

CHAPTER 20

ECONOMIC APPRAISAL



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20.1 INTRODUCTION

Economic benefits are social and environmental benefits which are quantified and then converted into money cost and discounted against the cost of construction and maintenance for deriving Economic Internal Rate of Return (EIRR). When actual revenue earned from fare collection, advertisement and property development are discounted against construction and maintenance cost, interest (to be paid) and depreciation cost, Financial Internal rate of Return (FIRR) is obtained. Therefore, EIRR is viewed from socio-economic angle while FIRR is an indicator of pure financial profitability and viability of any project

20.1.1 Economic appraisal of a project starts from quantification of measurable economic benefits in economic money values, which are basically the savings of resource cost due to introduction of the metro line. Economic savings are derived from the difference of the cost of the same benefit components under 'with' and 'without' metro line. Total net savings/or benefit is obtained by subtracting the economic cost of the project (incurred for construction (Capital) and maintenance (recurring) costs for the metro line) from the benefits out of the project in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

20.1.2 The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first four benefit components given in **Table 20.1** are direct benefits due to shifting of trips to metro, but other benefit components are due to decongestion effect on the road. Benefit components were first estimated applying market values then were converted into respective



Economic values by using separate economic factors which are also given in table 20.1. Depending upon methodology of estimation, economic factors are assumed. Overall economic value of benefit components is 93% of the market value. Similarly economic value of the cost components are 80% of the market cost.

Table 20.1: Benefit Components due to Metro

	Benefit Components	Economic Factors
1	Construction Cost	80%
2	Maintenance Cost	80%
3	Annual Time Cost Saved by Metro Passengers	90%
4	Annual Fuel Cost Saved by Metro Passengers	90%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	90%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	90%
9	Annual Fuel Cost Saved by Road Passengers	90%
10	Annual Infra Structure Maintenance Cost	90%
11	Overall economic factor for the benefit components	93%

20.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Some of the values used for economic analysis are shown in **Table 20.2**.

Table 20.2: Values adopted for some important variables

	Values	Important variables
1	Rs. 2.791/min (2013)	Time Cost derived from passenger's journey time and fare paid (mode wise).
2	Market Rate (2012)	Fuel Cost (value of Petrol, Diesel and CNG).
3	Table 20.3	Vehicle Operating Cost (Derived from Life Cycle Cost of different passenger vehicles per km)
4	Table 20.4 (CPCB)	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton).
5	Table 20.5 (Accident Rate & Cost)	Accident Rate (No of fatal and all accidents per one Cr.KM). Accident costs are derived from published papers at current rate.
6	51.3%	Passenger km to Vehicle km conversion factor (derived from modal split within study area as reported in chapter 2)
7	Road User Cost Study Model (CRRI-2010)	Fuel Consumption of vehicles at a given speed is derived
8	Rs. 1.0/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and



		annual vehicle km
9	13.54 min	Average Journey Time Saved for average km journey after Shifting (Derived)
10	24.05 kmph	Average Journey Speed (Speed & Delay Study)

Table 20.3: Vehicle Operating Cost in Rs.

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	3.94	3.31	2.01	0.57	0.72	2.25	2.75
Capital Cost	2.40	2.67	1.20	0.18	0.16	0.72	1.72
Total VOC	6.98	6.58	3.54	0.82	0.96	3.27	4.92

Table 20.4: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

VEHICLE	CO	HC	NOX	PM	CO	CO2
BUS	3.72	0.16	6.53	0.24	3.72	787.72
2W-2 STROKE	1.4	1.32	0.08	0.05	1.4	24.99
2W-4 STROKE	1.4	0.7	0.3	0.05	1.4	28.58
MINI BUS	2.48	0.83	8.26	0.58	2.48	358.98
4W-SMALL	1.39	0.15	0.12	0.02	1.39	139.51
4W-LARGE	0.58	0.05	0.45	0.05	0.58	156.55
TATA MAGIC	1.24	0.17	0.58	0.17	1.24	160
3W	2.45	0.75	0.12	0.08	2.45	77.89
Cost	RS. 100000 PER TON					500

Table 20.5: Accident Rate[§] and Cost in Rs

Accident Rate in the year 2016	Cr. Vehicle KM	Cost in Rs
All Types.	2.0	588911
Fatal Accident.	0.2	1692648

§ 2011 figure of accidents in Nagpur is used

Traffic parameter values used for economic analysis are given in **Table 20.6.**

Table 20.6: Traffic parameter values

TRAFFIC INPUT	2016	2021	2026	2031	2036	2041
Trips/day NAGPUR METRO	352442	383439	419135	458893	508656	563735
Line Length (km)	39.5	39.5	39.5	39.5	39.5	39.5
Average Trip length (km)	6.42	6.45	6.49	6.53	6.52	6.52
Passenger km/km	57274	62641	68908	75897	83973	93080

**Table 20.7: Average modal split in the study area**

Vehicles	% PASS	% Vehicle
BUS	0.33%	10.00%
MINI BUS	0.00%	0.00%
CAR	10.71%	30.00%
TAXI	0.39%	1.16%
2 WH	30.68%	33.75%
AUTO	9.18%	22.96%
CYCLE	2.13%	2.13%

20.3 ECONOMIC BENEFIT STREAM

Benefits in terms of money value are estimated directly from the projected passenger km saved for the horizon years (2016, 2021, 2026, 2031 and 2041) and values for other years are interpolated on the basis of projected traffic. Market values are used for calculating costs and then appropriate economic factors (see table 20.1) are applied. For each year values of each benefit components are obtained and thus benefit stream is estimated. Benefit Components Stream for **Nagpur Metro Rail** is shown in **Table 20.8**.



Table 20.8 Component wise Benefit Value Stream

Year	Year	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Operating Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost in Cr. Rs.	Total Benefits without Discount in Cr. Rs.
2018	2019	527.12	249.46	231.95	50.27	12.79	63.27	4.42	86.62	1225.91
2019	2020	556.10	256.49	252.95	45.77	13.98	67.14	4.71	89.16	1286.30
2020	2021	586.68	263.80	275.85	40.03	15.29	71.26	5.00	91.78	1349.69
2021	2022	618.93	271.38	300.79	43.65	16.72	75.62	5.31	94.47	1426.86
2022	2023	654.19	279.55	328.34	47.65	18.30	80.33	5.63	97.34	1511.31
2023	2024	691.46	288.05	358.41	52.01	20.03	85.33	5.96	100.30	1601.55
2024	2025	730.86	296.90	391.24	56.78	21.92	90.65	6.30	103.34	1697.98
2025	2026	772.49	306.10	427.09	61.98	23.99	96.30	6.65	106.49	1801.09
2026	2027	816.50	315.88	466.54	67.70	26.27	102.37	7.02	109.80	1912.09
2027	2028	863.58	325.95	509.45	73.93	28.77	108.79	7.41	113.18	2031.05
2028	2029	913.37	336.43	556.33	80.73	31.50	115.61	7.80	116.66	2158.42
2029	2030	966.02	383.20	670.29	97.27	34.49	140.97	9.06	132.67	2433.97
2030	2031	1021.72	396.04	732.60	106.31	37.76	149.98	9.54	136.88	2590.83
2031	2032	1080.62	409.42	800.75	116.20	41.34	159.57	10.04	141.22	2759.17
2032	2033	1141.72	424.85	880.08	124.65	45.24	171.18	10.70	146.51	2944.92
2033	2034	1206.26	440.86	967.27	133.70	49.51	183.63	11.40	151.99	3144.64
2034	2035	1274.46	457.48	1063.10	143.42	54.18	196.98	12.16	157.68	3359.46
2035	2036	1346.51	474.71	1168.43	153.84	59.29	211.31	12.96	163.59	3590.63
2036	2037	1422.63	492.60	1284.18	165.02	64.88	226.68	13.81	169.71	3839.52
2037	2038	1503.06	511.17	1411.41	177.01	71.00	243.17	14.72	176.07	4107.60
2038	2039	1588.03	530.43	1551.24	189.88	77.70	260.86	15.69	182.66	4396.48
2039	2040	1677.81	550.42	1704.92	203.68	85.02	279.83	16.72	189.50	4707.90
2040	2041	1772.67	571.16	1873.83	218.48	93.04	300.18	17.82	196.59	5043.77
2041	2042	1872.88	592.68	2059.47	234.35	101.82	322.02	19.00	203.95	5406.18
2042	2043	1978.76	615.02	2263.51	251.38	111.42	345.44	20.25	211.59	5797.37

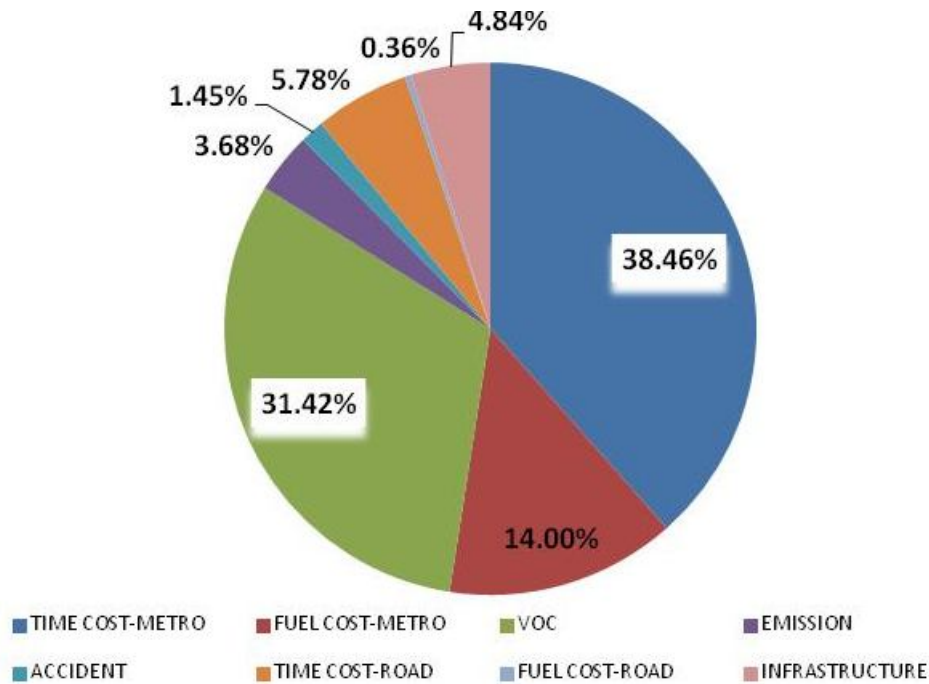


Figure 20.1 Percent of Benefits

Total Benefit between the years 2019-2043 (Component wise) are shown in figure 20.1 which shows that benefits are mainly coming from saving of travel time (metro and road) (44.25%), vehicle operation cost (VOC) (31.42%) and fuel cost (14.36%). Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 9.97%. In this area (Nagpur City), personalized modes (cars, three and two wheelers) are dominant (87.87%) which have made vehicle by passenger ratio very high (51%). Average modal split obtained from the past study shows that about 10% passengers were using public bus within the city. Traffic volume count survey shows that 80.91% vehicle trips are by private modes as. Obviously presence of dependable mass transport system is not there.



20.4 METRO CONSTRUCTION COST

20.4.1 Total cost of metro construction (CAPITAL COST) is derived after considering cost of all major component such as Relocation and Rehabilitation(RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. RECURRING COST includes energy cost, maintenance cost, and operation cost. Economic analysis period is taken from 2013-14 to 2042-43 out of which 6 years (2013-2018) are marked as construction period. Additional capital expenditure may be incurred in the years 2021-22 & 2026-27 (purchase of more rolling stock), 2031-32 and 2040-41. Operation is expected to start in 2018- 2019 (Year 6). This cost stream is generated with Central taxes. Detail is shown in **Table 20.9**.

Table 20.9: Estimated Capital and Recurring Cost including Central Tax

Year	Year	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs
2013	2014	447	0
2014	2015	995	0
2015	2016	1809	0
2016	2017	2334	0
2017	2018	1923	0
2018	2019	719	162
2019	2020	194	175
2020	2021	0	190
2021	2022	241	207
2022	2023	0	224
2023	2024	0	242
2024	2025	0	262
2025	2026	0	284
2026	2027	184	321
2027	2028	0	347
2028	2029	0	376
2029	2030	0	407
2030	2031	0	440
2031	2032	157	481
2032	2033	0	521
2033	2034	0	564
2034	2035	0	610
2035	2036	0	661



2036	2037	400	735
2037	2038	0	795
2038	2039	0	861
2039	2040	1702	932
2040	2041	1363	1008
2041	2042	511	1133
2042	2043	0	1226

20.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are presented in **table 20.10**. Project period is 2013-2043, EIRR (with central tax) is found to be **17.70%** and B/C ratio as 3.45 and with 12 % discount, EIRR is 5.09% and B/C ratio is 0.70. NPV without discount is Rs 51210 Cr. and with 12% discount rate, NPV is Rs.3404 Cr. which shows that the project is economically viable.

Table 20.10. Economic Indicator Values (with Central Tax)

Nagpur Metro Network	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Total cumulative cost	20914	6537
Total cumulative benefit	72125	4545
Benefit Cost Ratio	3.45	0.70
NPV	51210	3404
EIRR	17.70%	5.09%

20.6 SENSITIVITY ANALYSIS

Sensitivity analysis for EIRR and B/C ratio is performed for both with and without discount and the output is given in the **table 20.11**. 2042-43 is taken for the year of comparison. EIRR and B/C ratio after discount of 12% shows that the project is economically viable.

Table 20.11 Sensitivity of EIRR

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT (12%)		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	17.70%	3.45	20914	5.09%	1.52	6537
-10%	0%	17.09%	3.32	20914	4.55%	1.46	6537
-20%	0%	16.47%	3.18	20914	3.99%	1.40	6537
0%	10%	16.35%	3.14	23006	3.88%	1.38	7191
0%	20%	15.15%	2.87	25097	2.81%	1.27	7845
-10%	10%	15.76%	3.02	23006	3.36%	1.33	7191
-20%	20%	13.99%	2.65	25097	1.78%	1.16	7845



20.7 Quantified Benefits.

Benefits which are shown in previous tables are money value of the benefits. These benefits are estimated first and the converted into money value. For brevity, only 5 year estimates are shown in table 20.8 (Reduction of Vehicle gas Emission) and in table 20.12 (Reduction of Fuel, Time of Travel, Vehicle on Road etc).

Table 20.12 Environmental Benefits Quantified

Tons/Year	2019	2020	2021	2022	2023
CO	1892.94	1484.86	1513.21	1543.73	1574.88
HC	980.89	746.28	760.52	775.86	791.52
NOX	235.59	236.60	241.12	245.98	250.95
PM	54.82	53.25	54.27	55.37	56.48
SO2	4.06	3.76	3.83	3.91	3.99
CO2	64621	65861	67118	68472	69854
Total Emission Saved	67789	68386	69691	71097	72531

From Table 20.12, it may be seen that In 2020, CO2 reduction will be 65.86 thousand tons and reduction of other gases will be 3.168 thousand tons.

Table 20.13 Travel Benefits Quantified

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Time Saved by Metro Passengers in Cr. Hr.	3.21	3.32	3.44	3.56	3.69
Annual Fuel Saved by Metro Passengers in thousand Tons.	46.77	48.17	49.63	51.19	52.82
Daily vehicles reduced (off the road)	56453	57536	58634	59817	61024
Reduced No of Fatal Accidents in Year	19.38	19.81	20.24	20.70	21.18
Reduced No of Other Accidents in year	174.46	178.27	182.16	186.32	190.58
Annual Vehicle km Reduced in Thousand Km.	26.344	26.849	27.362	27.914	28.477

Amount of travel in terms of vehicle reduced due to shifting of passengers to Metro Rail is equivalent to reduction of 57 thousand vehicles on the road in 2020. More than 19 fatal accidents and 182 other accidents may be avoided (approximately 4% of 2011 published figure). Hence it is expected that there will be some improvement of the overall ambience of the city.

20.8 Transport Oriented Development (TOD) & EIRR

There will be generation (addition of extra trips) of Ridership on Metro due to Transport Oriented Development Introduction of Modern Mass Transit System (Metro) will have an impact on city's landuse in near future. Values of land which are closer to the metro line will increase very quickly, commercial activities near station areas will increase and people will not hesitate to live in remote areas of



the city (but near to metro station). Due to presence of metro existing bus routes may change, some old routes may stop operation and some new routes may be introduced. A detail study will be needed to identify, quantify and to estimate economic impact of such likely changes. Detail discussion and evaluation is beyond the scope within this chapter. Nevertheless, it will be interesting to know, for 10% increase of ridership, increase in EIRR value will be 6.57%, and for 20% increase EIRR will increase by 9.96%, keeping other traffic inputs unchanged
