International Journal of Advance Research in Engineering, Science & Technology(IJAREST),
ISSN(O):2393-9877, ISSN(P): 2394-2444,
Volume 2,Issue 5, May-2015, Impact Factor: 2.125

Economic Appraisal of Highway Project:

A Case Study of Nashik-Peth Section of NH-848

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Abstract: *Roads build the nation. Roads are the dominant mode of transportation in India. Roads carry almost 85 percent of the country's passenger traffic and more than 62 percent of its fright traffic. Due to improvement in transportation network, reduction in transportation costs can be realized in numerous ways, such as reduction in travel time, decrease in vehicle operating costs, increased safety and reduction in the level of air and noise pollution. In addition to reduction in transportation cost, it also increase comfort to passengers and also enhancing land value. Economic appraisal is a critical component of a comprehensive project evaluation methodology that considers all key quantitative and qualitative impacts of highway investments. The scope of present study consists of evaluating the impact on traffic and checking economical viability of the project. Strengthening and widening for two lanes with paved shoulder of flexible pavement road namely, Nashik-Peth Section of NH-848 is taken as a case study. In spite of heavy initial investment in strengthening and widening to two lane with paved shoulder of flexible pavement, economic analysis carried out using HDM-IV software results indicates that there is great saving towards Vehicle Operating cost (VOC) and Travel Time cost (TTC) after improvement. Economic Internal Rate of Return of 27.30% also indicate that improvement of flexible pavement is economic viable.*

Key words: Economic Appraisal, Vehicle Operating Cost, Travel Time Cost

I. INTRODUCTION

Transportation occupies high space in modern life. Advancement in all spheres of life has been to a large extent influenced by transportation facility. Transportation is best thought of as a tool to transport goods and peoples from one place to another. Investment in highways or other facilities generates benefit in the form of lowering the transportation cost for making movement and also enhances the level of Gross Domestic Product (GDP) through mobilization of unemployed factors of production thus enabling economic growth and development. The bulk of passengers and goods movement in India takes place by roads, which are facilitated through an extensive road network. Roads provide mobility and accessibility to the people. Roads build the country. For any nation, road transport is very important for economic growth. The construction of road brings a variety of benefits that is enjoyed by all sectors of the economy.

II. OBJECTIVES

- To study the different aspects of economic appraisal of highway project.
- To collect detailed data of traffic, accidents and to analyze the data of various surveys.
- To check the economic viability of the case-study by HDM-4 software.

III. LITERARURE REVIEW

David Ashley et.al (1998) carried out a research to know the viability of privatized transportation project and developed a Project Scoring Table(PST). A principal way by which the PST can help define public-private partnerships is by distinguishing those decisions in which the interests of the owner and the developer are the same, and when they are different. **Archondo Callao (2004)** carried out a research to check the efficiency of HDM-4 software for developing countries for strategic planning and programming of road networks. The biggest challenges in carrying out a network HDM-4 evaluation are; (i) the network data collection, which can be an uncomplicated process if proper simplifications and assumptions are made; (ii) the limitations of HDM-4 version 1.3, particularly on the presentation of the evaluation results. **Rena Shukla (2005)** carried out a study of economic appraisal of road projects. Highway Development and Management (HDM) model was used for the economic appraisal of case study of Sardar Patel ring road of Ahmedabad city. The IRR obtained by using HDM-IV (version 1.1) software for an alternative suggesting 4-lane bypass; bituminous road was 28%(with time saving). **Ross B. Corotis (2007)** carried out a study for

highway user travel time evaluation. This study has investigated an alternative approach to the very important valuation of user time, which serves both as a benefit measure for new projects and a cost item during construction and maintenance. **Garry D. Creedy et.al (2010)** carried out a study for evaluation of risk factors leading to cost overrun in delivery of highway construction projects. This can be useful for owners in determining more realistic decision-to-build highway budget estimates by taking into account the economies of scale associated with larger projects. **G.P. Ong et.al (2012)** carried out a research for hazard based analysis of highway project development. Transport agencies around the world recognize the importance of on-time on-budget delivery of highway projects and understand the need for an efficient transport development process. The tools presented in this paper can assist highway agencies with improving project development processes in order to accomplish better use of federal and state funds, cause less disruption to project programs, and reduce the risk of upsetting letting schedules for construction bidding. **Yi Jiang, Guangyuan Zhao and Shuo Li (2013)** reviewed the current methods and practices of economic analysis of highway projects and developed a excel based computer program for economic appraisal of highway project. The output of the economic evaluation is presented with user friendly tables and graphs.

IV. ADOPTED METHODOLOGY

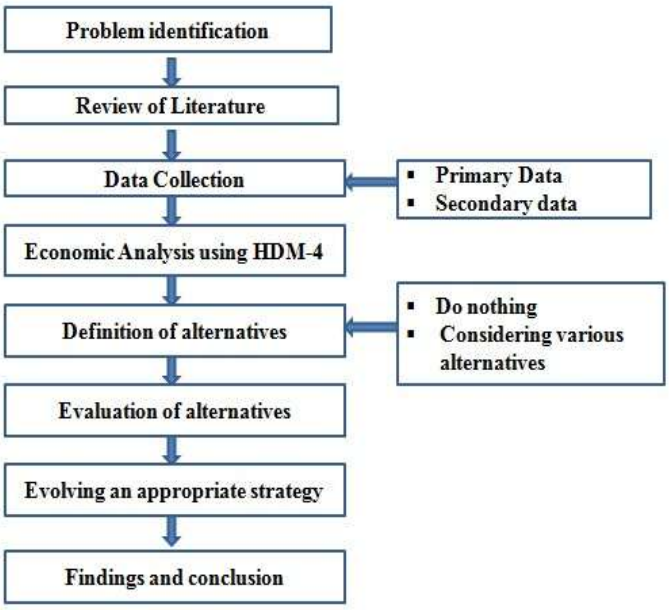

Fig. 1: Methodology adopted for the study

V. STUDY AREA

Nashik-Peth is situated at north-west part of Maharashtra and is a section of **NH 848 (old SH 22)**, having total length of **54 Kilometre**. The project road lies between 73°47' (E) to 73°26' (E) longitude and 20°02' (N) to 20°17' (N) latitude.

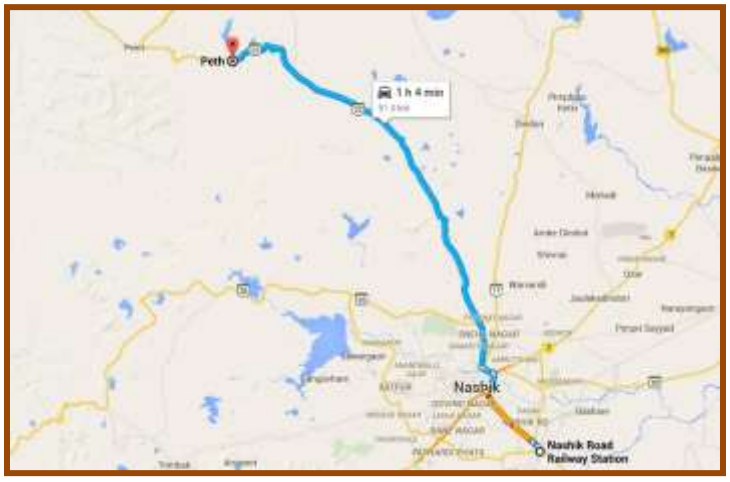

Fig 2: Google Image of the Study Area

➢ Climate:

The climate of Nashik district is characterized, by dryness except in the south-west monsoon season. The year may be divided into four seasons. The cold season from December to February followed by the hot season from March to May and the south-west monsoon season from June to September followed by the post-monsoon season during October and November. May is the hottest month with the mean daily maximum temperature at 37.4 °C (99.3 ºF) at Nasik. December is the coldest month with the mean daily minimum temperature at 10.2 °C (50.4 °F) at Nasik. The normal annual rainfall in Nashik varies from 2,600 mm to 3,000 mm. Nearly all the rain falls between June and October, with July and August being the wettest months. The cold-weather season is the most pleasant part of the year.

➢ Existing Carriageway, Alignment and Geometry:

The road has 5.5 m width intermediate lane carriageway with 0.5 m to 1.5m wide earthen shoulders on either side of the carriageway. The carriageway is provided with flexible pavement. The alignment is passing through rolling terrain in most of its length except at few stretches of hilly terrain. The average travel speed is 30-40km/hr or less, because of poor condition of pavement and geometry of the road.

➢ Embankment and Surface Drainage:

The drainage condition along the project corridor is very poor and needs to be improved. The existing shoulder slope does not facilitate proper drainage and water stagnation on the shoulders is a common problem specifically in monsoon. Earthen ditches exists in some stretches; especially in sections having steep gradient but have not been maintained properly and were found choked at number of places. The high embankments are eroded in the absence of drainage chutes.

➢ There are sixteen intersections (1 major, 15 minor), seven minor bridges and one hundred and seventeen culverts on the study road.

➢ Existing Pavement Condition by Pavement Condition Survey by Visual Inspection:

Fig 4: Pavement Condition

VI. TRAFFIC SURVEYS, ANALYSIS AND FORECAST

➢ Classified Volume Count Survey:

The objective of classified traffic volume count survey is to estimate traffic intensity on the road. The classified volume count survey at one strategic location on the project road has been carried out for 7 days with 24 hours/day. External classified volume count survey was carried out at one location for 3 days. The all values obtained category wise were converted from Average Daily Traffic (ADT) to Average Annual Daily Traffic (AADT) by applying seasonal correction factors.

Sr No.	Location	AADT Nos	AADT PCUs	Up (%)	Down (%)
1	Near Chachadgaon Village	4058	5725	49.1	50.9
2	Near Vani Village (External)	7742	8499	48.8	51.2

Table 1: Average Annual Daily Traffic

➢ Origin and Destination Survey:

The objective of the Origin-destination survey is to estimate the number of trips with respect to origin and destination. O-D surveys helps in the estimation of future diverted traffic on project road once a better transportation facility is available. Zoning system and Road side interview method was used to know the travel pattern. The outcome of the survey is briefed here.

- Near Chachadgaon village, the travel pattern of **Goods vehicles** reveals that maximum 13.2% and 30.8% of goods trips have Origin & Destination as Gujarat (Vapi, Valsad, Dharampur, Saputara, Ahwa). So Gujarat is the most influencing zone of the project road. The travel pattern of **Passenger vehicles** reveals that maximum 48.3% and 39.4% of passenger trips have Origin & Destination as Nashik. So Nashik is the most influencing zone of the project road.
- Near Vani village, the travel pattern of **Goods vehicles** reveals that average 16.4% of goods vehicles on NH-360 are interacting between Gujarat and Ahmednagar. The travel pattern of **Passenger vehicles** reveals that average 24.8% of passenger vehicles on NH-360 are interacting between Nashik and Saptashrungigadh.

➢ Willingness to Pay Survey:

To assess the willingness of the road users to pay toll, if the facility is developed on a commercial basis, the WTP survey was conducted. Tollable vehicles such as Car, Bus and Trucks have been interviewed for WTP survey. WTP survey has been conducted along with origin destination survey at one location near Chachadgaon village on project

road. It was necessary to understand the response of the road users and their willingness against a longer period. Truck and Bus Operators were interviewed to facilitate an understanding of the willingness to pay for commercial vehicles.

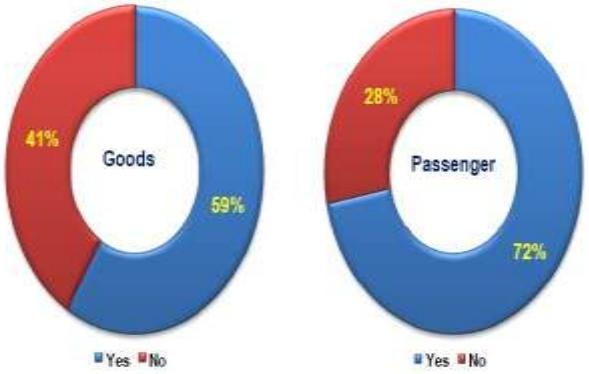

Fig 5: Willingness to Pay Survey

➢ Axle Load Survey:

Traffic loading on highway pavements is a heterogeneous combination of different types of vehicles, carrying a wide spectrum of wheel loads. The objective of Axle Load Survey is to get Vehicle Damage Factor (VDF) which is vital for Pavement Design. The variation in Axle loads is determined by reducing the actual axle loads to an "Equivalent Standard Axle Load".

Table 2: Adopted VDF Values

Homogeneous Section	LCV 4 W	LCV 6 W	2 Axle	3 Axle	MAV
Nashik-Peth	0.06	0.31	3.60	3.82	4.77

➢ Turning Movement Count Survey:

The objective of intersection traffic volume count survey was to obtain information on direction-wise movement of the traffic at one major intersection on the project road. The remaining intersections are minor having negligible traffic flow. On the basis of connectivity and traffic flow, the turning movement count survey has been carried out at one major (Surgana- T) intersection. Peak hour traffic was 711 PCU. Junction can be improved as a channelized intersection for smooth & efficient traffic movements.

➢ Speed Delay Survey:

The purpose of the travel time and delay study is to evaluate the quality of traffic movement along a route and to determine the locations, types and extents of traffic delays. The efficiency of flow is measured by travel and running speeds. In the actual study, total travel and running times are observed and then converted into speed measures. A test vehicle is driven along the study route in accordance with moving car technique, in which, a safe level of vehicular operation is maintained by observing proper following and passing distances and by changing speed at reasonable rates of acceleration and deceleration. Delay information is recorded when the traffic flow is stopped or greatly impeded. Following information was collected during the survey:

- Number of vehicles in the opposite direction of test vehicle;
- Number of vehicles overtaken by the test vehicle;
- Number of vehicles overtaking the test vehicle;
- Amount of delay occurred; and Location & reasons for the delay, etc.

Table 3: Summary of Speed Delay Survey (Nashik to Peth)

Direction	**Nashik to Peth**
Distance Covered	54 km
Average journey speed	36.95 kmph
Average running speed	44.57 kmph
Average journey time	87.69 mins
Direction	**Peth to Nashik**
Distance Covered (Km)	54 km
Average journey speed	41.75 kmph
Average running speed	47.92 kmph
Average journey time	77.61 mins

➢ Road Accidents Characteristics and Analysis:

The increasing road accidents on major roads in our country are a major cause of concern. Considering the urban

expanse, population growth and increasing trend of vehicles on the roads; the safety of the commuters is equally vital. There are many reasons for the growth in the number of accidents in India. Accidents are caused not merely due to the increase in population and rise in vehicle ownership. They are also caused due to the casual approach of road users in observing driving rules, not adhering to safety precautions and regulations. Rush and negligent driving have proved to be a frequent cause of serious and fatal accidents. Similarly, poor road geometry and inadequate signage have also increased the incidence of accidents on highways. One of the major causes of pedestrian safety is endangered by extended trading activities of shops and commercial activity on footpaths and sidewalks. This compels pedestrians to clog the road space, hence vulnerable to accidents. Accident data were collected from Dindori and Peth police station along the project road which are shown in Table 4 below.

Table 4: Road accidents analysis

Year	Nature of Accident		
	Fatal	Major	Minor
Peth Police Station			
2010	2	7	2
2011	0	4	3
2012	4	3	1
2013	5	1	1
2014	1	2	4
Dindori Police Station			
2010	7	0	4
2011	8	0	2
2012	3	1	1
2013	7	0	1
2014	1	0	0
Total Road Accidents	38	18	19

➢ Traffic Demand Forecast:

Traffic forecast have been carried out for a period of 30 years with the horizon year as 2044. Econometric Model Method: IRC 108-1996 is used for calculation of traffic growth rates. Past Trends in Economy and Population, Vehicle registration are analyzed for Project Influence Areas (PIA). The transport demand elasticity values are taken from IRC SP: 19 and Vision 2021, MORTH. Traffic Growth Rates are calculated according to IRC 108-1996.

Table 5: Adopted Traffic Growth Rates

Year	2 W	Auto	Car	Bus	LCV
2015-19	10	5	11.8	5.3	10.5
2020-24	9.3	5	11.1	5.1	9.4
2025-29	8.7	5	10.4	5	8.5
2030-34	8	5	9.7	5	7.6
2035-39	7.4	5	9.1	5	6.9
2040-44	6.7	5	8.4	5	6.2

Year	2 Axle Trucks	3 Axle Trucks	MAV	Tractors with Trailors	Tractors without Trailors
2015-19	5.5	5.5	5.5	10.7	8
2020-24	5	5	5	9.9	7.2
2025-29	5	5	5	9	6.3
2030-34	5	5	5	8.2	5.5
2035-39	5	5	5	7.4	5
2040-44	5	5	5	6.6	5

➢ Design Traffic:

For project road homogeneous section, the cumulative numbers of axles during the design period (ESAL) is calculated using the following equation:

$$\text{Design Traffic (N)} = A \times 365 \times \frac{(1+r)^n - 1}{r} \times LDF \times VDF$$

Where,

N = Cumulative numbers of standard axles to be catered for in the design in terms of MSA

A = Operating Year AADT (Direction wise)/Initial traffic in year of completion in terms of commercial vehicle per day

r = Annual growth rate of a given commercial Vehicle

n = Design life in year

LDF = Lane Distribution Factor

VDF = Vehicle Damage Factor

The cumulative numbers of standard axles have been calculated assuming that the project road will be opened to traffic in the year 2017. Since project road is of intermediate lane carriageway width, for entire section, Lane Distribution Factor of 0.5 is used for determination of MSA.

Table 6: Million Standard Axles (MSA)

Year	Nashik-Peth	
	By calculated Growth Rate	Adopted
15	16.53	20

- Capacity Analysis and Level of Service:

Capacity analysis is fundamental to the planning, design and operation of roads. It is a valuable tool for evaluation of the investment needed for the future improvements. The capacity figures used for determining the desired carriageway width in differing terrain with respect to traffic volume and composition are as per IRC: 64-1990, IRC SP: 73 -2010 and IRC SP: 84- 2009. As per IRC 64:1990, it is recommended that on major arterial routes LOS B should be adopted for the design purpose. On other roads under exceptional circumstances, LOS C could also be adopted for design. For LOS C, Design service volume can be taken as 40 % higher than those for LOS B. The project road is passing through plain and rolling terrain. For the purpose of augmentation of the facilities and up gradation of the project highway, the design service volume for the Plain/rolling terrain condition and level of Service B & C is taken into consideration.

VII. COST ESTIMATE

The detailed estimate is worked out based on the quantities calculated for the items of work to be executed in the proposed study and also rates derived after detail analysis and as contained in the Basic schedule of Rates (2012-2013), PWD, Nashik. The cost estimate has been done with the consideration that the full proposed length of the road will be constructed in single section. The Summary of the cost estimate is described in the following table.

Table 7: Detail Cost Estimate

Sr. No.	Item of Works	Cost (Amount in Rs.)
	Civil Works	53.456
1	Site Clearance & Dismantling	4,40,57,200
2	Earthwork	15,91,29,940
3	Sub-Bases, Bases (Non- Bituminous) & Shoulders	68,33,54,784
4	Bases and Surface Courses (Bituminous Layers)	83,84,01,462
5	Bases and Surface Courses (Cement Concrete)	1,17,81,250
6	Culverts	11,85,88,234
7	Major / Minor Bridges, ROBs, Flyovers & Underpasses	7,97,68,180
8	Drainage and Protective Works	14,24,97,757
9	Traffic Signs, Markings & Other Road Appurtenances	4,25,61,487
10	Maintenance of Road During Construction	1,67,97,483
11	Miscellaneous Items	11,71,45,140
	Add 0.5% Quality Control	1,12,70,415
	Add 1% Insurance / EPF etc.	2,25,40,829
A	Total Construction Cost	2,28,78,94,160
B	Contingencies @ 1% on (A)	2,28,78,942
C	Sub-total [A + B]	2,31,07,73,102
D	Construction Supervision Charges @ 4% on [A]	9,15,15,766
E	Escalation @ 5% per annum for 2 Years i.e. 10% of A	22,87,89,416
F	Sub Total [D + E]	2,63,10,78,284
G	Land Acquisition [@10% of A]	22,87,89,416
H	Utility Shifting [@2.5% of A]	5,71,97,354
I	R & R cost [@10% of A]	22,87,89,416
J	Environmental Mitigation Measures Cost including Forest Clearance [@7.5% of A]	17,15,92,062
K	Environment Impact Assessment, Land Acquisition, Resettlement and shifting of utilities	68,63,68,248
	Total Cost [F + K]	3,31,74,46,532

VIII. ECONOMIC ANALYSIS

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. It is therefore important that decisions about investments in roads are made on objective judgments and therefore, Economic appraisal has been carried out for each traffic homogenous section of entire Project road. The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the proposed study is worthy of investment keeping in view the benefits to the society. The Proposal for project road is i.e. rehabilitation and up gradation to 2 lanes with paved shoulders of Nashik-Peth section, NH-848. In order to assess the benefits accrued to the society; both the options of 'Without Improvement' and 'With Improvement' have to be compared. For this purpose, the entire existing road has been considered along with its proposed maintenance and improvement proposals. In general, in case of economic analysis is also recommended that analysis period should not be long as it may lead to erroneous results. However, in order to be able to draw the conclusions on common platform Economic Analysis have

also been carried out for 20 years of analysis period. The summary of Economic internal rate of return (EIRR) worked out, for construction option based on life cycle cost analysis is presented below. HDM-4 output of discounted Net Benefit Cost Ratios is presented vide **Annexure 1.** HDM -4 output of economic analysis summery is presented vide **Annexure 2.**

Table 8: Result of Economic Analysis

Homogenous Section	Net Economic Benefit (Discounted NPV @ 12%)	Economic Internal Rate of Return (12%)
Nashik-Peth	5153.26	27.4

IX. SENSITIVITY ANALYSIS

The Sensitivity analysis has been carried out in order to study the viability of the project against the uncertainties in traffic forecasting and the possible variations of project cost due to unforeseen reasons. The sensitivity analysis has been for worst condition, considering that traffic will drop 20% and cost of construction will increase 20%.
Scenario 1: Base cost and Base Benefits.
Scenario 2: Base cost plus 20% and Traffic minus 20%

Table 9: Results of Sensitivity Analysis

Sr No.	Scenario	EIIR (%)
1	Base cost and Base Benefits	27.3
2	Base cost plus 20% and Traffic minus 20%	20.2

X. EXPECTED SOCIO-ECONOMIC BENEFITS OF THE PROJECT (SOCIAL DEVELOPMENT OUTCOMES)

Better road, free and fast movement of goods and traffic, direct link with the adjoining places of the district will not only earn economic benefits to the district but also bring in many more inputs towards social development. Some of socio-economic benefits of the project are being enumerated out as below:

- Travel times will greatly reduce and local communities will enjoy enhanced accessibility to socio-economic services (health centers, markets, employment opportunities), with reduction in travel time.
- Reduced travel times will reduce vehicle operating costs (VOCs) for local communities and auto rickshaw, bus, and truck operators, thereby reducing maintenance costs and increasing profits.
- More services will be available along the route (large/small buses, trucks/pickups, three-wheelers, etc.) via private and public sector operators. More frequent and better-quality services will be available around the clock.
- Income and employment opportunities will increase as a result of the diversification of commercial enterprises.

XI. CONCLUSION

The road is economically viable for proposed improvement as it yields more than 12% return (assumed interest rate for the analysis). The proposed improvement is also viable for worst sensitivity alternatives.

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ANNEXURE-I
DISCOUNTED NET BENEFITS STREAM

HDM-4

Annexure 1: Discounted Net Benefit Streams
HIGHWA\DEVELOPMENT & MANAGEMENT
Study Name: Nashik-Peth Run Date: 16-02-2015
Currency: INR (millions)
Discount rate: 12.00 %
Discounted Net Benefit Streams
Section: Nashik-Peth
Alternative: 2 lane Improvement
Sect ID: N_P Road Class: Primary or trunk
Length: 54.00 km Width: 5.50 m Rise+Fall: 25.00 m/km Curvature: 115.00 deg/km

Year	Increase in Road Agency Costs			Savings in Road User Costs			Total Net Benefits
	Capital Works	Recurrent Works	Special Works	Normal (+ Diverted) Traffic MT VOC	MT Time	NMT Time & Operation	
2015	1,072.39	-10.056	0	0	0	0	-1,062.33
2016	1,436.23	-7.865	0	9.169	0.19	2.669	-1,416.34
2017	0	-7.192	0	159.998	226.382	-5.242	388.33
2018	0	-6.386	0	161.001	219.72	-3.684	383.423
2019	0	-6.022	0	161.931	212.68	-1.379	379.254
2020	0	-7.243	0	162.38	205.904	0.801	376.328
2021	105.055	-6.643	0	162.068	199.07	2.585	265.311
2022	0	-5.931	0	176.126	194.351	8.418	384.826
2023	0	-5.295	0	180.261	190.976	10.201	386.734
2024	0	-4.728	0	186.611	189.821	12.425	393.585
2025	0	-0.049	0	205.83	199.569	17.387	422.834
2026	59.611	-0.043	0	241.42	230.03	25.902	437.783
2027	0	-0.039	0	260.796	248.707	30.957	540.498
2028	0	-0.035	0	252.16	241.11	28.126	521.431
2029	0	-0.031	0	242.896	232.904	25.552	501.383
2030	0	-0.028	0	234.287	225.305	23.21	482.83
2031	33.825	-0.025	0	226.199	218.171	21.078	431.647
2032	0	-0.022	0	219.332	211.517	19.507	450.378
2033	0	-0.02	0	212.231	205.263	17.729	435.244
2034	-31.128	-0.018	0	204.491	198.361	16.113	450.11
Total:	2,675.98	-67.669	0	3,659.19	3,850.03	252.357	5,153.26

ANNEXURE- II
ECONOMIC ANALYSIS SUMMARY

HDM-4
Economic Analysis Summary
Alternative: 2 lane Improvement vs Alternative: Base Case
Analysis Mode: Analysis by Project

	Increase in Road Agency Costs		Savings in MT VOC	Savings in MT Travel Time Cost	Savings in NMT Travel & Operating Costs	Net Economic Benefits
	Capital	Recurrent				
Undiscounted	3034.95	-113.06	15002	15001.37	1251.53	28332.98
Discounted	2675.98	-67.67	3659.19	3850.03	252.36	5153.26

Economic Internal Rate of Return (EIRR) = 27.4% (No. of solutions = 1)