SUSTAINABLE ECONOMIC EVALUATION OF ALTERNATIVE RURAL ROUTES LEADING TO A PORT THROUGH A MINING AREA

Srinivas G, Transportation Planner, IBI Group, gsrinivas87@gmail.com

Dhingra S L,Institute Chair Professor & Emeritus Fellow,IIT Bombay,sl.dhingra@gmail.com

Vedagiri P, Assistant Professor, IIT Bombay, vedagiri@iitb.ac.in

ABSTRACT

The Road connectivity of port is an essential component for running the port activities. There may be different possible alternatives one may propose for this route connectivity. The evaluation of those alternative routes to choose the best among them is a complex thing when those alternatives pass through a mining area in the rural jurisdiction which was leased with some terms and conditions which restrict the mining activity if an alternative passes through it. One may need to consider all the positive and negative impacts involved even with the mining activity in the sustainable and echo-friendly evaluation process of different route alternatives. Here it is attempted to consider all the possible costs or benefits related to economic, social and environmental factors which can be quantifiable in the analysis process. In this paper, Net Present Value (NPV) is used as a method for economic evaluation by taking the case study of three alternative routes leading to a Redi port in Goa, India.

Keywords: Sustainability, Economic Evaluation, Mining Activity, Rural Roads, NPV

INTRODUCTION

Economic analysis is a technique whereby the costs of and benefits from a scheme are quantified over a selected time horizon and evaluated by a common yardstick. Economic analysis is not concerned about past events and investments. It is essentially a study of the future. The analysis, therefore, should estimate future traffic, costs and benefits. The very basis of economic analysis being the selection of the most attractive option and in this regard, it is necessary that the analyst evaluates a number of possible alternatives.

It is very much essential that these alternatives should be evaluated in-order to promote the sustainable development. Hence there is a need to consider all the impacts of proposed road

such as economical, environmental and social (especially for rural roads) to achieve the comprehensive sustainability.

Figure 1 - Components of Comprehensive Sustainability (SPARTACUS Model)

A scheme/project/infrastructure can not be called sustainable unless all these three components of sustainability are achieved. Hence all the three impacts are considered in this study to achieve the comprehensive sustainability in evaluation of alternative routes. There can be direct and indirect costs and benefits of any new transport infrastructure. Direct costs and benefits may include planning costs, land acquisition costs, construction costs, user costs such as vehicle operating cost, noise pollution, air pollution, time savings…etc. But many a times it has been observed that the social costs are neglected which are associated with any transportation infrastructure from construction state to the total life of the project. It has been nicely explained by OCED, 1988 that there are many negative impacts of transport infrastructure related to atmosphere, land use, Solid Waste, water, noise, accidents and other impacts. However these general impacts, they may change from project to project depending on location context, project context and also the types of society which is affected by the project. Hence the identification of costs and benefits is most crucial part of any economic evaluation, however the measurability is also equally important at the same time.

Hence economic evaluation without any social cost-benefit analysis can not be called sustainable. Hence the term sustainable economic evaluation is intentionally mentioned in this paper to stress the fact the economic evaluation of any transport infrastructure project should be sustainable and it should consider all the direct and indirect costs associated with the project.

STUDY OBJECTIVES AND SCOPE

The objective of the study is to perform sustainable economic evaluation of all the three alternative routes as mentioned above to decide the best route by comparing the alternative routes from the Net Present value (NPV) method of economic evaluation as per IRC-SP-30 “Manual on Economic Evaluation of Highway Projects in India”, 2009. The other sub-objective of the study is to consider all the costs and benefits related to economic,

environmental and social impacts of proposed development of constructing roads passing through mine area.

STUDY AREA AND ALTERNATIVE ROUTE ALIGNMENTS

The existing port at Redi is located along the Konkan Coast in Vengurla Taluka of Sindhudurg district (15°45' N latitude and 73°39' E longitude), India. Redi Port has umpteen supplies of iron ore and bauxite with the mines located within immediate vicinity. Presently iron ore is being handled at Redi Port. The geographical location of the study area is shown in the Figure 2.

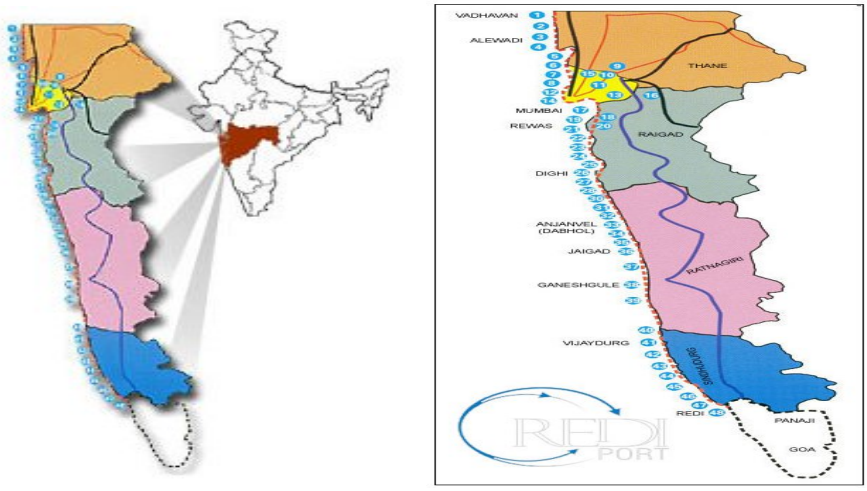

Figure 2 - The geographical location of study area in India (Redi Port in Goa)

The study area for the analysis consists of four alternate routes which ultimately lead to the Jetty at Redi port. The proposed road would be utilized only by the trucks or other commercial vehicles as it is being constructed as port connectivity road. The roads are,

- Alternate Route 1: Port Proposed Route of length- 4687 m
- Alternate Route 2: Old Road of length- 4175 m
- Alternate Route 3: Port Proposed Route with diversion of length- 4622 m

The Redi port proposed road starts from the Terekhol road and it connects Redi port / village to other areas like Goa or Sawantwadi, also it will be the road that intended users of Redi port would like to use to approach the port. Another alternative to reach the port is the Kharbandara route. It begins from the Terekhol Road much before the Terekhol road enters Redi village. It hugs the coastline and proceeds towards the port. This route has been named as Kharbandara route (Alternative 4 which is shown in Figure 3) as it begins from the area by that name. As the alternative-4 (Khar Bandara road) is of 7.03 km of road which is much longer than any other alternative, it is kept as futuristic alternative only and it is not considered in the present study. Hence it is finalized to study the three possible alternative routes which are shown in the Figure 3.

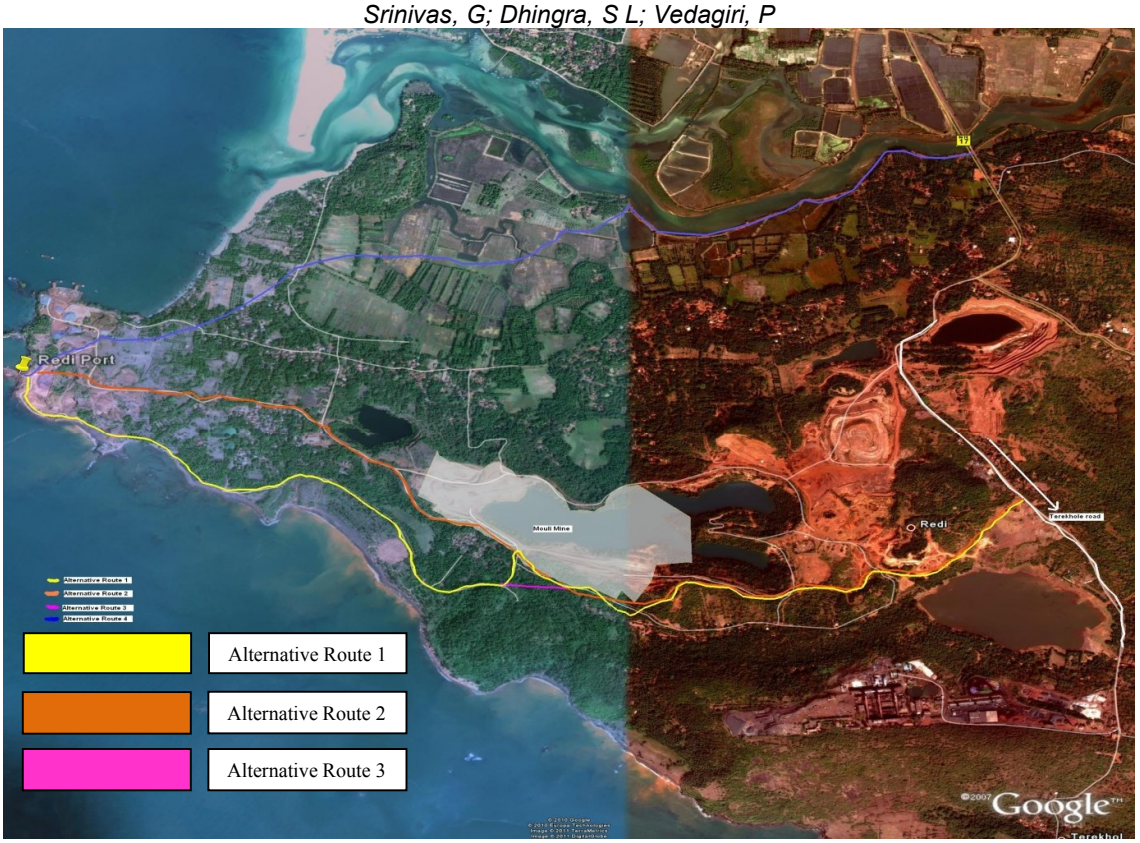

Figure 3 - Map showing the alternative routes leading to Redi port (with the courtesy of Google Earth)

NEGATIVE AND POSITIVE IMPACTS OF MINING ACTIVITY[1]

Even though the Mining of ores brings a lot of benefits economically and socially, mining activity has the significant impact on many surrounding aspects like land, atmosphere, water regime, ecology and society. It adversely affects the atmosphere by increasing the air and noise pollution levels in the climate and also by increasing the temperature in the surrounding area due to industrial activity and decrease in vegetation. Damage to the environment is mainly done by the reject dumps, pumping out of muddy waters from the working pits including those where the mining operations have gone below the water table, and slimes from the beneficiation plant. The damage is more evidenced during monsoon where the rain water carries the washed out material from the waste dumps to the adjoining low-lying agricultural fields and water streams. However on closure, the open pits acts as water bodies and recharge ground water table. Several major environmental problems caused due to mining operations are as under:

- Deforestation

[1] Executive Summary of EIA and EMP of Project Proposal for Mahankali Mines M.L.No. 2037 at Chikkabyladakere, Hosadurga, Karnataka, 2007 at http://kspcb.org/PH/Alok%20Kumar%20Exec%20Summary%20Engl.pdf

- Land degradation
- Groundwater pollution
- Surface water pollution
- Dust pollution
- Damage to beaches
- Health Impacts to people

Hence the mining agency should adopt the remedies such as plantation in the surrounding area and developing check dams to reduce the problems associated with these mining activities. So, plantation cost and cost for developing check dams, cost incurred in the reduction of noise levels which balances the adverse impacts of the mining activity also should be considered as part of the costs in the analysis process. In a an report on environmental impact assessment of an iron ore mining project, it is estimated that for the 2 lakh ton iron ore capacity project the cost required for executing the environmental management program is about 17 lakh rupees per annum which covers green belt development check dams/De-silting, dump plantation, water spraying for dust suppression, environmental monitoring, health and safety, socio-economic development in the nearby villages in the buffer zone. Hence it is adopted that the total mitigation cost or cost of environmental management plan as 8 lakh per annum for 1lakh ton capacity iron ore mining for the analysis purpose however it has to be estimated specific to any project under the consideration.

On other side, the mining causes significant contribution to the economic development such as contribution to the Gross Domestic Product (GDP) and creation employment and on closure of the mining activity the open pits acts as water bodies and recharge ground water table. So, employment generation, rechargeable water storage should also be taken as the benefits. Hence it is of very important aspect one may have to consider in the sustainable economic evaluation of the alternative routes passing through mining area. It is suitably assumed here that, present project envisages an employment of about 100 labour both directly in mining operations and indirectly in the ancillary activities like transport, etc. for the extraction of 1 lakh ton of iron ore mine. However the exact employment potential depends on the mechanism of mining. It is also essential for establishing captive steel industries in this region, which shall further improve the employment opportunity and lifestyle of the local villagers and for the Government revenue in terms of royalty, taxes and through exports.

STUDY METHODOLOGY

The total study methodology is explained through the simple flow chart in figure, however each of the steps has been detailed out sufficiently in the subsequent sections.

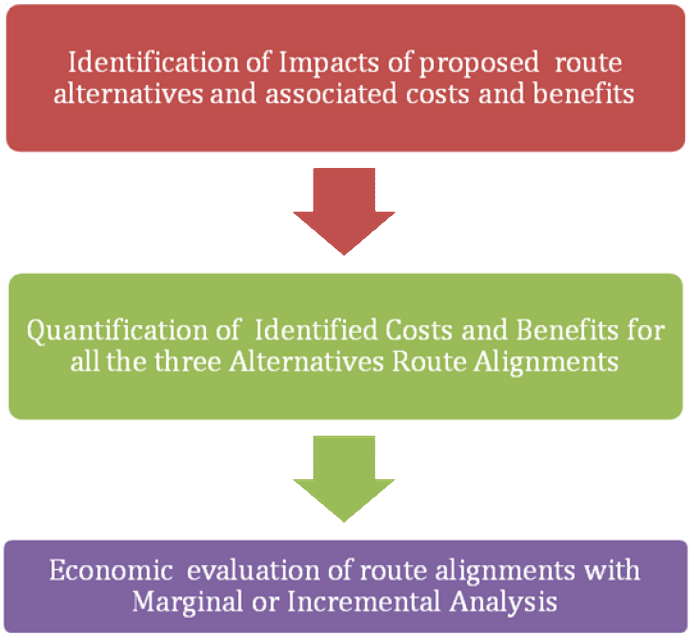

Figure 4 – Methodology adopted for economic evaluation

COSTS AND BENEFITS OF PROPOSED ROUTE ALIGNMENTS

In additional to the total transportation costs/benefits and environmental costs due to transportation activity, the costs and benefits associated with the mining activity through which the route passes are also considered. All the economic and environmental costs such as capital, operation & maintenance costs, vehicle operating costs, pollution costs and time savings are all considered which are even applicable to many of the transport infrastructure projects. After analysing the mining activity and its importance and impacts, it has been identified that if an alternative goes from the mining area it can cause huge loss interms of loss of opportunity. It has been observed from field visit that, there are many people who are all depending mainly on the mining activity as an employment. The open pits left after completion of mining activity upto the saturation limit are being used as drinking water source for the villages around as there is direct seepage of water into that pits at that depth. However the mining owner is responsible for purifying the water and supply to the villages. As per the environmental management plan of India, the mining owner has to compensate for all negative impacts associated with the mining activity as explained in the earlier section. Hence, Costs and benefits belonging to economic, social and environmental impacts are identified very specific to this project of the proposed three route alignments as listed in the Table 1.

Table 1 - Identified quantifiable costs and benefits for the analysis in the present study

[2]Costs/ Benefit Factors	Economical	Environmental	Social
Capital Cost of Road Construction	-		
Periodic Operation and Maintenance cost of Road	-		
Vehicle Operating Cost (VOC) Savings	+		
Value of Time Cost Savings	+		
Cost of Mine ore loss	-		
Pollution Emission Cost due to transportation		-	
Cost of Employment loss			-
Cost of loss in Water Supply from open pit of mining			-
Savings in Costs of Environmental Management Plan			+

Explanations and the procedure for calculation of all the costs and benefits mentioned in the table 1 are summarized as below.

Capital and Operational-Maintenance Cost

The capital cost of construction of the road facility includes the following:

(i) Survey, investigation and design costs
(ii) Land acquisition costs
(iii) Construction costs
(iv) Physical contingencies (unforeseen items and unforeseen increase in cost not attributable to escalation and unforeseen increase in quantities)
(v) Supervision, quality control and administration charges

It is considered that, the cost of construction for the road is INR 40,000,00 per Km which includes the construction of probable maximum number of culverts and bridges.

There has been certain assumptions are made as per the rates during the study time, viz.

1. Land acquisition cost of Normal Land area= INR 80,000 /- per acre = INR 19.7 per m^2

2. Land acquisition cost of mining Land area=INR 3,000,00 /- per acre = INR 74.1 per m^2

The **cost of maintenance** of the facility includes the following:

1. Ordinary repairs such as patch repairs, pot-hole filling, dressing earth work, etc.

2. Periodic repairs, such as renewals and resurfacing

[2] "+" Indicates Benefits and "-" Indicates Costs

3. Any emergent or special repairs

4. Operational expenses, such as traffic signals, traffic aid posts, lighting, policing etc., Supervision and administration charges.

The operation and maintenance cost is taken as 5% of the total construction cost equally distributed over the 5 years. Then the overlay cost is considered as ` 2,000,00 /- and so on. The calculated capital and O&M costs are shown in the Table 2.

Table 2 - The calculation of Capital and O&M cost for all the route alignments

Alternative **[1]**	Length from Terechole Road in m **[2]**	Area loss to Mouli Mine in Sq. m **[3]**	Total Normal Area loss in Sq. m **[4]**	Land Acquisition cost (INR) **[5]** = [3] x 19.7+[4] x 74.1	Constrcution cost (INR)**[6]=**[2]x40lakh /1000	Capital Cost (INR) **[7]** = [5]+[6]	Base year O&M cost (INR) **[8]** = [2] x 40000/1000
1	4687	28572	56527	3235583	1,87,48,000	21983584	187480
2	4175	48252	37996	4328180	1,67,00,000	21028180	167000
3	4622	15935	54371	2256148	1,84,88,000	20744148	184880

Cost of the Mine ore Soil Lost from the Mauli Mine

Area loss to the mine owner under the condition of clearance of 50 m is calculated by using the Google earth tool (Figure 5) for all the alternatives. It is converted as width lost from the boundary of mine by assuming the total mine area lost as a rectangular strip of length 1 Km. As per mining rules it is the policy in that area that, the digging pattern of the mine area from the edge or boundary should be as shown in the Figure 6 in order to enhance the movement of trucks and other mining equipment. The calculated mine soil lost in each alternative are shown in the Table 3. Here it is assumed that the density of mine soil is about 1.3 t/m3.

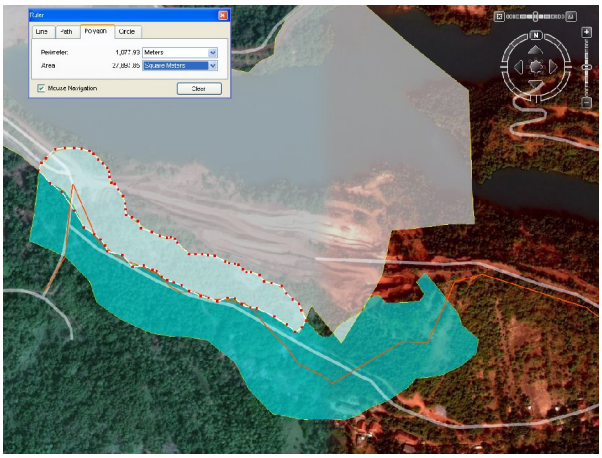

Figure 5 - Calculation of Mine area lost due to passage of route alignment through the mine (With the courtesy of Google Earth)

The calculated lost mine area is converted as width lost from the boundary of mine by assuming the total mine area lost as a rectangular strip of length 1 Km for the computational ease. As per mining rules it is the policy in that area that, the digging pattern of the mine area from the edge or boundary should be as shown in the Figure 5 in order to enhance the movement of trucks and other mining equipment. It is also assumed here that the cost of Mine ore soil is ` 150 /- per ton as per the funding mining agency for this study. Boundary

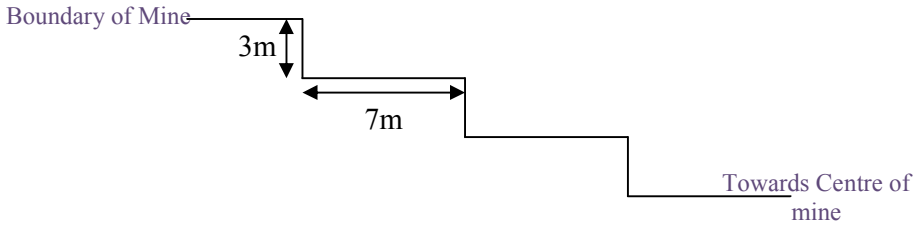

Table 3 - The calculation of Mine soil lost for mining in each route alignment

Alternative **[1]**	Length from Terechole Road m **[2]**	Area loss to Mouli Mine in Sq. m **[3]**	min loss to the Mine area in terms of Width in m if Length is 1 km **[4]**	Number of Strips of with 7 m **[5]**	Volume of Mine Soil lost in Cu. M **[6]**= 7x3x([5]x([5]+1)/2)x1000	weight of Mine soil lost in ton **[7] = [6]x1.3**	Cost of Mine ore soil lost (INR) [8] =[7]x75
1	4687	28572	28.572	4.08	217792	283129	Rs. 2,12,34,731
2	4175	48252	48.252	6.89	571289	742676.9	Rs. 5,57,00,765
3	4622	15935	15.935	2.27	78314	101809.3	Rs. 76,35,696

The Vehicle Operating Cost (VOC)

The Vehicle Operating Cost (VOC) components are

a) Fuel

b) Lubricants

c) Tyres

d) Spare parts

e) Maintenance labour

f) Depreciation

g) Wages of crew

h) Fixed costs, including overheads administration, interest on borrowed capital etc.

Here the VOC is taken for the each truck per day as INR 4.5/- /Km, from which the total VOC for the annum for all the truck trips road is calculated as,

The total yearly truck volume is determined based the number of ships the port handles and the capacity of truck in terms of tonnage of goods. It is assumed here that there can be 10% yearly growth rate in the tonnage handling of the port.

VOC (per annum) = VOC (Per day per vehicle per Km) * Total yearly truck traffic *Route length in Km

Value of Time (VOT) Cost

Here the VOT is given for the each vehicle per hour from which the total VOT for the annum for all the trucks on the road is calculated as

VOT (per annum) = VOT (INR/hr/Vehicle)* Total yearly truck traffic *Route length in Km /Average Speed

Where average speed is considered is 60 Km/Hour and VOT= INR 1000/- /hr./Vehicle (Source: Discussion with *New India Mining Corporation Pvt. Ltd*)

Pollution Emission Cost

Pollution cost = Pollution emission (Kg / 1000 Litres Daily)*cost per kg emission* route length in Km * Total yearly truck traffic*Fuel consumption per Km /1000

Here we have assumed cost per one Kg of emission of pollution as INR 10 /- (Source: Todd Littman, (2010))

Pollution emission = 96.5 Kg / 1000 Liters for trucks

Fuel consumption per Km = 0.0943 Liters/Km

Savings in cost of Environmental Management Plan (EMP) or Mitigation Plan

It already explained in the earlier section that the negative impacts casued by the mining activity should be compensated by the activities like green belt development check dams/De-silting, dump plantation, water spraying for dust suppression, environmental monitoring, health and safety, socio-economic development in the nearby villages in the buffer zone etc. These activities are combined called Environmental Management Plan (EMP) and the cost of

EMP is calculated as per the number of tonnes of minable ore in the mining area. The savings in EMP occurs due to the mine ore soil loss because of passage of route alignment through that mine area. For example, if the route passes through the mine area which causes loss of x tonnes of mine soil to the mining owner then the cost corresponding to the tonnes of lost mine ore soil need not spend. That means the negative impacts due to that mine soil will not be there. Here it is assumed suitable from a report on environmental impact assessment that the cost EMP for 1 ton minable iron ore is about INR 10,000,00 per annum.

Cost of Employment Loss

As the positive effect of mining activity, it causes employment opportunities to the people in the buffer zone of that mining area. Here it is assumed that 1 ton minable iron ore creates an employment opportunity of ` 10,000,00 throughout the mining period of 10 years. Cost of employment loss can be employment cost required for the mine ore soil that lost due to the passage of the particular route alignment through that mine area.

Cost of loss in water supply from open pit of mining

On closure of the mining activity, the open pits acts as water bodies and recharge ground water table which can be used to distribute the water for domestic purpose or for farming. If the mine soil which has to be extracted is lost in the road alignment, then the water storage capacity that can be formed as an open pit is lost. This is quantified as the cost of loss in water supply from the open pit to the people in the buffer zone by considering that it can be created after mining period only upto the analysis period. The cost 1000 litres of water immediately after the mining period is assumed as INR 5 /- and increases at the rate of 10% every year.

ECONOMIC EVALUATION USING INCREMENTAL ANALYSIS

After calculation of all the costs for different alternatives, economic analysis is carried out to determine the most realistic route alignment among three alternatives. The incremental analysis is performed to evaluate each of the alternatives against the other alternative. The results will enable us to determine whether each of the alternatives is worthwhile at all and to rank the alternatives in the order of their attractiveness.

On the above alternative, three analysis cases are performed as,

Case (1) : Alternative 2 against Alternative 1
Case (2) : Alternative 3 against Alternative 1
Case (3) : Alternative 3 against Alternative 2

Three common methods of economic evaluations normally adopted are as follows:

- Net Present Value (NPV) Method
- Benefit - Cost Ratio (B/C) Method

- Internal Rate of Return (IRR) Method

All these three methods are based on the Discounted Cash Flow (DCF) technique of discounting all future costs and benefits to a common year. Presently the NPV method is used in this study.

In this method, the stream of costs/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 give the Net Present Value (NPV). Any project with positive NPV is treated as acceptable. In comparing more than one project, a project with the higher NPV should be accepted. The NPV is algebraically expressed as:

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

Where,

NPVo = Net Present Value in the base year (Year zero)
B_t = Value of benefits which occur in the year t
C_t = Value of costs which occur in the year t
i = **discount rate** per annum in decimals = **10%**
n = **number of years taken for analysis** = **20** Years

After calculating all the costs for all the years of analysis period (taken as 25years as per IRC: SP-30 - 2009), the cases are considered.

RESULTS

The results drawn from the above method for different cases are summarized as in the following Table 4 and the detailed analysis sheets of NPV method for total analysis period are attached at the end of the paper for each case as annexure A, B and C. The same results are also graphically shown in the Figure 6.

Table 4 - NPV Values for all the cases of analysis

Sl. No.	Case	NPV in Rs Crores	Better Option
1	Alternative 1 Challenges Alternative 2	2.21	Alternative 1
2	Alternative 3 Challenges Alternative 1	2.74	Alternative 3
3	Alternative 3 Challenges Alternative 2	4.95	Alternative 3

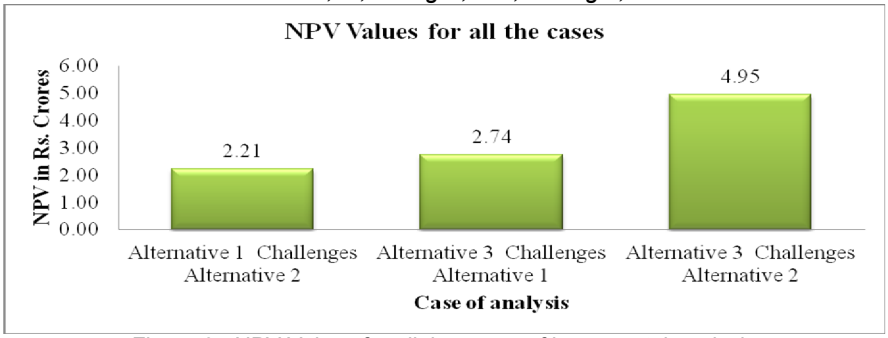

Figure 6 - NPV Values for all the cases of incremental analysis

CONCLUSIONS

It has been attempted in this study to identify all the possible costs associated with the three alternative road alignments which are covering all the impacts to such as economical, environmental, social, so the decision based on evaluation can be sustainable. However there are might be other impacts which are not discussed in this paper, the main objective of the paper to stress upon considering all the impacts associated with the project and also to show a case study to how should one can identify the costs and benefits specific to that project which are even out of the box effects i.e. indirect effects. Hence the transferability of results depends on context of the location, project and various aspects of social costs associated with it. From the results shown in the previous chapter we can confidently say that the 3 rd alternative is the best in terms of nation point of view as well as mine owner view also as it causes very less loss to the mining owner when compared to the other. Hence the final alignment can be port proposed route with the diversion from mining area (alternative 3) through which the gain is about INR 2.74 Crores w.r.t. the port proposed route (alternative 2) according to the sustainability concepts over the analysis period of 20 years.

ACKNOWLEDGEMENT

We are heartily thankful to the *New India Mining Corporation Pvt. Ltd*, Goa for their valuable support interms of funding the study and provision of timely information regarding some standard mining costs which were used in the analysis.

REFERENCES

IRC SP-30, 2009 “Manual on Economic Evaluation of Highway Projects in India”. India

Michael Wegener, 2000, “A new ISGLUTI” the SPARTACUS and PROPILIS Projects”, Second Oregon Symposium on Integrated land use transport models, Portland at http://tlumip.org/symposia/second/Wegener.pdf

Winfrey, Robley, 1969, “*Economic Evaluation of Highways*” Scranton, Pa., International Textbook Co.

Todd Littman, (2010), “Transportation Cost and Benefits Analysis II”, Victoria Transport Policy Institute; at http://www.vtpi.org/tca/tca0510.pdf

Executive Summary of EIA and EMP of Project Proposal for Mahankali Mines M.L.No. 2037 at Chikkabyladakere, Hosadurga, Karnataka, 2007 at http://kspcb.org/PH/Alok%20Kumar%20Exec%20Summary%20Engl.pdf

Organisation for Economic Cooperation and Development (OECD) (1988): "Transport and Environment:, OCDE, Paris.

Maibach, M., C. Schreyer, D. Sutter, H.P. van Essen, B.H. Boon, R. Smokers, A. Schroten, C. Doll, B. Pawlowska, and M. Bak (2008): Handbook on estimation of external costs in the transport sector, Internalisation Measures and Policies for All external Cost of Transport (IMPACT), Version 1.1 Report Delft.

ANNEXURE-A

Worksheet for the calculation of Economic Evaluation for Case 1

*All the costs are mentioned in rupees (₹)

Case 1 Alternate 1 challenges Alternate 2

Sl.No.	Year	Capital Cost		Cost of mine area lost		Cost of Employment Loss		O&M Cost		VOC		VOT		Pollution Cost		Savings in EMP Costs		Cost of Loss in Water Storage Capacity		Net Benefits (4+6+10+12+14+16)-(3+5+9+11+13+15)+ (12-18)+(8-7)+(20-19)	(B-C)/((1+r)^t) @ r=10%
		Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2	Alter 1	Alter 2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
0	2010	21983584	21028180	42469462	111401529	2831297	7426769	0	0	1739520	1503000	6442667	5566667	35177	30394	2831297	7426769	0	0	66859361.34	66859361.34
1	2011							193280	167000	1913472	1653300	5357000	4392667	29249	23984	2831297	7426769	0	0	-5851521.74	-5319565.22
2	2012							193280	167000	2104819	1818630	5892700	4831933	32174	26382	2831297	7426769	0	0	-5974498.80	-4937602.31
3	2013							193280	167000	2315301	2000493	6481970	5315127	35391	29020	2831297	7426769	0	0	-6109773.56	-4590363.31
4	2014							193280	167000	2546831	2200542	7130167	5846639	38930	31922	2831297	7426769	0	0	-6258575.80	-4274691.48
5	2015							193280	167000	2801514	2420597	7843184	6431303	42824	35115	2831297	7426769	0	0	-6422258.26	-3987717.10
6	2016							966400	835000	3081666	2662656	8627502	7074434	47106	38626	2831297	7426769	0	0	-6707428.97	-3786168.79
7	2017							193280	167000	3389832	2928922	9490252	7781877	51816	42489	2831297	7426769	0	0	-6800364.75	-3489662.38
8	2018							193280	167000	3728816	3221814	10439278	8560065	56998	46738	2831297	7426769	0	0	-7018226.11	-3274054.27
9	2019							193280	167000	4101697	3543995	11483205	9416071	62698	51411	2831297	7426769	0	0	-7257873.60	-3078046.91
10	2020							193280	167000	4511867	3898395	12631526	10357678	68968	56553	2831297	7426769	0	0	-7521485.84	-2899858.39
11	2021							193280	167000	4963054	4288234	13894678	11393446	75865	62208	0	0	1088961	2856449	-1448499.21	-507690.14
12	2022							966400	835000	5459359	4717058	15284146	12532791	83451	68429	0	0	1197857	3142094	-1695841.14	-540347.25
13	2023							193280	167000	6005295	5188764	16812561	13786070	91796	75272	0	0	1317642	3456304	-1747165.25	-506091.54
14	2024							193280	167000	6605824	5707640	18493817	15164677	100976	82799	0	0	1449406	3801934	-1919253.77	-505399.50
15	2025							193280	167000	7266407	6278404	20343199	16681144	111073	91079	0	0	1594347	4182128	-2108551.15	-504770.38
16	2026							193280	167000	7993047	6906244	22377518	18349259	122181	100186	0	0	1753782	4600340	-2316778.27	-504198.45
17	2027							193280	167000	8792352	7596869	24615270	20184185	134399	110205	0	0	1929160	5060374	-2545828.09	-503678.52
18	2028							966400	835000	9671587	8356556	27076797	22202603	147839	121226	0	0	2122076	5566412	-2902902.90	-522112.60
19	2029							193280	167000	10638746	9192211	29784477	24422863	162622	133348	0	0	2334284	6123053	-3074933.19	-502776.15
20	2030							193280	167000	11702621	10111432	32762925	26865150	178885	146683	0	0	2567712	6735358	-3379798.51	-502385.51
																				Sum	22122181.14

Result **Alternative 1 is Better than Alternative 2**

NET PRESENT VALUE OF BENEFITS in Rs. Crores **2.21**

ANNEXURE-B

Worksheet for the calculation of Economic Evaluation for Case 2

*All the costs are mentioned in rupees (₹)

Case 2 Alternate 3 challenges Alternate 1

Sl.No.	Year	Capital		Cost of mine area lost		Cost of Employment Loss		O&M Cost		VOC		VOT		Pollution Cost		Savings in EMP Costs		Cost of Loss in Water Storage Capacity		Net Benefits (4+6+10+12+14+16)-(3+5+9+11+13+15)+ (12-18)+(8-7)+(20-19)	(B-C)/((1+r)^t) @ r=10%
		Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1	Alter 3	Alter 1		
1	2	3	4	5	6	7	8	7	8	9	10	11	12	13	14	17	18	19	20		
0	2010	20744148	21983584	15271393	42469462	1018093	2831297	0	0	1663920	1739520	6162667	6442667	33648	35177	1018093	2831297	0	0	28794633.40	28794633.40
1	2011							184880	193280	1830312	1913472	5048267	5357000	27563	29249	1018093	2831297	0	0	-1411225.59	-1282932.36
2	2012							184880	193280	2013343	2104819	5553093	5892700	30320	32174	1018093	2831297	0	0	-1371867.69	-1133774.95
3	2013							184880	193280	2214678	2315301	6108403	6481970	33352	35391	1018093	2831297	0	0	-1328574.00	-998177.31
4	2014							184880	193280	2436145	2546831	6719243	7130167	36687	38930	1018093	2831297	0	0	-1280950.94	-874906.73
5	2015							184880	193280	2679760	2801514	7391167	7843184	40356	42824	1018093	2831297	0	0	-1228565.57	-762842.56
6	2016							924400	966400	2947736	3081666	8130284	8627502	44391	47106	1018093	2831297	0	0	-1137341.67	-641999.72
7	2017							184880	193280	3242509	3389832	8943312	9490252	48830	51816	1018093	2831297	0	0	-1107555.38	-568351.03
8	2018							184880	193280	3566760	3728816	9837644	10439278	53713	56998	1018093	2831297	0	0	-1037830.46	-484155.57
9	2019							184880	193280	3923436	4101697	10821408	11483205	59085	62698	1018093	2831297	0	0	-961133.04	-407614.23
10	2020							184880	193280	4315780	4511867	11903549	12631526	64993	68968	1018093	2831297	0	0	-876765.89	-338031.20
11	2021							184880	193280	4747358	4963054	13093904	13894678	71492	75865	0	0	391574	1088961	1726628.97	605172.92
12	2022							924400	966400	5222094	5459359	14403294	15284146	78642	83451	0	0	430732	1197857	1932051.87	615611.27
13	2023							184880	193280	5744303	6005295	15843623	16812561	86506	91796	0	0	473805	1317642	2087457.05	604661.95
14	2024							184880	193280	6318733	6605824	17427986	18493817	95156	100976	0	0	521185	1449406	2295362.76	604440.75
15	2025							184880	193280	6950607	7266407	19170784	20343199	104672	111073	0	0	573304	1594347	2524059.03	604239.66
16	2026							184880	193280	7645667	7993047	21087863	22377518	115139	122181	0	0	630634	1753782	2775624.94	604056.86
17	2027							184880	193280	8410234	8792352	23196649	24615270	126653	134399	0	0	693698	1929160	3052347.43	603890.67
18	2028							924400	966400	9251258	9671587	25516314	27076797	139318	147839	0	0	763067	2122076	3390342.17	609782.84
19	2029							184880	193280	10176383	10638746	28067945	29784477	153250	162622	0	0	839374	2334284	3691576.39	603602.24
20	2030							184880	193280	11194022	11702621	30874740	32762925	168575	178885	0	0	923311	2567712	4059894.03	603477.38
																				Sum	27360784.26

Result	**Alternative 3 is Better than Alternative 1**	**NET PRESENT VALUE** OF BENEFITS in Rs. Crores	**2.74**

ANNEXURE-C

Worksheet for the calculation of Economic Evaluation for Case 3

*All the costs are mentioned in rupees (₹)

Case 3 Alternate 3 challenges Alternate 2

Sl.No.	Year	Capital		Cost of mine area lost		Cost of Employment Loss		O&M Cost		VOC		VOT		Pollution Cost		Savings in EMP Costs		Cost of Loss in Water Storage Capacity		Net Benefits (4+6+10+12+14+16)-(3+5+9+11+13+15)+ (12-18)+(8-7)+(20-19)	(B-C)/((1+r)^t) @ r=10%
		Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2	Alter 3	Alter 2		
1	2	3	4	5	6	7	8	7	8	9	10	11	12	13	14	17	18	19	20		
0	2010	20744148	21028180	15271393	111401529	1018093	7426769	0	0	1663920	1503000	6162667	5566667	33648	30394	1018093	7426769	0	0	95653994.74	95653994.74
1	2011							184880	167000	1830312	1653300	5048267	4392667	27563	23984	1018093	7426769	0	0	-7262747.33	-6602497.58
2	2012							184880	167000	2013343	1818630	5553093	4831933	30320	26382	1018093	7426769	0	0	-7346366.49	-6071377.26
3	2013							184880	167000	2214678	2000493	6108403	5315127	33352	29020	1018093	7426769	0	0	-7438347.56	-5588540.62
4	2014							184880	167000	2436145	2200542	6719243	5846639	36687	31922	1018093	7426769	0	0	-7539526.74	-5149598.21
5	2015							184880	167000	2679760	2420597	7391167	6431303	40356	35115	1018093	7426769	0	0	-7650823.83	-4750559.66
6	2016							924400	835000	2947736	2662656	8130284	7074434	44391	38626	1018093	7426769	0	0	-7844770.64	-4428168.51
7	2017							184880	167000	3242509	2928922	8943312	7781877	48830	42489	1018093	7426769	0	0	-7907920.13	-4058013.41
8	2018							184880	167000	3566760	3221814	9837644	8560065	53713	46738	1018093	7426769	0	0	-8056056.56	-3758209.84
9	2019							184880	167000	3923436	3543995	10821408	9416071	59085	51411	1018093	7426769	0	0	-8219006.64	-3485661.14
10	2020							184880	167000	4315780	3898395	11903549	10357678	64993	56553	1018093	7426769	0	0	-8398251.73	-3237889.60
11	2021							184880	167000	4747358	4288234	13093904	11393446	71492	62208	0	0	391574	2856449	278129.75	97482.78
12	2022							924400	835000	5222094	4717058	14403294	12532791	78642	68429	0	0	430732	3142094	236210.73	75264.02
13	2023							184880	167000	5744303	5188764	15843623	13786070	86506	75272	0	0	473805	3456304	340291.80	98570.41
14	2024							184880	167000	6318733	5707640	17427986	15164677	95156	82799	0	0	521185	3801934	376108.98	99041.25
15	2025							184880	167000	6950607	6278404	19170784	16681144	104672	91079	0	0	573304	4182128	415507.88	99469.28
16	2026							184880	167000	7645667	6906244	21087863	18349259	115139	100186	0	0	630634	4600340	458846.67	99858.40
17	2027							184880	167000	8410234	7596869	23196649	20184185	126653	110205	0	0	693698	5060374	506519.34	100212.15
18	2028							924400	835000	9251258	8356556	25516314	22202603	139318	121226	0	0	763067	5566412	487439.27	87670.24
19	2029							184880	167000	10176383	9192211	28067945	24422863	153250	133348	0	0	839374	6123053	616643.20	100826.09
20	2030							184880	167000	11194022	10111432	30874740	26865150	168575	146683	0	0	923311	6735358	680095.52	101091.87
																				Sum	49482965.41

Result **Alternative 3 is Better than Alternative 2**

NET PRESENT VALUE OF BENEFITS in Rs. Crores	**4.95**