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An Economic Analysis of Light Rail Transit in Addis Ababa, Ethiopia

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Abstract:

The growing demand for public transport in metro cities has serious repercussion on urban land use patterns and pollution level. A sustainable urban transport system could be developed by an appropriate combination of different modes of transportation. The proposed light rail transit system in Addis Ababa is expected to provide multiple benefits such as time saving to passengers, reduction in accidents, reduction in traffic congestion, fuel savings, employment generation and reduction in pollution. These benefits will accrue to government, passengers, general public and to society in nutshell. This paper tries to measures all these benefits against the cost streams through an economic analysis. The NPV of the cost stream for 32 years calculated @ 12% as 699.24 million US$. The economic internal rate of return on investments in the LRT is calculated as 33.63 percent.

Key words: EIRR, Light Rail Transit, NPV, economic viability, sensitivity analysis.

JEL Classification: D6, R4, R42

1.0 Introduction:

Addis Ababa is one of the fast growing cities in east –Africa with a population of 3.38 million as per 2007 census. It is one of

the cities that almost entirely on roads as means of mass transport. The total length of the road network in Addis has increased from a 2200 km in 1997 to 2814 km in 2001 and it is expected to grow to 3700 km in the year 2021. This increase in road length is not at par with the phenomenal growth in the number of vehicles on these roads in Addis. The cumulative figure of vehicles in 1998 in Addis Ababa was 79, 464 and it is expected to increase to 2, 72, 741 by the year 2021 of which car will be 1, 02, 263, bus 32,870 and two-wheelers 7,961 approximately. With gradual vertical expansion of the city, the average trip length of buses has gone up and the increased congestion on roads has made the corresponding journey time of about one hour. Further the aged fleet, and the chaotic movement of mini –buses and taxis making the life and property in the city unsafe and hazardous. This is also making the emission level high thus making Addis a polluted city in the World. The major cause of this pollution is created by automobiles contributing more than two thirds of the total atmospheric pollution. In this context, the decision of the Federal Government of Ethiopia to develop a mass transport system for the capital city of Addis Ababa providing an alternative mode of transport to the passengers is an appropriate and also a decision in right direction. The first concrete step in the launching of a Light Rail Transit System (LRT) for Addis was taken when an Ethiopian Railway Corporation (ERC) took charge of LRT in March 2008. This was followed by issuing of EPC turnkey tender by ERC in April 2008. Beforehand, a steering committee for LRT under the Ministry of Transport (MoT) was formulated. Addis Ababa City Road Administration (AACRA) LRT desk constituted in December 2007 issued a RFP in January 2008 in this regard. Meanwhile, three tenders were received. But the proposal failed due to high cost, failure to meet the cost breakdown and unconfirmed source of finance. But a MoU was signed between MoT and China Railway Engineering Corporation (CREC) in

March 2009.CREC presented the conceptual design and cost estimates in July 2009. The EPC turnkey contract was signed in September 2009. The loan agreement was signed with China Export-Import Bank in June 2011.

Features: The metropolitan electric railway in Addis Ababa will have 34.25 km with a North-South line of 16.9 km and East-West line 17.35 km. East-West line will cover area such as Ayat Village to Tor Hailoch passing through Megenagna, Legehar and Mexico Square and North-South will pass through Menelik II Square, Merkato, Lideta, Legehar, Meskel Square, Gotera and Kaliti. Both the line will share a common track of 2.7 km. LRT will be constructed in two phases *viz.* LRT (Phase I) and LRT Extension (Phase II). The LRT alignment and extension is presented in Figure 1.

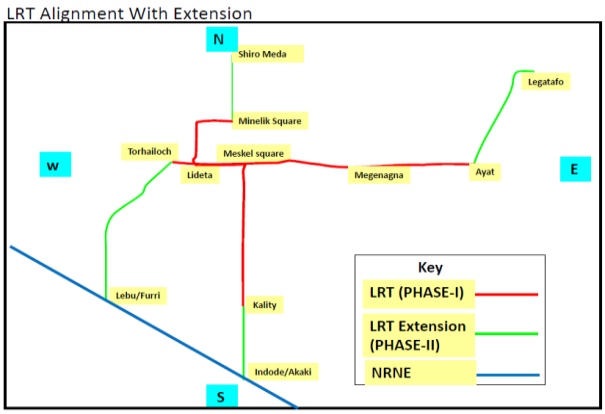

Figure 1: LRT Alignment and Extension

The nominal track gauge will be 1435 mm with maximum grade typical 5%. It will have a high capacity of 15,000 passengers per hour per direction (pphpd). Maximum capacity in all the four directions will be 60,000 pphpd. The maximum service speed will be 80 km per hour. Initially the LRT will cover 39 stations with initial injection of LRVs =41 with carrying capacity of 286 passengers per train. The headway will

be 6 minutes at the beginning with reduction to 90 seconds thereafter. The working hours has been targeted up to 16 to 18 hours per day. The LRT is further based on a reliability factor of 98%. The ambience in the train will be pleasant and attractive. The LRT will be environment friendly and will have great impact on city form and structure. It will have low life-cycles cost and will increase the land value. The fare will be based on passenger – kilometre based on the affordability of the passenger. (Jemere, Y, 2012). The project will be financed through 85% foreign debt from China Export and Import Bank and 15% through equity.

2.0 Literature Review

Road safety in the developing world is multidimensional. It is not only related not only with accidents but also has economic, social and health issue. The road accident that impaired the lives of millions each year and accompanied by substantial economic loss is more severe in Africa and particularly the Sub-Saharan Africa. The vehicle population in Sub-Saharan Africa is only 4% but about 10% of global road deaths take place the Region. However, in the developed World there is 40% registered vehicle but it only account 14% of road deaths. The road accident death in Ethiopia is 1700 with the figure of 7000 reported injuries. But the actual casualty number is twice as these numbers are only those that are reported to the police and there is an under reporting always. The road accidents in Ethiopia which causes five times more fatality than in Zambia and Botswana or two times serious fatality than Kenya and Tanzania is basically concentrated in four regions of Ethiopia. These four regions account 90% of the road accidents, of which Addis Ababa accounts 42% of road crash (Ethiopian Roads Authority, 2005).

Addis Ababa with an area of 540 square kilometres is a fast growing African city. More than 75% of the registered

vehicles in Ethiopia are found in this city. Realising the importance of transport sector, government is investing huge resources in enhancing public transport system. The city transport system face with a number of challenges with reference to public transport (Mohapatra, 2014).

There is a general agreement on the value of mass transit as a sustainable solution to urban mobility in the case of rising traffic congestion air and noise pollution and road safety (Jain, 2010; Sakamoto et al, 2010). In recent years, the global mass transit debate focus around investment in light rail transit, mono rail, metro projects, BRT etc. (Currie, 2006).

The predominantly road-based urban transportation sector in Ethiopia is a great challenge. There is a phenomenal growth in annual motorization in Ethiopia which is increasing from 1.82% in 1998-99 to 3.76% in 2002-03 (Ethiopian road Authority). The annual motorization in Ethiopia even if considered low in the World is currently around 6% per annum. The total motor vehicle in Addis Ababa is 77% of the total motor vehicles in Ethiopia. This creates a chaotic environment in the city with serious threats to road safety, life and property. In 2002, there were only 92,233 total vehicles in Addis Ababa road that increased to approximately 0.18 million in 2014. This is expected to grow up to approximately around 0.27 million in 20121 and to 0.46 million in 2030. The situation in urban centres leads to more energy use and reduces the mobility and productivity (Hess et al, 2005). Addis Ababa is no exception.

Addis Ababa population is growing at the rate of 3.8% per annum. Thus, an accessible, convenient, reliable, and affordable public transit system is critical to the urban mobility of Addis growing population. The public transport plays an important role not only for low-income commuters who constitute a large majority of the capital city population but also is only affordable transit option and are important from the point of view in mitigating environmental and social impacts.

The public transport service historically dominated by buses carrying over 80% of public transit users is overwhelmed by demand. Buses are unreliable, slow, unsafe and uncomfortable. The greatest advantage of bus service is fare, which remains low due to government control. The service gaps left by public bus are filled by largely unregulated minivans and taxis which are unaffordable on a daily basis by majority of city's population. In response to the above-mentioned situation the Federal Government of Ethiopia has taken a major role in promoting sustainable urban transport development in Addis Ababa recently. The LRT project in Addis has all the economic, environment and social benefits like such projects in other major cities of the World and also is connected with strong financial incentives.

The LRT in Addis is an interesting example of a sustainable urban development initiative in Ethiopia which is also connected with country's vital rai project Djibouti – Ethiopia railway project. This is planned as an integral component of a larger multi-modal transport system for the city; its design and implementation engendered widespread support and utilized innovative technology; and the scheme benefited from clear governance and multi-tiered financing arrangements. However, the scale of financing and implementation of the proposed 34 plus kilometre metro is markedly different from the light rail transit project experience of other countries of Sub-Saharan Africa. The project proposed to be implemented in late 2015 will initially serve 0.5 million passengers per day and also could be promoted as a viable mass transit model for other large Sub-Saharan African metro cities (Yee, 2008). In Addis, more passengers are turning towards private motor vehicles as their transportation mode of choice. Thus, the combined influence of rising motor vehicle ownership and growing population has led to an untidy traffic situation on Addis roads. The increasing congestion, pollution and alarming

increases in traffic accidents have plagued the country's capital in recent to opt for mass transit alternatives.

3.0 Objective:

The objective of this paper is to carry out an economic analysis to assess the viability of the proposed LRT project in Addis Ababa in term of cost-benefit approach for a horizon period of 32 years.

4.0 Methodology and Approach

Economic viability of the project is being assessed within the broad framework of "Cost-Benefit Analysis", generally used for appraisal of public investment projects. In economic evaluation, benefits are computed for the economy as a whole rather than for an individual entity that has made the investment. In case of financial analysis the profits become the major factor for evaluation whereas in economic analysis the benefits to the economy are the main criteria for evaluation.

The economic analysis involves comparison of project costs and benefits in economic terms under the "with" and "without" project conditions and determination of the Economic Internal Rate of Return (EIRR) of the project using discounted cash flow technique. This shows the return which the society could expect from the proposed investment during the project life, i.e. the benefit period. The feasibility of the project is determined by comparing the EIRR with the current accounting rate of return of 12%. This represents the opportunity cost of capital and is considered an appropriate minimum criterion for economic viability by both the Federal Republic of Ethiopia and international funding agencies like the World Bank and the African Development Bank (AfDB).

The main steps followed are:

i) Estimation of future traffic on the proposed facilities
ii) Estimation of capital and maintenance costs (both regular and periodic) at economic prices
iii) Estimation of economic benefits
iv) Comparison of annual streams of costs with benefits and estimation of EIRR

The project is further subjected to sensitivity analysis by assessing the effects of adverse changes in the key variables on the base EIRR. This helps to gauge the economic strength of the project to withstand future risks and uncertainties.

4.1 Definition of "Without" and "With" Project Situations

4.1.1 "Without Project" Situation

In the "without project" situation, there will be no LRT. The traffic on North-South and East-West corridor will remain on road leading to heavy congestion and causes substantial delay to the traffic.

4.1.2 "With Project" Situation

In order to avoid the above-mentioned bottleneck it has been proposed to construct a LRT in Addis. This will ease out the traffic congestion and will leads social benefits.

4.2 Project Cost and Scheduling

The total project cost is estimated as 475 million US$. 85% of the total project cost will be financed through external debt from China Export-Import Bank and 15 % will be financed by raising equity in the open market by Ethiopian government. The debt and equity ratio thus is 85:15.

The project cost consists of two main components:

- Capital cost
- Maintenance cost

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices as these are not real costs to the economy, but are only transfer payments.

All financial costs have been converted into economic costs by applying a Standard Conversion Factor (SCF) of 0.85, as suggested by the Ministry of Transport, Ethiopia and AfDB/World Bank and is generally used for economic evaluation of transport projects in Africa.

4.2.1 Capital Cost

The capital cost includes the cost of construction of Light Rail Transit system in Addis. This will be incurred during the period 2012 to 2015 for the Phase I of construction of LRT. The financial cost of LRT is estimated at market prices. The economic cost is derived by applying SCF of 0.85 to the financial cost. The capital cost of the project in financial and economic terms is presented in **Table 1**.

Table 1: Capital Cost of the LRT Project at 2015 Prices
(In million US$)

Sl. No.	***Total Cost***	***Financial Cost***	***Economic Cost***
1.	Construction of LRT in Addis	475.00	403.75

Source: East-African News, April, 2015.

4.2.2 Maintenance Cost

Maintenance costs are recurring costs, comprising routine and periodic maintenance components. The routine maintenance involves day-to-day repairs and maintenance of LRT facilities. First five years maintenance will be provided by China Railway Engineering Corporation (CREC) and Shenzhen Metro Group initially for 116 million US$.

In addition to the capital cost, the routine maintenance cost would start incurring from the next year of starting of the project (in this case 2016 is the next year of the project). The first maintenance cost of 116 million US$ (financial cost) will be incurred from 2nd year to 5th year (2016 to 2020). The annual maintenance cost during these years will be 19.72 million US$ per annum (economic cost). The second maintenance cost of 232.10 million US$ (financial cost) is 10% more than the first maintenance cost and will be incurred from 6th year to 10th year (2021 to 2025). The annual maintenance cost during these years will be 39.46 million US$ per annum (economic cost). The third maintenance cost of 255.31 million US$ (financial cost) is 10% more than the second maintenance cost and will be incurred from 11th year onward to 15th year (2026 to 2030). The annual maintenance cost during these years will be 43.40 million US$ per annum (economic cost). The fourth maintenance cost of 280.84 million US$ (financial cost) is 10% more than the third maintenance cost and will be incurred from 16th year onward to 20th year (2031 to 2035). The annual maintenance cost during these years will be 47.74 million US$ per annum (economic cost). The fifth maintenance cost of 308.93 million US$ (financial cost) is 10% more than the fourth maintenance cost and will be incurred from 21st year onward to 25th year (2036 to 2040). The annual maintenance cost during these years will be 52.52 million US$ per annum (economic cost). The sixth maintenance cost of 339.82 million US$ (financial cost) is 10% more than the fifth maintenance cost and will be incurred from 26th year onward to 30th year (2041 to 2045). The annual maintenance cost during these years will be 57.77 million US$ per annum (economic cost). The seventh maintenance cost of 373.80 million US$ (financial cost) is 10% more than the sixth maintenance cost and will be incurred from 31st year and 32nd year (2046 to 2047). The annual maintenance cost during these two years will be 63.55 million US$ per annum (economic cost).

The annual maintenance cost of the project in financial and economic terms is summarized in **Table 2**.

Table 2: Maintenance Cost of the LRT Project at 2015 Prices
(In million US$)

Sl. No.	*Maintenance Cost*			
	Year	*Financial*	*Economic*	*Annual Maintenance Cost (Economic)*
	5 – Years Slab			
1	2016-2020	116.00	98.60	19.72
2	2021-2025	232.10	197.29	39.46
3	2026-2030	255.31	217.01	43.40
4	2031-2035	280.84	238.71	47.74
5	2036-2040	308.93	262.59	52.52
6	2041-2045	339.82	288.84	57.77
7	2046-2047	373.80	317.73	63.55

Calculated by Author

4.2.3 Debt-Equity Model:

Here, a debt-equity model on 85:15 patterns has been assumed. The debt to be incurred is 5.7 times of the equity to be raised from the market. A loan repayment period of 15 years from 2015-2030 has been further assumed. The total debt amount is 403.75 million US$ and the equity amount is 71.25 million US$. The interest rate on the debt is taken as @3% per annum. Total amount of interest rate to be paid during this period is calculated as 94.48 million US$. The assumption of the debt-equity model is presented in Table 3.

Table 3: Assumptions of Debt-Equity Model

Sl. No.	*Items*	*Assumptions*
1	Debt -Equity	85:15
2	Interest Rate	3%
3	Moratorium Period	5 year
4	Loan Repayment Period	15 years.
5	Infrastructure Development	3 years (Phase I)

The debt-equity model is presented in Table 4.

Table 4: Debt-Equity Model

(In million USD)

Year		*Opening Balance*	*Loan*	*Interest*	*Principal Repayment*	*Closing Balance*	*Equity*
Year 0	2015	0.00	80.75	2.42	0.00	80.75	14.25
Year 1	2016	80.75	80.75	4.85	0.00	161.50	14.25
Year 2	2017	161.5	80.75	7.27	0.00	242.25	14.25
Year 3	2018	242.25	80.75	9.69	0.00	323.00	14.25
Year 4	2019	323	80.75	12.11	0.00	403.75	14.25
Year 5	2020	403.75	0.00	12.11	26.92	376.83	0.00
Year 6	2021	376.83	0.00	11.31	53.83	323.00	0.00
Year 7	2022	323.00	0.00	9.69	53.83	269.17	0.00
Year 8	2023	269.17	0.00	8.08	53.83	215.33	0.00
Year 9	2024	215.33	0.00	6.46	53.83	161.50	0.00
Year 10	2025	161.50	0.00	4.85	53.83	107.67	0.00
Year 11	2026	107.67	0.00	3.23	53.83	53.83	0.00
Year 12	2027	53.83	0.00	1.62	26.92	26.92	0.00
Year 13	2028	26.92	0.00	0.81	26.92	0.00	0.00
Year 14	2029	0.00	0.00	0.00	0.00	0.00	0.00
Year 15	2030	0.00	0.00	0.00	0.00	0.00	0.00

Calculated by Author

4.3 Project Benefits

The economic benefits of the LRT by the changes brought out by it in the transport sector of the economy. A high proportion of current passenger traffic from road is diverted to LRT because of the operation of light rail. The growing passenger traffic demand in Addis is being fulfilled by LRT. This results in reduction in the number of buses, cars and other vehicles carrying passengers on Addis roads. Reduction in numbers of vehicles on road reduces the congestion thus save travel time for passengers still using roads. The vehicular pollution gets reduced with introduction of LRT as LRT is run on electricity and there is less use of gasoline and diesel. Thus, there will also be high amount of fuel savings and saving in foreign exchange. The road accidents also get reduced with introduction of LRT. Further, LRT also bring less investment by government in bus transport as well as the private sector investment on buses, passenger cars and other vehicles carrying passengers. There

will be substantial decline in motor vehicles' operation and maintenance charges to both the government and the private sector. The private car owners will also able to save the capital and operation and maintenance costs by switching over from road to light rail for travel. LRT will also be substantially beneficial for people of Addis as they can save the travel time as well as there is less road congestion. Less road congestion leads to health benefits. Introduction of LRT increases the real estate prices. It will not only help the property or house owners due to increased valuation of their property but also will help in increasing the per capita income. But the redistribution of income may not be desirable as the average per capita income of Addis is more than average per capita of the nation. Benefits also come in terms of employment generation for unskilled labour during construction period of LRT (2012 -2015) as well as to the skilled and unskilled professionals during the operation phase. The fare box revenues and the revenues from advertisement and property development are the financial benefits from the LRT. The benefits accrue to the local economy due to operation of the LRT are many. However, certain economic benefits are easy to quantify and certain other are complex to quantify due to paucity of data. Here the following benefits have been quantified against the cost streams. Benefits from the LRT will be both direct and indirect. The present analysis, however, is restricted to quantification of direct benefits as presented below. The indirect benefits like idle fuel consumptions and improved environmental conditions are difficult to quantify and hence are not included in the economic analysis.

- ✓ Revenue tariff from LRT,
- ✓ Saving in fuel (gasoline and diesel) due to reduction in number of buses, car and two wheelers,
- ✓ Saving in time due to operation of LRT,
- ✓ Accidents Savings

- ✓ Employment generation for both professional and unskilled labor.

All the above benefits from the project will accrue mainly to due to operation of LRT. The traffic on the existing road would also benefit since they would enjoy reduced congestions after the operation of LRT. The benefits considered for economic evaluation are "*with project*" situations.

The cost-benefit streams of LRT project in Addis which has been taken into consideration for economic analysis in this study is presented in Table 5.

Table 5: Cost-Benefit Streams

Sl. No.	***Cost***
1	Capital Cost of LRT
2	Operation and Maintenance Cost
Benefits	
1	Revenue tariff of operation of LRT
2	Saving in fuel (gasoline and diesel)
3	Saving in time due to operation of LRT
4	Accidents Savings
5	Employment generation

4.3.1 Revenue Tariff of Operation of LRT

The committee set up by government proposed the cost of a passenger ticket from start to the end of the journey @ ETB 20 to 30. However, government is contemplating a price of ETB 5 for the above-mentioned journey. But there is no confirm data on such decision. Therefore the author has taken this price of ETB 5 (0.25 US$) for such journey. The price of the passenger ticket has further been hiked by 10% of the existing price for the first five year slab starting from 2016 up to 2020. Thereafter, in every five-year slab the price of the passenger ticket has been hiked by 5% of the existing price. As per the available data the number of passenger will be 0.5 million per day in the beginning. However, thereafter the author has considered the growth of passenger number @ 5% for each five-year slab starting from 2016. The passenger numbers and

passenger tariff for 32-years of study period is presented in Table 6.

Table 6: Number of Passenger and Revenue Tariff from Ticket

Items	*2016-20*	*2021-25*	*2026-30*	*2031-35*	*2036-40*	*2041-45*	*2046-47*
Passenger per day (in million)	0.500	0.525	0.551	0.579	0.608	0.638	0.670
Ticket Tariff (in US$)	0.28	0.29	0.30	0.32	0.33	0.35	0.37

NB: 1US$= 20 ETB

The revenue tariff flows for 32 years (2015 to 2047) is presented in Table 7.

Table 7: Revenue Tariff from Ticket Sale during 2015-2047

Year	*Tariff (in Million USD)*
2015	0.000
2016	45.625
2017	45.625
2018	45.625
2019	45.625
2020	45.625
2021	55.332
2022	55.332
2023	55.332
2024	55.332
2025	55.332
2026	61.003
2027	61.003
2028	61.003
2029	61.003
2030	61.003
2031	67.256
2032	67.256
2033	67.256
2034	67.256
2035	67.256
2036	74.150
2037	74.150
2038	74.150
2039	74.150
2040	74.150
2041	81.750
2042	81.750
2043	81.750
2044	81.750

Year	*Tariff (in Million USD)*
2045	81.750
2046	90.130
2047	90.130

NB: Revenue Tariff has been calculated from 2016 taking into account that the operation of LRT begin from 2016.

4.3.2 Savings in Passenger Time

The savings of travel time of passengers traveling in LRT are calculated by multiplying the number of passengers travelled daily and the time saved on the average passenger lead in Addis. The Value of Time (VOT) of passenger in Addis is first calculated as below:

Value of Time (VOT): The Value of Time (VOT) has been estimated for the population greater than 5 years of age, based on the average earnings per person in Ethiopia. The unit VOT for work is taken as the average earning per hour. The unit VOT of commuting trips (i.e. from home to work and back/home to school and back /other social and recreational purposes) has been taken as 30% of VOT of work/ business trips.

The unit VOT of a person in Ethiopia has been estimated based on the following:

- Average monthly earnings per person in Addis = ETB 6,858[1] = 340 US$
- Hourly income, considering 8 work hours a day and 22 work days a month = ETB 39 = 2.06 US$
- Wage Rate or VOT for business trip is taken as the hourly income = ETB 39 /hour = 2.06 US$
- VOT for Non-business trip @ 30% of VOT of business trip = ETB 13/hour = 0.62US$
- Business trips are 25% and non-business trips are 75% of total trips
- Thus, Average VOT is estimated as ETB 20/hour[2] = 0.98 US$

[1]Addis Ababa Finance and Economic Development Bureau, 2008

Time savings of passengers using LRT is calculated as below:

- Savings in time by individual passenger travelling in LRT per day =12.6 minutes
- Number of work or business day per year = 300
- Savings in time by individual passenger travelling in LRT per year in hours =63
- Value of time of a person per hour =20 Ethiopian Birr (ETB) = 0.98 US$

Where (1 US$ =20.2 ETB)

- Total numbers of passengers those will save time by travelling in LRT in 2015 = 0.50 million
- Total hours saved in a year in million in 2015 (= time saved by a passenger in a year × number of passenger using LRT = 63 * 0.50) = 31.50
- Benefits due to time savings in year in million USD in 2015 = 30.89 million US$
- Value of Time increases @5% per annum

Total time savings from 2015 to 2047 in monetary terms is presented in Table 8.

Table 8: Total Time Savings during 2015-2047

Year	*Increase in Number of Passengers (in million)*	*Increase in Income per Annum (in US$)*	*Savings in Time (in Million US$)*
2015	0.500	0.98	30.89
2016	0.500	1.03	32.44
2017	0.500	1.08	34.06
2018	0.500	1.14	35.76
2019	0.500	1.19	37.55
2020	0.500	1.25	39.43
2021	0.525	1.31	43.47
2022	0.525	1.38	45.65
2023	0.525	1.45	47.93
2024	0.525	1.52	50.32
2025	0.525	1.60	52.84
2026	0.551	1.68	58.26

[2] VOT assumed to increase @ 5% per annum.

Year	*Increase in Number of Passengers (in million)*	*Increase in Income per Annum (in US$)*	*Savings in Time (in Million US$)*
2027	0.551	1.76	61.17
2028	0.551	1.85	64.23
2029	0.551	1.94	67.44
2030	0.551	2.04	70.81
2031	0.579	2.14	78.07
2032	0.579	2.25	81.97
2033	0.579	2.36	86.07
2034	0.579	2.48	90.37
2035	0.579	2.60	94.89
2036	0.608	2.73	104.62
2037	0.608	2.87	109.85
2038	0.608	3.01	115.34
2039	0.608	3.16	121.11
2040	0.608	3.32	127.17
2041	0.638	3.49	140.20
2042	0.638	3.66	147.21
2043	0.638	3.84	154.57
2044	0.638	4.04	162.30
2045	0.638	4.24	170.41
2046	0.670	4.45	187.88
2047	0.670	4.67	197.28

Calculated by the author.
NB: Time savings in 2015 has not been taken into consideration for benefits streams.

The time savings due to decongestions of road due LRT operation has not been taken into consideration due to data lag and calculation difficulties for data lag.

4.3.3 Fuel Savings

The operation of LRT in Addis will result in reductions in numbers of vehicles plying in Addis road as certain numbers of passengers will travel in LRT. The experience of other countries implied a 30% influence of vehicles in due to operations of LRT. Further, this constitutes 45% reduction in car numbers, 70% two-wheelers and 25% buses. Taxis and other mode of vehicles are personal preference, thus may not be affected by LRT. Taking these as parameter the calculation of fuel savings has

been done with respect to total reduction of 45% car, 70% two-wheelers and 25% of buses in Addis road.

The vehicles in Addis Ababa constitute 77% of the total registered vehicles in Ethiopia. The registered vehicles data of Addis has been derived from 2002 registered vehicle data of Ethiopia (Road Transport Authority). Further, there is an annual motorization of 5.8% happens in Ethiopia. The annual motorization rate in Addis although higher than this rate but the author has taken 5.8% increase in number of cars and buses and 8% increase in number of two-wheelers in Addis for calculation purpose. The 2002 vehicle data has been extrapolated applying the above. The numbers of car, buses and two-wheelers that will be affected up to 2047 has been derived by applying a general reduction in number of 45% car, 25% bus and 70% two wheelers. The number of car, two wheelers that will be affected by LRT operation is presented in Table 9.

Table 9: Total Numbers of Vehicles Affected due to LRT Operation during 2015-2047

Years	*Car & Jeep*	*Two Wheelers*	*Buses*
2015	65768	4394	21795
2016	69582	3968	23059
2017	73618	5125	24396
2018	77888	5535	25811
2019	82405	5977	27308
2020	73251	5399	24530
2021	92242	6972	30570
2022	97592	7530	32343
2023	103252	8132	34219
2024	109240	8783	36203
2025	115576	9485	38303
2026	122280	10244	40524
2027	129372	11064	42875
2028	136876	11949	45361
2029	144814	12905	47992
2030	153214	13937	50776
2031	162100	15052	53721
2032	171502	16256	56837
2033	181449	17557	60133
2034	191973	18961	63621
2035	203107	20478	67311

2036	214888	22117	71215
2037	227351	23886	75346
2038	240538	25797	79716
2039	254489	27861	84339
2040	269249	30090	89231
2041	303782	34957	98727
2042	321401	37753	104454
2043	340042	40773	110512
2044	359765	44035	116922
2045	380631	47558	123703
2046	402708	51363	130878
2047	426065	55472	138469

2002 Vehicle data (Road Transport Authority, Ethiopia) has been extrapolated.

To calculate the fuel savings, a figure of 1 liter of gasoline savings by car and two- wheelers and 3 liters of diesel savings by bus has been taken into account. The price of 1 liter of gasoline has been taken as 0.82$ and 1 liter of diesel as 0.74$ (June 2015 price) for calculation purpose. The price of gasoline and diesel price has been subjected into an annual increase at the rate of 3% per annum for another 32 year time period. The price of 1 liter of gasoline and 1 liter of diesel is presented in Table 10.

Table 10: Fuel Prices in Addis (in US$)

Year	*Gasoline Price (1 Litre)*	*Diesel Price (1 Litre)*
2015	0.82	0.74
2016	0.84	0.76
2017	0.87	0.79
2018	0.90	0.81
2019	0.92	0.83
2020	0.95	0.86
2021	0.98	0.88
2022	1.01	0.91
2023	1.04	0.94
2024	1.07	0.97
2025	1.10	0.99
2026	1.14	1.02
2027	1.17	1.06
2028	1.20	1.09
2029	1.24	1.12
2030	1.28	1.15
2031	1.32	1.19

Year	*Gasoline Price (1 Litre)*	*Diesel Price (1 Litre)*
2032	1.36	1.22
2033	1.40	1.26
2034	1.44	1.30
2035	1.48	1.34
2036	1.53	1.38
2037	1.57	1.42
2038	1.62	1.46
2039	1.67	1.50
2040	1.72	1.55
2041	1.77	1.60
2042	1.82	1.64
2043	1.88	1.69
2044	1.93	1.74
2045	1.99	1.80
2046	2.05	1.85
2047	2.11	1.91

Calculated from 2015 fuel price data

The fuel savings from 2015 to 2047 has been calculated by multiplying the amount of fuel saved by each category of vehicles and with their respective prices and fuel saved per day. The fuel saved by each category of vehicles per annum is presented in Table 11.

Table 11: Fuel Savings due to Reduction in Number of Vehicles in Addis on Account of LRT *(In million US$)*

Year	*Car & Jeep*	*Two-Wheelers*	*Buses*	*Total*
2015	19.68	1.32	17.66	38.66
2016	21.45	1.22	19.25	41.92
2017	23.38	1.63	20.97	45.98
2018	25.47	1.81	22.85	50.14
2019	27.76	2.01	24.91	54.68
2020	25.42	1.87	23.04	50.33
2021	32.97	2.49	29.58	65.03
2022	35.92	2.77	32.23	70.93
2023	39.15	3.08	35.12	77.35
2024	42.66	3.43	38.28	84.37
2025	46.49	3.82	41.71	92.01
2026	50.66	4.24	45.45	100.36
2027	55.21	4.72	49.53	109.46
2028	60.16	5.25	53.98	119.39
2029	65.56	5.84	58.82	130.22
2030	71.44	6.50	64.10	142.04

Year	*Car & Jeep*	*Two-Wheelers*	*Buses*	*Total*
2031	77.85	7.23	69.85	154.94
2032	84.84	8.04	76.12	169.00
2033	92.46	8.95	82.95	184.35
2034	100.75	9.95	90.40	201.10
2035	109.79	11.07	98.51	219.37
2036	119.65	12.31	107.35	239.31
2037	130.38	13.70	116.98	261.07
2038	142.08	15.24	127.48	284.80
2039	154.83	16.95	138.92	310.71
2040	168.73	18.86	151.39	338.97
2041	196.08	22.56	172.52	391.17
2042	213.68	25.10	188.01	426.78
2043	232.85	27.92	204.88	465.65
2044	253.75	31.06	223.26	508.07
2045	276.52	34.55	243.30	554.37
2046	301.34	38.43	265.13	604.90
2047	328.38	42.75	288.93	660.06

Author's calculation

4.3.4 Accident's Savings

Introduction of LRT will result in reduction in the number of vehicles from Addis road. This also includes diverted traffic. While this in itself may not reduce the number of accidents, it will result in reduction fatal (killed) as well as serious injury accidents (KSI). Studies world - wide, show that LRT measures generally result in reducing KSI, saves damage to vehicles, helps in reduction in compensation paid to the affected by insurance agency (Murty, M.N. et. al. , 2006). However, due to data lag the author's calculated the reduction in KSI as below.

The monetary value or cost of a fatal accident is defined as the loss in productivity of the person killed. This has been calculated based on the average age of the victim, his per capita earnings, growing at 5% per annum over a total working life of 20 years. In the absence of any other data, the cost of a serious injury has been assumed as 25% of the cost of a fatal accident. Thus, the major benefit of LRT measures is the reduction in KSI and the resultant saving in loss of productivity.

It is envisaged that total accidents will not increase with growth in population in the future. The benefits to the

motorists, in terms of reduction in congestion, have not been taken into consideration. As mentioned earlier, the benefits of LRT measures will accrue primarily due to saving in productivity loss of KSI accidents of categories in Addis.

KSI Reduction: The reduction in the number of KSI accidents has been estimated based on the following data/assumptions/parameters:

- No of persons killed in Addis Ababa = 474 per year[3]
- No of persons seriously injured in Addis Ababa= 704 per year[4]
- Reduction in KSI Accidents due to LRT= 30%[5]
    - Reduction in killed = 30% of 474 = 142 per year
    - Reduction in Seriously Injured = 30% of 704 = 211 per year

The cost of a fatal accident or saving in future earnings of a person killed is estimated as below:

- Per capita earning of a person in Ethiopia = 6,858 ETB per month = 340 US$ [6]
    - Average work life = 20 years
    - Growth in earnings per year @ 5%
    - Based on the above assumptions, future earnings saved due to saving of a fatal accident is estimated as 2,939,466 ETB = 1,45,576 US$ per person[7]

[3] The annual growth rate of killed in accidents was 3.75% in between 1997 to 2003. Total number of fatal accidents was 283, which increased to 474 (killed) at the above mentioned growth rate in 2015.

[4] The annual growth rate of serious injury in accidents was 2.48% in between 1997 to 2003. Total number of serious injury accidents 487 respectively, which increased to 704 (serious injury) at the above mentioned growth rate in 2015.

[5] Studies worldwide including *Social Cost-Benefit Analysis of Delhi Metro* (Murty, M.N. et. al. 2006) show that introduction of LRT measures reduces 30% reduction in vehicles number. Thus this will result in reduction in KSI by 30%.

[6] Addis Ababa Finance and Economic Development Bureau, 2008.

[7] Saving in future earnings due to fatal accidents =6858*12*(((1+0.05)^21)-1)/((1+0.05)-1) =2,939,466 ETB, (Formula: S = earnings per month

- Cost of a Serious Injury = 25% of cost of fatal accident i.e. 734,866 ETB = 36,394
- Saving in productivity loss due to reduction in killed accidents =417,839,961 ETB = 20,693,342 US$ [8]
- Saving in productivity loss due to reduction in serious accidents =155,198,855 ETB = 7,686,156 US$
- Total benefits of reductions in KSI = 573,038,816 ETB = 28,379,498 US$ = 28.38 million US$

The benefits of reductions in KSI due to operation of LRT systems has been taken same for the 32 years as future earnings is calculated for working life of 20 years.

4.3.5 Employment Generation

The LRT project creates jobs for both unskilled labours and skilled professional. As defined by Murty and Goldar (2006) in Indian context, the unskilled labour employed on the construction and maintenance of LRT will be benefited to the extent of the difference between the project wage rate and the wage rate in an alternative employment.

Employment of Unskilled Labour: The job created for unskilled labour in LRT Addis project is defined below:

- Number of unskilled labour working in the construction of LRT = 3000
- Working days in a year = 300
- No of years since construction begin (2012 -2015) = 3 year = 900 days
- Wage rate per day = ETB 80 = 3.96 USD

(salary)*12*[(1+r)^ (n+1)-1/(1+r)-1], where S= saving in future earnings, r=rate of growth of earnings per annum and n= work life).

[8] Decimal values have been taken into consideration.

- Total earnings in 3 years up to 2015 = 216,000,000 ETB = 10.69 million US$
- Increase in wage rate per annum = 5%
- Number of unskilled labour employed daily after 2015 construction end = 300
- Increased in number of unskilled labour every year = 5%

Employment of Skilled Professional: The job created for skilled professional in LRT Addis project is defined below:

- Number of skilled professional working in the construction of LRT = 500
- Working days in a year = 300
- No of years since construction begin (2012 -2015) = 3 year = 900 days
- Wage rate per day = ETB 230 = 11.37 USD
- Total earnings in 3 years up to 2015 = 103,317,000 ETB = 103.32 million US$
- Increase in wage rate per annum = 5%
- Number of skilled professional employed daily after 2015 construction end = 500
- Increased in number of skilled professional every year = 5%

The monetary income (benefits) for both unskilled labour and skilled professional are presented in Table 12.

Table 12: Benefits from Employment Generation

Year	***Income Generation from Employment (in million US$)***		
	Income of Unskilled Labour	*Income of Skilled Professional*	*Total Income*
2015	10.69	2.84	13.53
2016	0.37	3.29	3.66
2017	0.41	3.81	4.22
2018	0.45	4.41	4.86
2019	0.50	5.10	5.60
2020	0.55	5.91	6.46
2021	0.61	6.84	7.45
2022	0.67	7.92	8.59

Year	*Income Generation from Employment (in million US$)*		
	Income of Unskilled Labour	*Income of Skilled Professional*	*Total Income*
2023	0.74	9.16	9.91
2024	0.82	10.61	11.43
2025	0.90	12.28	13.18
2026	0.99	14.22	15.21
2027	1.09	16.46	17.55
2028	1.21	19.05	20.26
2029	1.33	22.05	23.39
2030	1.47	25.53	27.00
2031	1.62	29.56	31.17
2032	1.78	34.21	36.00
2033	1.97	39.61	41.57
2034	2.17	45.85	48.02
2035	2.39	53.08	55.47
2036	2.63	61.44	64.08
2037	2.90	71.13	74.03
2038	3.20	82.34	85.54
2039	3.53	95.32	98.85
2040	3.89	110.34	114.24
2041	4.29	127.74	132.03
2042	4.73	147.87	152.60
2043	5.22	171.18	176.40
2044	5.75	198.16	203.91
2045	6.34	229.40	235.74
2046	6.99	265.55	272.54
2047	7.71	307.41	315.12

Calculated by Author

5.0 Economic Analysis

The cost-benefit analysis would signify whether adequate returns in terms of benefit results from making a capital investment. The appraisal is done based on the costs and benefit that would be incurred over the analysis period if no investment is made and by comparing the costs and benefits arising as a result of making an investment. The annual cost and benefit streams are used to derive the net cash flow for the project. The analysis considers 32 years of benefit period from the opening year i.e. 2015. For the present purpose, the viability has been established by assessing the Economic

Internal Rate of Return (EIRR) and Net Present Value (NPV) using the discounted cash-flow technique for the LRT project in Addis. The EIRR has been compared with the accounting rate of return of 12 percent. The result is presented in **Table 13.**

Table 13: Result of the Economic Analysis (EIRR)

Year	*Cost*						*Benefits*					*Net Benefit*
	Capital	*Maintenance*	*Interest on debt*	*Equity capital*	***Total Cost***	*Tariff*	*Fuel Savings*	*Time Savings*	*Accident Savings*	*Employment Generation*	***Total Benefits***	
2015	403.75	0.00	2.42	14.25	***420.42***	0.00	0.00	0.00	0.00	13.53	***13.53***	*-406.89*
2016		19.72	4.85	14.25	***38.82***	45.63	41.92	32.44	28.38	3.66	***152.03***	*113.21*
2017		19.72	7.27	14.25	***41.24***	45.63	45.98	34.06	28.38	4.22	***158.26***	*117.02*
2018		19.72	9.69	14.25	***43.66***	45.63	50.14	35.76	28.38	4.86	***164.77***	*121.11*
2019		19.72	12.11	14.25	***46.08***	45.63	54.68	37.55	28.38	5.60	***171.84***	*125.76*
2020		19.72	12.11	0.00	***31.83***	45.63	50.33	39.43	28.38	6.46	***170.23***	*138.39*
2021		39.46	11.31	0.00	***50.76***	55.33	65.03	43.47	28.38	7.45	***199.67***	*148.90*
2022		39.46	9.69	0.00	***49.15***	55.33	70.93	45.65	28.38	8.59	***208.87***	*159.72*
2023		39.46	8.08	0.00	***47.53***	55.33	77.35	47.93	28.38	9.91	***218.90***	*171.37*
2024		39.46	6.46	0.00	***45.92***	55.33	84.37	50.32	28.38	11.43	***229.83***	*183.91*
2025		39.46	4.85	0.00	***44.30***	55.33	92.01	52.84	28.38	13.18	***241.75***	*197.45*
2026		43.40	3.23	0.00	***46.63***	61.00	100.36	58.26	28.38	15.21	***263.21***	*216.57*
2027		43.40	1.62	0.00	***45.02***	61.00	109.46	61.17	28.38	17.55	***277.57***	*232.55*
2028		43.40	0.81	0.00	***44.21***	61.00	119.39	64.23	28.38	20.26	***293.26***	*249.05*
2029		43.40	0.00	0.00	***43.40***	61.00	130.22	67.44	28.38	23.39	***310.43***	*267.03*
2030		43.40	0.00	0.00	***43.40***	61.00	142.04	70.81	28.38	27.00	***329.23***	*285.83*
2031		47.74	0.00	0.00	***47.74***	67.26	154.94	78.07	28.38	31.17	***359.81***	*312.07*
2032		47.74	0.00	0.00	***47.74***	67.26	169.00	81.97	28.38	36.00	***382.61***	*334.87*
2033		47.74	0.00	0.00	***47.74***	67.26	184.35	86.07	28.38	41.57	***407.63***	*359.89*
2034		47.74	0.00	0.00	***47.74***	67.26	201.10	90.37	28.38	48.02	***435.13***	*387.38*
2035		47.74	0.00	0.00	***47.74***	67.26	219.37	94.89	28.38	55.47	***465.37***	*417.63*
2036		52.52	0.00	0.00	***52.52***	74.15	239.31	104.62	28.38	64.08	***510.54***	*458.02*
2037		52.52	0.00	0.00	***52.52***	74.15	261.07	109.85	28.38	74.03	***547.48***	*494.96*
2038		52.52	0.00	0.00	***52.52***	74.15	284.80	115.34	28.38	85.54	***588.22***	*535.70*
2039		52.52	0.00	0.00	***52.52***	74.15	310.71	121.11	28.38	98.85	***633.20***	*580.68*
2040		52.52	0.00	0.00	***52.52***	74.15	338.97	127.17	28.38	114.24	***682.90***	*630.39*
2041		57.77	0.00	0.00	***57.77***	81.75	391.17	140.20	28.38	132.03	***773.53***	*715.76*
2042		57.77	0.00	0.00	***57.77***	81.75	426.78	147.21	28.38	152.60	***836.73***	*778.96*
2043		57.77	0.00	0.00	***57.77***	81.75	465.65	154.57	28.38	176.40	***906.75***	*848.98*
2044		57.77	0.00	0.00	***57.77***	81.75	508.07	162.30	28.38	203.91	***984.41***	*926.64*
2045		57.77	0.00	0.00	***57.77***	81.75	554.37	170.41	28.38	235.74	***1070.65***	*1012.88*
2046		63.55	0.00	0.00	***63.55***	90.13	604.90	187.88	28.38	272.54	***1183.84***	*1120.29*
2047		63.55	0.00	0.00	***63.55***	90.13	660.06	197.28	28.38	315.12	***1290.96***	*1227.42*
Economic Internal Rate of Return (EIRR)												***33.63%***
Net Present Value (NPV @12%)												***$699.24***

Calculated by Author

The NPV of all the cost streams at 12% calculated as 699.24 million US$. The Economic Internal Rate of Return of LRT project in Addis calculated as 33.63% is well above the desired rate of return of 12%. Thus the project is economically viable.

5.1 Sensitivity Analysis

The robustness of the project's viability is further demonstrated by the sensitivity analysis. Because of the uncertainties

surrounding many of the variables like traffic forecasts, cost changes etc., a sensitivity analysis is carried out to test the economic strength of the project. The variations in the following parameters have been examined, considering them to be on the conservative side:

i) Increase in cost by 15 percent
ii) Decrease in benefits by 15 percent
iii) Increase in cost by 15 percent and decrease in benefits by 15 percent

The results of the sensitivity analysis are presented in **Table 14.**

Table 13: Sensitivity Analysis *(In million US$)*

Year	*Cost increase by 15%*	*Benefits decrease by 15%*	*Cost increase by 15% and Benefits Decrease by 15%.*
2015	-469.95	-408.92	-471.98
2016	107.39	90.41	84.59
2017	117.02	93.28	93.28
2018	121.11	96.39	96.39
2019	125.76	99.98	99.98
2020	138.39	112.86	112.86
2021	148.90	118.95	118.95
2022	159.72	128.39	128.39
2023	171.37	138.53	138.53
2024	183.91	149.44	149.44
2025	197.45	161.18	161.18
2026	216.57	177.09	177.09
2027	232.55	190.91	190.91
2028	249.05	205.06	205.06
2029	267.03	220.46	220.46
2030	285.83	236.45	236.45
2031	312.07	258.10	258.10
2032	334.87	277.48	277.48
2033	359.89	298.75	298.75
2034	387.38	322.12	322.12
2035	417.63	347.82	347.82
2036	458.02	381.44	381.44
2037	494.96	412.84	412.84
2038	535.70	447.47	447.47
2039	580.68	485.70	485.70
2040	630.39	527.95	527.95
2041	715.76	599.73	599.73

2042	778.96	653.45	653.45
2043	848.98	712.97	712.97
2044	926.64	778.98	778.98
2045	1012.88	852.28	852.28
2046	1120.29	942.72	942.72
2047	1227.42	1033.77	1033.77
EIRR	***29.84%***	***28.34%***	***25.33%***

Calculated by Author

The result of the sensitivity analysis shows that even in the worst case of increase in cost and decrease in benefits the projects remains economically viable.

6.0 Conclusion

The LRT project in Addis is economically viable at 33.63%, even though the project benefits due some other factors such as reduction in environmental pollutions, reductions in vehicle operating costs etc. has not been taken into consideration in the above analysis due to data lag.

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