70.40	123.20	172.80	232.00	326.40
Depreciation	Rs.	715.48	646.24	600.08	577.00	553.92	530.84
Interest	Rs.	530.84	438.52	392.36	369.28	346.20	323.12
Maintenance							
- Labour	Rs.	186.50	186.50	186.50	186.50	186.50	186.50
- Parts	Rs.	217.18	217.18	217.18	217.18	217.18	217.18
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
Total	Rs.	3831.02	3217.31	2855.05	2697.69	2767.33	3373.74

TABLE 28: VEHICLE OPERATING COSTS ON UN-IMPROVED ROADS FOR CARS PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	106.70	100.70	108.70	117.70	132.43	155.25	190.21
Engine Oil	Litres	1.44	1.44	1.44	1.44	1.44	1.20	1.20
Tyre Wear	Tyre	0.037	0.049	0.094	0.148	0.148	0.300	0.269
Depreciation	% Veh.	0.77	0.71	0.66	0.62	0.59	0.56	0.54
Interest	% Veh.	0.70	0.58	0.51	0.45	0.41	0.37	0.34
Maintenance								
- Labour	Hrs.	4.99	4.99	4.99	4.99	4.99	4.99	4.99
- Parts	% Veh.	0.2764	0.2764	0.2764	0.2764	0.2764	0.2764	0.2764
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	749.03	706.91	763.07	826.25	929.66	1089.86	1335.27
Engine Oil	Rs.	19.44	19.44	19.44	19.44	19.44	16.20	16.20
Tyre Wear	Rs.	44.77	59.29	113.74	179.08	250.47	363.00	688.49
Depreciation	Rs.	1177.72	1085.94	1009.47	942.29	902.40	858.52	825.93
Interest	Rs.	1070.65	887.11	780.14	688.27	627.10	565.92	520.03
Maintenance								
-Labour	Rs.	49.90	49.90	49.90	49.90	49.90	49.90	49.90
-Parts	Rs.	422.75	422.75	422.75	422.75	422.75	422.75	422.75
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
Total	Rs.	4004.26	3581.34	3438.51	3357.98	3401.72	3546.15	4018.57
ECONOMIC COSTS								
Fuel Consumption	Rs.	572.98	540.76	583.72	632.05	711.15	833.69	1021.43
Engine Oil	Rs.	16.56	16.56	16.56	16.56	16.56	13.80	13.80
Tyre Wear	Rs.	31.60	41.85	80.28	126.39	176.78	256.20	485.93
Depreciation	Rs.	429.12	395.68	367.82	345.53	328.81	312.09	300.94
Interest	Rs.	390.11	323.23	284.22	250.78	228.49	206.20	189.48
Maintenance								
- Labour	Rs.	49.90	49.90	49.90	49.90	49.90	49.90	49.90
- Parts	Rs.	154.04	154.04	154.04	154.04	154.04	154.04	154.04
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
Total	Rs.	2114.31	1872.02	1816.54	1805.25	1865.73	2005.92	2375.52

TABLE 29: VEHICLE OPERATING COSTS ON UN-IMPROVED ROADS FOR MINI BUSES PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	153.93	141.93	133.93	141.93	155.51	169.83	179.29
Engine Oil	Litres	2.16	2.16	2.16	2.16	2.16	1.80	2.16
Tyre Wear	Tyre	0.041	0.056	0.112	0.161	0.242	0.355	0.466
Depreciation	% Veh.	0.31	0.28	0.26	0.25	0.24	0.23	0.22
Interest	% Veh.	0.19	0.16	0.13	0.12	0.11	0.10	0.09
Maintenance								
- Labour	Hrs.	19.47	19.47	19.47	19.47	19.47	19.47	19.47
- Parts	% Veh.	0.2835	0.2835	0.2835	0.2835	0.2835	0.2835	0.2835
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	654.20	603.20	569.20	603.20	660.92	721.78	761.98
Engine Oil	Rs.	29.16	29.16	29.16	29.16	29.16	24.30	29.16
Tyre Wear	Rs.	59.45	81.20	162.40	233.45	350.90	514.75	965.70
Depreciation	Rs.	495.22	447.30	415.35	399.38	384.80	367.42	351.45
Interest	Rs.	303.52	255.60	207.67	191.70	175.72	159.75	143.77
Maintenance								
- Labour	Rs.	194.70	194.70	194.70	194.70	194.70	194.70	194.70
- Parts	Rs.	452.89	452.89	452.89	452.89	452.89	452.89	452.89
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
Total	Rs.	2879.14	2574.05	2441.37	2444.48	2539.09	2695.59	3129.65
ECONOMIC COSTS								
Fuel Consumption	Rs.	511.05	471.21	444.65	471.21	516.29	563.84	595.24
Engine Oil	Rs.	24.84	24.84	24.84	24.84	24.84	20.70	24.84
Tyre Wear	Rs.	36.12	49.34	98.67	141.84	213.20	312.76	586.75
Depreciation	Rs.	172.34	155.67	144.55	138.98	133.43	127.87	122.31
Interest	Rs.	105.63	88.95	72.27	66.71	61.15	55.60	50.04
Maintenance								
- Labour	Rs.	194.70	194.70	194.70	194.70	194.70	194.70	194.70
- Parts	Rs.	157.61	157.61	157.61	157.61	157.61	157.61	157.61
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
Total	Rs.	1892.29	1652.32	1547.29	1535.89	1591.22	1693.08	1961.49

TABLE 30: VEHICLE OPERATING COSTS ON UN-IMPROVED ROADS FOR BUSES PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	343.69	299.25	269.96	309.34	422.47	459.62	494.08
Engine Oil	Litres	6.22	5.80	5.53	4.86	3.86	3.56	3.80
Tyre Wear	Tyre	0.039	0.054	0.109	0.159	0.246	0.367	0.751
Depreciation	% Veh.	0.28	0.26	0.24	0.23	0.22	0.21	0.20
Interest	% Veh.	0.15	0.12	0.11	0.10	0.09	0.08	0.07
Maintenance								
- Labour	Hrs.	24.14	24.14	24.14	24.14	24.14	24.14	24.14
- Parts	% Veh.	0.2660	0.2660	0.2660	0.2660	0.2660	0.2660	0.2660
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	1460.68	1271.81	1147.33	1314.70	1795.50	1953.39	2099.84
Engine Oil	Rs.	83.97	78.30	74.66	65.61	52.11	48.06	51.30
Tyre Wear	Rs.	86.78	120.15	242.53	353.78	547.35	816.58	1670.98
Depreciation	Rs.	1034.39	960.50	866.62	849.68	812.73	755.79	838.85
Interest	Rs.	554.14	443.31	406.37	369.42	332.48	295.40	258.60
Maintenance								
- Labour	Rs.	241.40	241.40	241.40	241.40	241.40	241.40	241.40
- Parts	Rs.	982.67	982.67	982.67	982.67	982.67	982.67	982.67
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
Total	Rs.	5904.03	5198.14	4841.58	4907.26	5394.24	5643.29	6633.64
ECONOMIC COSTS								
Fuel Consumption	Rs.	1141.05	993.51	896.27	1027.00	1402.60	1525.94	1640.35
Engine Oil	Rs.	71.53	66.70	63.60	55.89	44.39	40.94	43.70
Tyre Wear	Rs.	54.29	75.17	151.73	221.33	342.43	510.86	1045.39
Depreciation	Rs.	630.72	585.67	540.61	518.09	495.56	473.04	450.51
Interest	Rs.	337.88	270.30	247.78	225.26	202.73	180.20	157.68
Maintenance								
- Labour	Rs.	241.40	241.40	241.40	241.40	241.40	241.40	241.40
- Parts	Rs.	599.18	599.18	599.18	599.18	599.18	599.18	599.18
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
Total	Rs.	4536.05	3931.93	3620.57	3618.15	3958.29	4121.56	4668.21

TABLE 31: VEHICLE OPERATING COSTS ON UN-IMPROVED ROADS FOR TRUCKS PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80
PHYSICAL FACTORS							
Fuel Consumption	Litres	502.26	359.85	332.58	304.24	341.62	501.25
Engine Oil	Litres	6.22	5.80	5.53	4.86	3.86	3.56
Tyre Wear	Tyre	0.039	0.054	0.109	0.159	0.246	0.367
Depreciation	% Veh.	0.31	0.28	0.26	0.25	0.22	0.23
Interest	% Veh.	0.23	0.19	0.17	0.15	0.14	0.12
Maintenance							
- Labour	Hrs.	24.09	24.09	24.09	24.09	24.09	24.09
- Parts	% Veh.	0.2745	0.2745	0.2745	0.2745	0.2745	0.2745
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
FINANCIAL COSTS							
Fuel Consumption	Rs.	2134.61	1529.36	1413.46	1293.02	1415.89	2130.31
Engine Oil	Rs.	83.97	78.30	74.66	65.61	52.11	48.06
Tyre Wear	Rs.	110.25	152.66	308.14	449.49	695.44	1037.51
Depreciation	Rs.	1067.05	963.79	894.95	860.52	826.10	791.68
Interest	Rs.	791.68	659.00	585.16	550.73	516.32	481.90
Maintenance							
- Labour	Rs.	240.90	240.90	240.90	240.90	240.90	240.90
- Parts	Rs.	944.86	944.86	944.86	944.86	944.86	944.86
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
Total	Rs.	5953.32	5148.87	4812.13	4695.13	4941.62	5895.22
ECONOMIC COSTS							
Fuel Consumption	Rs.	1667.50	1194.70	1104.17	1010.08	1134.18	1664.15
Engine Oil	Rs.	71.53	66.70	63.60	55.89	44.39	40.94
Tyre Wear	Rs.	62.40	86.40	174.40	254.40	393.60	587.20
Depreciation	Rs.	715.48	646.24	600.08	577.00	553.92	530.84
Interest	Rs.	530.84	438.52	392.36	369.28	346.20	323.12
Maintenance							
- Labour	Rs.	240.90	240.90	240.90	240.90	240.90	240.90
- Parts	Rs.	633.55	633.55	633.55	633.55	633.55	633.55
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
Total	Rs.	4502.20	3887.01	3559.06	3431.10	3596.74	4240.70

TABLE 32: VEHICLE OPERATING COSTS ON SHINGLE ROADS FOR CARS PER 1000 KM

Description	Unit	Speed Km/Hr 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	109.14	103.44	111.15	120.15	134.87	157.69	192.95
Engine Oil	Litres	1.44	1.44	1.44	1.44	1.44	1.20	1.20
Tyre Wear	Tyre	0.073	0.097	0.179	0.264	0.407	0.586	1.110
Depreciation	% Veh.	0.77	0.71	0.66	0.62	0.59	0.56	0.54
Interest	% Veh.	0.70	0.58	0.51	0.45	0.41	0.37	0.34
Maintenance								
- Labour	Hrs.	7.38	7.38	7.38	7.38	7.38	7.38	7.38
- Parts	% Veh.	0.6102	0.6102	0.6102	0.6102	0.6102	0.6102	0.6102
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	766.16	726.15	780.27	843.45	946.79	1106.98	1354.51
Engine Oil	Rs.	19.44	19.44	19.44	19.44	19.44	16.20	16.20
Tyre Wear	Rs.	88.33	117.37	216.59	319.44	492.47	709.06	1343.10
Depreciation	Rs.	1177.72	1005.94	1009.47	948.29	902.40	856.52	825.93
Interest	Rs.	1090.5	887.11	780.14	688.27	627.10	569.92	520.03
Maintenance								
- Labour	Rs.	73.80	73.80	73.80	73.80	73.80	73.80	73.80
- Parts	Rs.	933.30	933.30	933.30	933.30	933.30	933.30	933.30
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
Total	Rs.	4619.25	4113.11	4093.01	4055.99	4195.30	4445.78	5226.87
ECONOMIC COSTS								
Fuel Consumption	Rs.	586.08	555.47	596.88	645.21	724.25	846.80	1036.14
Engine Oil	Rs.	16.56	16.56	16.56	16.56	16.56	13.80	13.80
Tyre Wear	Rs.	62.34	82.84	152.87	225.46	347.58	500.44	947.94
Depreciation	Rs.	429.50	395.68	367.82	345.53	328.81	312.09	300.94
Interest	Rs.	390.11	323.23	284.22	250.78	228.49	206.20	189.48
Maintenance								
- Labour	Rs.	73.80	73.80	73.80	73.80	73.80	73.80	73.80
- Parts	Rs.	340.06	340.06	340.06	340.06	340.06	340.06	340.06
Time Costs	Rs.	470.00	350.00	280.00	230.00	200.00	180.00	160.00
Total	Rs.	2368.45	2137.64	2112.21	2127.40	2259.55	2473.19	3062.16

TABLE 33: VEHICLE OPERATING COSTS ON SHINGLE ROADS FOR MINI BUSES PER 1000 KM

Description	Unit	Speed Km/Hr 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	156.52	144.30	136.53	144.52	158.10	172.42	181.89
Engine Oil	Litres	2.16	2.16	2.16	2.16	2.16	2.16	2.16
Tyre Wear	Tyre	0.082	0.111	0.212	0.310	0.469	0.689	1.302
Depreciation	% Veh.	0.31	0.28	0.26	0.25	0.24	0.23	0.22
Interest	% Veh.	0.19	0.16	0.13	0.12	0.11	0.10	0.09
Maintenance								
- Labour	Hrs.	21.89	21.89	21.89	21.89	21.89	21.89	21.89
- Parts	% Veh.	0.5059	0.5059	0.5059	0.5059	0.5059	0.5059	0.505
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	665.21	613.28	580.25	614.21	671.93	732.79	773.03
Engine Oil	Rs.	29.16	29.16	29.16	29.16	29.16	29.16	29.16
Tyre Wear	Rs.	118.90	160.95	307.40	449.50	680.05	999.05	1887.90
Depreciation	Rs.	495.22	447.30	415.35	399.38	384.40	367.42	351.45
Interest	Rs.	302.52	255.60	207.67	191.70	175.72	159.75	143.77
Maintenance								
- Labour	Rs.	218.90	218.90	218.90	218.90	218.90	218.90	218.90
- Parts	Rs.	808.17	808.17	808.17	808.17	808.17	808.17	808.17
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
Total	Rs.	3328.08	3043.36	2976.09	3051.02	3258.33	3570.38	4442.38
ECONOMIC COSTS								
Fuel Consumption	Rs.	519.65	479.08	453.28	479.81	524.89	572.43	603.87
Engine Oil	Rs.	24.84	24.84	24.84	24.84	24.84	24.84	24.84
Tyre Wear	Rs.	72.24	97.79	186.77	273.11	413.19	607.01	1147.06
Depreciation	Rs.	172.34	155.67	144.55	138.98	133.43	127.87	122.31
Interest	Rs.	105.63	88.95	72.27	66.71	61.55	55.60	50.04
Maintenance								
- Labour	Rs.	218.90	218.90	218.90	218.90	218.90	218.90	218.90
- Parts	Rs.	281.25	281.25	281.25	281.25	281.25	281.25	281.25
Time Costs	Rs.	690.00	510.00	410.00	340.00	290.00	260.00	230.00
Total	Rs.	2084.85	1856.48	1791.86	1823.6	1948.05	2147.90	2678.27

TABLE 34: VEHICLE OPERATING COSTS ON SHINGLE ROADS FOR BUSES PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80	90
PHYSICAL FACTORS								
Fuel Consumption	Litres	347.11	302.67	273.38	312.76	425.89	463.04	497.50
Engine Oil	Litres	6.22	5.80	5.53	4.86	3.86	3.56	3.80
Tyre Wear	Tyre	0.236	0.236	0.342	0.392	0.488	0.590	0.878
Depreciation	% Veh.	0.28	0.26	0.24	0.23	0.22	0.21	0.20
Interest	% Veh.	0.15	0.12	0.11	0.10	0.09	0.08	0.07
Maintenance								
- Labour	Hrs.	28.72	28.72	28.72	28.72	28.72	28.72	28.72
- Parts	% Veh.	0.434	0.434	0.434	0.434	0.434	0.434	0.434
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
FINANCIAL COSTS								
Fuel Consumption	Rs.	1475.22	1286.35	1161.87	1329.23	1810.03	1967.92	2114.38
Engine Oil	Rs.	83.97	78.30	74.66	65.61	52.11	48.06	51.30
Tyre Wear	Rs.	525.10	525.10	760.95	872.20	1085.80	1312.75	1953.55
Depreciation	Rs.	1034.39	960.50	866.62	849.68	812.73	775.79	738.85
Interest	Rs.	559.14	443.31	406.37	369.42	332.48	295.54	258.60
Maintenance								
- Labour	Rs.	287.20	287.20	287.20	287.20	287.20	287.20	287.20
- Parts	Rs.	1603.30	1603.30	1603.30	1603.30	1603.30	1603.30	1603.30
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
Total	Rs.	7028.32	6284.06	6040.97	6106.64	6613.65	6840.56	7497.18
ECONOMIC COSTS								
Fuel Consumption	Rs.	1152.41	1004.86	907.62	1038.36	1413.95	1537.29	1651.70
Engine Oil	Rs.	71.53	66.70	63.60	55.89	44.39	40.94	43.70
Tyre Wear	Rs.	328.51	328.51	476.06	545.66	679.30	821.28	1222.18
Depreciation	Rs.	630.72	585.67	540.61	518.09	495.56	473.04	450.51
Interest	Rs.	337.88	270.30	247.78	225.26	202.73	180.20	157.68
Maintenance								
- Labour	Rs.	287.20	287.20	287.20	287.20	287.20	287.20	287.20
- Parts	Rs.	977.61	977.61	977.61	977.61	977.61	977.61	977.61
Time Costs	Rs.	1460.00	1100.00	880.00	730.00	630.00	550.00	490.00
Total	Rs.	5245.86	4620.85	4380.48	4378.07	4730.74	4867.56	5280.58

TABLE 35: VEHICLE OPERATING COSTS ON SHINGLE ROADS FOR TRUCKS PER 1000 KM

Description	Unit	Speed Km/Hrs 30	40	50	60	70	80
PHYSICAL FACTORS							
Fuel Consumption	Litres	505.60	363.20	335.92	307.59	344.96	539.97
Engine Oil	Litres	6.22	5.80	5.53	4.86	3.86	3.56
Tyre Wear	Tyre	0.045	0.064	0.131	0.191	0.290	0.435
Depreciation	% Veh.	0.31	0.28	0.26	0.25	0.24	0.23
Interest	% Veh.	0.23	0.19	0.17	0.15	0.14	0.12
Maintenance							
- Labour	Hrs.	27.44	27.44	27.44	27.44	27.44	27.44
- Parts	% Veh.	0.446	0.446	0.446	0.446	0.446	0.446
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
FINANCIAL COSTS							
Fuel Consumption	Rs.	2148.80	1543.60	1427.66	1307.26	1466.08	2294.87
Engine Oil	Rs.	83.97	78.30	74.66	65.61	52.11	48.06
Tyre Wear	Rs.	127.22	180.93	370.34	539.96	819.83	1229.75
Depreciation	Rs.	1067.05	963.79	894.95	860.52	826.10	791.68
Interest	Rs.	791.68	654.00	585.10	550.73	516.32	481.9
Maintenance							
- Labour	Rs.	274.40	274.40	274.40	274.40	274.40	274.
- Parts	Rs.	1535.18	1535.18	1535.18	1535.18	1535.18	1535.1
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
Total	Rs.	6608.30	5810.20	5512.29	5423.66	5740.02	6875.92
ECONOMIC COSTS							
Fuel Consumption	Rs.	1678.59	1205.82	1115.25	1021.20	1145.27	1792.70
Engine Oil	Rs.	71.53	66.70	63.60	55.89	44.39	40.94
Tyre Wear	Rs.	72.00	102.40	209.60	305.60	464.00	696.00
Depreciation	Rs.	715.48	646.24	600.08	577.00	553.92	530.84
Interest	Rs.	530.84	438.52	392.36	369.38	346.20	323.12
Maintenance							
- Labour	Rs.	274.40	274.40	274.40	274.40	274.40	274.40
- Parts	Rs.	1029.37	1029.37	1029.37	1029.37	1029.37	1029.37
Time Costs	Rs.	580.00	580.00	350.00	290.00	250.00	220.00
Total	Rs.	4952.21	4343.45	4034.66	3922.84	4107.55	4907.37

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