

ECONOMIC EVALUATION OF TOWN BYPASS: A CASE STUDY OF MANDVI

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Abstract— A bypass road is special road that divert large part of traffic from main town to avoid traffic congestion from local traffic and improve the road safety. Such condition is existing in Mandvi town in Kutch, district of Gujarat state. In this town large part of through traffic and local traffic cause unnecessary slow movement of the traffic which in turns to increase in vehicle operating cost and number of accident occurred in town due to the heavy traffic. Feasibility of bypass is carried out. Land acquisition estimate and pavement design is done. Economic evaluation of Mandvi bypass is worked out using Cost-Benefit Ratio, Net Present Value Method, and Internal Rate of Return Method.

Keywords— Bypass Road, Economic Evaluation Methods, Net Present Value Method, Benefit/Cost ratio, Internal Rate of Return.

INTRODUCTION

India is a developing country. Growth of population is very high so that supply and demand of transport is also increasing that is why India needs better transportation infrastructure growth. At present, demand is increasing at 150 times and infrastructure is increasing at 8 times in a year. So, in India traffic problem is severe in city area. To reduce the traffic congestion in city area, bypass highway is most preferable solution. Bypass is a type of special road that diverts the through traffic from the city area. This decreases the congestion and increases the safety at through road. Bypass road is also important for the development of the city. Bypass has negative impacts, like business community that serves the need of highway travelers, in some cases being adversely affected by declining sales and employment losses.

Highway economic analysis, also known as highway project appraisal, is a technique whereby the cost of and benefit from a scheme are quantified over a selected time horizon and evaluated by a common yardstick.

Economic analysis is not concerned about past event and investment. It is essentially a study of future. The analysis, therefore, should estimate future traffic, cost and benefits. Economic- evaluation serves number of purposes like Preparation of highway plans, to rank scheme, to assess in phasing the road programme, to compare and select mutually exclusive schemes, to evaluate alternative strategies such as stage-construction or full construction.

I. PROBLEM DEFINITION

Mandvi town is located in Mandvi taluka, Kutch district of Gujarat, India. At present the traffic of Mandvi- Layja National Highway originate from Gandhidham to Narayan Sarovar, Gandhidham to Mata No Madh, Gandhidham to Hajipir, and Gandhidham to Sanghipuram. Plenty of various natural resources for industry support found in surrounding area of Mandvi so that traffic grown on Mandvi- Layja National Highway. The another for traffic is tourism. Mandvi is a famous tourism spot.

This National Highway is important due to border security as it connects army headquarter-Bhuj. Due to this, there is heavy traffic and Mandvi town is facing problems like air pollution, noise pollution, traffic congestion and accidents. To avoid these problems bypass road is justified. The location of Mandvi town and study location is given in Figure 1.

II. OBJECTIVES OF STUDY

The objectives are:

- To determine necessity of Mandvi town bypass
- To carry out economic evaluation of proposed Mandvi town bypass

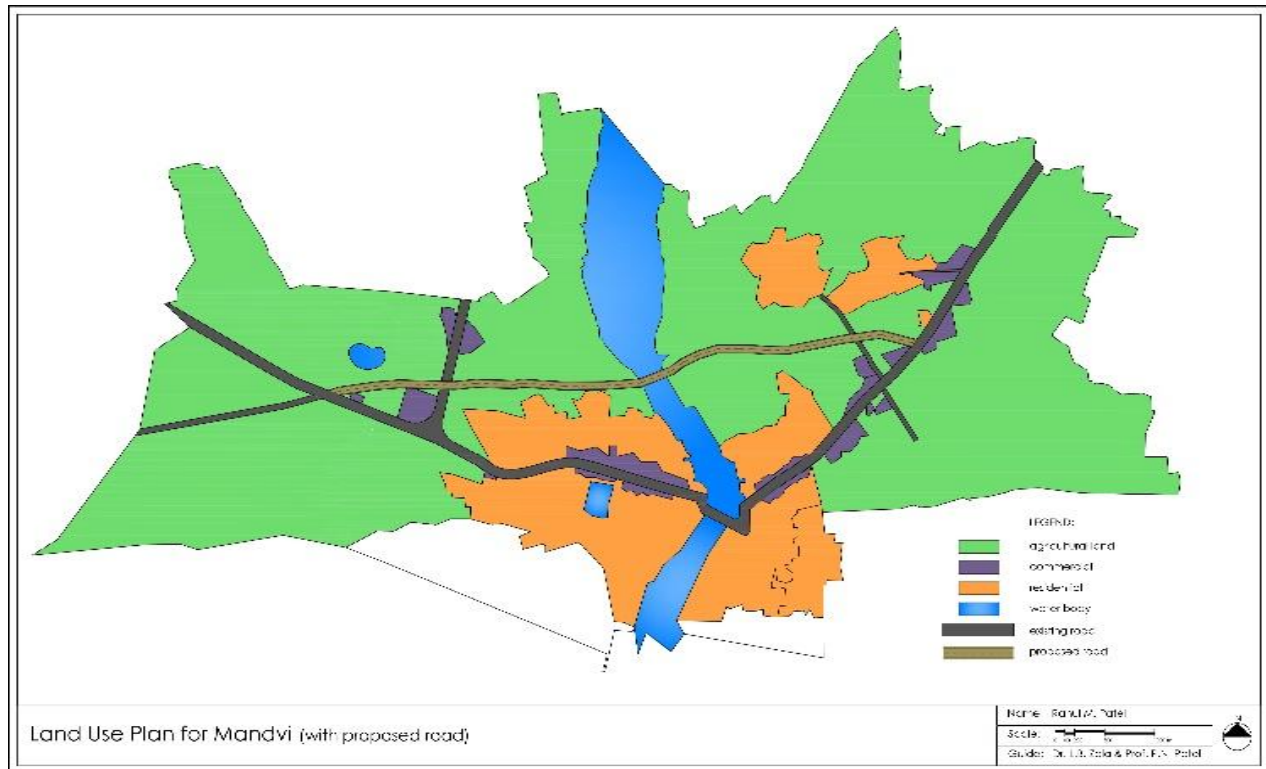


Figure 1 Study Bypass at Mandvi Town

III. LITERATURE REVIEW

Several economic evaluation studies have been done in India and other countries. Study is carried out for economic analysis by present worth method in Pune city at national game road. (Vidhya Patil et. al. 2012). In USA, Wisconsin department of transportation is carried out that no economic impact of highway bypass on medium and large communities and small communities have adverse impact. (WisDOT 1998). This paper is on economic analysis of town bypass and land use pattern has been changed after opening of bypass and road safety level was improved. (Wafa Elias et. al. 2006). Economic evaluation of Vapi- Silvassa road in Gujarat four lane flexible pavement or rigid pavement by IRR, NPV, and B/C is carried out and rigid pavement is viable. (Dipa D. Patel 2007). Feasibility study carried out in Gadag city to minimize the Vehicle Operating Cost and improve Level of Service for through traffic (Karthik G.L. et. al. 2014). Usefulness of bypass at Mandvi carried out by economic analysis. Various method used for economic evaluation in this research paper are listed:

Net Present Value(NPV) Method

In this method, the stream of cost/benefits associated with the project over an extended period of time is calculated and is discounted at a selected discounted rate to give the present value. Benefits are treated as positive and costs as negative and the summation gives the Net Present Value (NPV) as in equation (1).

$$NPV_0 = (B_0 - C_0) + \frac{B_1 - C_1}{1+i} + \frac{B_2 - C_2}{(1+i)^2} + \dots + \frac{B_n - C_n}{(1+i)^n} \dots \dots (1)$$

Where,

NPV_0 = Net present value in the year = 0

B_n = Value of the benefits which occurs in the n^{th}

C_n = Costs which occur in the n^{th} year

Any project with positive NPV is treated as acceptable. In comparing more than one project, a project with the higher NPV should be accepted.

A. Benefit- Cost Ratio Method

The benefit/cost ratio method is one of the widely used method for evaluation of highway projects. In this method, procedure is to discount all the costs and benefits to their present worth and calculate the ratio of the benefits to costs. Negative flows are considered as costs whereas positive flows as benefits. Ratio benefits to costs is as in equation (2).

$$\frac{B}{C} = \frac{\text{Benefits in the reference year}}{\text{Annual costs}} \dots\dots\dots (2)$$

If B/C ratio is more than 1, the project is worth undertaking.

B. Internal Rate of Return (IRR) Method

The rate of return of a cash flow pattern is the interest rate at which the present worth of that cash flow pattern reduce to zero. In other words, it is the discount rate which makes the discounted future benefits equal to the initial outlay. The cost worked out using equation (3).

$$C_0 = \frac{B_1 - C_1}{1+i} + \frac{B_2 - C_2}{(1+i)^2} + \frac{B_3 - C_3}{(1+i)^3} + \dots + \frac{B_n - C_n}{(1+i)^n} \dots\dots\dots (3)$$

In this method of comparison, the internal rate of return is computed. Then the alternative which has the highest internal rate of return is selected as the best alternative.

IV. DATA COLLECTION

The data is very important item of work for analysis. The data collected involve roadway inventory Traffic data, Growth, Material characteristics and cost. The data and description of is as under:

A. Road Inventory

Road inventory is carried out on NH- 41 from Chainage No. 97-200km to 104-200km which is passing through Mandvi town. Road inventory is given in Table 1. Existing pavement type is bituminous pavement throughout.

Table 1 Mandvi Road Inventory

Chainage (km)	Carriage Way Width (m)	Shoulder (m)				Footpath
		Paved		Unpaved		
		L	R	L	R	
97+200	7.00	1.3	1.75			-
97+300	7.00	-	-	1	1.6	-
97+900	7.00	-	-	1.7	2	-
98+275	7.00	-	-	1.35	1.5	-
98+850	6.00	-	-	1.7	1	-
98+950	5.80	-	-	1.5	0.75	Yes
100+150	6.60	-	-	-	-	-
100+375	8.70	-	-	-	-	-
101+00	5.75	-	-	-	-	-
101+200	10.00	-	-	-	-	Yes
101+500	10.00	-	-	-	-	Yes
102+150	12.00	-	-	-	-	Yes
102+800	11.00	-	-	-	-	Left Side
103+00	11.00	-	-	-	-	-
103+625	8.70	-	-	2	1.4	-
104+050	7.60	1.3	1.15	-	-	-
104+200	7.60	1.3	1.1	-	-	-

B. Traffic Volume Counts

Traffic volume count was carried out for 4 days and 24 hours. Total traffic volume for 4 days is given in Table 2. From that average traffic volume is 15110.5 PCUs/day. Traffic composition is shown in Figure 2.

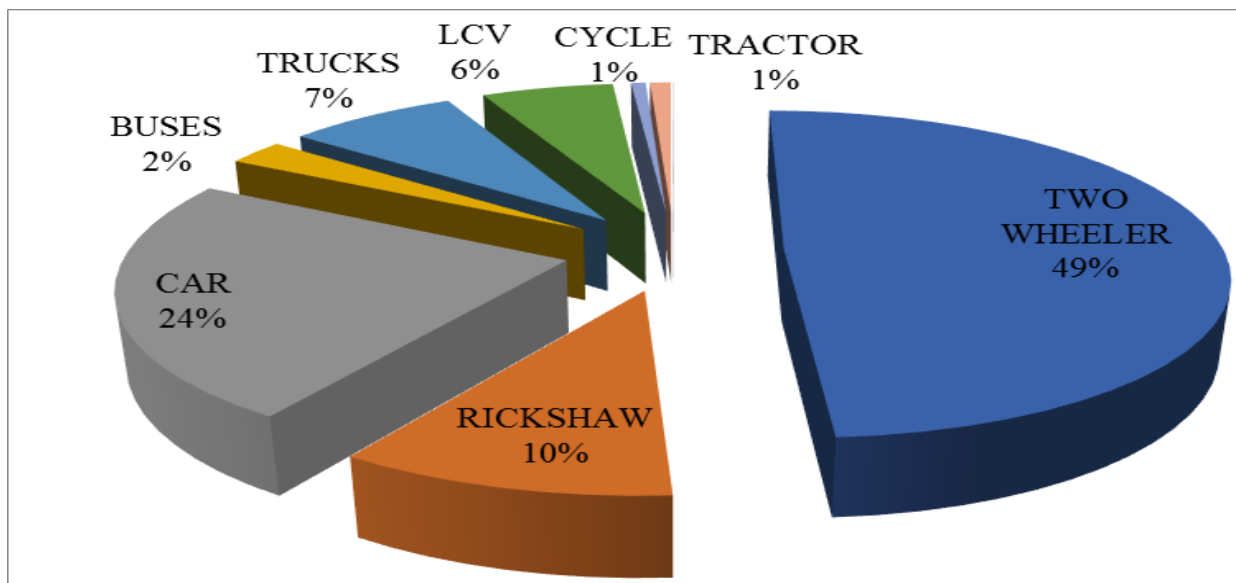


Figure 2 Traffic Composition

Table 2 Traffic Volume Count

Day	1	2	3	4	Total	Average
Traffic (PCU)	14384	15189.5	16229.5	14639	60442	15110.5

According to the above Figure 2, most of car and bus traffic is because of tourism and total traffic of truck and LCV is because of industrial transportation toward Mundra port

C. Origin and Destination Survey

O-D survey carried out at 3rd and 4th January for 24 hours. Proposed bypass route is passing through location A, B and C. Table 3 is indicating bypassable traffic percentage.

Table 3 Results of O-D Survey

Type	Total Traffic	Bypassable Traffic	% Bypassable Traffic
Car	2944	1696	57.61
Bus	379	191	50.40
LCV	843	477	56.58
Truck	1157	944	81.59
Tractor	86	26	30.23
T.W.	7482	2453	32.79

D. Travel Time and Delay Study

Travel time and delay study determined that, in one direction Average travel time is 13.65min and Average travel speed is 29.9 kmph. And in other direction, Average travel time is 13.79min and Average travel speed is 29.58 kmph. For both direction, average travel time with free speed is 8.4 min. So, the average delay for both direction is 5.25min and 5.39min respectively.

E. Accident Data

Accident data on selected stretch (7km) at NH- 41, collected from Mandvi police station. Cost estimation of accident data as per the IRC: 30- 2009 is worked out as in Table 4.

Table 4 Cost Analysis of Accident Data

Type of accident	Year							Total	Cost of accident (Rs.)	Total Cost of the accidents (Rs. Lakh)
	2011	2012	2013	2014	2015	2016	2017 (may)			
Fatal	12	15	12	14	9	19	9	90	1017003	915.30
Major Injury	42	31	25	29	18	13	2	160	198547.5	317.68
Minor Injury	39	26	14	11	13	5	1	109	35017.5	38.17
Total	93	72	51	54	40	37	12	359		1271.15

F. CBR Test and Soil Classification

Data revealed that some soil samples along proposed route of bypass road area are fall under MI and some are CL classification as per IS:1498-1970. Effective CBR is 7.3%. Design of 2- lane road with paved shoulder is given in Fig. 3.

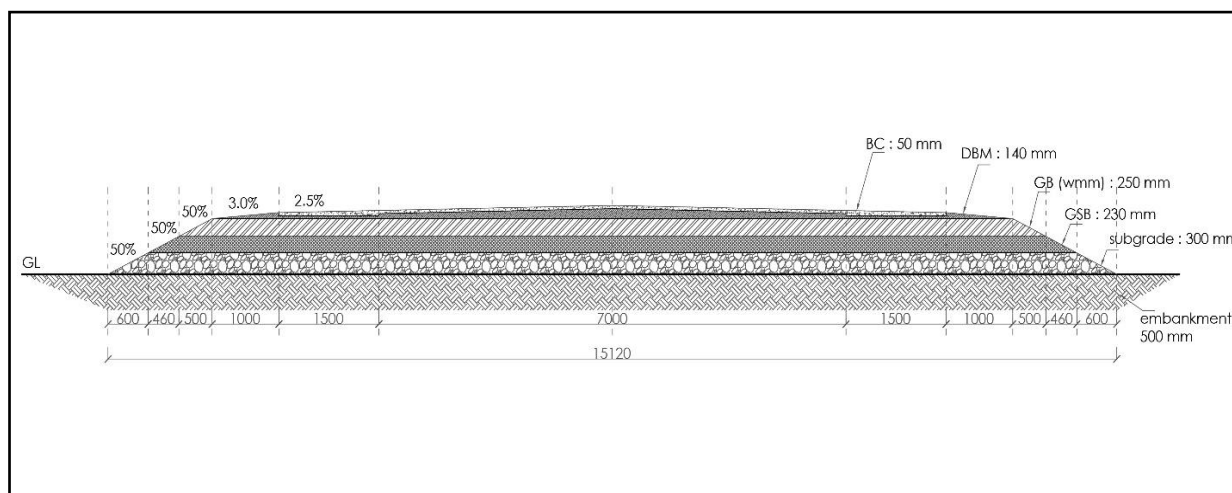


Figure 3 Flexible Pavement Composition

Data Analysis

A. Cost of Construction

Cost estimation of proposed bypass road 2-lane with paved shoulders having flexible pavement is as shown Table 5.

Table 5 Cost of Construction of Flexible Pavement

Sr. No.	Items	Rate (Rs.)	Unit	L(m)	B(m)	H(m)	Qty. (m ³)	MT	Amount (Rs)
1	BC	1924	MT	1000	10	0.05	500	1205	2318420
2	DBM	1474	MT	1000	11	0.14	1540	3711.4	5470603.6
3	Prime Coat	32	7.5kg/10Sq.m.	1000	12		12000		384000
4	GB(WMM)	1350	Cu.m.	1000	12.5	0.25	3125		4218750
5	GSB	744.39	Cu.m.	1000	13.46	0.23	3095.8		2304482.56
6	Sub Grade	158.65	Cu.m.	1000	14.52	0.3	4356		691079.4
7	Earth Work	158.65	Cu.m.	1000	15.12	0.5	7560		1199394
							Total Cost		16586729.6

There is a 150 m wide river in selected stretch. So, according to the field expert cost of bridge is Rs.4.5 crores approximately.

B. Traffic Forecast

Traffic forecast is calculated by taking 6.5% growth rate for year 2018 to 2034. Volume capacity ratio is calculated for different cases as Table 6, Table 7 and Table 8.

There are Thermal Power Plant project and cargo jetties in under construction. According to L&T report, its construction will be finished till year 2020-21. So, commercial traffic will increase by 50% after year of completion.

Table 6 Volume- Capacity Ratio on Existing Pavement (Case- I)

Year	2018	2019	2020	2021	2022	2023	2024	2025
V/C	0.43	0.46	0.49	0.61	0.65	0.69	0.74	0.79
PCU/Hour(Q)	1302	1387	1477	1836	1955	2082	2218	2362

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
V/C	0.84	0.89	0.95	1.00	1.00	1.00	1.00	1.00	1.00
PCU/Hour(Q)	2515	2679	2853	3038	3236	3446	3670	3909	4163

Table 7 Volume- Capacity Ratio on Existing Pavement after Opening of Bypass Road (Case- II)

Year	2018	2019	2020	2021	2022	2023	2024	2025
V/C	0.43	0.46	0.21	0.23	0.27	0.28	0.30	0.32
PCU/Hour(Q)	1302	1387	645	687	801	853	909	968

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
V/C	0.34	0.37	0.39	0.42	0.44	0.47	0.50	0.53	0.57
PCU/Hour(Q)	1031	1098	1169	1245	1326	1412	1504	1602	1706

Table 8 Volume- Capacity Ratio on Bypass Road (Case- III)

Year	2018	2019	2020	2021	2022	2023	2024	2025
V/C	0	0	0.28	0.30	0.38	0.41	0.44	0.46
PCU/Hour(Q)	0	0	832	886	1154	1229	1309	1394

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
V/C	0.49	0.53	0.56	0.60	0.64	0.68	0.72	0.77	0.82
PCU/Hour(Q)	1485	1581	1684	1793	1910	2034	2166	2307	2457

C. Vehicle Operating Cost

Distance-related congestion factor and Time- related congestion factor equations are used to calculate the Vehicle operating cost for different modes as given in IRC: 30- 2009.

Distance- related congestion factor for various categories of vehicle are given below:

Car	: $CF_D = 0.893 + 0.259 * (V/C)$
Bus	: $CF_D = 0.8 + 1.1 * (V/C)$
LCV	: $CF_D = 0.9 + 1.00 * (V/C)$
Truck	: $CF_D = 0.925 + 0.482 * (V/C)$
T.W.	: $CF_D = 0.917 + 0.112 * (V/C)$

Time- related congestion factor for various categories of vehicle are given below:

Car	: $SF- 55, V_{CN} = 88.148 - 0.0079 * Q$
Bus	: $SF- 56, V_{BU} = 70.116 - 0.0071 * Q$
LCV	: $SF- 57, V_{LCV} = 70.118 - 0.0071 * Q$
Truck	: $SF- 58, V_{HCV} = 61.631 - 0.0062 * Q$
T.W.	: $SF- 60, V_{TWO} = 55.243 - 0.0073 * Q$

For example:

Time- related congestion factor for car is as below:

$$\text{Congestion Factor}(CF_T) = \frac{\text{Intercept of the above equation (88.148)}}{\text{Speed of cars } (V_{CN})}$$

Computation of Vehicle operating cost for three alternative cases for 7km existing road and 6.11km bypass road is given in Table 9, Table 10 and Table 11 respectively.

For example:

Total VOC = Traffic volume $\times$ (CF_D + CF_T) $\times$ Distance $\times$ 365.

Table 9 VOC (Rs. lakh) for Case- I

YEAR	CAR	BUS	LCV	TRUCK	T.W.	TOTAL VOC
2018	261.81	62.31	165.49	241.77	224.36	955.74
2019	278.82	67.75	178.21	257.49	238.94	1021.22
2020	296.95	73.74	192.02	274.22	254.47	1091.41
2021	316.25	85.24	314.39	429.16	275.16	1420.20
2022	336.80	93.16	339.74	457.06	294.81	1521.57
2023	358.70	102.06	369.56	491.13	316.06	1637.51
2024	382.01	111.97	402.91	532.12	339.09	1768.11
2025	409.11	122.97	439.81	577.12	364.10	1913.11
2026	438.63	135.20	480.71	626.58	391.33	2072.46
2027	470.60	148.81	526.12	681.06	421.07	2247.67
2028	505.27	163.97	576.66	741.17	453.68	2440.75
2029	542.94	180.88	633.03	807.63	489.58	2654.06
2030	583.98	199.75	696.06	881.30	529.32	2890.40
2031	628.79	220.86	766.72	963.14	573.59	3153.10
2032	677.90	244.48	846.20	1054.34	623.30	3446.22
2033	731.89	270.97	935.91	1156.30	679.71	3774.77
2034	792.38	300.70	1037.58	1270.72	744.51	4145.88

Table 10 VOC (Rs. lakh) for Case- II

YEAR	CAR	BUS	LCV	TRUCK	T.W.	TOTAL VOC
2018	261.81	62.31	165.49	241.77	224.36	955.74
2019	278.82	67.75	178.21	257.49	238.94	1021.22
2020	124.72	33.99	78.04	49.36	170.50	456.60
2021	132.82	36.20	83.11	52.57	181.58	486.28
2022	141.46	38.55	130.07	82.27	193.38	585.73
2023	150.65	41.05	138.52	87.62	205.95	623.80
2024	160.44	43.72	147.52	93.31	219.34	664.35
2025	170.87	46.57	157.11	99.38	233.60	707.53
2026	181.98	49.59	167.33	105.84	248.78	753.52
2027	193.81	52.82	179.36	112.72	264.95	803.65
2028	206.41	56.25	192.86	120.04	282.17	857.73
2029	219.82	60.17	207.48	127.85	300.52	915.84
2030	234.11	65.39	223.34	136.16	320.05	979.05
2031	249.33	71.12	240.55	145.01	340.85	1046.86
2032	265.54	77.43	259.23	154.43	363.01	1119.63
2033	282.79	84.36	279.54	164.47	388.16	1199.33
2034	301.18	92.01	301.64	175.16	415.40	1285.39

Table 11 VOC (Rs. lakh) for Case- III

YEAR	CAR	BUS	LCV	TRUCK	T.W.	TOTAL VOC
2018	0.00	0.00	0.00	0.00	0.00	0.00
2019	0.00	0.00	0.00	0.00	0.00	0.00
2020	136.50	29.61	87.13	186.70	57.64	497.58
2021	145.37	31.53	92.80	198.84	61.39	529.93
2022	154.82	33.58	147.31	311.18	65.38	712.27
2023	164.89	35.78	158.49	331.40	69.63	760.19
2024	175.60	38.87	170.61	352.95	74.16	812.18
2025	187.02	42.27	183.75	375.89	78.98	867.90
2026	199.17	46.00	198.03	400.32	84.11	927.64
2027	212.12	50.12	213.55	426.34	89.91	992.04
2028	225.91	54.64	230.44	454.05	96.32	1061.36
2029	240.59	59.64	248.83	483.57	103.24	1135.86
2030	256.23	65.15	268.86	515.00	110.73	1215.97
2031	272.89	71.30	291.65	550.01	118.85	1304.69
2032	290.62	78.19	317.85	595.71	127.67	1410.04
2033	310.56	85.83	346.83	645.83	137.28	1526.33
2034	333.02	94.33	378.92	700.91	147.77	1654.94

V. COMPUTATION OF INTERNAL RATE OF RETURN (IRR), NET PRESENT VALUE (NPV) AND BENEFIT-COST RATIO (B/C)

The Internal Rate of Return is calculated using the standard procedures like Trial and Error method or by Computer. Both costs and benefits are discounted at different rates till both are balanced in trial and error method. Results are shown in Table 12.

Table 12 Results of Economic Evaluation

	Existing Road (Case- I)	Existing Road after Bypass Road (Case- II)	Bypass Road (Case- III)
Construction & Maintenance Cost	267.75 lakh	267.75 lakh	1523.32 lakh
VOC	38154.17 lakh	14462.24 lakh	15408.96 lakh
B/C			2.03
NPV			1267.51 lakh
IRR			22.54%

VI. CONCLUSIONS

- Mandvi traffic volume is 15110.50 PCU/day which is higher than design volume as per IRC: 64- 1990. So, it is required to construct new facility.
- The economic viability of proposed bypass road is carried out using IRC: SP:30-2009 and results are stated below:
 - B/C Ratio for bypass road 2.03, which is greater than one so the project, is economically justified.
 - NPV for Bypass road is 1267.51 lakh which is positive.
 - IRR Value is 22.54%.
 - Bypass road around the Mandvi will save VOC, Vehicle operating cost in existing road is Rs. 38154.17 lakh that will decrease by constructing bypass road to Rs. 15408.96 lakh.
- Based on the results of economic evaluation of Mandvi Bypass, it is concluded that Bypass road is more economical as compared to existing road.

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