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MINISTRY OF COMMUNICATIONS
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TRENDS IN VOCs USED IN NHA PROJECTS

NTRC-191

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September, 1996

CONTENTS

EXECUTIVE SUMMARY

Saving in Vehicle Operating Costs (VOC) constitutes main benefits of the highway improvement projects. NTRC todate undertook two studies on VOC which have been used by the NHA and other road agencies. The VOC were last updated by JICA as part of National Transport Plan Study (1995).

The present study envisages the computation of VOCs through the application of Highway Design Maintenance (HDM) model developed by the World Bank. It also provides for the comparative analysis of HDM-VOCs viz-a-viz VOCs used for economic appraisal of NHA projects. The objective is to set out data trends and discern the variations in terms of percentage change among the two sets of the VOCs compiled for various projects during past six years. A sample of 20 NHA projects, including 10 projects for highway improvement, 2 Bypass schemes and 8 Bridge projects was taken. However, the HDM model was run to compute the VOCs only for seven projects (initiated almost simultaneously) out of 20 because of the non-availability of data regarding road characteristics i.e. vertical/horizontal profile - an essential component to estimate VOCs by the model, for the remaining projects.

The study revealed that two sets of VOCs were at a sharp variance from each other. Under the un-improved road conditions HDM values evinced large divergence from the PC-I estimates ranging from - 40% for truck 2 axle to + 201% for car in the project of improvement of Kararo-Wad Section (N-25). All the seven projects for which HDM-VOCs were computed, the wagon and bus costs indicated increasing trend (37% to 232% and 10% to 176% respectively) over the VOCs of PC-Is under improved road conditions while decline in HDM values was particularly found in Sukkur

Bypass project. However, the variability within the HDM-VOC estimates for these projects was insignificant relative to large variations within VOCs used in the PC-Is of these projects.

Comparative analysis of variations within the HDM-VOCs suggests that the road characteristics viz. rise and fall, horizontal curvature etc. are important parameters in the computation of the VOCs which apparently have not been taken into account while estimating the VOCs used in the PC-Is of the seven projects.

Moreover, comparing the VOCs through HDM between the projects of similar nature / conditions, variations were insignificant but consistent in trend as opposed to large variations with irregular trend within the PC.I values.

Another important finding of the study is the amount of savings in VOCs, estimated by the model with and without the project. The HDM-VOCs savings present a systematic and steady pattern relative to the wide divergence found in the savings estimated from the PC.I-VOCs. This was also confirmed by the statistical analysis by calculating co-efficient of variations for HDM-VOCs which were less than that of PC.I-VOCs.

The comparison of PC.I-VOCs relative to each other revealed that the VOCs of the projects of same year or with time difference of less than a year were at large variance with each other In most of the project, VOCs were compiled on the basis of NTRC studies (1985, 1991 & 1994) and JICA study (1995). In some cases values were raised by applying escalation factor of 1.5% and 6.5% respectively.

The study also revealed that indices of VOCs used in PC-I when converted into constant prices of 1993 showed on an average, increase over JICA values while bus and truck VOCs were little short of JICA estimates.

It may be concluded from the comparative analysis that HDM model provides robust formulation for predicting the VOCs and needs to be adapted by using local conditions to update the VOCs. However, in the absence of wide use/application of HDM-VOC model for the economic analysis of highway schemes in the country, VOC's compiled in JICA (1995)/NTRC (1994) studies may be set out as benchmarks for PCIs of NHA and other road projects.

CHAPTER - I

INTRODUCTION

Transportation costs born by the road users in terms of vehicle operation and its depreciation are considered to be higher than the highway construction/improvement costs which consume large proportion of the National Budget. There is a need to develop better understanding towards these costs, which is essential for sound planning and management of road investment programs. It is therefore important to compile information on Vehicle Operating Costs (VOCs) which is a significant determinant for estimating the future benefits in the economic feasibility study of the highway construction/improvement.

In the past VOC studies were conducted by the foreign consultant (VOC in West Pakistan-1968),Ministry of Communications and National Highway Board respectively (vehicle user costs in Pakistan-1977 and 1982). Since its inception, NTRC has undertaken two research studies on operating costs of vehicles in 1985 and 1991 respectively. The 1985 study was based on research studies namely Highway Speed Survey (1980), Fuel Consumption Study (1981) and the data/information derived from published work carried out in other countries and has been updated in 1994. The other study (1991) was based on theoretical models developed by TRRL and the empirical values including the results of Road Freight Industry Survey conducted in Pakistan by TRRL in 1987. Besides, VOCs were also worked out on the basis of equations developed by World Bank (1966) in the feasibility studies for different projects carried out by NTRC and in the National Transport Plan Study conducted by JICA in 1988. The latest values of the VOCs are available in JICA Study of 1995 conducted/updated in collaboration with NTRC.

World Bank in 1969 initiated a study in collaboration with leading research institutions/agencies of several countries to develop a quantitative relationship between road construction/ maintenance expenditures and vehicle operation costs. This Highway Design and Maintenance (HDM) standards study provided planning models as a basis for highway decision making. It also led to the development of relationships for estimating VOCs as a function of vehicle type and road characteristics. The VOCs relationships were provided separately in a computer program from large model, which is known as HDM-VOC model.

1.1 Objective and Scope

The present study envisages application of HDM model to estimate the operating costs of different vehicles and analysis of trends in the HDM-VOCs viz-a-viz the vehicle operating costs used in the economic analysis of NHA projects during the past six years. The objective is to set out data on trends by identifying variations among the two sets of the VOCs computed by the HDM model for NHA projects and VOCs estimated through conventional methods and used in these projects since 1990.

1.2 Data and Methodology

The data input for the study is the values of VOCs collected from the PC-I of the different projects and the operating costs computed for different vehicles by HDM model for these projects which had been/are being implemented by NHA during 1990-96.

The World Bank HDM model for VOCs is based on various components comprising the road characteristics, vehicle parameters, including speed and price inputs of vehicle, time, fuel, lubricants, crew/passenger time costs etc. Four types of representative vehicles i.e. cars, wagons, buses and truck 2-axle were considered for HDM model. The PC-I estimates of VOCs were obtained from a sample of

20 road improvement schemes including two feasibility studies prepared by NHA since 1990 onward which are indicated in the table below :

Table 1.1

PROJECTS CONSIDERED FOR THE STUDY

S.No.	Name of Projects	Year of Preparation
I)	Additional Carriageway (N-5) Chablat Nowshera Section and Nowshera Bypass	1995
ii)	Projects for strengthening and Improvement Program of N-5	March, 1996
iii)	Improvement of Uthal-Bela and Sorab - Kalat Sections of N-25	March, 1995
iv)	Improvement of Kararo - Wad Section of N-25	Nov. 1995
v)	Mekran Coastal Road project feasibility study	1994
vi)	Construction of Peshawar - Torkham Expressway	1996
vii)	Improvement of Mansehra - Naran Section	1993
viii)	Dualization of N-5 from Hala - Mian Channu & Bypasses	1992
ix)	Re-alignment of N-5 Near Lahore	1991
x)	Maintenance Backlog Reduction Program (MBRP) of World Bank	1990
xi)	Lahore Bypass Project	1994
xii)	Sukkur Bypass Project	1994
xiii)	Bridge over River Chenab at Chinniot	1992
xiv)	Construction of Overhead Bridge at Wazirabad Railway Crossing	1992
xv)	Feasibility Study for Bridge over River Indus at Mithankot	1990
xvi)	Bridge over River Indus linking Mithankot and Chachran Shauj	May, 1995

xvii)	Bridge over River Chanab linking Shorkot and Garh Maharaja	June, 1995
xviii)	Bridge over River Sutlej linking Pak Pattan with Minchinabad	July, 1995
xix)	Bridge over River Tawaii near Sialkot	Sept.,1995
xx)	Bridge over River Indus near Larkana	Sept.,1995

In order to run the HDM model, NHA was approached to provide input data for road characteristics, e.g. roughness, road geometry including positive & negative gradients (rise & fall) horizontal curvature, attitude of terrain etc. etc. in respect of these projects. However, data meeting the requirements of HDM model were received from NHA only for the seven projects identified at S.No. (i), (iii), (iv), (viii), (xi), (xii) and (xiii) in table 1.1.

The comparison between the two sets of VOCs was made to investigate the variability of the operating costs of vehicles without and with project. As regards the VOCs used in the PC-I of 20 projects, the trends in their values were estimated and studied with respect to time. That is, the PC-Is/projects prepared/implemented in the same years were taken into account and values of VOCs used therein compared with each other.

1.3 Limitations

It may, however, be clarified that trend analysis among PC.I-VOCs have limitations. For example, no two PC-Is or more are similar as far as road characteristics/conditions and terrain of the project area are concerned. The PC-Is were invariably different in these parameters. HDM-VOC included in World Bank's HDM-III model assumes free traffic flow conditions. It does not account for traffic congestion, environmental consideration, road safety and wide range of pavement structure.

The study has been organized in five Chapters. Following the Introduction Chapter II deals with the application of the World Bank HDM model to compute the VOCs for the seven projects and compare it with VOCs used in the PC-Is. The variations between the HDM VOC and the VOCs estimated in JICA and NTRC studies were also analyzed and included the Chapter. Chapter III reports the comparison of VOC trends prevailed in the 20 projects taken in the sample. A statistical analysis of the variations measuring their significance is presented in Chapter IV. This also includes the indices of PC.I-VOCs worked out by bringing them to constant prices of 1993 with a view to identify increase/decrease over JICA study estimates. The final Chapter indicates the findings and conclusions of the study.

CHAPTER II

ESTIMATING VOCs BY HDM MODEL

HDM-VOC model calculates various components of VOCs and unit costs under large and diversified road network and free flow traffic conditions. The detailed mechanistic relationships were developed from controlled experiments & user surveys conducted in Kenya, Brazil, India and the Caribbean. The model covered the vehicle types ranging from small car to medium/articulated truck and computed speed, physical quantities consumed and total operating costs. HDM-VOC relationships can be adapted in other countries using local price inputs and vehicle parameters.

In this study, HDM-VOC model was applied to the road projects to see the difference in the two estimates of VOCs, that is HDM-VOCs and the VOCs which were calculated by conventional methods and used in these projects. As mentioned in the introduction the road characteristics data in respect of vertical profile comprising positive & negative gradients, proportion of uphill travel and horizontal curvature/super elevation was received from NHA only for the following seven schemes out of a sample of 20 projects included in the study:

i). Dualization of N-5 project

ii). Improvement of Kararo-Wad Section of N-25

iii). Improvement of :

a) Uthal-Bela Road Project (N-25)

b) Sorab-Kalat Section of N-25

i). Additional Carriage-way Chablat-Nowshera Section and Nowshera Bypass

ii). Bridge over River Chenab Near Chiniot

iii). Sukkur Bypass

iv). Lahore Bypass

The representative vehicles indicated in JICA study considered for the analysis include Car (Toyota Crolla), Wagon (Toyota Hiace), Bus (Hino) and Truck 2 axle. Data regarding vehicle characteristics i.e. types of vehicle, tare weight, average payload etc. and price inputs such as economic costs of vehicle, fuel, lubricants, passenger/crew time cost etc. were taken from the JICA (1995) & NTRC (1994) Studies. The data relating to road roughness for the seven projects indicated above were obtained from NHA. The HDM-VOC model requires the road roughness in terms of international standard values i.e. Inter- national Roughness Index (IRI) in m/km. For some of the projects it was given in mm/km, which was converted in IRI values (in m/km) by the using equation obtained from Road Note 5 as under:

$$IRI\ (m/km) = 0.0032\ (BI)^{\wedge}\ 0.89$$

(Where BI = Bump Integrator trailer at a speed of 32 km/hr measuring roughness in mm/km).

The roughness of roads under both conditions i.e. un-improved and improved surface for seven projects is tabulated below :

Table 2.1

Sl. No.	Name of Project	Average Roughness (IRI in m/km) Un-improved	Improved
1.	Dualization of N-5	10.0	4.0
2.	Improvement of Kararo-Wad Section (N-25)	7.0	2.5
3.	Additional Carriageway (Chablat-Nowshera) N-5 i/c Nowshera Bypass	5.1	2.5
4.	Chenab Bridge at Chiniot	5.1	2.5
5.	Sukkur Bypass	5.1	2.5
6.	Improvement of N-25 between Uthal-Bela & Sorab-Kalat Section	8.0	3.5
7.	Lahore Bypass	5.0	3.1

HDM-VOC model was run for the road network which had been/was being improved under the projects indicated above. The operating costs of different vehicles under un-improved and improved road conditions were computed and presented alongwith the VOCs used in the PC-I of seven projects in the Table 2.2 as under :

Table 2.2

ESTIMATING VEHICLE OPERATING CPST BY HDM-VOC MODEL (Rs./Km)

		Car		Wagon		Bus		Truck-2axle	
		Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.
	Av.Sp(kph).→	50	90	50	90	40	60	30	50
S.No	Name of Project								
1	Dual.N-5	6.01	3.46	7.78	4.14	10.28	7.46	9.32	5.57
2	Imp.Kararo	5.18	3.48	7.01	4.72	12.84	10.78	11.23	8.37
	wadSec.								
3 a)	Add.Carr.	4.76	3.31	5.71	3.86	9.8	7.4	7.64	5.11
	Ch-Now.N5								
b)	Now.byp.	4.75	3.3	5.71	3.85	9.77	7.36	7.61	5.07
4	Chenab Br-	4.77	3.34	5.71	3.85	9.99	7.64	7.86	5.07
	at Chiniot.								
5	Sukkur By.	4.80	3.44	5.75	3.96	9.92	7.58	7.76	5.26
6	Imp.of N-25								
	between								
(a)	Uthal-Bela	5.39	3.43	5.99	3.78	10.09	7.48	8.67	5.45
	&								
(b)	Sorab-Kalat	5.40	3.47	6.07	3.85	10.22	7.64	8.81	5.62
7	Lhr.bypass	4.74	3.3	5.56	3.76	9.66	7.28	7.2	4.81
	Ave.	5.09	3.39	6.14	3.97	10.29	7.85	8.46	5.59
VEHICLE OPERATING COSTS USED IN PC-Is (Rs./Km)									
1	Dual.N-5	2.3	1.73	2.94	2.5	5.11	3.58	3.59	2.68
2	Imp.Kararo	1.72	1.6	3.9	3.1	7.2	3.9	18.6	7.5
	wadSec.								
3	Add.Carr.	5.43	4.39			7.86	6.74	6.64	6.04
	Ch-Now.N5								
	Now.byp.								
4	Chenab Br-	2.11	1.44	1.89	1.16	4.54	2.94	4.5	2.7
	at Chiniot.								
5	Sukkur By.	6.05	4.14	4.51	2.89	9.97	6.25	8.09	5.46
6	Imp.of N-25								
	between								
	Uthal-Bela	4.7	3.94	3.87	2.68	7.42	5.58	6.01	3.81
	&								
	Sorab-Kalat								
7	Lhr.Byp.	3.03	2.46	3.11	2.11	5.5	5.04	5.83	4.44
	Ave.	3.62	2.81	3.37	2.41	6.80	4.86	7.61	4.66

2.1 Variations within the VOCs Relative to each of the Seven Projects Computed by HDM Model

It is evident from the table that the operating costs of almost all the vehicles varied insignificantly for the three Bypass projects under both conditions of road. Unlike the HDM-VOCs, the costs used in the PC-Is of two projects viz (Sukkur Bypass as against Lahore Bypass) indicated significant variations of increasing trend (23% to 100%) under both road conditions. Taking into consideration the projects with hilly terrain, such as, Improvement of Kararo-Wad Sections and Improvement of Uthal-Bela Sections (both sections of N-25), lesser variations were found within the HDM-VOCs of cars and trucks for the two project sections as compared to the variations within the values of the VOCs used in the PC-Is of these projects. As for the two projects of N-5 viz. Dualization of N-5 and Additional Carriageway between Chablat-Nowshera more than the VOCs of the former project calculated through HDM indicated insignificant increase over the HDM-VOCs of Chablat-Nowshera project under improved road condition. As opposed to this, there was significantly declining trend exist within the VOCs used in these projects.

The above analysis suggested that the road charac-. teristics viz. gradients (rise and fall) horizontal curvature etc. are important variables in the computation of the VOCs which apparently have not been taken into account while estimating the VOCs used in the PC-Is of the seven projects. Moreover, VOCs through HDM varied consistently within the projects of similar nature or conditions than the variations within the PC.I-VOCs where trend pattern showed widening gap between or within themselves. Another feature of the VOCs by HDM observed pertains to the amount of savings in the operating costs with and without the improvement of the road condition. It can be seen from the table 2.1 that pattern of savings accrued as a result of reduction in the VOCs with the improved road

conditions used in the PC-Is was quite irregular/diversified as compared to the trend found in the savings to be derived from HDM-VOCs for the same PC-Is. The HDM-VOCs savings presented a systematic and steady pattern.

2.2 Comparison of HDM-VOCs with PC.I-VOCs

HDM-VOCs were compared with the PC.I-VOCs computed under conventional method. This comparison revealed vast differences between the two sets of operating costs estimated for different vehicles under un-improved/improved road conditions. The details of the variability in terms of percentage increase (+)/decrease (-) in the two methods of estimating VOCs (i.e. HDM-VOCs as opposed to PC-I VOCs) are given in Table 2.3 below :

Table 2.3

PERCENTAGE INCREASE (+) /DECREASE (-) FOR HDM-VOCsOVER VOCs USED IN THE PC-Is (Percent)

		Car		Wagon		Bus		Truck-2axle	
S.no	Name of Project	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.
1	Dual.N-5	161	100	165	66	101	108	160	108
2	Imp.Kararo	201	118	80	52	78	176	-40	12
	wadSec.								
3	Add.Carr.	-12	-25			25	10	15	-15
	Ch-Now.N5								
	Now.byp.								
4	Chenab Br-	126	132	202	232	120	160	75	88
	at Chiniot.								
5	Sukkur By.	-21	-17	27	37	-0	21	-4	-4
6	Imp.of N-25								
	between								
	Uthal-Bela	15	-13	55	41	36	34	44	43
	&								
	Sorab-Kalat								
7	Lhr.Byp	56	34	79	78	76	44	23	8
	Av.inc/dec(%)	41	21	82	65	51	61	11	20

HDM-VOCs showed increase over the PC-Is-VOCs ranging from maximum of as high as 201% for car under un-improved road conditions to a minimum of 12% for truck 2 axle under improved road conditions in the project of improvement of Kararo-Wad Section (N-25). The HDM-VOC for truck showed decline as opposed to VOCs of PC-I, which varied from 4% with and without the Sukkur Bypass project to 40% without the project of improvement of Kararo-Wad Section (N-25). The wagon and bus costs by HDM-VOCs model indicated increasing trend over the VOCs of the PC-Is for the seven projects under improved road conditions. However, the car VOCs in the two out of the seven projects calculated by HDM indicated declining trend as their values were less than the VOCs used in the PC-Is under both conditions of roads. Regarding truck VOCs, HDM values in Sukkur Bypass project were slightly lesser than PC-I values (4%) under both road conditions. It may be concluded that the decline in the HDM values against the PC-I values of VOCs may be spurious.

2.3 HDM-VOCs versus Estimates of JICA & NTRC Studies

Comparing the average operating costs calculated through HDM on the basis of information provided for seven projects with the values of VOCs computed in JICA/NTRC Studies, the variations found are tabulated below:

Table 2.4

(Rs/Km)

S.No	Item	Car		Wagon		Bus		Truck-2axle	
		Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.
1	HDM-VOC (AVERAGE)	5.09	3.39	6.14	3.97	10.29	7.85	8.46	5.59
2	JICA(1995)	3.38	2.64	4.68	3.82	10.46	6.74	7.64	5.44
3	NTRC(1994)	5.66	4.39	4.19	2.9	8.68	6.25	8.09	5.71
	%-age inc (+)/ dec. (-)(1/2)	51	28	31	4	-2	16	11	3
	%-age inc (+)/ dec.(-)(1/3)	-10	-23	47	37	19	26	5	-2

Clearly, the average car VOCs by HDM were significantly greater than JICA estimates but trend was opposite and on the decline when compared with the operating costs of car computed in NTRC study. In case of wagons and trucks JICA estimates for improved road were close to VOCs by HDM model. The detailed comparison (in terms of percentage increase/decrease) of VOCs computed by the HDM model for each of the seven projects viz-a-viz the values of VOC calculated in the JICA and NTRC studies is reflected in the following tables 2.5 and 2.6 as under :

Table 2.5

PERCENTAGE INCREASE (+)/DECREASE(-) FOR HDM-OVER VOCs USED IN THE JICA STUDY
(Percent)

S.No	Name of Project	Car		Wagon		Bus		Truck-2axle	
		Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.
1	Dual.N-5	78	31	66	8	-2	11	22	2
2	Imp.Kararo	53	32	50	24	23	60	47	54
	wadSec.								
3 a)	Add.Carr.	41	25	22	1	-6	10	0	-6
	Ch-Now.N5								
	Now.byp.								
4	Chenab Br-	41	27	22	0	-4	13	3	-7
	at Chiniot.								
5	Sukkur By.	42	30	23	4	-5	12	2	-3
6	Imp.of N-25								
	25between								
(a)	Uthal-Bela	59	30	28	-1	-4	11	13	0
	&								
(b)	Sorab-Kalat	60	31	30	0	-2	13	15	3
7	Lhr.Byp.	40	25	19	-2	-8	8	-6	-12

Table 2.6

PERCENTAGE INCREASE (+) /DECREASE (-) FOR HDM-VOCs OVER VOCs USED IN THE NTRC STUDY (Percent)

S.No	Name of Project	Car		Wagon		Bus		Truck-	
		Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.
1	Dual.N-5	6	-21	86	43	18	19	15	-2
2	Imp.Kararo	-8	-21	67	63	48	72	39	47
	wadSec.								
3	Add.Carr.	-16	-25	36	33	13	18	-6	-11
	Ch-Now.N5								
	Now.byp.								
4	Chenab Br-	-16	-24	36	33	15	22	-3	-11
	at Chiniot.								
5	Sukkur By.	-15	-22	37	37	14	21	-4	-8
6	Imp.of N-25'								
	25between								
(a)	Uthal-Bela	-5	-22	43	30	16	20	7	-5
	&								
(b)	Sorab-Kalat	-5	-21	45	33	18	22	9	-2
7	Lhr.Byp.	-16	-25	33	30	11	16	-11	-16

CHAPTER III

TRENDS IN VOCs USED IN PC-Is OF NHA PROJECTS

Considering the limitations indicated in the Chapter of Introduction, effort has been made to select the like wise PC-Is and compare the economic vehicle operating costs used in the economic appraisal of these projects. The data has been analyzed and the variations and trends have been studied in terms of percentage change. As indicated earlier, a sample of 20 projects has been selected to compare the VOCs used in the projects implemented during more or less same year. The sample comprises 10 projects of highway improvement/construction, 2 Bypass schemes and 8 Bridge projects. This includes 2 feasibility studies on bridges and one document relating to Maintenance Backlog Reduction program (MBRP) financed by World Bank in 1990.

The comparative analysis was carried out within the VOCs used in the projects. A list of tables indicating the project-wise analysis may be seen at the end of the study (p.31).

3.1 Highway Improvement/construction Projects

Comparable figures of two projects namely Additional Carriageway (N-5) Chablat Nowshera Section including Bypass and Nowshera-Peshawar Section of the overall project of Improvement program of N-5 have been taken. Although the N-5 improvement program was prepared in March, 1996 but the VOCs used for economic analysis pertained to 1994 as these were derived from JICA (1995)/NTRC(1994). The comparison of the VOCs used in the two projects is presented in Table 3.1.

Operating costs of cars on both un-improved and improved road conditions for Nowshera-Peshawar Section fell by 12.4% and 10% respectively while truck VOCs showed trivial decrease

(5.07%) after improvement when compared with the VOC estimates of Additional Carriageway (N-5) project. The bus operating cost is at sharp variance with the cost used in Additional Carriageway project under improved road condition indicating an increase of little over one third of the cost of bus in the Improvement project of N-5 (37%). However, the overall average of the entire sections under the N-5 Improvement Program has higher VOCs than those used for Additional Carriageway (N-5) project except the decline in the car operating costs in the former scheme (Col. 9, Table 3.1).

Three Baluchistan projects namely Makran Coastal Road Project (feasibility report), Improvement of N-25 (Uthal-Bela and Sorab-Kalat Sections) and Improvement of Kararo-Wad Section (N-25) prepared in 1994 and 1995 respectively were considered and the VOCs used therein compared and presented in Table 3.2. It is pointed out that figures of savings in VOCs were indicated in the feasibility report. Hence the operating costs of different vehicles were derived/calculated from the benefits given for Liari-Ormar Section, the longest stretch with distance of 248 Kms included in the feasibility study.

Ostensibly, there were substantial variations among three projects. The operating costs of cars and buses for both the road improvement projects evinced declining trend (Col. 6 & 7, Table 3.2) when compared with the Makran Coastal Road project, whilst the truck (2-axle) costs in the Kararo-Wad project were 97% and 13% higher than those used in Coastal Road project under un-improved & improved road conditions respectively. Notwithstanding the fact that increased VOCs (Cars & buses) were attributed to the existing gravel road, but after improvement, the operating costs of these vehicles in the feasibility were still on the rise than the values computed for the other two projects. However, VOCs for wagons and trucks showed reversal of trends prevailing in other VOC estimates (i.e. increasing trends) when Kararo-Wad project was compared with Uthal-Bela/Sorab-Kalat project - all

of which are sections of N-25. That is, there were insignificant increase in the operating costs of wagons whilst increase in truck (2-axle) value amounted to about 97% on improved road condition and over 200% on un-improved road condition for Kararo-Wad project. However, it declined in case of heavy trucks (- 12%).

As regards the NWFP projects, improvement of Mansehra-Naran Section and construction of Peshawar-Torkham expressway were taken into account for the study. The Peshawar-Torkham project was prepared in 1996 while Mansehra-Naran project in 1993. The reason for selecting former project and comparing it with the later one is that no other road scheme of NWFP prepared in 1993 was available. The VOCs values used in these projects and the trend prevailing therein are reflected in Table 3.3.

The operating cost of vehicles for Mansehra-Naran Section project were estimated from the savings in VOCs. Although, these two projects were prepared at different time period, the VOC values for cars & buses used in these projects remained unchanged on improved conditions of road. The truck VOCs declined by 15% for the Peshawar-Torkham Section when compared with the VOC used in Mansehra-Naran Section.

The Table 3.4 presents the comparison of VOCs between projects prepared in 1991 for Punjab & Sind sections of N-5. These are; Re-alignment of N-5 near Lahore and Dualization of N-5 Hala to Mian Channu and Bypasses.

The comparison reveals that VOCs in Dualization project based on NTRC Study (1991) for cars, wagons and buses indicated wide divergence with downward trend from the VOCs used in Re-alignment project on un-improved (-31% to -42%) and improved (-12% to 33%) conditions of road. However, the truck operating costs under both conditions of road in the Re-alignment scheme showed

deviation from the trend prevailing as these registered significantly upward trend (28% and 42% respectively) as against the VOCs used in Dualization project.

For the year 1990, two projects namely the World Banks's Maintenance Backlog Reduction Program (MBRP) and Feasibility Study for Bridge at Mithankot were considered for the study. Despite the fact that these projects are different in nature, the VOC values used in them were compared on the pretext that they were prepared in the same year. Moreover, there was no other NHA project available which could be compared with MBRP. The comparable VOCs and the variations/trends present therein are indicated in Table 3.5.

Under the improved condition of road, increasing trend over the Mithankot Bridge Scheme was observed among the operating costs of all the vehicles except the bus VOC (Col. 6, Table 3.5). The decrease in the bus operating cost was of the order of only 9% under improved road condition.

3.2 Bypass Projects

The two projects namely Lahore Bypass and Sukkur Bypass even though prepared in a span of five months time (Lahore Bypass in October, 1994 while Sukkur in March, 1995), the operating costs of all vehicles based on NTRC study (1994) and used in Sukkur Bypass project showed sharp variation in terms of increase over the VOCs used in Lahore Bypass project. The trends in VOC are reported in Table 3.6. This is explicit indicator of the fact that physical characteristics and other parameters of the project area/road facility were not taken into account while estimating the VOC values for working out the benefits accrued/derived from the project.

The rise in the car operating cost after the completion of Sukkur Bypass was over two third the operating costs on the improved road conditions under Lahore Bypass project while there was almost

quarter increase in case of bus VOCs in Sukkur project over the bus cost in Lahore project under improved road conditions (Col. 6, Table 3.6).

3.3 Bridge Projects

Three bridge projects prepared by NHA in 1995 for Punjab were compared in terms of the VOC values used in the economic analysis of these projects. It may be added that information regarding saving in VOC was available in the PC-I of Tawii Bridge project and the values of VOCs were derived/computed from this data which almost tallied with the VOC estimated in NTRC Study (1994). In the Chenab Bridge project, the VOC of Truck included values for truck 2-axle, multi-axle and Tractor Trolleys. The comparison of VOC can be seen in Table 3.7.

Evidently, the VOCs in all the cases were on the rise in River Tawaii bridge projects (Col. 5) as against the same values of VOCs adopted in the two other projects i.e. Chenab bridge (Col. 3) and Sutlej bridge (Col. 4). However, the bus operating costs on un-improved condition showed insignificant decline (-1.7%).

The comparison in the two schemes of bridges over River Indus in Sind namely Bridge linking Mithankot (May, 1995) and Larkana Bridge (Sept. 1995) were made as reported in Table 3.8.

It is pertinent to point out that VOC values used in Larkana Bridge project were based on NTRC Study (1994) and inflated by 6.5%. The VOCs used in the Larkana project had an increasing trend over the VOCs of Mithankot bridge scheme on the improved condition of road (Col. 6, Table 3.8).

Two other bridge projects prepared in the years 1991 and 1992 respectively for Punjab were compared separately and variations reflected in Table 3.9.

Despite there was difference of little over six months in the preparation time of these projects, the variations presented a declining trend when the values of VOCs used in overhead Bridge project compared with the values used in Chinniot Bridge project. The operating costs of all the vehicles used in Chinniot bridge project indicated downward trend to the extent of one third of the operating costs of all the vehicles taken in overhead bridge project on un-improved as well as improved road conditions (Col. 5, Table 3.9). This may be due to the reason that VOC values used in Overhead bridge were based on NTRC Study of (1985) and were raised at an escalation factor of 1.5%.

3.4. Variation in VOCs compiled in JICA/NTRC Studies Viz-a-viz Other Projects.

Comparison of the VOCs were also made between the projects and the JICA Study of 1995. The details are discussed in the following paragraphs.

a) JICA Study (1995) Versus Improvement of N-25 Project (1995)

Table 3.10 indicated the comparison of VOCs compiled in JICA Study (1995) with the Improvement Scheme of Uthal-Bela & Sorab-Kalat Sections of N-25 and the Improvement Project of Kraro-Wad Section of N-25 separately. Apparently, the JICA Study values of VOCs were somewhat matching with the VOCs used in Uthal-Bela improvement project of N-25 except the car operating costs which varied substantially from those of the JICA Study before and after the project. However, the other project namely the Kararo-Wad Section showed inconsistent pattern of variations with the values of JICA Study.

(b) Peshawar-Torkham (1996) & Nowshera-Peshawar Part Section of Improvement Project of N-5 (1996) Versus JICA Study (1995).

An examination of the comparison presented in Table 3.11 suggested that there were insignificant variations among VOCs of Peshawar-Torkham project Viz-a-viz JICA Study except the

car and bus operating costs compiled in JICA Study which increased by 18% and 25% respectively on un-improved condition of road and 28% on improved condition for the Nowshera-Peshawar project. It may be noted that truck operating costs in JICA Study declined quite insignificantly as the against the two projects of N-5 on improved condition of the road.

(c) VOCs used in 1990 NHA Projects Viz-a-viz NTRC Study 1991

VOC used in two projects namely Bridge over Indus at Mithankot and World Bank's Maintenance Backlog Reduction Program were compared with the values compiled in NTRC Study of 1991 as reported in Table 3.12. It was found that operating costs of all vehicles used in the MBRP indicated small variations except the cost of wagons when compared with the NTRC Study (1991) on the improved condition of road (i.e. -19%).

CHAPTER IV

STATISTICAL ANALYSIS

In the statistical analysis, standard deviations, co-efficient of variations are the parameters to measure dispersion or variations present in the data. The co-efficient of variations can be used to compare the performance (in terms of smaller spread/variations) of two sets of data. The statistical analysis also provides a measure to test the significance of variations within the data values. For this purpose, the t-statistics is normally used for the data having number of observations less than 30. These statistical measures are used for the values of VOCs computed/estimated by HDM model and conventional methods.

4.1 HDM-VOCs Versus VOCs of PC-Is

Two sets of VOCs, that is, VOCs computed by HDM model and the VOCs used in different PC-Is were compared by calculating the co-efficient of variations (C.V.) which are reflected in the table as under :

Table 4.1

(Rs/Km)

	Car		Wagon		Bus		Truck-2axle	
	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.	Un-imp.	Imp.
HDM_VOCs								
Ave.	5.09	3.39	6.14	3.97	10.29	7.85	8.46	5.59
Max	6.01	3.48	7.78	4.72	12.84	10.78	11.23	8.37
Min.	4.74	3.30	5.56	3.76	9.66	7.28	7.20	4.81
Std.	0.42	0.07	0.71	0.28	0.92	1.04	1.17	1.01
C.V. (%)	8.22	2.17	11.53	7.15	8.98	13.30	13.89	18.12
PC.I-VOCs								
Ave.	3.62	2.81	3.37	2.41	6.80	4.86	7.61	4.66
Max.	6.05	4.39	4.51	3.10	9.97	6.74	18.60	7.50
Min.	1.72	1.44	1.89	1.16	4.54	2.94	3.59	2.68
Std.	1.62	1.21	0.84	0.64	1.75	1.32	4.68	1.65
C.V. (%)	44.70	42.83	25.04	26.50	25.70	27.23	61.55	35.48

Evidently, the co-efficient of variations of the VOCs based on HDM model for seven projects (in percentage) were smaller than the co-efficient of variations of the VOCs used in PC-I of these projects. This suggests that there is consistency in the variability among the HDM-VOCs of the seven projects. As such the model provides robust formulation of predicting the operating costs than the VOCs being computed on the basis of conventional methods or set of equations as used in PC-Is. This can also be ascertained from the values of standard deviation calculated for the HDM-VOCs which were small as compared to the values of standard deviation of the VOC used in PC-Is. This indicates that dispersion in the VOC based on HDM model is small and the values are clustered closely about their mean.

4.2 VOCs at Constant Prices of 1993-94

To estimate the real increase/decrease in the operating costs of different vehicles used in the sample of 20 projects prepared at different times, the indices of the VOCs used in PC-I were constituted to convert them into constant prices of 1993. This was done by the use of the GDP deflators indicated in Economic Survey of 1995-96 which were based on 1980-81 prices. However, since comparison is required to be made with JICA Study, the base year was changed to 1993-94 and new GDP deflators were calculated as under :

GDP Deflators Index

	Base Year 1980-81 = 100	Calculated with Base Year 1993-94 = 100
1990-91	204.13	74.06= (204.13) / (275.57)
1991-92	224.69	81.54
1992-93	244.17	88.61
1993-94	275.57	100.00
1994-95	313.15	113.64
1995-96	344.00	125.05

Using the above deflators, the VOCs adopted in the different projects prepared during 1990-91 to 1994-95 were brought to constant prices of 1993-94 and is shown in Table 4.2 as under :

Table 4.2

VEHICLE OPERATING COST AT CONSTANT PRICES OF 1993-94

(Rs/Km)

S. No	Name Of Project	year	Vehicle Type / Road Conditions									
			Car		Wagon		Bus		Truck 2-Axle		Truck-Mxl.	
			Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.
1	Main.Backlog Red. Prog.	1990	5.48	3.56	4.69	3.86	8.37	5.04	5.82	3.51		
2	Mithankot Bridge(F.S.)	1990	5.71	2.75	7.83	3.28	13.56	5.54	4.98	2.55		
3	Re-align of N-5 near LHR	1990	4.48	3.04	6.14	3.97	11.98	6.90	3.78	4.85		
4	Wazbd Rly Cross Bridg	1991	3.89	2.64	3.48	2.15	8.34	5.41	8.28	4.97		
5	Chiniot Brid over Chenab	1991	2.59	1.77	2.32	1.42	5.57	3.61	3.07	3.31		
6	Hala-Mian Channu Dual	1991	2.82	2.12	3.48	3.07	6.55	4.39	2.31	3.29		
7	Mansehra-Naran	1992	4.73	3.01			15.54	8.85	12.38	9.59		
8	Brid ovr Chenab link Shrkt	1994	6.04	3.66	4.48	2.51	8.77	5.93	7.12	5.32	7.12	5.3
9	Lahore Bypass	1994	2.67	2.16	2.74	1.86	4.84	8.77	5.13	3.91	7.57	6.3
10	Brid ovr Indus link Mithkt	1994	6.04	3.66	4.48	2.51	8.77	5.93	7.12	5.32		
11	Sukkur Bypass	1994	5.32	3.64			4.44	5.50	7.12	4.80		
12	Chab-Nows (Add Carri)	1994	4.78	3.86			6.92	5.93	5.84	5.32		
13	Makran Coastal Rds	1994	7.28	4.20			9.93	6.01	8.32	5.32		
14	N-25 Uthal-Bela	1994	4.14	3.47	3.41	2.36	6.53	4.91	5.29	3.35		
15	Brid ovr Indus at Larkana	1995	6.63	4.53	4.94	3.17	10.92	6.85	8.86	5.98		
	(PC-1 for [illegible])											
16	Nowshera-Peshawar	1995	3.81	3.16	5.15	4.45	10.08	7.70	5.74	4.58		
17	Chichawatni-Sahiwal	1995	4.77	3.96	6.45	5.59	12.64	9.25	7.21	5.75		
18	Hyderabad-Hala	1995	4.26	3.54	5.77	4.99	11.29	8.26	6.43	5.13		
19	Hala-Sakrand	1995	4.26	3.54	5.77	4.99	11.29	8.26	6.43	5.13		
20	Rawalpindi-Hazara	1995	3.81	3.16	5.15	4.45	10.08	7.38	5.74	4.58		
21	N-25 Karo-Wad	1995	1.38	1.28	3.12	2.48	5.76	3.12	14.87	6.00		
22	Brid ovr Tawi at Sialkot	1995	6.56	3.44	4.64	2.40	7.84	5.44	10.88	5.04	9.68	5.5
23	Brid ovr Sutlej link Pakptn	1995	5.49	3.33	4.07	2.28	7.97	5.39	6.47	4.83	6.47	4.8
24	Peshawar-Torkham	1995	3.82	2.14			12.01	6.27	7.88	5.76		
	Average		4.61	3.15	4.64	3.25	9.17	6.28	6.96	4.92	7.71	5.4
	Maximum		7.28	4.53	7.83	5.59	15.54	9.25	14.87	9.59	9.68	6.3
	Minimum		1.38	1.28	2.32	1.42	4.44	3.12	2.31	2.55	6.47	4.8
	Standard Deviation		1.40	0.78	1.35	1.17	2.83	1.60	2.73	1.34	1.20	0.5
	Coeff.of Var.(%)		30.27	24.71	29.18	35.99	30.83	25.49	39.21	27.12	15.58	9.65
	T-Statistics		16.18	19.82	13.27	10.76	15.89	19.22	12.49	18.06	12.83	20.7

The overall average of VOCs at constant prices of 1993-94 were compared with the JICA VOC estimates of 1993. The average operating cost of cars showed increase over the JICA estimates (36% and 19% respectively) and VOCs of both bus and truck 2 axle were insignificantly short of JICA estimates under un-improved and improved conditions of road. The comparison is tabulated below :

Table4.3

(Rs/Km)

S. No.		Car		Wagon		Bus		Truck 2-Axle	
		Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.
1	Average VOCs @ Constt.(1993)	4.61	3.15	4.64	3.25	9.17	6.28	6.96	4.92
2	JICA Study(1995)	3.38	2.64	4.68	3.82	10.46	6.74	7.64	5.44
3	NTRC Study (1994)	5.66	4.39	4.19	2.90	8.68	6.25	8.09	5.71
4	Percentage Inc(+)/Dec(-)(1/2)%	36	19	-0	-15	-12	-7	-9	-10
5	Percentage Inc(+)/Dec(-)(1/3)%	-19	-28	11	12	6	-1	-14	-14

Comparison of VOCs at constant prices for individual projects with JICA estimates was also carried out to identify the deviation from the normal average trend. For example in four projects the car VOCs for both road conditions (as opposed to average cost) were less than JICA figures. In case of bus, the VOCs were greater in five projects while truck 2 axles increased over JICA figures in four projects under both conditions of road.

The detailed comparison in percentage increase (+)/decrease (-) follows :

Table 4.4

VOCs AT CONSTANT PRICES(1993) VS JICA STUDY PERCENTAGE INC.(+)/DEC.(-)

S. No.	Name Of Project	Car		Wagon		Bus		Truck 2-Axle	
		Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.
1	Main.Backlog Red. Prog.	62	35	0	1	-20	-25	-24	-35
2	Mithankot Bridge(F.S.)	69	4	67	-14	30	-18	-35	-53
3	Re-align of N-5 near LHR	33	15	31	4	15	2	-51	-11
4	Wazbd Rly Cross Bridg	15	-0	-26	-44	-20	-20	8	-9
5	Chiniot Brid over Chenab	-23	-33	-50	-63	-47	-47	-60	-39
6	Hala-Mian Channu Dual	-17	-20	-26	-20	-37	-35	-70	-40
7	Mansehra-Naran	40	14			49	31	62	76
8	Brid ovr Chenab link Shrkt	79	39	-4	-34	-16	-12	-7	-2
9	Lahore Bypass	-21	-18	-42	-51	-54	30	-33	-28
10	Brid ovr Indus link Mithkt	79	39	-4	-34	-16	-12	-7	-2
11	Sukkur Bypass	58	38			-58	-18	-7	-12
12	Chab-Nows (Add Carri)	41	46			-34	-12	-24	-2
13	Makran Coastal Rds	115	59			-5	-11	9	-2
14	N-25 Uthal-Bela	22	31	-27	-38	-38	-27	-31	-38
15	Brid ovr Indus at Larkana	96	72	6	-17	4	2	16	10
	(PC-1 for STR.&IMP.PROG)								
16	Nowshera-Peshawar	13	20	10	17	-4	14	-25	-16
17	Chichawatni-Sahiwal	41	50	38	46	21	37	-6	6
18	Hyderabad-Hala	26	34	23	31	8	23	-16	-6
19	Hala-Sakrand	26	34	23	31	8	23	-16	-6
20	Rawalpindi-Hazara	13	20	10	17	-4	10	-25	-16
21	N-25 Karo-Wad	-59	-52	-33	-35	-45	-54	95	10
22	Brid ovr Tawi at Sialkot	94	30	-0	-37	-25	-19	42	-7
23	Brid ovr Sutlej link Pakptn	62	26	-13	-40	-24	-20	-15	-11
24	Peshawar-Torkham Express	13	-19			15	-7	3	6

4.3 VOCs of PC-Is (Current Prices) Versus VOCs at Constant Price

To estimate the significance of variability among the current prices of VOCs on constant prices and compare with the VOCs on constant prices of 1993, the statistical test i.e. t-statistics was used

because of the reason that sample size of the study is 20. The t-statistics and other statistical measures are given as under :

Table 4.5

(Rs/Km)

	Car		Wagon		Bus		Truck 2-Axle		Truck-Mxl.	
	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.
Average	5.02	3.46	4.99	3.56	9.90	6.90	7.74	5.41	9.22	6.54
Maximum	8.29	5.67	8.07	6.99	15.81	11.57	18.60	8.50	12.10	7.16
Minimum	1.72	1.44	1.89	1.16	4.54	2.94	1.88	1.89	8.09	6.04
Standard Deviation	1.86	1.18	1.68	1.65	3.40	2.39	3.58	1.75	1.68	0.50
Coeff.of Var.(%)	37.10	34.17	33.64	46.28	34.32	34.70	46.23	32.30	18.17	7.70
T-Statistics	13.21	14.34	12.96	9.42	14.27	14.12	10.60	15.17	11.00	25.96

The analysis reveals that t-statistics was highly significant at 19 degrees of freedom and .01 to 0.1 level of confidence for all the VOCs both for un-improved and improved projects. This means that the VOCs used in the sample projects taken for the study presented substantial variations relative to each other.

The average, standard deviation, t-statistics were also calculated for the VOCs at constant prices and indicated below :

Table 4.6

(Rs/Km)

	Car		Wagon		Bus		Truck 2-Axle		Truck-Mxl.	
	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.	Un-Imp.	Imp.
Average	4.61	3.15	4.64	3.25	9.17	6.28	6.96	4.92	7.71	5.49
Maximum	7.28	4.53	7.83	5.59	15.54	9.25	14.87	9.59	9.68	6.30
Minimum	1.38	1.28	2.32	1.42	4.44	3.12	2.31	2.55	6.47	4.83
Standard Deviation	1.40	0.78	1.35	1.17	2.83	1.60	2.73	1.34	1.20	0.53
Coeff.of ar.(%)	30.27	24.71	29.18	35.99	30.83	25.49	39.21	27.12	15.58	9.65
T-Statistics	16.18	19.82	13.27	10.76	15.89	19.22	12.49	18.06	12.83	20.72

A comparison of the two statistical analysis revealed that variability in the averages of the VOCs at current prices are larger than that among the averages of VOC's at constant prices. This is due to the reason that in later case standard deviation had smaller values and thus were more close to the mean operating costs of the vehicles.

CHAPTER V

FINDINGS & CONCLUSIONS

Findings/conclusions emerged from the analysis are as follows :

HDM-VOCs Model Analysis

i) Generally, allowing for road characteristics and vehicle parameters, HDM model computed VOCs which indicated increasing trend when compared with the VOCs used in PC-I. However, in three projects, HDM-VOCs showed decrease against the PC.I-VOCs.

ii) Among the seven projects, the scheme namely, Improvement of Kararo-Wad Section of N-25 is the one in which car VOCs (computed through HDM model) showed maximum increase of 201% as compared to PC-I values while truck VOCs registered a maximum decline of 40% without the project (i.e. under-un-improved road conditions). The decreasing values of HDM as opposed to PC-I VOCs seems to be spurious.

iii) Among all the seven projects, the wagon and bus operating costs computed by the HDM model presented an increasing trend with significant variations over the PC.I-VOCs under the improved conditions of road.

iv) Comparing the VOCs, computed by HDM model between like-wise projects, variations are found insignificant among these projects and trend consistent and regular as opposed to large variations and irregular trend between the VOCs used in the PC-Is. This is evident from almost all the schemes including two Bypass projects, and two

projects for improvement of three sections namely Kararo-Wad, Uthal-Bela and Sorab-Kalat of N-25 which involve hilly terrain as well.

v) Comparative analysis of variations within the HDM-VOCs suggests that road characteristics e.g. gradients (rise & fall), radius of curvatures/superelevation etc. are important variables and required to be accounted for in computing the VOCs which apparently have not been incorporated in estimating VOCs used in PC-Is of the seven projects.

vi) An important finding of the study is the amount of savings in VOCs, calculated by HDM model, with and without project. These savings indicate a steady and systematic pattern as compared to the trend with large variations (with both the increasing and decreasing trends) present in the savings estimated from the PC.I-VOCs. This was also confirmed by the statistical analysis wherein co-efficient of variations - a measure to compare two sets of data, worked out for HDM-VOCs were found less than that of PC.I-VOCs. It may be concluded that HDM model provides robust prediction for estimating VOCs.

vii) Indices of VOCs used in PC-I when converted into constant prices of 1993 showed on an average, increase over JICA values while bus and truck VOCs were little short of JICA estimates.

PC.I-VOCs Analysis

viii) VOCs of the projects prepared/implemented in the same period of time generally revealed variations (both trends; increasing as well as decreasing) instead of similarity

among their estimates. Occasionally, VOCs among the projects having time lapse of one year or more had an erratic trend i.e. VOCs in the later years were on the decline as compared in the earlier year.

ix) Values of VOCs were normally taken from NTRC Studies of 1985, 1991 and 1994 as well as JICA Study (1995). In some of sample projects these VOCs were increased by applying escalation factor of 1.5% and 6.5% respectively to compute operating costs just after completion of project for the estimation of economic benefits.

x) Most of the PC-Is selected for the study lack absolute figures of VOCs. Rather, saving in VOCs were derived/computed.

xi) In case of heavy vehicles e.g. trucks etc., mostly one value of VOCs was used for all the two axles and multi axles trucks including tractor trolleys.

xii) VOCs for the Bridge projects were not computed on the basis of speed before and after the construction of the bridge, length of the approaches and the bridge. Rather, same values of VOCs were assumed for the bridge as that of road improvement/ construction projects.

xiii) In order to update the VOC or to bring uniformity in their values, there is a need to adapt World Bank's HDM-VOC model for developing countries to local conditions in Pakistan using estimates of local vehicle prices, labour rates & repair costs, vehicle utilization and other parameters.

xiv) In the absence of wide use/application of HDM-VOC model for the economic analysis of highway schemes in the country, JICA (1995)/NTRC (1994) studies may be set out as bench-mark for PC-Is of NHA and other road projects.

LIST OF TABLES

Table 3.1

Trends in Economic VOCs (Rs. / Km.)
(NHA Road Construction & Improvement Projects)

Veh Type	Road Condition	Addl. Carriagway (N-5) Chablat-Nowshera and Nowshera Bypass	N-5 Strengthening & Improvement Programme						Percentage change increased (+) / decrease (-)
			Nowshera-Peshawar section	Chichawatni-Sahiwal section	Hyd.-Hala Section	Hala-Sakrand Section	Rwp-Hazara Section	Avg. of all Sections of N-5 imp. prog. projects	
									col.4 / col.3
1	2	3	4	5	6	7	8	9	10
Car	Un-imp.	5.43	4.757	5.967	5.328	5.328	4.757	4.36	-12.39%
	Imp.	4.39	3.950	4.954	4.432	4.432	3.950	4.34	-10.02%
Wagon	Un-imp.	-	6.436	8.073	7.208	7.208	6.436	7.07	-
	Imp.	-	5.569	6.985	6.237	6.237	5.569	6.11	-
Bus	Un-imp.	7.86	12.607	15.814	14.120	14.120	12.607	13.850	+60.39%
	Imp.	6.74	9.226	11.573	10.333	10.333	9.226	10.138	+36.88%
Truck 2-Axle	Un-imp.	6.64	7.180	9.007	8.042	8.040	7.180	7.890	+8.13%
	Imp.	6.04	5.734	7.193	6.422	6.420	5.734	6.301	-5.07%

Table 3.2

Trends in Economic Operating Cost of Vehicles (Rs. / Km.)
(NHA Road Projects in Baluchistan)

Veh Type	Road Condition	Mekran Coastal Road Project 1994	Imp. of N-25 Uthal-Bela & Sorab-Kalat Section March 1995	Imp. of N-25 Kraro-Wad Section Nov. 1995	Percentage change increased (+) / decrease (-)		
					col.4/ col.3	col.5/ col.3	col.5/ col.4
1	2	3	4	5	6	7	8
Car	Un-imp.	8.27	4.70	1.72	-43.2%	-79.2%	-63.4%
	Imp.	4.77	3.94	1.60	-17.4%	-66.5%	-59.4%
Wagon	Un-imp.	-	3.87	3.90	-	-	+0.8%
	Imp.	-	2.68	3.10	-	-	+15.7%
Bus	Un-imp.	11.29	7.42	7.20	-34.3%	-36.3%	-2.9%
	Imp.	6.83	5.58	3.90	-18.3%	-42.9%	-30.1%
Truck 2-Axle	Un-imp.	9.45	6.01	18.6	-36.4%	+96.8%	+209.5%
	Imp.	6.04	3.81	7.5	-42.6%	+13.0%	+96.9%
Truck 3-Axle	Un-imp.	-	7.74	-	-	-	-
	Imp.	-	5.11	-	-	-	-
Truck multi Axle & Tractor Trolly	Un-imp.	-	12.01	19.1	-	-	+59.0%
	Imp.	-	8.10	7.1	-	-	-12.4%

Table 3.3

Trends in Economic Operating Cost of Vehicles (Rs. / Km.)
(NHA Road Projects in NWFP)

Veh Type	Road Condition	Imp. of Mansehra-Challas Rd. Mansehra-Naran Sec. 1993	Const. of Peshawer-Torkham Expressway 1996	Percentage change increased (+) / decrease (-)
				col.4 / col.3
1	2	3	4	5
Car	Un-imp.	4.193	4.78	14.0%
	Imp.	2.671	2.67	-
Bus	Un-imp.	13.769	15.02	9.1%
	Imp.	7.838	7.84	-
Trucks	Un-imp.	10.973	9.86	-10.1%
	Imp.	8.498	7.20	-15.3%

Table 3.4

Trends in Economic Operating Cost of Vehicles (Rs. / Km.) (NHA Projects, N-5)

Veh Type	Road Condition	Re-Alignment of N-5 Sec. near Lahore. 1990	Dualization N-5 Hala-Mianchannu sec. 1991	Percentage change increase (+) / decrease (-) col.4 / col.3
1	2	3	4	6
Car	Un-imp.	3.316	2.30	-30.6%
	Imp.	2.248	1.73	-23.0%
Wagon	Un-imp.	4.545	2.94	-35.3%
	Imp.	2.835	2.50	-11.8%
Bus	Un-imp.	8.867	5.11	-42.4%
	Imp.	5.344	3.58	-33.0%
Truck	Un-imp.	2.803	3.59	+28.1%
	Imp.	1.884	2.68	+42.3%

Table 3.5

Trends in Economic Operating Cost of Vehicles (Rs. / Km.)
World Bank's Maintenance Backlog Reduction Prog. and Mithan Kot Bridge Project

Veh Type	Road Condition	Feas. Study for Bridge over Indus at Mithan Kot Aug. 1990	W.B. Maint. Backlog Reduction Programme PC-I April 1990	Percentage change increased (+) / decrease (-) col.4 / col.3
1	2	3	4	5
Car	Un-imp.	4.228	4.057	-4.0%
	Imp.	2.039	2.636	+29.2%
Wagon	Un-imp.	5.801	3.474	-40.1%
	Imp.	2.426	2.856	+17.7%
Bus	Un-imp.	10.043	6.198	-38.3%
	Imp.	4.095	3.732	-8.9%
Truck	Un-imp.	3.685	4.307	+16.9%
	Imp.	1.89	2.603	+37.7%

Table 3.6

Trends in Economic Operating Cost of Vehicles (Rs. / Km.)
(NHA Bypass Projects)

Veh. Type	Road Condition	Lahore Bypass Project Oct. 1994	Sukkur Bypass Project March, 1995	Percentage change increased (+) / decrease (-) col.4/ col.3
1	2	3	4	5
Car	Un-imp.	3.028	6.05	+99.8%
	Imp.	2.462	4.14	+68.2%
Wagon	Un-imp.	3.107	-	-
	Imp.	2.114	-	-
Mini Bus	Un-imp.	3.895	4.51	+15.8%
	Imp.	2.541	2.89	+13.7%
Bus	Un-imp.	5.501	9.97	+81.2%
	Imp.	5.042	6.25	+24.0%
Truck 2-Axle	Un-imp.	5.834	8.09	+38.7%
	Imp.	4.436	5.46	+23.1%
Truck multi Axle	Un-imp.	8.597	-	-
	Imp.	7.159	-	-

Table 3.7

Trend in Economic VOCs (Rs/Kms.)
NHA Bridge projects of 1995 (Punjab)

Veh Type	Road Condition	Bridge over river Chanab linking Shorkot & Garh Maharaja June1995	Bridge over river Sutlej linking Pakpattan & Manchinabad July 1995	Bridge over river Tawari near Sialkot Sept 1995	Percentage change increased (+) / decrease (-)
					Col 5 / Col 3
1	2	3	4	5	6
Car	Un-imp.	6.86	6.86	8.2	+19.5%
	Imp.	4.16	4.16	4.3	+3.4%
Wagon	Un-imp.	5.09	5.09	5.8	+13.9%
	Imp.	2.85	2.85	3.0	+5.3%
Bus	Un-imp.	9.97	9.97	9.8	-1.7%
	Imp.	6.74	6.74	6.8	+0.9%
Truck	Un-imp.	8.09	8.09	13.6	+68.1%
	Imp.	6.04	6.04	6.3	+4.3%
Truck 3-Axle	Un-imp.	8.09	8.09	12.1	+49.6%
	Imp.	6.04	6.04	6.9	+14.2%

Table 3.8

Trend in Economic VOCs (Rs/Kms.)
NHA Bridge projects of 1995 (Sind)

Veh Type	Road Condition	Bridge over River Indus linking Mithankot & Chachran May 1995	Bridge over River Indus near Larkana Sept. 1995	Percentage change increased (+) / decrease (-) col.4 / col.3
1	2	3	4	5
Car	Un-imp.	6.86	8.29	+20.8%
	Imp.	4.16	5.67	+36.3%
Wagon	Un-imp.	5.09	6.18	+21.4%
	Imp.	2.85	3.96	+38.9%
Bus	Un-imp.	9.97	13.66	-37.0%
	Imp.	6.74	8.56	+27.0%
Truck	Un-imp.	8.09	11.08	+37.1%
	Imp.	6.04	7.48	+23.8%

Table 3.9

Trend in Economic VOCs (Rs/Kms.)
NHA Bridge projects of 1991/1992 (Punjab)

Veh Type	Road Condition	Const. of Overhead Bridge at Wazirabad Rly. crossing Sept. 1991	Bridge over Chanab River at Chinnot April 1992	Percentage change increased (+) / decrease (-)
1	2	3	4	5
Car	Un-imp.	3.171	2.11	-33.5%
	Imp.	2.153	1.44	-33.1%
Wagon	Un-imp.	2.838	1.89	-33.4%
	Imp.	1.745	1.16	-33.5%
Bus	Un-imp.	6.804	4.54	-33.3%
	Imp.	4.413	2.94	-33.4%
Truck	Un-imp.	6.753	4.50	-33.4%
	Imp.	4.046	2.70	-33.3%

Table 3.10

Comparison of VOCs (Rs. / Km.)
NHA Road Projects (1995) Viz-a-Viz JICA Study (1995)

Veh Type	Road Condition	JICA Study 1995	Improvement of N-25		Percentage change increased (+) / decrease (-)	
			Uthal-Bela & Sorab-Kalat Sections Mar.1995	Kraro-Wad Section Nov.1995	col.4/col.3	col.5/col.3
1	2	3	4	5	6	7
Car	Un-imp.	2.82	4.70	1.72	+66.7%	-39.0%
	Imp.	2.51	3.94	1.60	+57.0%	-36.3%
Wagon	Un-imp.	3.83	3.87	3.90	+1.0%	+1.8%
	Imp.	3.35	2.68	3.10	-20.0%	-7.5%
Bus	Un-imp.	8.06	7.42	7.20	-7.9%	-10.7%
	Imp.	6.70	5.58	3.90	-16.7%	-41.8%
Truck 2-Axle	Un-imp.	5.33	6.01	18.60	+12.8%	+249.0%
	Imp.	3.86	3.81	7.50	-1.3%	+94.3%
Truck 3-Axle	Un-imp.	7.36	7.74	-	5.2%	-
	Imp.	5.09	5.11	-	+0.4%	-
Truck multi Axle & Tractor Trolly	Un-imp.	11.44	12.01	19.1	+5.0%	+67%
	Imp.	8.71	8.10	7.1	-7.0%	-18.5%

Table 3.11

Comparison of VOCs (Rs. / Km.)
NHA Road Projects (1996) Viz-a-Viz JICA Study (1995)

Veh Type	Road Condition	JICA Study 1995	Peshawar-Torkham Project 1996	Nowshera-Peshawar Section of Imp. of N-5 Project 1996	Percentage change increased (+) / decrease (-)	
					col.4/ col.3	col.5/ col.3
1	2	3	4	5	6	7
Car	Un-imp.	4.04	4.78	4.76	+18%	+18%
	Imp.	2.54	2.67	3.95	+5%	+56%
Bus	Un-imp.	12.0	15.02	12.61	+25%	+5%
	Imp.	7.21	7.84	9.23	+9%	+28%
Truck	Un-imp.	9.6	9.86	9.01	+3%	-6%
	Imp.	7.35	7.20	7.19	-2%	-1%

Table 3.12

Comparison of VOCs (Rs./ Km.)
NHA Projects (1990) Viz-a-Viz NTRC Study (1991)

Veh. Type	Road Condition	Mithan Kot Bridge over Indus 1990	World Bank-MBRP 1990	NTRC Study 1991	Percentage change increased (+) / decrease (-)	
					col.5/ col.3	col.5/ col.4
1	2	3	4	5	6	7
Car	Un-imp.	4.23	4.00	3.51	-17%	-14%
	Imp.	2.04	2.64	2.68	+31%	+2%
Wagon	Un-imp.	5.80	3.47	2.70	-53%	-22%
	Imp.	2.43	2.86	2.31	-5%	-19%
Bus	Un-imp.	10.04	6.20	5.11	-4.9%	-18%
	Imp.	4.10	3.73	3.58	-13%	-4%
Truck	Un-imp.	3.69	4.31	3.59	-3%	-17%
	Imp.	1.89	2.60	2.68	+42%	+3%