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ON

Dynamic Strategic Planning for Rail Project Design

By

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Advisor

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POSTGRADUATE PROGRAM IN RAILWAY ENGINEERING

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Dynamic Strategic Planning for Rail Project Design

By: **Abdi Alemayehu**

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DECLARATION

I hereby declare that the work which is being presented in this thesis entitled “Dynamic Strategic Planning for Rail Project Design” is original work of my own, has not been presented for a degree of any other university and all the resource of materials used for this thesis have been duly acknowledged.

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

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LIST OF ABBREVIATIONS AND SYMBOLS

AD - Additional multiplier

AMP –Airport Master Planning

ASP-Airport Strategic Planning

BC- Benefit- Cost Ratio

CAF- Compound Amount Factor

CAPM-Capital Asset Pricing Model

C-Chance

Cpkm- Cost per kilometer

DA- Decision Analysis

DSP- Dynamic Strategic Planning

E_L-maintenance and repair costs

EV-Expected Value

GDP-Growth Domestic Product

HSR-High speed Railway

L-Low

LU - Land Use multiplier

N - Number of periods in the future where the Future amount is received

NPV- Net Present Value

P- Possibility

SP - Speed multiplier

TE - Terrain multiplier

UP - Upgrade multiplier

WACC-Weighted Average Cost of Capital

β_i - Index of investment risk compared to market portfolio

$\rho_{i,m}$- Correlation between market portfolio and project

σ_i- Standard deviation of project risk

σ_m- Standard deviation of market portfolio risk

P- Present amount

P_L - Investment price of the electric locomotive

r -discount rate

RAROC-Risk-adjusted return on capital

r_n -Nominal discount rate

ROA-Rail option Analysis

ROW- Right- of –Way

CPM- Calculate Cost per Mile

D-Decision

E- Events

ERC- Ethiopian Railway Corporation

F- Future amount

H-high

IRR- Internal Rate of Return

LRT- Light Rail Transit

M-medium

O- Outcomes

r_r- Real discount rate

S-Salvage Value

TR - Track multiplier

VaR- Value at Risk

ABSTRACT

Nowadays, the railway transport infrastructure in Ethiopia is the major issues in relation to the development of the country. To strengthen this infrastructure, related researches must be conducted at the beginning of the construction of the sector.

This paper which mainly concerned about the dynamic strategic planning for rail project design is done to predict and minimize failures caused by improper strategic planning. In most cases, financial performance of railways deviates a lot from the forecasts. Means that, costs exceed predictions by far and demand is less than what is forecasted. The logic behind this is that the financial performance of the system can be improved if there is a pre specified plan for every possible future scenario.

The entire analysis is done for Ethiopian railway projects deeply for first phase projects. The objective of this thesis is having a flexible plan for building and operating railway projects and to determine the optimum planning. The method to be used is based on data collecting through actual visit of construction site/area of concern and consult individuals for further clarification and confirmation. Additionally interviews with selected key stakeholders involved into ports and corridors management of railway operations area. Benefits of these options will be realized by arrival of new information as time goes by. This flexibility can increase long term benefits and minimizing the possibility of disastrous losses.

The final outcome of this study, based upon NPV and decision tree planning software is to construct two routes and the construction of additional routes will be determined depending on the demand; i.e. adding three more routes if the demand is high and keeping the existing routes if the demand is either medium or low. The results obtained were found to be realistic and useful for the planning of Ethiopian rail routes. Applications and an analysis of the Ethiopian rail project situation can help and improve the financial performance of the current rail route.

Chapter 1

1 INTRODUCTION

1.1 Background of the Research

The history of rail transport dates back nearly 500 years and includes systems with man or horse power and rail of wood or stone. In 1604, the first railway in Britain was built, but it was called a wagon way and it was made of wood. Modern rail transport systems first appeared in England in the 1820s. These systems, which made use of the steam locomotive, were the first practical forms of mechanized land transport, and they remained the primary form of mechanized land transport for the next 100 years. By 1900, the railway was mostly completed, and there were more than a hundred train companies in Britain. In 1904, an engine called 'The City of Truro' became the first to travel at more than 100 miles an hour. The electrification of the railways began in 1933. This means that the trains began to run on electricity instead of steam. Railways were originally intended to carry mostly goods rather than passengers but in the 1970s, the value of carrying passengers overtook goods for the first time.

The railway lines construction in Ethiopia was first started in October 1897 from Djibouti. The first commercial service began in July 1901, from Djibouti to Dire Dawa. By 1915 the line reached Akaki, only 23 kilometers from the capital, and two years later came all the way to Addis Ababa itself. Transportation infrastructure in Ethiopia has been neglected for decades, but is now a priority of the government of Ethiopia.

There is a high demand of railway transportation systems in the world including in our country Ethiopia for a long distance transport of passengers and goods. To satisfy such demands, it needs to have a railway transportation system with standard safety, comfort and reliable to user's (customers). And also need the advanced design and proper strategic planning, which have a direct or an indirect impact on the customers and users demand. The flexible design is achieved through *Dynamic Strategic Planning (DSP)*. It is dynamic because it recognizes the fact that the future is uncertain and needs to be managed flexibly instead of fixed; Strategic means the system performance is optimized on a long-term. Planning indicates that a set of steps is designed on what should be done under what circumstance.

There are several reasons why predictions do not reflect the future: The first type of error is conceptual, because it assumes that the future is an extension of the past. It is wrong to suppose that the future will be the same as the past. The second type of error is based on the fact that the past can be interpreted in various ways causing ambiguity. Many extrapolations are possible for the past data set. For instance, a wrong or incomplete model might be used for the forecasting. Or the data that are used as input for the model might be wrong, incomplete or misinterpreted.

1.2 Statement of the Problem

"If you don't know where you are going, you can't expect to get there"

Railways are mega-projects with very high costs. In the past 50 years, railways all over the world have been struggling to break and most of them have built up high debts. Most railways cannot cover their operational costs with their revenues even some can breakout or makes a small profit.

New lines are being planned which usually doesn't meet the financial expectations and increase railway debt. The cause that is affecting the expected performance is, *costs turn out to be much higher than expected* and *demand is lower than forecasted*. In railways, large deviation from the forecasted costs is very common. Actual railway costs are on average 45% higher than estimated costs (the standard deviation is 38) as documented by Flyvbjerg (2003).

The problems in forecasting of railways are common in developing country, which is also true in Ethiopian rail projects.

1.3 Objective

1.3.1 General Objectives

The objective of this thesis is:

- ✓ To determine the optimum planning.
- ✓ To identify the shortage and excesses lines.
- ✓ To make mechanisms losses can be reduced and opportunities can be exploited.

1.3.2 Specific Objectives

In conducting the study the following specific objectives will address the duties to be performed in order to achieve the general objective of the study.

- ✓ Minimize forecasts uncertainty using Decision tree plan.
- ✓ The system performance is optimized on a long-term
- ✓ Thinking in terms of making a switch from passive to pro-active management
- ✓ Setting measuring techniques that enable to evaluate forecasting.

1.4 Significance

This research has a great impact on future analysis and applications of dynamic strategic planning in the Ethiopian context. Especially, it will contributes a lot for future analysis of demand and forecast showing the position of excess lines and shortage line to control the demands of customer. Most practical costs exceed the forecasts by far and demand is less than what is predicted. This may be due to improper strategic planning. In addition to that it may be due to inflexibility of strategic planning. However, this paper provides the flexible planning and decision analysis to optimize the benefits of the projects by using dynamic strategic planning.

1.5 Benefits

Because of uncertainty, projects have a distribution of outcomes instead of just one single value. Still, the traditional economic valuation methods only look at the average outcome. Just like in statistics, we should not just look at the average but we also care about the shape and variance of the distribution. It is not only because we might be interested in the maximum amount of money we might lose (Value at Risk) or gain (Value at Gain) with a certain probability. It is also possible to manipulate the distribution so that there is less risk and more gain. With the average value calculations, the different uncertainties are ignored which leaves very little room to take corrective actions. Ignoring variety in outcomes does not mean that it does not exist.

This research is to develop of a proactive strategy for new lines of Ethiopian railway infrastructure, fulfilling overall business goals and objectives of the railway sector, taking into account the flexibility of these influencing factors and/or their potential for changing the reactive approach into a proactive strategy. While formulating a conceptual dynamic strategic planning, to provide support for infrastructure manager, this will be proactive and benefit the entire railway transport system.

1.6 Scope and Limitation

The study considers only the railway infrastructure issues for an Ethiopian railway first phase projects sector for effective and efficient management of the route construction process. While considering the conceptual route construction planning, cost-benefit modal have been taken into consideration, also, the net present values are considered for decision analysis applicability. The study is limited to the dynamic strategic planning of the route construction process and considers all related issues and questions. However, planning activities after route construction, human power and maintenance are not considered. Also, associated factors risk management is not considered.

1.7 Organization of the Thesis

This thesis is organized as follows: Chapter 2 includes a literature review documenting the need for planning improvements from freight and passenger railway, NPV improvements currently available, as well as current methods of cost estimation and their associated benefits and challenges. Chapter 3 methodologies of the research and data collected from ERC and other transportation sector factors that influence the cost of railway construction and the resulting cost components defined as design criteria used to capture those influences. Chapter 4 discusses the analysis and results of the rail project using decision tree after using net present value of all construction projects in Ethiopia. Chapter 5 offers the conclusions and limitations of this research, as well as recommendations for further research.

Chapter 2

2. LITERATURE REVIEW

This is one of the portions of the paper that reviews the previous related works which are basic guide for the introduction of the current work. Some of them may have a direct relation to rail system whereas the others may have indirect relations to the rail system. Generally there are many journals, articles, conference papers, proceedings and books related to the railway engineering and dynamic strategic planning for rail project. But to manage the paper work the review of literatures mainly considers more related works to this paper. This strengthens the deep analysis of the previous related works and selection of appropriate conditions, approaches and methodologies for the successful accomplishment of the paper.

Dynamic Strategic Planning is the improvement to systems analysis that recognizes risks and incorporates strategies for dealing with them into the plans. It incorporates two key methodologies:

- ❖ Decision analysis: The procedures for organizing and evaluating efficiently.
- ❖ Real Options: The application of the options analyses.

Dynamic Strategic Planning is a process that leads to the implementation of technological projects the flexibility to adjust easily over time to the actual situations and conditions as they arise, either to avoid bad situations or to take advantage of new opportunities. It leads systems planners and managers to recognize the great value of flexibility in the design of technological projects.

2.1 Dynamic Strategic Planning

DSP is flexible compared to fixed strategic planning

- ✓ It systematically structures the problem
- ✓ It accommodates uncertainties rather than relies on forecasts
- ✓ It values new information during the life of the project and gives decision- makers options

a. Structures of Problem

DSP structures the problem that affects all relevant chance and considers all possible outcomes. This process is done by means of a decision tree; the decision tree is a conceptual device that includes possible decisions that can be made and out comes that may occur as a result of the choices made and states of nature. The decision tree consists of two nodes

1) Decision node (D) – which are the moments when possible decisions are considered and a decision is made.
2) Chance node (C) – which is the periods after a decision, is made in which outcomes are determined by main events or states of nature.

   The sequence is

   D – C – D – C - - - -

The decision branches out from an initial node to subsequent nodes where there is further branching, hence the symbol of 'tree'. Thus, the decision tree systematically decomposes the problem by considering all possible decision makers insights that will assist them in identifying all factors involved in their decisions.

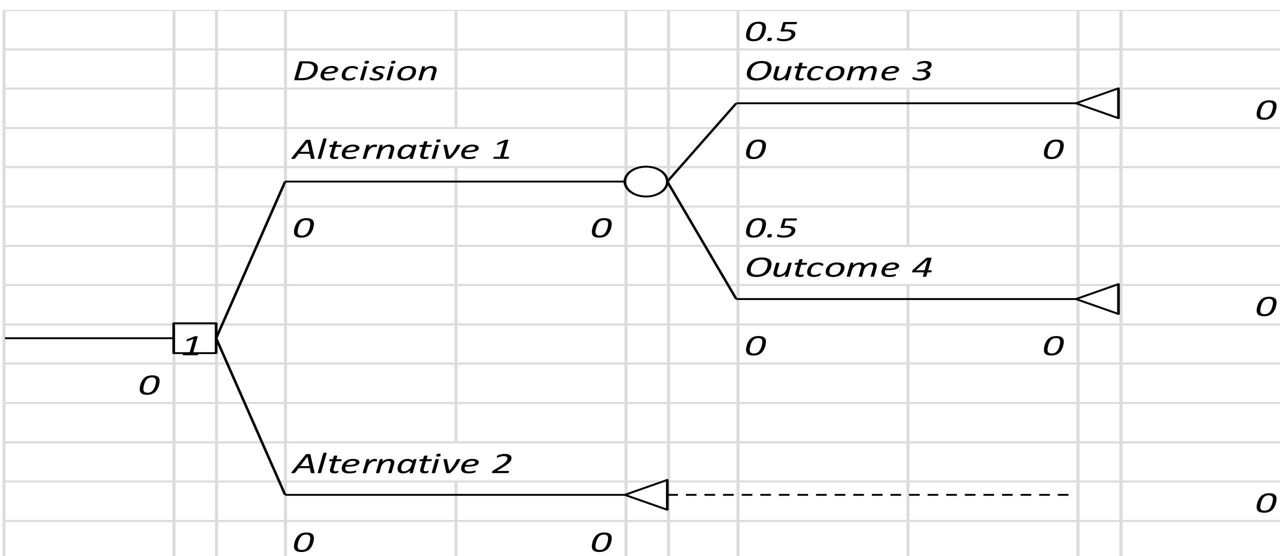


Figure 2-1 Decision tree structure

DSP accepts that the future cannot be known. It gives possible outcomes with ranges of possibilities in chance nodes in the decision tree. Assuming an outcomes and its possibility of occurrence are respectively represented by O_{ij} and P_j, which are subject to a possible decision D_i and an uncertain event, E_j, the sequence in a chance node is C probability, P_j Outcomes O_{ij} there are several assumptions in chance nodes. The first is that branches in chance nodes define all possible events are states of weather, Ej may represent fine, or cloudy, or rainy for example. The second assumption is that those events should be distinct, if they are not double counting will result. One way to estimate probability is to use distributions of outcomes obtained from past data. These distributions give the range of possibility of each outcome. If such historical data is not available, a reasonable probability for each outcome can be used. When outcomes are determined by two or more independent events, it is necessary to calculate their joint probability of occurrence.

Example: Consider the construction of a new line system whose success depends on its cost (low, medium, or high) and the states of ridership (low, medium, or high). The actual outcomes will depend on events that occur as a result of combinations of these two events such as "low cost and low ridership," "high cost and medium ridership" and so on. Again these resulting outcomes should be independent of each other. Therefore, the probability of "low cost and low ridership" is calculated by the probability of "low cost" times the probability of "low ridership". If many events are involved in a chance tree (if a number of possible outcomes could occur) these resulting outcomes such as a cost per ridership(low, medium or high) the probability of each cost per ridership can be obtained from the distribution of joint outcomes(cost per ridership) resulting from the sequence of chance events (cost and ridership). The expected value of each decision is its average value:

$$E_v(D_i) = \sum_j P_j O_{ij} \quad \text{(2.1)}$$

The best decision for a period decision tree is the one with the highest expected value:

$$Max(Ev(Di)) \quad \text{(2.2)}$$

To find an optimal decision for more than one period, we can simply calculate the best decision stage by stage, starting with the last period.

The advantage of this process is that we can define the best decision for each period and drop all other possible decisions from consideration; we can focus only on the best decision for each period. This process is known as "pruning" the decision tree. Since actual cases include a substantial number of possible decisions, the pruning predictably makes the problem less complex by eliminating all decisions that are not optimal.

c. Consideration of Value of Options

DSP incorporates the value of information concerning the level of the development into its analysis. This value of the new information can increase the overall expected value of the project. DSP can identify the optimal long- term decision. This optimal long- term decision is a strategy. It can be considered a sequence of decisions contingent on all the possible outcomes. It does not simply determine a single sequence of decisions best for all occasions but dynamically affects all possible decisions over the life time of the project. (Nishimura Y. , 1999)

2.1.1 Real Options and Decision Analysis

The future is impossible to forecast accurately. System design should thus be designed in a way that leaves room to adapt to factors that influence the (financial) performance of the project. This approach develops a technology investment strategy that responds flexible to an uncertain future. It means that losses can be reduced and opportunities can be exploited by keeping uncertainty in mind. Real Options are related to but not the same as financial options. A real option is the right, but not the obligation, to take an action that will either help maximize the upside or limit the downside of a capital investment. Real options differ from financial options because they are not based on tradable assets and there is no market for them. There are two classes of Real Options:

- ✓ Real Options on the System: these are options that do not influence the technology of the system, usually options to expand or abandon current operations
- ✓ Real Options in the System: this kind of options changes the technology of the system

When using Options on Systems, this means that the option, not the obligation, exists to further operate or invest in a system (flexibility of scale). Options in Systems indicate that in the future several different technology scenarios can be covered by the system (flexibility of scope). The distinction between both types of option can be a bit vague sometimes. The Real Options take a number of forms

- ➢ Waiting-To-Invest Options: option of delaying to invest in (part of) a project
- ➢ Growth Options: entry investment that may create opportunities to pursue follow on projects
- ➢ Flexibility Options: option to reallocate or switch resources
- ➢ Exit (or Abandonment) Options: the option to quit the project in response to new information
- ➢ Learning Options: initial investment like market studies that creates opportunity to respond better to uncertainties

Real Options Analysis is used together with Decision Analysis to calculate the impact of the possible actions in the states. Compared to the traditional fixed management approaches, Decision Analysis gives a strategy as uncertainties unfold. It is flexible in a way that there is always a contingency plan for limiting risks and exploiting opportunities. To create the flexible strategy, the possible states of an uncertainty, the probability that this state will occur and the impact of states on the performance of the system need to be defined. A decision tree with this information is set up over the lifetime of the project. It consists of Decision and Chance nodes where the Chance nodes have a certain occurrence probability. Each choice node represents a certain total value. Through valuation of the different nodes the system value is maximized. Real Options Analysis differs from Decision Analysis in that it focuses on identifying the possible actions. The management strategy that is created by combining ROA and DA is called Dynamic Strategic Planning. It is dynamic because it recognizes the fact that the future is uncertain and needs to be managed flexibly instead of fixed.

Strategic means the system performance is optimized on a long-term. Planning indicates that a set of steps is designed on what should be done under what circumstance. Although ROA and DA are central elements of Dynamic Strategic Planning, it involves a total of seven methods for system analysis: (Boyana Petkova, 2007)

1. Modeling of the system output: For every set of resources the technically efficient solution can be determined through the model. Thus the set of possible designs is established that is considered for further analysis.

2. Optimization of the cost: Every technically efficient solution must be evaluated in order to determine the efficient cost limit. That means that every level of production is achieved at the least cost.

3. Estimation of probabilities: There are several techniques available for this step: logic, frequency, statistical models and judgment.

4. Decision Analysis: A decision tree with decision nodes, chances nodes and their probabilities is set up. For each point in time an optimal strategy is determined that maximizes system value.

5. Sensitivity Analysis: The states and probabilities that are used in DA are estimated. It is necessary to investigate how sensitive the resulting strategies are to the estimates.

6. Real Options Analysis: Identifying flexibility options and estimating their cost.

7. Analysis of Implicit Negotiation: developing a strategy for the implementation of the technology policy. The approach to the design and valuation of flexibility in systems can be structured as follows.

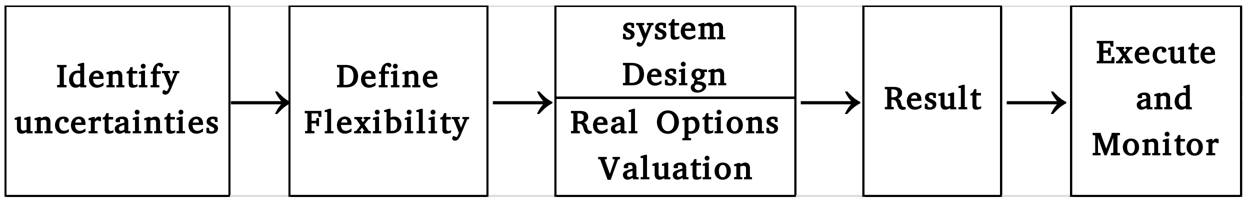


Figure 2-2 Structure of the design and valuation of flexibility in systems

2.1.2 Uncertainty and Risk

There is a difference between uncertainty and risk. Uncertainty deals with the spread of possible future scenarios, while risk is a measure of the effect that the relevant uncertainties have on our projects.

The following conditions must exist for risk to be evident (Boyana Petkova, 2007)

- Uncertainties and risks have a time horizon.
- Uncertainties exist in the future and will evolve over time.
- Uncertainties become risks if they affect the outcomes and scenarios of the system.

Risk can be measured in many ways

- Probability of occurrence
- Standard deviation or occurrence
- Coefficient of variation
- Value at Risk (VaR)
- Worst-case scenario or regret
- Risk-adjusted return on capital (RAROC)

No.	Risk class	Uncertainties	Data source or means of quantification
1	Market	-Demand for product/service provided by system -Demand as a function of environmental features -Energy prices (e.g. electricity, Oil)	-Historical data (if available) -Expert opinion -Simulation models of system performance
2	Technological	-Success/failure of new technology -Introduction of new, superior technology	-Expert opinion -Simulation models of system performance -Stochastic models
3	Climate (for systems whose performance depends on climate)	-Future ambient climate temperature and solar radiation -Global climate change and warming trends	-Stochastic climate models based on historical data and global climate change inputs -Simulation model of system subject to stochastic climate
4	Future use		-Expert opinion -Historical data
5	Regulatory	-Introduction of new standards for existing facilities	-Expert information and opinion

Table 2-1Risks, uncertainties and data sources for innovative technologies

2.1.3 Procedure of analysis

A decision tree is a convenient way to represent decisions and uncertainties considered in the analysis. In this study we use the decision tree. Decision node (D) is followed by chance node (C).

In order to conduct the analysis by using this decision tree, the study adopts a four- step procedure,

Step 1: Quantifies uncertainties. This step first selects uncertainties that could affect the decision criterion: Cost/PAX. By using historical data and past forecasts, the step then provides the distributions of possible events.

Step 2: Defines the alternative decisions. Since DSP can proposes a strategy for more than one period of time, alternatives for each period can be defined in this step.

Step3: Assigns probabilities for possible scenarios. When an uncertainty follows a continuous probability distribution of events or leads to many possible events, these events are divided into a number of scenarios such as high (H), medium (M) and low (L) A probability is assigned to each event in each scenario, for example, P_h, P_m or P_l. Naturally, these must cover all probabilities and the probabilities sum to 1: $P_h+P_m+P_l=1$

Step 4: Calculates the expected value (EV) for each decision. This step simply takes the average of outcomes by using probabilities in each chance node and by selecting a decision with the best outcome in each decision node. This procedure is repeated from the end of the tree to its beginning.

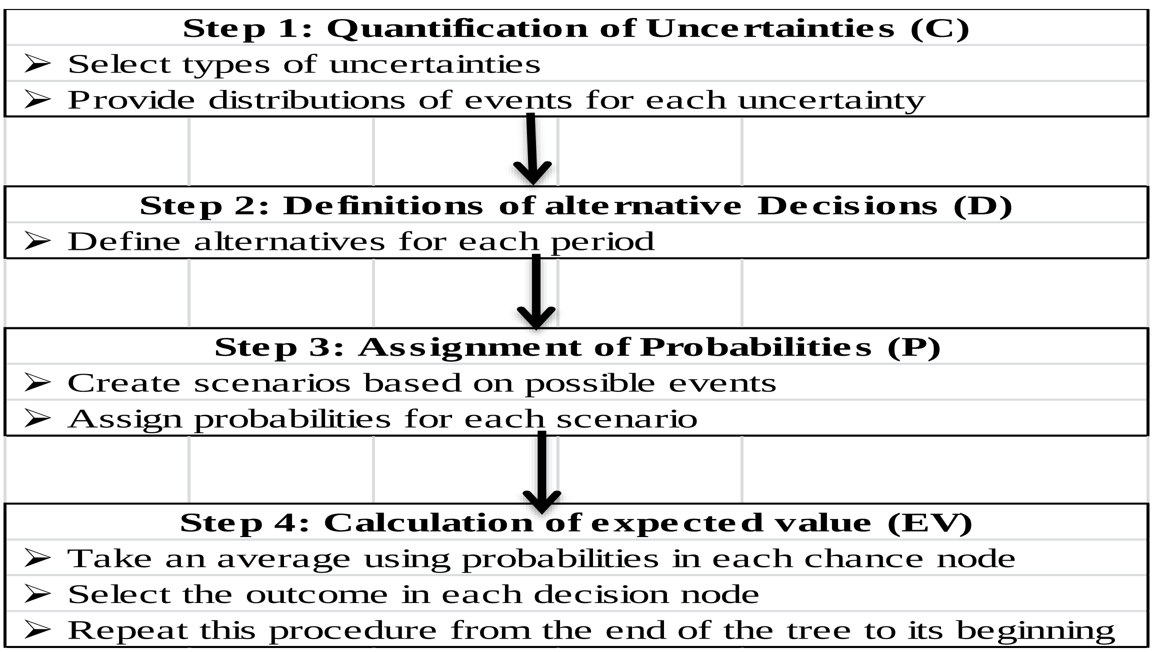


Figure 2-3 Procedure of Analysis

2.2 Evaluation of Projects

Concepts that are vital to the evaluation of projects will be introduced. We will explore an approach to evaluation and design of systems called Dynamic Strategic Planning (DSP). In DSP, the concepts of Real Options Analysis (ROA) and Decision Analysis (DA) play a central part. These two methods will be risen in on.

2.2.1 Purpose of Evaluation and Methods

Evaluation techniques help chose decision makers between different investment opportunities by maximizing the future value that can be realized with the current available budget. It has two objectives:

1. To decide if projects are valuable
2. To rank them in order of most to least useful

There is a trade-off between accuracy of an evaluation model and its simplicity. An evaluation model should display the value of a project as accurately as possible. But building a very extensive model might cost a lot of resources and time to build. Also, it may not be very practical for making decisions because of its complexity. Assumptions are made to limit the number of variables in the model so they increase the ease of use but also make it less realistic. (Boyana Petkova, 2007)

Evaluation methods are based on three different disciplines: engineering, economics, and operations research and can be divided into five categories:

- **Methods based on engineering economy**, like Net Present Value (NPV), Cost- Benefit Analysis etc.. Engineering economy implies that the stakeholders agree on maximizing monetary profit as the goal, that the outcomes can be modeled and predicted well and are linear with quantity.
- **Decision analysis** emphasizes uncertainty and choices that need to be made. The goal of decision analysis is to define the optimal strategy over time.
- **Decision analysis with utility** differs from regular Decision Analysis in that it assumes that not all quantities of an outcome are valued equally. Utility functions are used to model the lack of comparability between the quantities (non-linearity).
- **Social cost-benefit analysis** is a method of welfare economics. It deals with a single set of non-monetary preferences which can be nonlinear.

- **Welfare economics** deals with multiple stakeholder preferences which cannot be expressed in monetary terms. The strengths and weaknesses of the methods are summarized in

Approach		Assumption made				Operational characteristics
Disciplinary basis	Evaluation method	Time Value	Uncertain consequences	Nonlinear values	Multiple decision makers	
Engineering economy	Benefit-cost… etc	✓				Easy formulas
	Decision analysis	✓	✓			Probabilities inaccurate
	Decision analysis with utility	✓	✓	✓		Utilities approximate
Economics	Social cost-benefit analysis	✓		✓		Value data difficult to obtain
Economics	Welfare economics	✓		✓	✓	Only general guidelines available

Table 2-2 Project evaluation methods

2.2.2 Cost –Benefit Modeling and Analysis

Net Present Value (NPV) is the most popular financial valuation tool. It is applied by 96% of the CFOs of large companies (Teach, 2003) and it is also used by railroads and scholars to calculate the benefit of railway. The other tools are also mentioned in financial reports of the railroad companies but decisions seem to be made purely based on NPV. This is affirmed by the two approaches for modeling the impact of railway: social welfare on one side and profit on the other side. By using decision tree software analysis appropriate strategic planning dynamically for all routes.

2.2.3Benefit- cost ratio

The benefit –cost ratio is the ratio of the discounted value of benefits and costs:

$$BC = \frac{Discounted\ \text{Benefits}}{Discounted\ \text{Cost}} \quad \text{…………………………………………………………..…..….. (2.3)}$$

An advantage over the NPV is that the BC-ratio is a scaled measure of profitability. If the BC-ratio is larger than one, the project is profitable. Just like NPV, it is sensitive to the discount rate used. A large disadvantage of BC-ratio is that capital intensive projects are favored over projects with large reoccurring costs. This is the main reason to use NPV over BC-ratio.

2.2.4 Time value of Money

The value of money over time is an important concept in economical project evaluation. Money now has a different value than the same amount of money in the future. The value of future money differs with the opportunities that investors have. It is also called the opportunity cost of capital, but most widely known as the discount rate. This is the basis for NPV calculations. But it is also a vital concept in option valuation and flexible design. The formulas for single amounts of money are:

P = F / CAF ↔ F= P*CAF………………………………………………………..…………. (2.4)

P= Present amount

F= Future amount

CAF= Compound Amount Factor = $(1+r)^N$

r = discount rate

N = number of periods in the future where the Future amount is received

For finite series of equal cash flows, the present value can be calculated by:

$$F = \sum_i R(1+r)^i = R\frac{(1+r)^N - 1}{r}$$

$$R = P * CRF = P * \frac{r(1+r)^N}{(1+r)^N - 1}$$

……………………………..……………………………………. (2.5)

For infinite series, the denominator reduces to $(1+r)^N$ as $(1+r)^N >> 1$. This reduces the Capital Recovery Factor CRF to the discount rate r.

For small periods, calculations of series can be simplified by using the approximation $(1+r)^N = e^{rN}$. This can be derived from (1+r)^n=e^[log(1+r)*n] with log(1+r)=r for small r.

$e^{rN} = 2.C$ When rN=0.72

Actually this is true when the exponent is 0.693 but the approximation of the discounted series is better if 0.72 is used. This means that the present amount doubles when the future amount halves.

2.2.5 Discount Rate

The discount rate reflects the possible returns that can be achieved by investing a certain amount of money. It is also called the productivity of capital and is the lowest acceptable rate to investors and the highest rate among the remaining opportunities if more capital were available.

Determining the proper discount rate is difficult and should most definitely not be confused with the interest rate. The interest rate is a flat rate between a lender and a borrower and does not reflect individual opportunities that a person has to multiply his money. People would not borrow money if their investment opportunities were not yielding a higher return than the interest rate. The banks lend out a lower amount of money than what lenders would like so there is a fair the chance is bigger that lenders will actually pay off their debt.

There are two kinds of discount rates:

1) Nominal discount rate =r_n=discount rate including inflation = r_r+i
2) Real discount rate = r_r=discount rate without inflation= productivity rate

Both rates change over time as opportunities change and the inflation rate fluctuates.

Also, different time horizons imply different levels of discount rate. In general, for longer time horizons the risk is higher and the discount rate will be higher.

There are two ways in which to calculate the discount rate:

a) Weighted Average Cost of Capital (WACC)
b) Capital Asset Pricing Model (CAPM)

a) Weighted Average Cost of Capital (WACC)

Companies are founded by equity (selling shares of the company) and debt (borrowing money). The Weighted Average Cost of Capital (WACC) reflects the minimum return that a company should have on average to cover the desired productivity rates by equity and debt:

$$\text{WACC}=\frac{E}{E+D}r_E+\frac{D}{E+D}r_D \quad \text{.......} \quad (2.6)$$

Where: r_D=interest rate, r_E=return for shareholders=difference in shares and dividends

The expected return on investment for both equity and debt is a reflection of the confidence that people have in the company. The confidence depends for example on how well-established a company is, if it operates in a stable industry/region, and how strong it is financially and strategically.

The WACC represents the average discount rate for the company. It is an aggregate measure that does not take opportunity cost into account. Also, the individual risk of a project is not reflected in the WACC formula. Finally, it is a historical measure that may not reflect the current situation well.

b) Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model (CAPM) is a more refined way to determine the discount rate as it adjusts the discount rate for risk instead of averaging out projects. The CAPM is based on the principle of risk-aversion. This means that people want a higher compensation for projects with a higher variability in outcomes. The discount rate that is used for projects with a higher variability thus has to be increased.

The risk-free rate is the discount rate if there is no variability. It is a theoretical measure because nothing is really risk-free (the rates vary for different time spans).

The higher the variability of project outcomes, the higher the expected return on the investment is. Investors only expect to be compensated for market risk but not for project specific risk. Market risk affects the entire stock market while project risk is diversifiable.

The measure of risk that is used to define the relationship between the market portfolio and the individual project is βi:

$$\beta_i = \rho_{i,m} = \frac{\sigma_i}{\sigma_m} \qquad (2.7)$$

With:

β_i =index of investment risk compared to market portfolio

$\rho_{i,m}$=correlation between market portfolio and project

σ_i=standard deviation of project risk

σ_m= standard deviation of market portfolio risk

2.3 Net present value (NPV)

The Net Present Value is a measure of profitability that discounts all cash flows (benefits and costs) to the current point in time. Usually it is defined as the sum of present values of the periodic cash flows (revenues less costs) minus the initial investment:

The advantages of the NPV are that it depends on both the time value of money, which is represented by the periods 0..n and the discount rate which is a measure for risk. When the Net Present Value equals zero, it means that the minimum profitability standard is met. If the NPV is positive, extra profit above the minimum is realized. The major disadvantage is that the meaning of the NPV is not intuitive to most people. Also, it does not provide a measure of scale of the profitability versus the investment.

$$NPV = \sum_{t=1}^{35} \frac{Benefit_t - Cost_t}{(1+0.04)^t} \quad \text{......} (2.8)$$

Decision Rule

Accept the project only if it's NPV is positive or zero. Reject the project having negative NPV. While comparing two or more exclusive projects having positive NPVs, accept the one with highest NPV.

Advantage: Net present value accounts for time value of money. Thus it is more reliable than other investment appraisal techniques which do not discount future cash flows such payback period and accounting rate of return.

Disadvantage: It is based on estimated future cash flows of the project and estimates may be far from actual results.

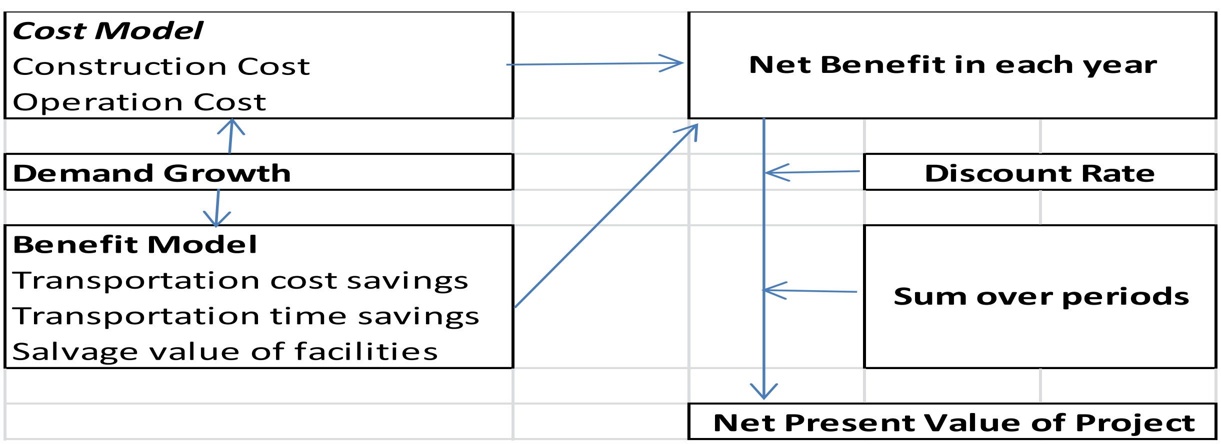


Figure 2-4 Frame work of Benefit-Cost Model

Listed below are some of the literatures surveyed that are estimated to be significant to this research that is directed on Dynamic strategic plan.

Airport Strategic Planning (ASP) focuses on the development of plans for the long-term development of an airport. The dominant approach for ASP is Airport Master Planning (AMP). The goal of AMP is to provide a detailed blue print for how the airport should look in the future, and how it can get there. Since a Master Plan is a static detailed blue print based on specific assumptions about the future, the plan performs poorly if the real future turns out to be different from the one assumed. With the recent dramatic changes occurring in the context in which an airport operates (e.g., low cost carriers, new types of aircraft, the liberalization and privatization of airlines and airports, fuel price developments, the European Emission Trading Scheme), the uncertainties airports face are bound to increase. Hence, there is a great need for finding new ways to deal with uncertainty in ASP. An alternative direction is to develop an adaptive approach that is flexible and over time can adapt to the changing conditions under which an airport most operate. (J.H.Kwakkel, 2010)

Railway track maintenance costs comprise between 25-35 percent of total freight train operating costs. Track maintenance planning models have been shown to reduce maintenance costs by 5 to 10 percent though improved planning. This paper describes a model which has been developed to deal with the track maintenance planning function at the medium to long-term levels. This model simulates the impacts of degrading railway track conditions and related maintenance work, in contrast to tradition models that mainly use expert systems. The model simulates the degrading track condition using an existing track degradation model. Track condition data from that model is used to determine if safety related speed restrictions are needed and what immediate maintenance work may be required for safe train operations. The model outputs the net present value of the benefits of undertaking a given maintenance strategy, when compared with a base-case scenario. The model approach has advantages over current models in investigating what if scenarios. The track engineer can assess the possible benefits in reduced operating costs from upgrading track infrastructure or from the use of improved maintenance equipment. After describing the model inputs and the assumptions used, the paper deals with the simulation of track maintenance and of train operating costs over time. The results of applying the model to a test track section using a number of different maintenance strategies are also given. (Simson, 2000)

The railroad industry is expected to see increased demand in the United States (U.S.) over the next 30 years. This demand will put a strain on the infrastructure and its ability to provide timely and efficient service. Various technologies are currently available to increase railroad capacity, but in time new track age will either need to be added to existing routes, built as new routes, or existing routes be upgraded to a higher speed classification. Anticipating these costs is a challenge, since few railroad miles are constructed annually and there are various factors affecting costs. However, it is possible to calculate cost per mile (CPM) accounting for right-of-way (ROW), design and build, materials, communications and signaling, and electrification, where applicable. This literature presents a methodology for estimating CPM of railroad construction in the U.S. as a function of design speed, geography, land use, number of tracks, and motive power. The proposed CPM estimates were compared to CPM estimates from feasibility studies, and resulted in the majority of costs being replicated by the methodology. The proposed methodology has been developed in an adaptable manner, where future project cost components may be included, creating a dynamic estimation methodology for analysis and planning activities, prior to feasibility study analyses. (White, 2000)

Capacity improvements including railway construction are planned at several levels of analysis. At the planning level strategic decisions are developed that determine the likely benefits and costs of a project, before further resources are utilized for more in-depth investigation. At the project level actual location specific studies are conducted to determine the overall costs of the project. It is at the planning level that the proposed CPM estimation methodology may be of use, where several forms of estimation are typically made. A review of available CPM methods is provided next. Cost estimation can be simply obtained by comparison. This method lies on the assumption that another project's cost can be similar to the study costs due to the similarities of actual projects. This form of estimation requires minimal devotion of resources, but the likelihood of accuracy is low, as one project will likely be different from another. In addition the assumed study cost may or may not include all of the applicable cost categories to the proposed project, leaving even greater chance for an inaccurate estimation due to assumptions. Challenges do exist when making decisions based on comparisons. First, utilizing another project's feasibility study costs to generalize one's own, makes the assumption that the project being analyzed is similar in every way to the project under study. Selecting a study cost by the means of comparison may lead to large discrepancies, if dissimilar location/service specific information is not acknowledged. Second, the proprietary nature of construction costs incurred by the predominately private railroads makes the sharing of costs rare. Third, very few miles of railway are constructed each year, making it unlikely that any available costs are representative of other projects or locales. Finally, many of the new railway projects and studies focusing on HSR in North America have yet to be built. While they have produced some cost estimates, these were not verified with actual construction and are open to certain levels of error due to unforeseen impacts that change the study assumptions.

Due to the increasing interest in railway construction and the difficulty in determining the costs, a CPM estimation methodology is proposed herein to serve as a planning tool for estimating expected construction costs based on the location and service characteristics of the intended project. The proposed methodology can provide reasonable and representative estimates at the planning level and can provide the groundwork for determining whether such a project would be financially feasible to study. (White, 2000)

Dynamic Strategic Planning (DSP) offers a new approach to AMP, although it is still based on traditional systems analysis, which is also at the heart of AMP (de Neufville and Odoni, 2003). DSP is an approach for making plans, particularly for infrastructure, that can be easily adjusted over time to the actual situation and conditions. In this way, bad situations can be avoided and opportunities can be seized. The resulting dynamic strategic plan defines a flexible development over several stages; it commits only to a first stage, and then proposes different developments in the second and subsequent stages. DSP recognizes that the future cannot be predicted accurately and hence that all forecasts will be wrong. Therefore, a plan should build in flexibility to deal effectively with a range of futures. In DSP, this flexibility is created through real options (de Neufville, 2000). An option is a right, but not an obligation, to take an action for a certain cost at some time in the future, usually for a predetermined price and a given period (de Neufville, 2003). A well-known example of a real option is to make a land use reservation (this is also known as ‘land banking’). Such a reservation offers planners the option to expand infrastructure in the future if this turns out to be needed (de Neufville, 1974)

While there are plans to build new expensive HSR connections. Financial performance of railways deviates greatly from the prognoses. In most cases, costs exceed the forecasts by far and demand is less than what is predicted. There is a lot of uncertainty in railway design yet the current strategies for building and operating railway systems is based on single-number design scenarios that will occur with 100% accuracy. Capital discounting techniques like the Net Present Value (NPV), Internal Rate of Return (IRR), or Payback Ratio are applied to determine if constructing a railway line is worthwhile. There are two big problems with the conventional valuation approaches. First, reducing the financial outcome distribution to the average value does not always get the same results as using the entire distribution. Second, and most important, the traditional approach is very rigid and does not allow for maximizing the project value as uncertainties develop, it only states if the project is (not) worthwhile for the chosen single values. One fixed strategy, a master plan, is developed and stuck to for all future scenarios without taking into account how uncertainties turn out. There is no risk limitation (by abandoning the project) and exploiting unexpected gains (by expansion). These sources of gaining value are not covered by the traditional methods. HSR technology, we want to show that a flexible building and operating strategy of the railway system can increase the value. This flexible design is achieved through Dynamic Strategic Planning (DSP). It is dynamic because it recognizes the fact that the future is uncertain and needs to be managed flexibly instead of fixed. Strategic means the system performance is optimized on a long-term. Planning indicates that a set of steps is designed on what should be done under what circumstance. (Boyana Petkova, 2007)

This thesis proposes DSP as a new planning method in rail projects. The conventional planning does not account for uncertainty and focuses only on a single decision.

As can be seen, all the research, journals, articles, and books above focus on conventional strategic planning and others sector of transportation dynamic strategic planning is done, and different kinds of strategic planning. But in my thesis it is new idea that is dynamic strategic planning for rail project design.

Chapter 3

3. METHODOLOGY AND DATA COLLECTION

3.1 Methodology

To fulfill the objectives of the study the following methodologies are used.

i. *Literature Review*: Survey of books, journal, articles, proceedings of international conferences, and other relevant literature is done.

ii. *Data Collection*: data regarding the Ethiopian rail route projects are collected from Ethiopian Railway Corporation, and data regarding the Construction cost of each routes, tariff per km and salvage value to calculate NPV, in this particular method of my research data gathering is performed through actual visit of area of concern and consult individuals for further clarification and confirmation. Other data used in the thesis are obtained from books. The data include demand forecast for each routes.

iii. Modeling and Analysis: The cost-benefit model development as well as the corresponding dynamic analysis is performed using decision tree plan software depends on forecasted demand.

iv. Conclusions and Recommendations.

3.2 Data Collection

3.2.1 Ethiopian Rail Project Routes

In this section introduces the Ethiopian Rail Project. The new railroad network is planned to have at least 8 main routes that extends to all compass points. The rail line will link about 49 urban centers, where railway stations are to be established. The proposed rail line crosses the borders of almost all regions. The government plans to construct 4,780 Km railroad network. The new railway system enhances the freight transport capacity of the nation by *'at least five million tones. 'Though the* *construction of the new railroad system is to be conducted in two phases',* below are the towns that the proposed rail line connects.

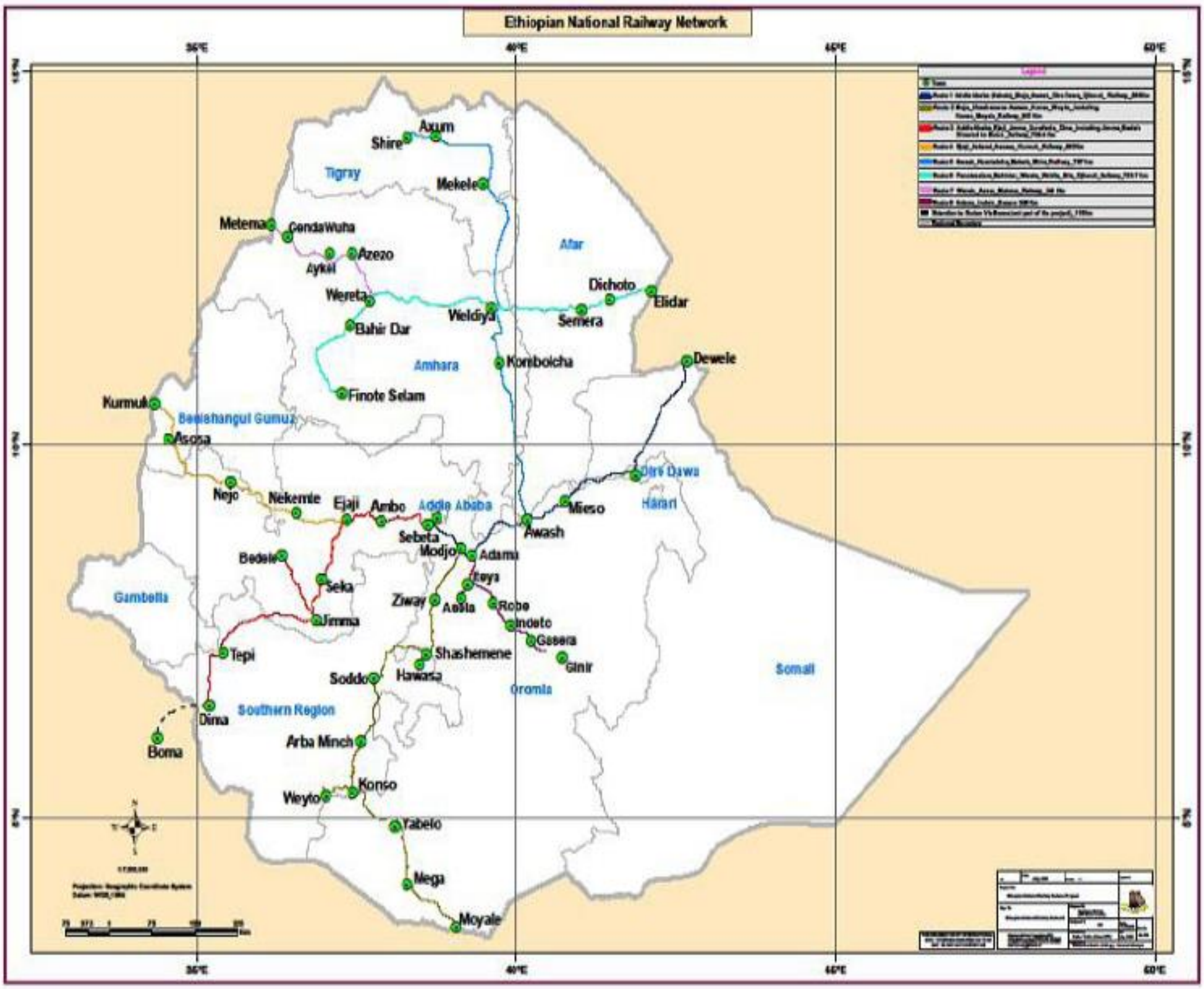


Figure 3-1 Towns Rail Line Connects.

Towns proposed rail line connects.			
No.	Construction Direction	Rail line connects	End Point
1	TO WESTERN	Addis Ababa ↔ Sebeta ↔Ambo ↔ Ijaji ↔ Nekemet ↔ Nejo ↔Asosa ↔Kurmuk, Sudan border	Kurmuk
2	TO SOUTH-WESTERN	Addis Ababa ↔ Sebeta ↔ Ambo ↔ Ijaji ↔ Seqa ↔ Bedele	Bedele
		Addis Ababa ↔ Sebeta ↔ Ambo ↔ Ijaji ↔ Seqa ↔ Jimma ↔ Tepi ↔ Dima	Dima
3	TO SOUTHERN	Addis Ababa ↔ Sebeta ↔ Mojo ↔ Zeway ↔ Shashemene ↔ Hawassa	Hawassa
		Addis Ababa ↔ Sebeta ↔ Mojo ↔ Zeway ↔ Shashemene ↔ Sodo ↔ Arbaminch ↔ Konso ↔ Weyto	Weyto
		Addis Ababa ↔ Sebeta ↔ Mojo ↔ Zeway ↔ Shashemene ↔ Sodo ↔ Arbaminch ↔ Konso ↔ Yabelo ↔ Mega ↔ Moyale, Kenya border	Moyale
		Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Iteya ↔ Asela	Asela
		Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Iteya ↔ Indeto ↔ Gasera↔ Ginir	Ginir
4	TO NORTHERN	Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Awash ↔ Combolcha ↔ Dessie ↔ Weldya ↔ Wereta ↔ Bahirdar ↔ Finoteselam	Finoteselam
		Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Awash ↔ Combolcha ↔ Dessie ↔ Woldya ↔ Mekele ↔ Aksum ↔ Shire	Shire
5	TO NORTH-WESTERN	Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Awash ↔ Combolcha ↔ Dessie ↔ Weldya ↔ Wereta ↔ Azezo ↔ Gendaweha ↔ Metema, Sudan border	Metema
6	TO NORTH-EASTERN	Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Awash ↔ Combolcha ↔ Dessie ↔ Woldeya ↔ Semera ↔ Ditchto ↔ Galafi, Djibouti border	Galafi
7	TO EASTERN	Addis Ababa ↔ Sebeta ↔ Mojo ↔ Adama ↔ Awash ↔ Dire Dawa ↔ Mieso ↔ Dewele, Djibouti border	Dewele

Table 3-1 Main routes of Ethiopian railway

The construction of railway requires a large amount of Money. The estimated cost for the construction of one kilometer railway in Ethiopia is expected to be three million USD. The construction cost for a new railway line investment on railway project can be divided as locally implemented costs which are about 45 percent of the total cost with 30 percent of it for civil work and 15 percent for earth work. The other 55 percent that is foreign implemented costs; with 25 percent of it for track and rail works, 10 percent for electrification, 15 percent for signaling and communication, and the remaining 5 percent for others. (Million Fikru, 2012)

3.2.2 Passenger and Freight Actual and Forecast Demand

It is very difficult to forecast future transportation demand accurately. In forecasting future transportation demand, usually many model specifications are constructed and compared with each other in most rational explanatory powers. Even a model that fits past data very wall, however, does not guarantee the accurate prediction of actual demand in future.

There are many factors that affect overall national market growths. Four factors are identified: 1) GDP growth 2) technological innovations 3) contingent events 4) currency markets.

1) GDP growth

   The national economic situation has a great impact on transportation demand. Usually, there is a strong correlation between GDP and transportation demand. Accordingly, in forecasting future demand, GDP is often used as an explanatory variable. If GDP does not grow as expected, forecasts will tend to overestimate actual demand. In periods during which GDP grew more than expected, the number of both national railway passengers and national seaport cargoes generally grew more than forecasted.

2) Technological innovations

   Apart from the economic situation technological innovations sometimes drastically change the structure of transportation demand. The advent of air travel, for example drastically decreased the need for international passengers to travel by sea. The emergence of container transportation systems also drastically decreased the volume of general bulk cargo.

3) Conditional Events

   Contingent events sometimes significantly affect transportation demand.

4) Currency markets

While a strong birr is supposed to increase imports and travelers going abroad, a weak birr is supposed to increase exports and travelers coming to Ethiopia.

Table 3.2 shows the actual demand in the past ten consecutive years thought out Ethiopian (Ethiopia Customs Authority Bulletin and National Bank, export and import trade by volume and value, 2013)

Year	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Qty, in (000)Ton	4,036	5,630	6.106	5,499	6,947	8,626	9,511	10,018	10,504	10,604

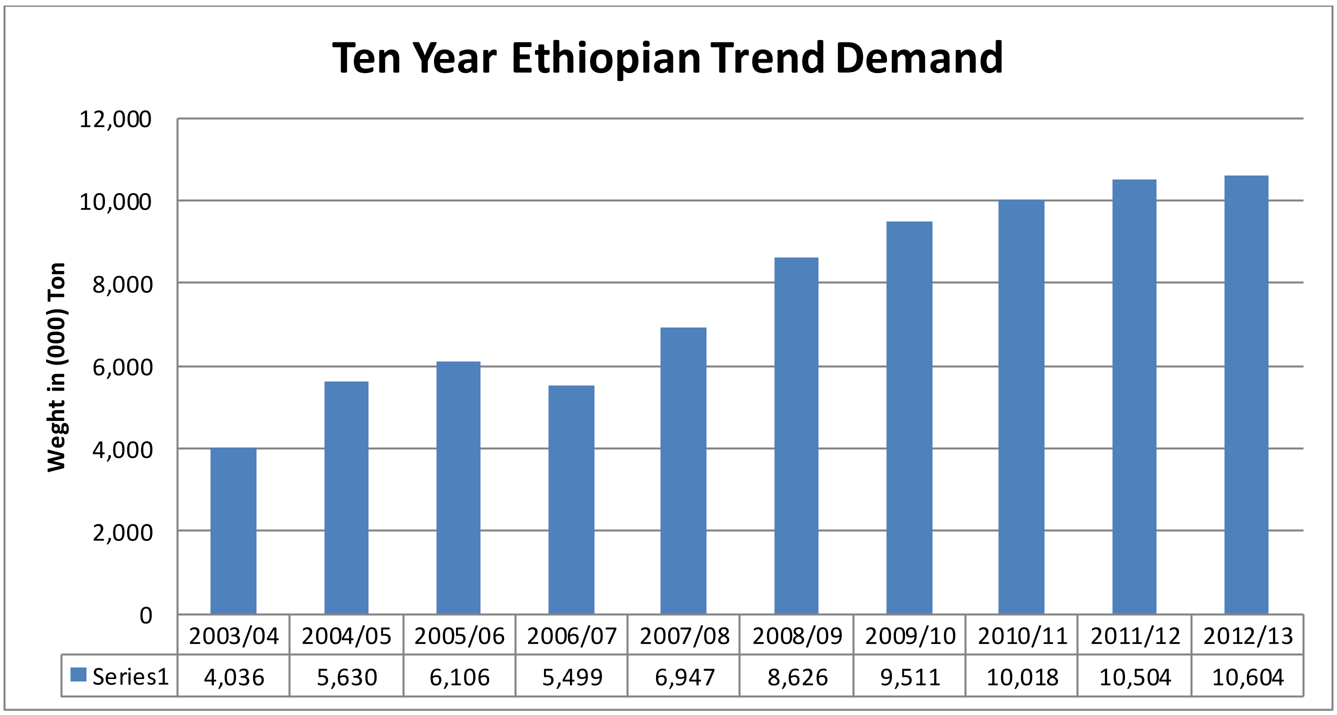


Table 3-2 Actual Demand in the Past Ten Consecutive Years

Table 3.3 and 3.4 shows the sample estimated forecast market demand between Addis Ababa to Djibouti Railway (Million Fikru, 2012)

Passenger demand forecast							
Year	*2007*	*2010*	*2015*	*2018*	*2020*	*2025*	*2030*
Estimated passenger (Mil)	4.35	4.61	5.10	5.42	5.64	6.24	6.89

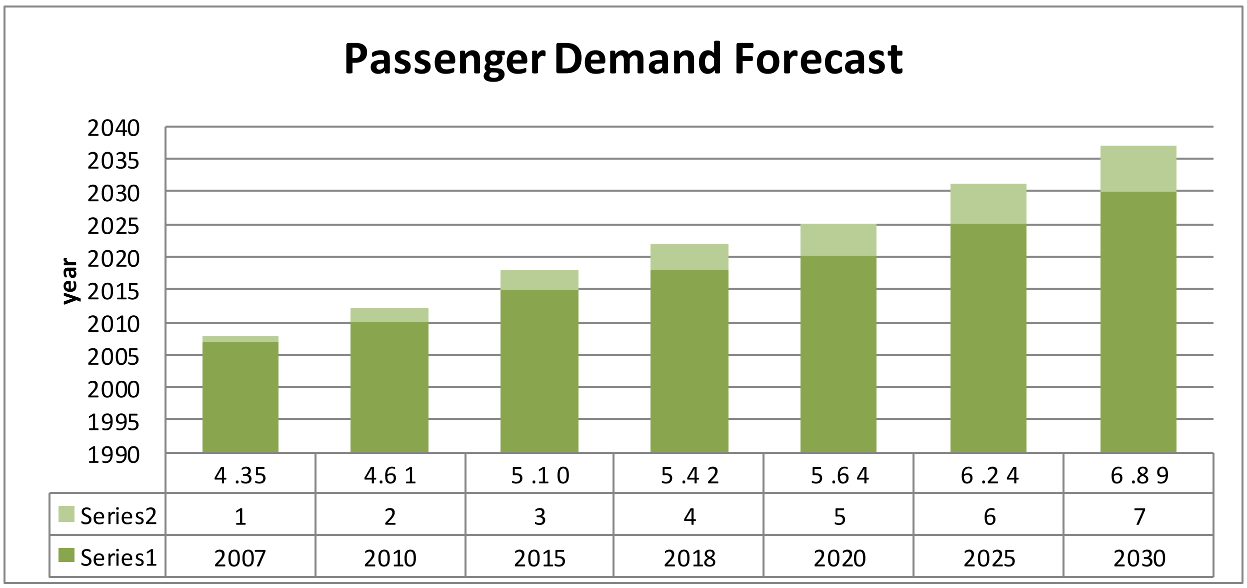


Table 3-3 Passenger Demand Forecast

Freight demand forecast							
Year	2010	2012	2015	2018	2020	2025	2030
Estimated freight(Mil tons)	2.10	2.89	4.68	7.58	10.44	14.23	19.8
Domestic freight	1.05	1.45	2.34	3.79	5.22	7.11	9.9
Total freight (Million ton)	3.15	4.34	7.02	11.37	17.66	21.34	29.7

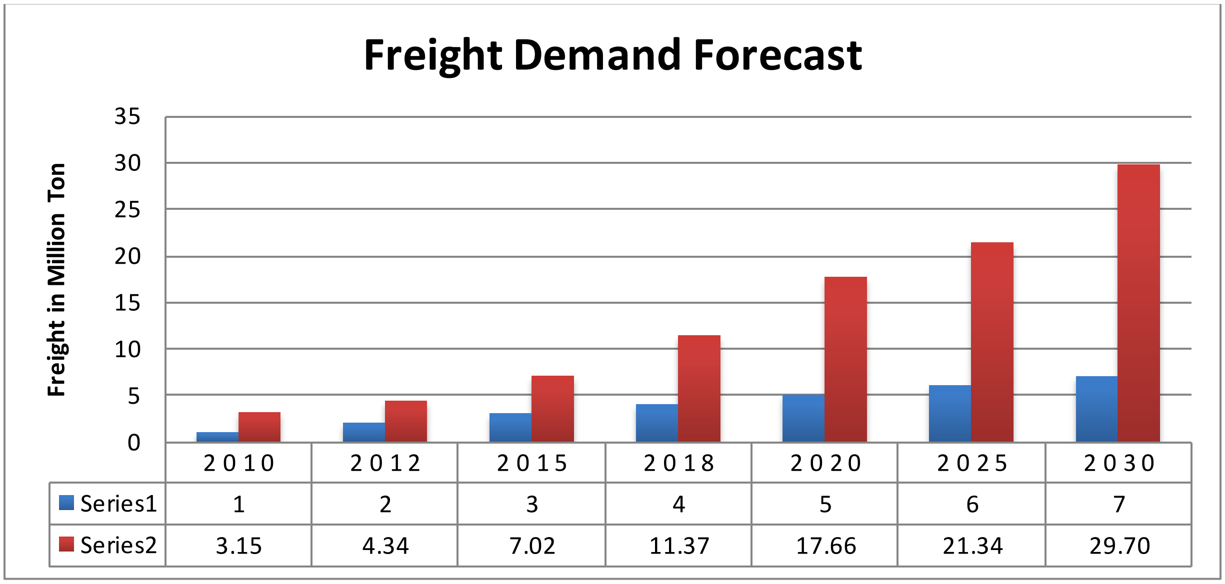


Table 3-4 Freight Demand Forecast

Phase one

Route 1 Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3 Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele **_430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**

Phase two

Route 2 Konso_Moyale **318km**

Part of route 3 Jimma _Dimma_ **300.1km**

Route 4 Ejaji_Nekemt_ Asossa_Kermuk_ **460km**

Part of route 5 Mekele _Shire_ **201.2km**

Part of route 6 Finotselam_ Bahirdar_werela_weldia_**461km**

Route 7 Weleta_Azezo_Metema_**244km**

Route 8 Adama_Indeto_ Gasera_**245km**

Chapter 4

4. RESULT AND DISCUSSION

4.1 Construction Cost-Benefit Model

The basic structure of the cost-benefit analysis is calculating the net present value (NPV) for both the conventional cost-benefit analysis and the proposed DSP valuation. The benefit valuation period is set as 30 years, the total analysis period, including the construction stage, is 35 years. (Taku, May 1999)

4.1.1 Cost Model

Costs refer to the Purchase, Construction, Maintenance and Operation of equipment.

a) Construction Cost per Km estimation

Railway construction costs and estimates, and, with the use of multipliers, it is possible to determine further cost estimates based on different location or service characteristics.

These components are estimated representative of those needed to install a fully operational railway infrastructure. Note that, maintenance, control, or rolling stock expenses are not included.

These cost components are also influenced by factors related to the type of location or service to be instituted. These factors are in Table 4.1 and include:

- ✓ Construction (adding to existing, building new, or upgrading existing railways)
- ✓ Service (passenger, freight, or mixed use)
- ✓ Speed (maximum intended speed: 120kmph)
- ✓ Motive power (electric or non-electric)
- ✓ Trackage (single, double, or other)
- ✓ Terrain (plains, hills, or mountains)
- ✓ Land Use (urban, suburban, or rural)

Cost per Kilometer Components and Corresponding Influencing factors				
Row	**Design and Building**	**Electric Infrastructure**	**Materials**	**Control and Communication**
Construction	Construction	Construction	Construction	Construction
Speed	Speed	Speed	Speed	Speed
Service	Service	Service	Service	Service
Trackage	Trackage	Trackage	Trackage	Trackage
Land Use	Land Use	Motive Power		
Terrain	Terrain			
	Motive Power			

Table 4-1 Cpkm influencing factor

Railway construction costs are influenced by various factors that make it difficult to create an estimate that is applicable to every site. These factors can be grouped in two categories:

I. Location characteristics and
II. Service characteristics.

Location characteristics, such as land use and terrain of the area, can have considerable influence on costs. Service characteristics include the speed and the level of service, which also have a great influence on cost. These influencing factors are considered in the CPkm components presented in table 4.1 and help account for differences that may be encountered in railway construction.

It must be noted that Design & Build is based on four assumptions

i. The costs associated with a double-track construction would be 1.5 times the costs of a single-track project in the same location. This assumption was made since the existing grade, geometry, and structures offer existing work and economies of scale to be built alongside of.
ii. CPKm increases by 1.1 from rural to suburban and 1.2 from rural to urban areas. This assumption represents the increased presence of intersections and structures that affect optimal railway placement. While the number of intersections will increase with more densely populated areas, it was determined that a less obtrusive railway would accordingly be built to avoid unnecessary interactions with surface traffic or built-up areas. For central business

districts, no multiplier has been included due to the small proportion that this land use represents of the whole. In addition, some projects may utilize current conventional rail infrastructure for built-up areas, therefore cost estimation was estimated too variable to determine.

iii. CPKm increases by 1.5 from plains to hills and 1.5 from hills to mountains. This assumption was made as the slope, length of slope, maximum curvature, and additional structures encountered result in greater engineering work to Design & Build the railway. This information is based on the effect of terrain on passenger car equivalents for truck traffic with regards to highway capacity (Transportation Research Board, 2000).

iv. The cost to upgrade a railway is one-third of the corresponding cost to build. This assumption was made as all or a portion of the grade, structures, and necessary geometry is already in place, requiring adaptation or partial building, rather than complete rebuilding. (Jeffrey Tyler Von Brown, 2011)

The estimation methodology includes multiple influences and cost categories, and relies on numerous sources of information. To demonstrate the application of the methodology the equation is shown below.

Scenario CPM = (Design & Build base cost x TE x LU x SP x TR x UP x AD)
+ (ROW base cost x TE x LU x SP x TR)
+ (Materials base cost x TR)
+ (C&S base cost x TR)
+ (Electric Infrastructure base cost x TR)………………………………………………….. (4.1)

Where:

TE = Terrain multiplier

LU = Land Use multiplier

SP = Speed multiplier

TR = Track multiplier

UP = Upgrade multiplier

AD = Additional multiplier

1Mile=1.609344km

Type of track	Max. speed[km/h]	Easy Topology [1million/Km unit]	Topography of average difficulty [1million/km unit]	Difficult Topography [1million/km unit]
Single Track	100-120	2-3	5-15	20-40
Double Track	100-120	2-4	7-20	20-50
	300	3-6	10-30	40-50

Table 4-2 Summery of Construction cost

Investments include the following items:

- work management,
- Preparation of the ground; deforestation, etc.,
- Rerouting of roads,
- Embankments (fills, excavated material, track bed, etc.),
- Drainage, protection against frost,
- Protecting structures,
- Structures: walls, water ducts, bridges, tunnels,
- Overpasses and underpasses,
- Noise barriers and other noise-protection equipment and structures,
- Fences,
- Service access roads,
- General expenses
- Initial additional maintenance

b) Electric locomotives

The following adjustment may be helpful to estimate price of Locomotive:

P_L = investment, i.e. average or median price of an electric locomotive, 10^6 \$/unit

W = continuous output or rating at wheel-rim, MW

$$P_L = \frac{W}{3} + 1 \qquad (4.2)$$

Most prices are within an interval of $P_L \pm 20\%$.

4.1.2 Schedule of Ethiopian railway route Construction project

The project is to be develop first phase of first decision will constructed as planning it will take five years, then after five years of construction project start operation for five year then after five year of operation start construction of first phase second decision as plan. Fig 4.1 shows the construction schedule of the project.

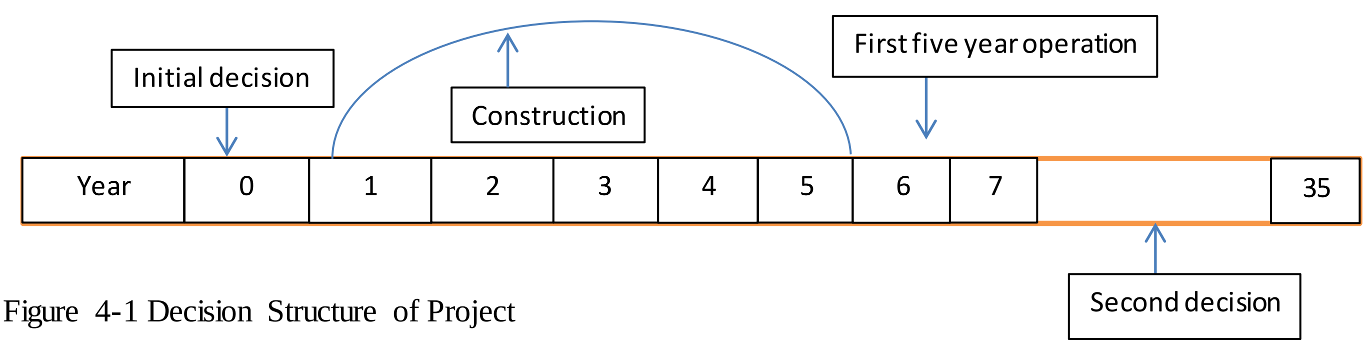


Figure 4-1 Decision Structure of Project

By using the above formula we calculation one kilometer estimated about 2.5 million USD and the actual data obtained from the ERC is for One kilometer estimated to be 3 million USD then the average of the two are 2.75 million USD that is about 50 million ETB.

Year	1	2	3	4	5
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00

Table 4-3 Constriction cost estimation of first phase first decision for two routes

c) Operation Cost Model

i. Maintenance costs

Yearly maintenance costs, long term average (economic life or life cycle), at the prices applicable as of the date of commissioning of the equipment (J.P. Baumgartner, January 2001) (yearly **percentage of the investment**):

Type of maintenance	Cost /year in average	Cost/year in range
Embankments, cuttings	0.5%	(0 to 1%)
Drainage structures	2%	(1 to 3%)
Walls	0.5%	(0.1 to 1.5%)
Steel bridges	1.5%	(1 to2%)
Concrete bridges	1%	(0.1 to 2%)
Tunnels	0.5%	(0.1 to 2%)
Buildings, platforms	1%	(0.5 to 2%)
Roads, parking lots	0.3%	(0.1 to 0.5%)
Signaling equipment	0.05%	(0.01 to 0.1%)
Telecommunications Equipment	0.08%	(0.05 to 0.1%)
Electrical equipment	0.5%	(0.2 to 1%)
Machinery	0.5%	(0.2 to 1%)

Table 4-4 Cost estimation of maintenance for one year

Maintenance costs of electric locomotives long term average (life cycle maintenance costs),

$$E_L = 0.2P_L \quad (4.3)$$

Where:

E_L=maintenance and repair costs long term average $/km

P_L = Investment price of the electric locomotive, 106$

ii. Consumption of Electricity, Estimated Cost

Annual average, including consumption for heating and air conditioning

Type train	Maximum speed[km/h]	Gradient[mm/m]	Unit consumption [W/TKL][1]	Average cost [$/kw]
Passenger	120	0-5	25 (20-30)	0.1 (0.06-0.16)
Goods	80	0-5	15 (10-20)	

1) TKL=ton-kilometer including mass of Locomotive

Table 4-5 Tractive Power Consumption

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Passenger/ Freight (Million ton)	2.63	2.50	2.88	2.88	3.13	1.89	3.00	1.90	2.36	2.49	2.21	2.94	3.75	4.31	3.73
0peration cost (Million)	526.38	500.00	575.00	575.25	625.00	377.00	600.00	380.00	472.50	497.50	442.50	587.50	750.00	862.50	745.00

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Passenger/ Freight (Million ton)	3.18	3.20	3.61	3.06	3.75	3.8	3.8	3.78	3.99	4.1	4.2	4.8	4.77	4.88	5
0peration cost (Million)	635.00	640.00	722.50	612.50	750.00	760.00	760.00	756.00	798.00	820.00	840.00	960.00	954.00	976.00	1,000.00

Table 4-6 Operation Cost in each year of first phase first decision of two routes

4.1.3 Benefit Model

a) Tariff: Transportation Cost Equation

Tariff rates are fixed in relation to operating revenues and expenses. The process may be either regulated or market determined. Export rates to Djibouti were significantly below import rates, as might be expected from the traffic imbalance. On all three routes to Dire Dawa, Gondar and Mekele, rates were significantly higher for traffic from Addis Ababa than in the opposite direction...

$CC_m = Q * CC_u * [t_m / (365 * 24)]$………………………………………………. (4.4)

Where:

u = unit cost of item to producer in dollars per unit

Q = number of units shipped

t_m = shipment throughput time for mode m in hours

CC_u = carrying cost per unit ($/unit-year)

CC_m = carrying cost per order associated with mode m ($/unit-year)

R_m = cost rate for mode m ($/container-mile)

$CC_u = u * x\%$ (x is a standard percentage used by a shipper)

The total transportation cost (including truck, initial transfer, transportation, and inventory carrying cost) can then be expressed by equation (4.5) below.

Total Transportation Cost = $T_m + D + T_{sm} + CC_m$ ……………………………… (4.5)

Where:

v_m = average speed in miles per hour for mode m

d = distance traveled in miles

T_m = transportation cost (in dollars) for mode m

D_m = Dray cost (in dollars) for mode m

T_{sm} = transfer cost (in dollars) at terminal for mode m

CC_m = carrying cost (in dollars) for mode m

N_c = number of containers in shipment

$T_m = N_c * R_m * d$

D_m = \$100 per container for rail, \$88 for barge and \$0 for truck

T_{sm} = \$150 per container for rail, \$200 per container for barge, and \$0 for truck

CC_m = (number of units shipped) * (unit cost of item to producer) * (x yearly %) * (Throughput time in hours / (365 days per year *24 hours a day)) and, throughput time in hours = d/v

Each of these factors above is either known or will be assumed, except for the distance traveled. Therefore, the distance traveled is must be determined. The mode specific equations are defined by equations (4.6) below.

Rail Cost= (number of containers)(\$/container-mile)(d)

+ (Q)(u)(x%)[(d/v) / (365 * 24) + (D_{rail})(number of containers)

+ ($T_{s\ rail}$)(number of containers) ……………………………………………(4.6)

Constants in the above equations are as follows:

v_{rail} = 37 miles per hour

R_{rail} = \$0.35 (per container-mile)

The above parameters have been estimated and are described in greater detail in references (Moriyama, 2003)

Formula for calculating total basic charge

$$S = \left[\sum \left(s_{nj} * l_n \right) * \alpha_{mj} \right] * z_j \quad \ldots\ldots (4.7)$$

Where:

S – Total basic charge

S_{nj} – unit rate for defined type of train (j) and given line section (n)

l_n – length of line section

α_{mj} – coefficient that depends on total gross load (m) of a given train (j)

z_j – profit (max. 5%) presumed for defined type of train (j)

Dry Bulk Tariff

Some representative tariffs for 2009 freight from Comet are as follows:

- ✓ Djibouti- Addis Ababa: Birr 65/ quintal or Birr 0.70 per ton-km
- ✓ Addis Ababa – Djibouti: Birr 35 /quintal or Birr 0.38 per ton km

Current minimum price charged as per private freight transport operators are as follows:

- ✓ Addis Ababa –Dire Dawa: Birr 35/quintal (0.67/ton km)
- ✓ Dire Dawa –Addis Ababa: Birr 40/quintal (0.77/ton km)

These freight rates have risen considerably over the past three years. For instance the rate per tonne km has risen from 0.42- 0.46 per tonne-km in 2005/2006 to 0.70 per tonne-km in 2009. (The Management of Commercial Road Transport in Ethiopia , May 2009)

Generally the transportation cost is calculated based on tariff data.

Benefit = (1.4birr/ton-km)…………………………………………………………... (4.8)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Passenger/ Freight (Million ton)	2.63	2.50	2.88	2.88	3.13	1.89	3.00	1.90	2.36	2.49	2.21	2.94	3.75	4.31	3.73
Tariff(Million birr)	3,947.81	3,750.00	4,312.50	4,314.38	4,687.50	2,827.50	4,500.00	2,850.00	3,543.75	3,731.25	3,318.75	4,406.25	5,625.00	6,468.75	5,587.50

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Passenger/ Freight (Million ton)	3.18	3.20	3.61	3.06	3.75	3.8	3.8	3.78	3.99	4.1	4.2	4.8	4.77	4.88	5
Tariff(Million birr)	4,762.50	4,800.00	5,418.75	4,593.75	5,625.00	5,700.00	5,700.00	5,670.00	5,985.00	6,150.00	6,300.00	7,200.00	7,155.00	7,320.00	7,500.00

Table 4-7 Benefit in each year of first phase first decision of two routes

4.1.4 Salvage Value

Salvage value of terminal should be added at the end of the final year of the valuation period. Among the value of land, crane, and warehouse are taken into account.

The formula, S=0.9*C*(1-t/100)………………………………………………………………. (4.9)

Where S=Salvage Value, C=development Cost, t=duration of usage,

Major projects and cost-benefit components Ethiopian		
Project	*Railway*	*New railway inter regional*
		New railway LRT
Cost Quantified		*Construction cost*
		Operation Cost
Benefit Quantified		*Reduce Transportation cost*
		Time saving
Discount rate		*4%*
Benefit Valuation Period		*30 years*

Table 4-8 summery of Cost-Benefit Components

4.1.5 Simple NPV Based On a Deterministic Scenario

The NPV for phase 1 is calculated based on a deterministic scenario. (Medium cases are used as the deterministic scenario for all uncertainties). This is the cost-benefit analysis that ERC now basically uses in evaluating projects. The resulting NPV for this phase 1 is Positive **13,206.14 Million** birr so this investing is justifiable by the current ERC Criterion (Table 4.9)

Phase one Initial Decision for route two cons. At medium demand												
*Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_* ***656km***												
Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _ ***430.3km***												
1Km=2.8 million USD	=	***50 million ETB***			Total Distance=656+430.3=**1086.3km**							
UNIT=1million birr												
Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00							
Operation cost						526.38	500.00	575.00	575.25	625.00	377.00	600.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	526.38	500.00	575.00	575.25	625.00	377.00	600.00
Benefit Component												
Tariff						3,947.81	3,750.00	4,312.50	4,314.38	4,687.50	2,827.50	4,500.00
Salvage value												
Total Benefit	0	0	0	0	0	3947.81	3750	4312.5	4314.375	4687.5	2827.5	4500
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	3421.44	3250.00	3737.50	3739.13	4062.50	2450.50	3900.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	2704.01	2469.73	2730.95	2627.06	2744.48	1591.80	2435.93
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-45464.58	-42994.85	-40263.89	-37636.83	-34892.36	-33300.56	-30864.63

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	380	472.5	497.5	442.5	587.5	750	862.5	745	635	640	722.5	612.5
Total Cost	380	472.5	497.5	442.5	587.5	750	862.5	745	635	640	722.5	612.5
Benefit Component												
Tariff	2850	3543.75	3731.25	3318.75	4406.25	5625	6468.75	5587.5	4762.5	4800	5418.75	4593.75
Salvage value												
Total Benefit	2850	3543.75	3731.25	3318.75	4406.25	5625	6468.75	5587.5	4762.5	4800	5418.75	4593.75
Net Benefit	2470	3071.25	3233.75	2876.25	3818.75	4875	5606.25	4842.5	4127.5	4160	4696.25	3981.25
PV of Net Benefit	1483.418	1773.5703	1795.5866	1535.6534	1960.444	2406.4371	2660.9641	2210.0538	1811.2857	1755.3344	1905.3923	1553.1711
Cumulative NPV	-29381.21	-27607.64	-25812.054	-24276.4	-22315.96	-19909.519	-17248.555	-15038.501	-13227.216	-11471.881	-9566.4889	-8013.3178

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	750	760	760	756	798	820	840	960	954	976	1000
Total Cost	750	760	760	756	798	820	840	960	954	976	1000
Benefit Component											
Tariff	5625	5700	5700	5670	5985	6150	6300	7200	7155	7320	7500
Salvage value											10000
Total Benefit	5625	5700	5700	5670	5985	6150	6300	7200	7155	7320	17500
Net Benefit	4875	4940	4940	4914	5187	5330	5460	6240	6201	6344	16500
PV of Net Benefit	1828.694	1781.8048	1713.2739	1638.7083	1663.219	1643.3385	1618.673	1778.7615	1699.658	1671.9745	4181.3553
Cumulative NPV	-6184.623	-4402.8186	-2689.5447	-1050.8364	612.3825	2255.721	3874.394	5653.1555	7352.8135	9024.7879	***13,206.14***

Table 4-9 Actual investment by NPV per year of first phase first decision of two routes

4.2 Strategic Opportunities and Options

DSP is a multi-stage decision; there are decision opportunities at two stages; the initial decision and the decision at the end of the five years of operation.

- 1st decision at year 0 for phase 1

This section explores two kinds of investments for phase 1. The first is to build only two routes.

I. Route 1 Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**
II. Part of Route 3 Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele **_430.3km**

This is not the actual case but an alternative investment that might have been better in terms of the NPV. The second choice is to build three routes this case study is to demonstrate DSP, (the case simplifies the choices)

I. Route 1 Addis Ababa (Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**
II. Part of Route 3 Addis Ababa (Sebeta)_ Ejaji_Seka_ Jimma_ Bedele **_430.3km**
III. Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

- 2nd decision at year 11

At the end of decision 1of phase 1 ERC will start decision two of phase 1 an additional investment. The decision two for phase 1 depends on the outcomes decision 1 of phase 1. Decision-makers can take advantage of information on the phase 1 construction cost and the demand growth from year 6 to year 10 during the first five years of operation. The information on construction cost is assumed as being perfect information, i.e. if construction cost for decision 2 of phase 1 will also be high, medium, or low, respectively, for decision 1, the construction cost for decision 2 will also be high, medium or low, respectively. The information on project demand for the first five years of operation is not perfect information. Nevertheless, the information on the share acquire during phase 1 is helpful for decision-makers to determine what strategy they should take for decision 2.

- Decision tree analysis

Before proceeding to a precise real options valuation, a simplified decision tree analysis is carried out to help decision- makers understand the essence of DSP. Three outcomes of construction costs have been already defined. The three outcomes of demand growths are created by convoluting three outcomes of market demand growth and three outcomes of project shares.

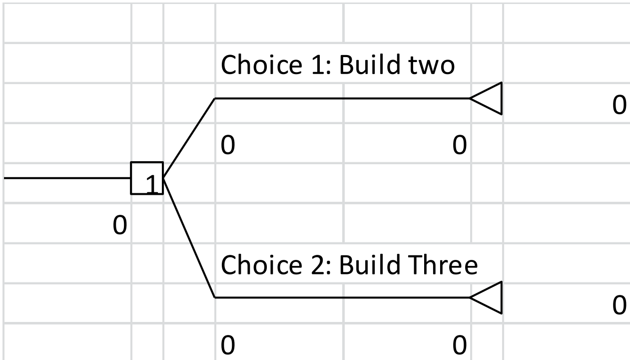


Figure 4-2 Choice of phase 1 at year 0

5 year plan		**1st**	**2nd**	**3rd**	**4th-7th**
Year	0	1-5	6-10	11-15	16-35
Phase		1		Phase 1 Decision 2	
Stage	Initial decision	Construction	Operation	Operation and construction expansion	

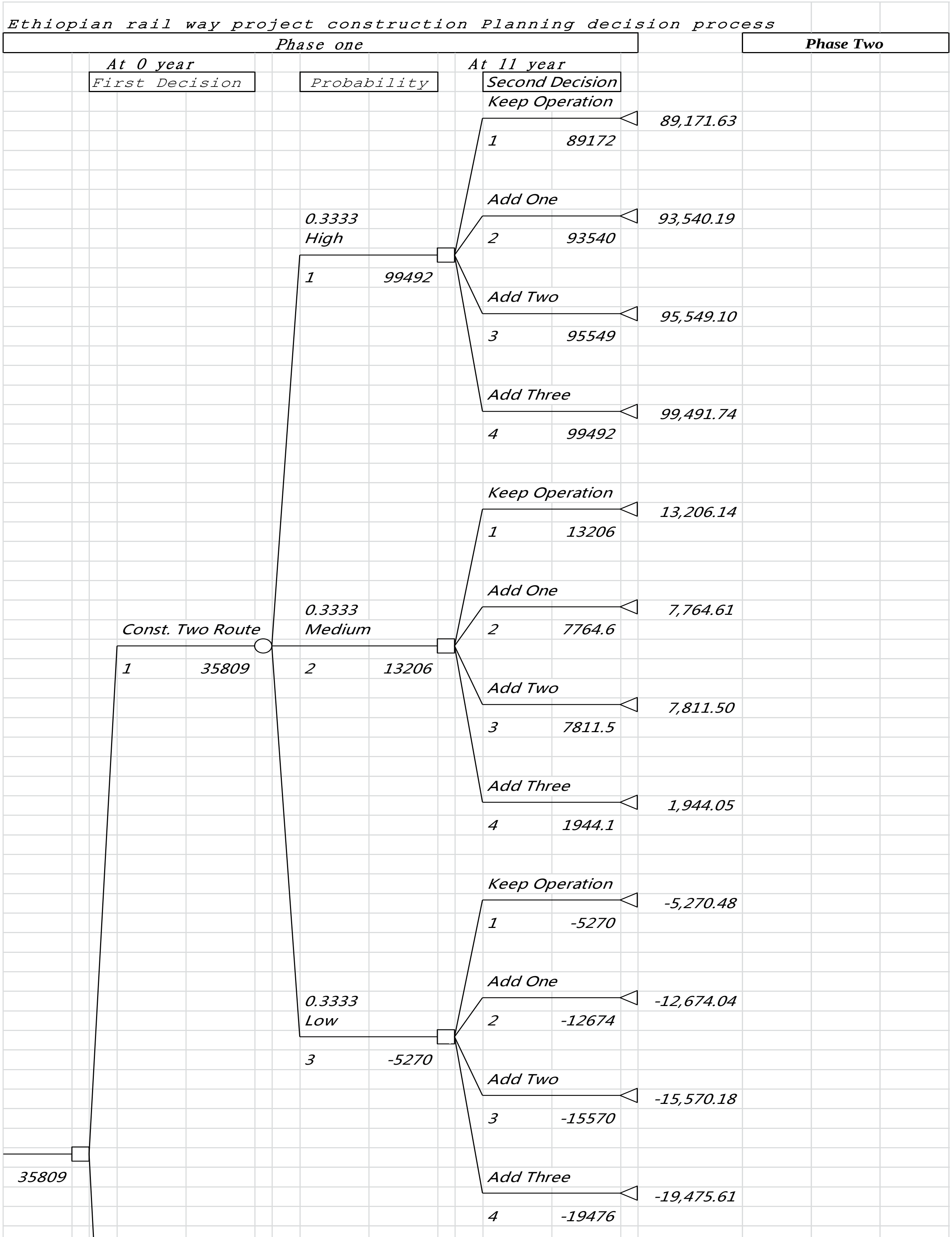
Table 4-10 Strategic decision opportunities

The optional decision for decision 2 maximizes the expected NPV given observations of construction cost and demand growth during decision 1.

In our case, the actual investment case (choice 2); if construction cost is medium, the best choice for decision 2 is the total NPV **13,206.17** Million birr.

No.	0 -5 Construction year Initial cons. route	Demand Level	11-15 construction year Expansion	NPV Calculated (million)
1	TWO Route 1) Route 1 2) Part of route3	High demand	Keep operation	89,171.63
			Add One	93,540.19
			Add TWO	95,549.10
			Add THREE	99,491.74
		Medium demand	Keep operation	13,206.14
			Add One	8,778.27
			Add TWO	7,811.50
			Add THREE	1,944.05
		Low demand	Keep operation	-5,270.48
			Add One	-12,674.04
			Add TWO	-15,570.18
			Add THREE	-19,475.61
2	THREE Route 1) Route 1 2) Part of route 3 3) Part of route 5	High demand	Keep operation	102,818.54
			Add One	105,457.97
			Add TWO	108.700.72
		Medium demand	Keep operation	8,376.43
			Add One	9,053.84
			Add TWO	2,486.50
		Low demand	Keep operation	-13,795.53
			Add One	-16,061.14
			Add TWO	-20,666.47

Table 4-11 Summery of NPV Calculated for each Decision


Ethiopian rail way project construction Planning decision process
Phase one
Phase Two
At 0 year
First Decision
Probability
At 11 year
Second Decision
Keep Operation
89,171.63
1 89172
Add One
93,540.19
0.3333
High
2 93540
1 99492
Add Two
95,549.10
3 95549
Add Three
99,491.74
4 99492
Keep Operation
13,206.14
1 13206
Add One
7,764.61
0.3333
Const. Two Route
Medium
2 7764.6
1 35809
2 13206
Add Two
7,811.50
3 7811.5
Add Three
1,944.05
4 1944.1
Keep Operation
-5,270.48
1 -5270
Add One
-12,674.04
0.3333
Low
2 -12674
3 -5270
Add Two
-15,570.18
3 -15570
35809
Add Three
-19,475.61
4 -19476

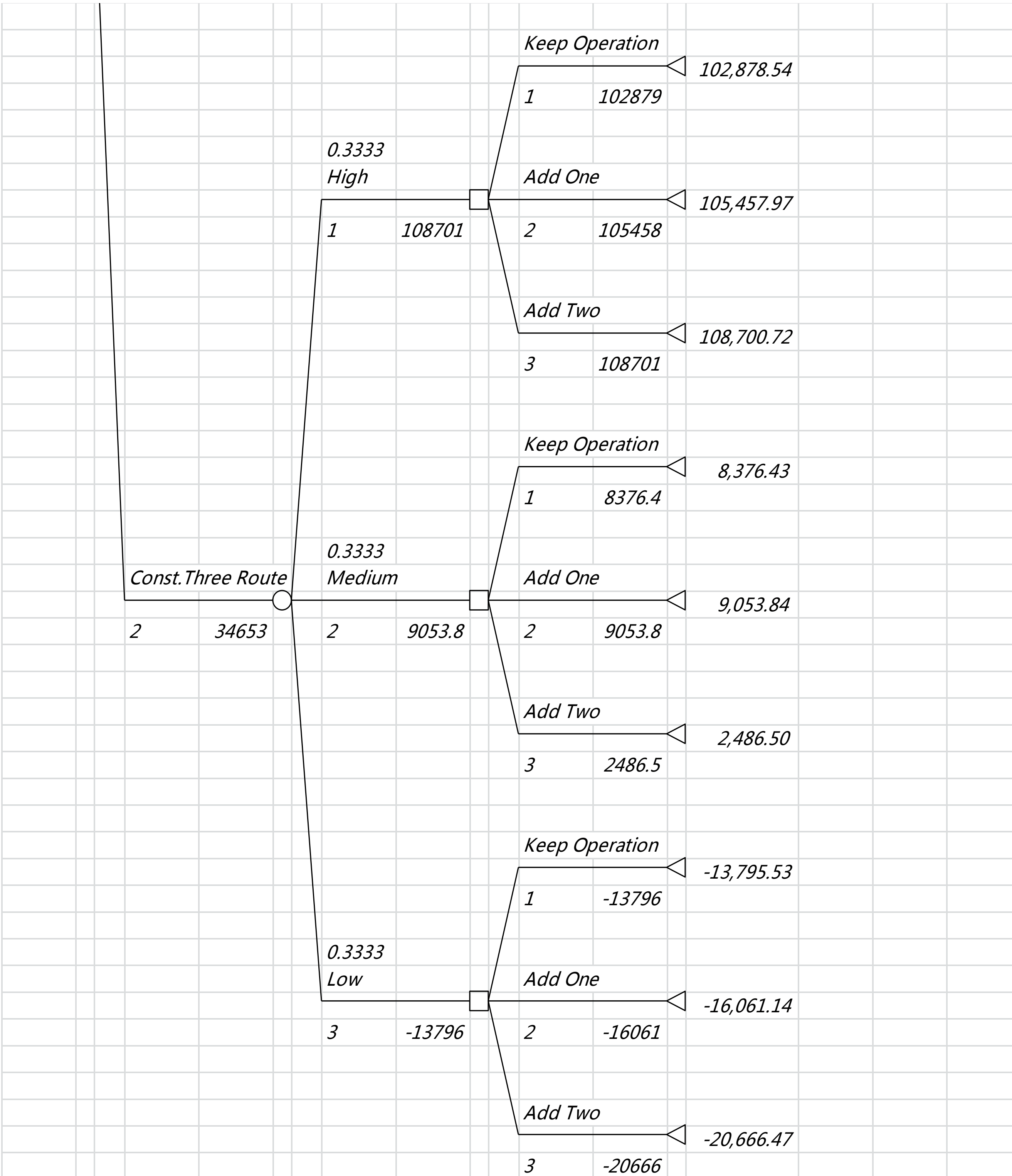


Table 4-12 Tree plan analysis result

4.3 Choose Real Options Value Calculator

1. Monte-Carlo simulation and Black-Scholes equation

Although the decision tree analysis illustrates the concept of DSP, it lacks the precision because of simplifications in creating discrete outcomes of uncertainties in this case study. For this case, only three outcomes for demand uncertainties (high, medium and low) are used throughout each phase.

1.1) Monte-Carlo simulation

The Monte- Carlo simulation fits this case study in valuing Real Options value. Because statistical references (Mean, standard deviation, and distribution) of demand uncertainties are now determined, simulation overcomes the problems of decision tree analysis explained above.

Monte –Carlo simulation is applied to the determination of demand growth paths.

First, using the statistical information defined, for realizations of demand growth paths are generated. The expected NPV of the realizations for the phase 1 investment (either choice 1 or choice 2 without phase 2 expansions) gives a base expected NPV, which is defined for the phase 1 facilities.

Second, for each one of the realizations, further realizations of demand paths are generated for the period after year 11.

Option value is realized when the expected value of expansion, given information on phase 1, is greater than the expected value of non-expansion. The option value arises by resolutions of demand uncertainty and cost uncertainty. Because market demand uncertainty is never resolved, it has nothing to do with option value here. All option value coming from the resolution of demand uncertainty is attributed to the resolution of the project share uncertainty here.

NPV with real options value (Total NPV)

- ✓ Choice 1: Building a two route for phase 1 and exercise the suitable option when it is most advantageous for phase 2.
  Total NPV= Base Expected NPV +Option Value …………………………………… (4.10)
- ✓ Choice 2: Building three route for phase 1 and exercise the option when it is advantageous for phase 2.

Total NPV =Base Expected NPV+ Option value…………………………………….. (4.11)

1.2) Black- Scholes equation

Is also applicable to the calculation of option value here because the expansion opportunity at year 11. This equation is popular because it provides a simple solution and quick answer when appropriate. The equation is:

$$V = N(d_1) * A - N(d_2) * X * \exp(-rf * T) \quad \text{………………………………………………………. (4.12)}$$

Here, V= Current value of call option

A= Current value of underlying asset

X= Cost of investment

rf= Risk-free rate of return

T= Time to expiration

N (d_1) and N (d_2) are the values of the normal distribution at d1 and d2

$$d_1 = \frac{[In(A/X) + (r + 0.5 * \sigma^2) * T]}{(\sigma * T^{0.5})} \quad \text{………………………………………………………. (4.13)}$$

$$d_2 = d_1 - \sigma * T^{0.5}$$

$\sigma = volatility$ of the underlting asset

4.4 Discussion

The best decision depends on decision tree plan for this case is:

First Decision (Initial constructed)	If Demand	Second Decision (Expansion of routes)
Construct Two Routes	High	Add Three route
	Medium	Keep Operation
	Low	Keep Operation

Table 4-13 Result of the analysis

- If High demand, our decision two must be Add Three route because

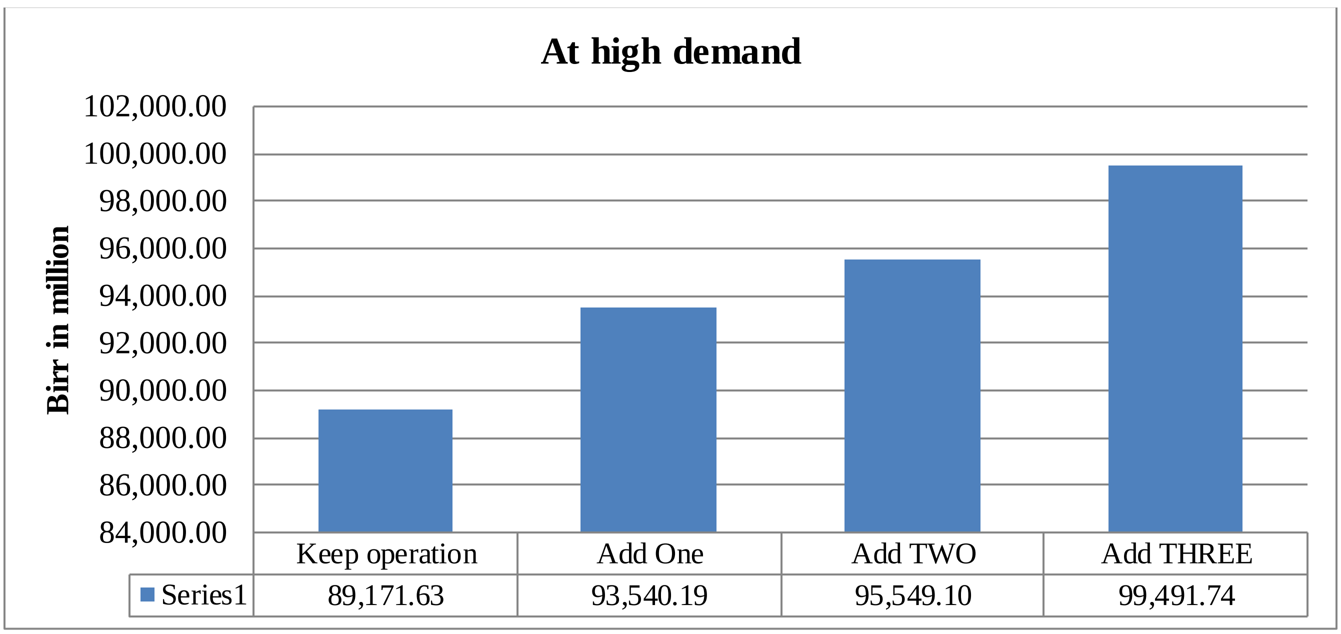


Table 4-14 High Demand level

- If Medium demands our decision Two is must be Keep Operation because

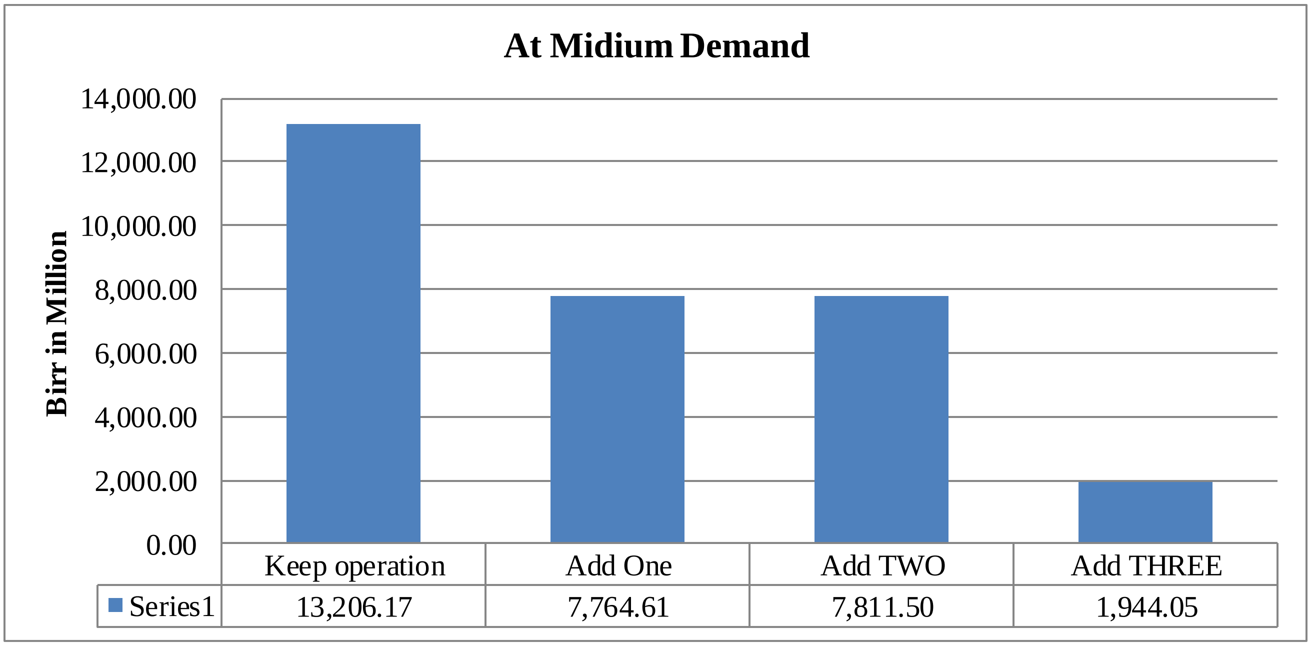


Table 4-15 Medium Demand level

- If Low demand our second decision must be Keep Operation because:

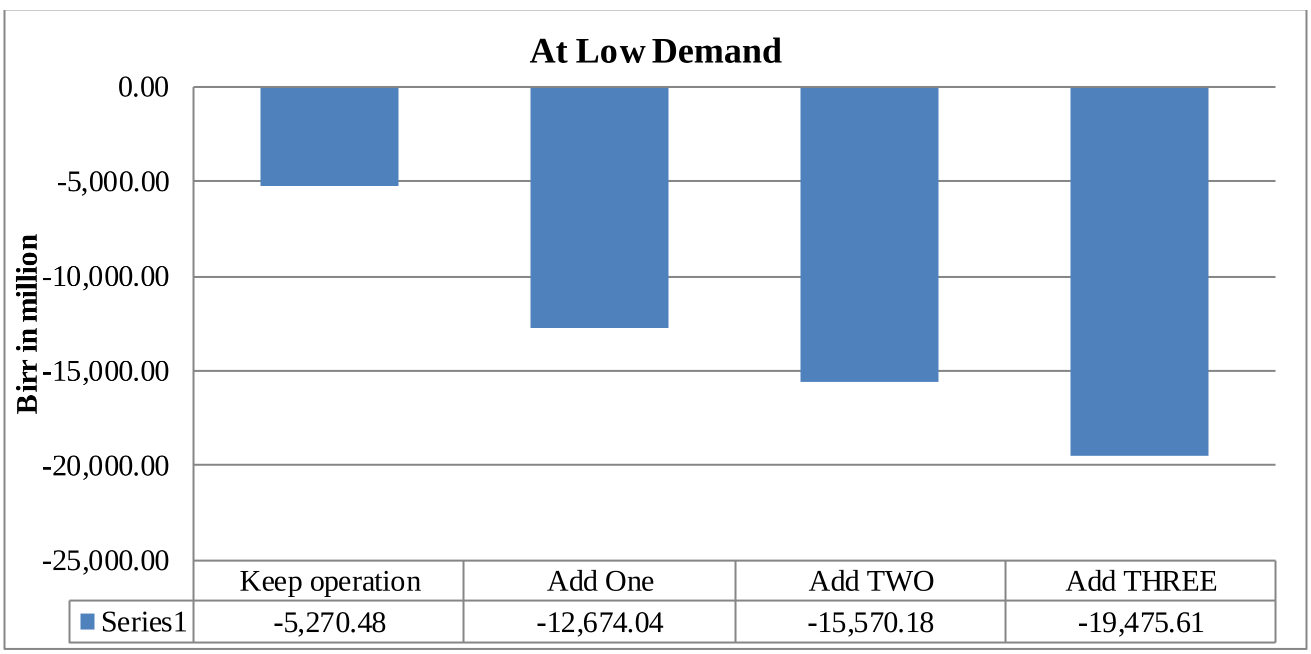


Table 4-16 Low Demand Level

Chapter 5

5 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

This thesis shows that it is beneficial for the Ethiopian railway corporation to incorporate Dynamic Strategic Planning (DSP) into its decision-making in investing transportation infrastructure projects. The planning based on DSP is more precise than the conventional method and that DSP has advantages over the conventional method in terms of its ability to increase the real value of projects.

Conventional cost-benefit analysis does not systematically take into account future uncertainties and risks and can lead to wrong decisions. DSP is the approach that takes into account future uncertainties and risks and insures managerial flexibility. It can maximize the expected net present value (NPV) of a project. In other words, it can minimize the loss of NPV caused by a failure to choose the best strategy.

As travel demand increases with rising GDP, countries are looking for fast transportation modes to meet this demand. In this thesis ways to enhance the expected value of Rail projects have been investigated. The problem with the traditional valuation methods is that uncertainty is treated as noise that is remained to be ignored. Risks due to uncertainty are not limited and opportunities are not exploited. In contrast, in advanced flexible planning methods like Dynamic Strategic Planning uncertainty is treated as a system attribute which is to be modeled and explored. DSP can be a powerful tool to recognize uncertainty in rail way and act accordingly. Also DSP has advantages over the conventional method in terms of its ability to increase the real value of projects.

The evaluation techniques that are used for the evaluation of a rail project system technology have been explored. Net Present Value technique is the most popular techniques. It is conceptually superior to other techniques that do not account for the value of time and immediate gives an indication if a project is valuable.

Based on this result, the study introduced four important processes to the application of DSP to a project. The first process is to define the type and degree of uncertainties, the second is these uncertainties are quantified by using the historical data concerning costs; the third process is the creation of alternatives the last process is the calculation of expected profitability. This examination suggested that DSP not only make the planning realistic but also increase the possibility of obtaining governmental financial support.

5.2 Recommendation for Future Work

Although the applications of flexible system planning are limited in this thesis (mainly infrastructure cost management), the methodology has much theoretical potential and it is therefore recommended that Ethiopian Railway corporation continues to invest in DSP research.

DSP is the approach that takes into account future uncertainties and risks and insures managerial flexibility. ERC should recognize the real options value of adding one or more routes. If ERC first develops two routes and benefit is high it should add three after the five years of operation because the resulting NPV 99,491.74 birr million, is greater than the NPV without adding it 89,171.63 birr million; if the benefit (demand) is medium or low, should not add routes.

The analysis performed in this research is based on some assumptions and restrictions. However, complete analysis and, thus, understanding the actual planning of Ethiopian rail project construction is attained taking every possible detail into account. Therefore, the following are recommended for future work as extensions and elaborations of this research

- ERC uses DSP as a basis of its route construction decision-making.
- Exact Construction and Operation cost of each project should be determined annually.
- Real Options Value must be calculated using Monte-Carlo simulation and Black-Scholes equation to get the exact demand forecast.
- The Ethiopian railway exact tariff system should be known to calculate NPV of the project.

5.3 New Contribution of this thesis

Ethiopian Railway Corporation is currently using planning conventional method for route construction that does not accommodate uncertainties. It forecasts only one set of circumstances, decides for one alternative based on that forecast, and invests in it extensively. Once the decision has been made, it is difficult for decision-makers to revise their plans if the circumstances change. In order to maintain such highly uncertain situations, there need to be a more flexible planning method which can identify future risks. The new contribution of this thesis is the existing options will be realized by arrival of new information as time goes depending upon the demand and project evaluation. This flexibility can increase long term benefits, minimizing the possibility of disastrous losses.

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Appendices

Appendix 1: Cost- Benefit Model

1) Cost Model
   a) Construction cost: This is basically based on actual data obtained from the ERC and International standard estimation calculation i.e average of the two.
   b) Operation cost: **Op. cost** = maintenance + electricity consumption + wage of the worker
2) Benefit Model
   a) Transportation cost: This is calculated based on Tariff data
   b) Transportation time value: The average speed on roads is less than that of rail.
   c) Salvage Value: salvage value of the terminal should be added at the end of the final year of the valuation period. The value of crane and warehouse are taken into account.
3) NPV calculation

   Discount rate = 4%

   Total years of operations = 30 years

   Total years of construction and Operations = 35 years

   Level of demands

   a) High demand
   b) Medium demand
   c) Low demand

<u>Phase one Initial Decision for route two cons. At high demand</u>

*Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_* ***656km***

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _ ***430.3km***

1Km=2.8 million USD = 50 million ETB Total Distance=656+430.3=***<u>1086.3km</u>***

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00							
Operation cost						800.00	870.00	960.00	996.00	1040.00	1120.00	1160.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	800.00	870.00	960.00	996.00	1040.00	1120.00	1160.00
Benefit Component												
Tariff						6,000.00	6,525.00	7,200.00	7,470.00	7,800.00	8,400.00	8,700.00
Salvage value												
Total Benefit	0	0	0	0	0	6000.00	6525	7200	7470	7800	8400	8700
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	5200.00	5655.00	6240.00	6474.00	6760.00	7280.00	7540.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	4109.64	4297.34	4559.51	4548.55	4566.81	4728.95	4709.46
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-44058.96	-39761.62	-35202.12	-30653.57	-26086.76	-21357.81	-16648.34

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	1196.00	1240.00	1280.00	1314.00	1360.00	1396.00	1400.00	1560.00	1600.00	1680.00	1780.00	1840.00
Total Cost	1196.00	1240.00	1280.00	1314.00	1360.00	1396.00	1400.00	1560.00	1600.00	1680.00	1780.00	1840.00
Benefit Component												
Tariff	8970.00	9300.00	9600.00	9855.00	10200.00	10470.00	10500.00	11700.00	12000.00	12600.00	13350.00	13800.00
Salvage value												
Total Benefit	8970.00	9300.00	9600.00	9855.00	10200.00	10470.00	10500.00	11700.00	12000.00	12600.00	13350.00	13800.00
Net Benefit	7774.00	8060.00	8320.00	8541.00	8840.00	9074.00	9100.00	10140.00	10400.00	10920.00	11570.00	11960.00
PV of Net Benefit	4668.86	4654.45	4619.80	4560.11	4538.22	4479.18	4319.25	4627.76	4563.87	4607.75	4694.25	4665.85
Cumulative NPV	-11979.48	-7325.03	-2705.23	1854.88	6393.10	10872.28	15191.52	19819.29	24383.16	28990.91	33685.16	38351.02

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1880	1912	1960	1998	2100	2200	2320	2360	2400	2500	2600
Total Cost	1880	1912	1960	1998	2100	2200	2320	2360	2400	2500	2600
Benefit Component											
Tariff	14100	14340	14700	14985	15750	16500	17400	17700	18000	18750	19500
Salvage value											10000
Total Benefit	14100	14340	14700	14985	15750	16500	17400	17700	18000	18750	29500
Net Benefit	12220	12428	12740	12987	13650	14300	15080	15340	15600.00	16250.00	26900
PV of Net Benefit	4583.927	4482.6458	4418.4431	4330.87192	4376.8918	4408.957	4470.6207	4372.7888	4275.87	4282.72	6816.876163
Cumulative NPV	42934.94	47417.59	51836.0336	56166.9055	60543.797	64952.754	69423.375	73796.164	78072.03	82354.75	**89,171.63**

Phase one ADD ONE Route second decision at high demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele **_430.3km**

Initial Total Distance=656+430.3=**1086.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

1Km=2.8 million USD = 50 million ETB

Added Distance= 558.2 Km

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						5,000.00	5,500.00
Operation cost						800.00	870.00	960.00	996.00	1040.00	1120.00	1160.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	800.00	870.00	960.00	996.00	1040.00	6120.00	6660.00
Benefit Component												
Tariff						6,000.00	6,525.00	7,200.00	7,470.00	7,800.00	8,400.00	8,700.00
Salvage value												
Total Benefit	0	0	0	0	0	6000.00	6525	7200	7470	7800	8400	8700
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	5200.00	5655.00	6240.00	6474.00	6760.00	2280.00	2040.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	4109.64	4297.34	4559.51	4548.55	4566.81	1481.04	1274.18
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-44058.96	-39761.62	-35202.12	-30653.57	-26086.76	-24605.71	-23331.53

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	6,000.00	6,750.00	4,660.00									
Operation cost	1196	1240	1280	1714	1760	1796.00	1800.00	1960.00	2000.00	2080.00	2180.00	2240.00
Total Cost	7,196.00	7,990.00	5,940.00	1,714.00	1,760.00	1,796.00	1,800.00	1960.00	2000.00	2080.00	2180.00	2240.00
Benefit Component												
Tariff	8970	9300	9600	12855	13200	13,470.00	13,500.00	14,700.00	15,000.00	15,600.00	16,350.00	16,800.00
Salvage value												
Total Benefit	8970	9300	9600	12855	13200	13470.00	13500	14700	15000	15600	16350	16800
Net Benefit	1774.00	1310.00	3660.00	11141.00	11440.00	11674.00	11700.00	12740.00	13000.00	13520.00	14170.00	14560.00
PV of Net Benefit	1065.42	756.49	2032.27	5948.27	5872.99	5762.61	5553.32	5814.37	5704.84	5704.84	5749.14	5680.17
Cumulative NPV	-22266.11	-21509.62	-19477.35	-13529.08	-7656.09	-1893.48	3659.84	9474.21	15179.04	20883.88	26633.02	32313.19

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	2280	2312	2360	2398	2500	2600.00	2720.00	2760.00	2800.00	2900.00	3000.00
Total Cost	2,280.00	2,312.00	2,360.00	2,398.00	2,500.00	2,600.00	2,720.00	2760.00	2800.00	2900.00	3000.00
Benefit Component											
Tariff	17100	17340	17700	17985	18750	19,500.00	20,400.00	20,700.00	21,000.00	21,750.00	22,500.00
Salvage value											16000
Total Benefit	17100	17340	17700	17985	18750	19500.00	20400	20700	21000	21750	38500
Net Benefit	14820.00	15028.00	15340.00	15587.00	16250.00	16900.00	17680.00	17940.00	18200.00	18850.00	35500.00
PV of Net Benefit	5559.23	5420.44	5320.17	5197.91	5210.59	5210.59	5241.42	5113.94	4988.51	4967.96	8996.25
Cumulative NPV	37872.42	43292.86	48613.03	53810.94	59021.53	64232.11	69473.53	74587.47	79575.98	84543.94	**93,540.19**

<u>Phase one ADD TWO Route, Second Decision</u>

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_mekele_ **558.2km** | Initial Total Distance=656+430.3=**<u>1086.3km</u>**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

1Km=2.8 Million USD = 50 million ETB | **Added Total Distance=558.2+272.8= 831 Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						7,750.00	8,000.00
Operation cost						800.00	870.00	960.00	996.00	1,040.00	1,120.00	1,160.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	800.00	870.00	960.00	996.00	1,040.00	8,870.00	9,160.00
Benefit Component												
Tariff						6,000.00	6,525.00	7,200.00	7,470.00	7,800.00	8,400.00	8,700.00
Salvage value												
Total Benefit	0	0	0	0	0	6000.00	6525	7200	7470	7800	8400	8700
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	5200.00	5655.00	6240.00	6474.00	6760.00	-470.00	-460.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	4109.64	4297.34	4559.51	4548.55	4566.81	-305.30	-287.31
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-44058.96	-39761.62	-35202.12	-30653.57	-26086.76	-26392.06	-26679.37

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	9000	8500	8300									
Operation cost	1196	1240	1280	1914	1960	1996	2000	2160	2200	2280	2380	2440
Total Cost	10196	9740	9580	1914	1960	1996	2000	2160	2200	2280	2380	2440
Benefit Component												
Tariff	8970	9300	9600	14355	14700	14970	15000	16200	16500	17100	17850	18300
Salvage value												
Total Benefit	8970	9300	9600	14355	14700	14970	15000	16200	16500	17100	17850	18300
Net Benefit	-1226	-440	20	12441	12740	12974	13000	14040	14300	14820	15470	15860
PV of Net Benefit	-736.3038	-254.08904	11.1052901	6642.35161	6540.3752	6404.3312	6170.3515	6407.6727	6275.3205	6253.3788	6276.58638	6187.3266
Cumulative NPV	-27415.68	-27669.766	-27658.661	-21016.309	-14475.93	-8071.6029	-1901.2514	4506.4213	10781.742	17035.121	23311.7071	29499.034

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	2480	2512	2560	2598	2700	2800	2920	2960	3000	3100	3200
Total Cost	2480	2512	2560	2598	2700	2800	2920	2960	3000	3100	3200
Benefit Component											
Tariff	18600	18840	19200	19485	20250	21000	21900	22200	22500	23250	24000
Salvage value											17500
Total Benefit	18600	18840	19200	19485	20250	21000	21900	22200	22500	23250	41500
Net Benefit	16120	16328	16640	16887	17550	18200	18980	19240	19500	20150	38300
PV of Net Benefit	6046.8829	5889.3338	5771.02773	5631.43406	5627.4323	5611.3998	5626.8157	5484.5148	5344.8364	5310.5746	9705.81253
Cumulative NPV	35545.917	41435.2503	47206.278	52837.7121	58465.144	64076.544	69703.36	75187.875	80532.711	85843.286	**95,549.10**

Phase one ADD THREE, Second decision for Two cons. At high demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

Initial Total Distance=656+430.3=**1086.3km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**

1Km=2.8 Million USD = 50 million ETB

Added Total Distance=558.2+272.8+587= 1,418 Km

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						12,750.00	14,000.00
Operation cost						800.00	870.00	960.00	996.00	1,040.00	1,120.00	1,160.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	800.00	870.00	960.00	996.00	1,040.00	13,870.00	15,160.00
Benefit Component												
Tariff						6,000.00	6,525.00	7,200.00	7,470.00	7,800.00	8,400.00	8,700.00
Salvage value												
Total Benefit	0	0	0	0	0	6000.00	6525	7200	7470	7800	8400	8700
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	5200.00	5655.00	6240.00	6474.00	6760.00	-5470.00	-6460.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	4109.64	4297.34	4559.51	4548.55	4566.81	-3553.21	-4034.90
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-44058.96	-39761.62	-35202.12	-30653.57	-26086.76	-29639.96	-33674.86

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	14,500.00	15,000.00	14,650.00									
Operation cost	1,196.00	1,240.00	1,280.00	2,314.00	2,360.00	2,396.00	2,400.00	2,560.00	2,600.00	2,680.00	2,780.00	2,840.00
Total Cost	15,696.00	16,240.00	15,930.00	2,314.00	2,360.00	2,396.00	2,400.00	2,560.00	2,600.00	2,680.00	2,780.00	2,840.00
Benefit Component												
Tariff	8970	9300	9600	17355	17700	17,970.00	18,000.00	19,200.00	19,500.00	20,100.00	20,850.00	21,300.00
Salvage value												
Total Benefit	8970	9300	9600	17355	17700	17970.00	18000	19200	19500	20100	20850	21300
Net Benefit	-6726.00	-6940.00	-6330.00	15041.00	15340.00	15574.00	15600.00	16640.00	16900.00	17420.00	18070.00	18460.00
PV of Net Benefit	-4039.46	-4007.68	-3514.82	8030.51	7875.15	7687.76	7404.42	7594.28	7416.29	7350.46	7331.47	7201.64
Cumulative NPV	-37714.32	-41722.00	-45236.82	-37206.31	-29331.16	-21643.40	-14238.98	-6644.70	771.59	8122.05	15453.53	22655.17

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	2,880.00	2,912.00	2,960.00	2,998.00	3,100.00	3,200.00	3,320.00	3,360.00	3,400.00	3,500.00	3,600.00
Total Cost	2,880.00	2,912.00	2,960.00	2,998.00	3,100.00	3,200.00	3,320.00	3,360.00	3,400.00	3,500.00	3,600.00
Benefit Component											
Tariff	21600	21840	22200	22485	23250	24,000.00	24,900.00	25,200.00	25,500.00	26,250.00	27,000.00
Salvage value											25000
Total Benefit	21600	21840	22200	22485	23250	24000.00	24900	25200	25500	26250	52000
Net Benefit	18720.00	18928.00	19240.00	19487.00	20150.00	20800.00	21580.00	21840.00	22100.00	22750.00	48400.00
PV of Net Benefit	7022.19	6827.13	6672.75	6498.48	6461.13	6413.03	6397.61	6225.67	6057.48	5995.81	12265.31
Cumulative NPV	29677.35	36504.48	43177.23	49675.71	56136.83	62549.86	68947.47	75173.14	81230.62	87226.43	**99,491.74**

Phase one Initial Decision for Three route cons. at high demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km** Initial Total Distance=656+430.3+558.2=**1644.5km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

1Km=2.8 million USD = 50 million ETB

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00							
Operation cost						1,200.00	1,270.00	1,360.00	1,396.00	1,440.00	1,520.00	1,560.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	1,200.00	1,270.00	1360.00	1396.00	1440.00	1520.00	1560.00
Benefit Component												
Tariff						9,000.00	9,525.00	10,200.00	10,470.00	10,800.00	11,400.00	11,700.00
Salvage value												
Total Benefit	0	0	0	0	0	9000.00	9525	10200	10470	10800	11400	11700
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	7800.00	8255.00	8840.00	9074.00	9360.00	9880.00	10140.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	6164.45	6273.12	6459.30	6375.27	6323.28	6417.86	6333.41
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-66830.98	-60557.86	-54098.56	-47723.28	-41400.00	-34982.14	-28648.73

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	1596	1640	1680	1714	1760	1,796.00	1,800.00	1,960.00	2,000.00	2,080.00	2,180.00	2,240.00
Total Cost	1,596.00	1,640.00	1,680.00	1,714.00	1,760.00	1,796.00	1,800.00	1960.00	2000.00	2080.00	2180.00	2240.00
Benefit Component												
Tariff	11970	12300	12600	12855	13200	13,470.00	13,500.00	14,700.00	15,000.00	15,600.00	16,350.00	16,800.00
Salvage value												
Total Benefit	11970	12300	12600	12855	13200	13470.00	13500	14700	15000	15600	16350	16800
Net Benefit	10374.00	10660.00	10920.00	11141.00	11440.00	11674.00	11700.00	12740.00	13000.00	13520.00	14170.00	14560.00
PV of Net Benefit	6230.36	6155.88	6063.49	5948.27	5872.99	5762.61	5553.32	5814.37	5704.84	5704.84	5749.14	5680.17
Cumulative NPV	-22418.37	-16262.49	-10199.00	-4250.73	1622.26	7384.87	12938.19	18752.56	24457.40	30162.23	35911.38	41591.55

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	2280	2312	2360	2398	2500	2,600.00	2,720.00	2,760.00	2,800.00	2,900.00	3,000.00
Total Cost	2,280.00	2,312.00	2,360.00	2,398.00	2,500.00	2,600.00	2,720.00	2760.00	2800.00	2900.00	3000.00
Benefit Component											
Tariff	17100	17340	17700	17985	18750	19,500.00	20,400.00	20,700.00	21,000.00	21,750.00	22,500.00
Salvage value											16000
Total Benefit	17100	17340	17700	17985	18750	19500.00	20400	20700	21000	21750	38500
Net Benefit	14820.00	15028.00	15340.00	15587.00	16250.00	16900.00	17680.00	17940.00	18200.00	18850.00	35500.00
PV of Net Benefit	5559.23	5420.44	5320.17	5197.91	5210.59	5210.59	5241.42	5113.94	4988.51	4967.96	8996.25
Cumulative NPV	47150.78	52571.21	57891.38	63089.29	68299.88	73510.46	78751.88	83865.82	88854.34	93822.29	**102,818.54**

Phase one ADD ONE, Second decision for route three cons. At high demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km** — Initial Total Distance=656+430.3+558.2=**1,644.5km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

1Km=2.8 Million USD = 50 million ETB — **Added Total Distance= 272.8Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00						2,500.00	2,890.00
Operation cost						1,200.00	1,270.00	1,360.00	1,396.00	1,440.00	1,520.00	1,560.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	1,200.00	1,270.00	1,360.00	1,396.00	1,440.00	4,020.00	4,450.00
Benefit Component												
Tariff						9,000.00	9,525.00	10,200.00	10,470.00	10,800.00	11,400.00	11,700.00
Salvage value												
Total Benefit	0	0	0	0	0	9000.00	9525	10200	10470	10800	11400	11700
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	7800.00	8255.00	8840.00	9074.00	9360.00	7380.00	7250.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	6164.45	6273.12	6459.30	6375.27	6323.28	4793.91	4528.33
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-66830.98	-60557.86	-54098.56	-47723.28	-41400.00	-36606.10	-32077.77

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	2,500.00	2,750.00	3,000.00									
Operation cost	1,596.00	1,640.00	1,680.00	1,914.00	1,960.00	1,996.00	2,000.00	2,160.00	2,200.00	2,280.00	2,380.00	2,440.00
Total Cost	4,096.00	4,390.00	4,680.00	1,914.00	1,960.00	1,996.00	2,000.00	2,160.00	2,200.00	2,280.00	2,380.00	2,440.00
Benefit Component												
Tariff	11970	12300	12600	14355	14700	14,970.00	15,000.00	16,200.00	16,500.00	17,100.00	17,850.00	18,300.00
Salvage value												
Total Benefit	11970	12300	12600	14355	14700	14970.00	15000	16200	16500	17100	17850	18300
Net Benefit	7874.00	7910.00	7920.00	12441.00	12740.00	12974.00	13000.00	14040.00	14300.00	14820.00	15470.00	15860.00
PV of Net Benefit	4728.92	4567.83	4397.69	6642.35	6540.38	6404.33	6170.35	6407.67	6275.32	6253.38	6276.59	6187.33
Cumulative NPV	-27348.85	-22781.02	-18383.32	-11740.97	-5200.60	1203.73	7374.09	13781.76	20057.08	26310.46	32587.04	38774.37

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	2,480.00	2,512.00	2,560.00	2,598.00	2,700.00	2,800.00	2,920.00	2,960.00	3,000.00	3,100.00	3,200.00
Total Cost	2,480.00	2,512.00	2,560.00	2,598.00	2,700.00	2,800.00	2,920.00	2,960.00	3,000.00	3,100.00	3,200.00
Benefit Component											
Tariff	18600	18840	19200	19485	20250	21,000.00	21,900.00	22,200.00	22,500.00	23,250.00	24,000.00
Salvage value											20000
Total Benefit	18600	18840	19200	19485	20250	21000.00	21900	22200	22500	23250	44000
Net Benefit	16120.00	16328.00	16640.00	16887.00	17550.00	18200.00	18980.00	19240.00	19500.00	20150.00	40800.00
PV of Net Benefit	6046.88	5889.33	5771.03	5631.43	5627.43	5611.40	5626.82	5484.51	5344.84	5310.57	10339.35
Cumulative NPV	44821.25	50710.59	56481.62	62113.05	67740.48	73351.88	78978.70	84463.21	89808.05	95118.62	**105,457.97**

Phase one ADD TWO, Second decision for route three cons. At high demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km** — Initial Total Distance=656+430.3+558.2=**1644.5km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**

1Km=2.8 Million USD = 50 million ETB — **Added Total Distance=272.8+587= 859.8 Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00						8,500.00	8,240.00
Operation cost						1,200.00	1,270.00	1,360.00	1,396.00	1,440.00	1,520.00	1,560.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	1,200.00	1,270.00	1,360.00	1,396.00	1,440.00	10,020.00	9,800.00
Benefit Component												
Tariff						9,000.00	9,525.00	10,200.00	10,470.00	10,800.00	11,400.00	11,700.00
Salvage value												
Total Benefit	0	0	0	0	0	9000.00	9525	10200	10470	10800	11400	11700
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	7800.00	8255.00	8840.00	9074.00	9360.00	1380.00	1900.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	6164.45	6273.12	6459.30	6375.27	6323.28	896.42	1186.73
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-66830.98	-60557.86	-54098.56	-47723.28	-41400.00	-40503.58	-39316.85

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	8,500.00	9,000.00	8,750.00									
Operation cost	1,596.00	1,640.00	1,680.00	2,314.00	2,360.00	2,396.00	2,400.00	2,560.00	2,600.00	2,680.00	2,780.00	2,840.00
Total Cost	10,096.00	10,640.00	10,430.00	2,314.00	2,360.00	2,396.00	2,400.00	2,560.00	2,600.00	2,680.00	2,780.00	2,840.00
Benefit Component												
Tariff	11970	12300	12600	17355	17700	17,970.00	18,000.00	19,200.00	19,500.00	20,100.00	20,850.00	21,300.00
Salvage value												
Total Benefit	11970	12300	12600	17355	17700	17970.00	18000	19200	19500	20100	20850	21300
Net Benefit	1874.00	1660.00	2170.00	15041.00	15340.00	15574.00	15600.00	16640.00	16900.00	17420.00	18070.00	18460.00
PV of Net Benefit	1125.48	958.61	1204.92	8030.51	7875.15	7687.76	7404.42	7594.28	7416.29	7350.46	7331.47	7201.64
Cumulative NPV	-38191.37	-37232.76	-36027.84	-27997.33	-20122.18	-12434.42	-5029.99	2564.29	9980.57	17331.04	24662.51	31864.15

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	2,880.00	2,912.00	2,960.00	2,998.00	3,100.00	3,200.00	3,320.00	3,360.00	3,400.00	3,500.00	3,600.00
Total Cost	2,880.00	2,912.00	2,960.00	2,998.00	3,100.00	3,200.00	3,320.00	3,360.00	3,400.00	3,500.00	3,600.00
Benefit Component											
Tariff	21600	21840	22200	22485	23250	24,000.00	24,900.00	25,200.00	25,500.00	26,250.00	27,000.00
Salvage value											25000
Total Benefit	21600	21840	22200	22485	23250	24000.00	24900	25200	25500	26250	52000
Net Benefit	18720.00	18928.00	19240.00	19487.00	20150.00	20800.00	21580.00	21840.00	22100.00	22750.00	48400.00
PV of Net Benefit	7022.19	6827.13	6672.75	6498.48	6461.13	6413.03	6397.61	6225.67	6057.48	5995.81	12265.31
Cumulative NPV	38886.34	45713.47	52386.22	58884.69	65345.82	71758.85	78156.46	84382.12	90439.60	96435.41	**108,700.72**

Phase one Initial Decision for route two cons. At medium demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

1Km=2.8 million USD = 50 million ETB Total Distance=656+430.3=**1086.3km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00							
Operation cost						526.38	500.00	575.00	575.25	625.00	377.00	600.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	526.38	500.00	575.00	575.25	625.00	377.00	600.00
Benefit Component												
Tariff						3,947.81	3,750.00	4,312.50	4,314.38	4,687.50	2,827.50	4,500.00
Salvage value												
Total Benefit	0	0	0	0	0	3947.81	3750	4312.5	4314.375	4687.5	2827.5	4500
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	3421.44	3250.00	3737.50	3739.13	4062.50	2450.50	3900.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	2704.01	2469.73	2730.95	2627.06	2744.48	1591.80	2435.93
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-45464.58	-42994.85	-40263.89	-37636.83	-34892.36	-33300.56	-30864.63

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	380	472.5	497.5	442.5	587.5	750	862.5	745	635	640	722.5	612.5
Total Cost	380	472.5	497.5	442.5	587.5	750	862.5	745	635	640	722.5	612.5
Benefit Component												
Tariff	2850	3543.75	3731.25	3318.75	4406.25	5625	6468.75	5587.5	4762.5	4800	5418.75	4593.75
Salvage value												
Total Benefit	2850	3543.75	3731.25	3318.75	4406.25	5625	6468.75	5587.5	4762.5	4800	5418.75	4593.75
Net Benefit	2470	3071.25	3233.75	2876.25	3818.75	4875	5606.25	4842.5	4127.5	4160	4696.25	3981.25
PV of Net Benefit	1483.418	1773.57035	1795.5866	1535.6534	1960.444	2406.4371	2660.96409	2210.053787	1811.2857	1755.3344	1905.3923	1553.1711
Cumulative NPV	-29381.21	-27607.64	-25812.054	-24276.4	-22315.96	-19909.519	-17248.5551	-15038.50131	-13227.216	-11471.881	-9566.4889	-8013.3178

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	750	760	760	756	798	820	840	960	954	976	1000
Total Cost	750	760	760	756	798	820	840	960	954	976	1000
Benefit Component											
Tariff	5625	5700	5700	5670	5985	6150	6300	7200	7155	7320	7500
Salvage value											10000
Total Benefit	5625	5700	5700	5670	5985	6150	6300	7200	7155	7320	17500
Net Benefit	4875	4940	4940	4914	5187	5330	5460	6240	6201	6344	16500
PV of Net Benefit	1828.694	1781.80481	1713.2739	1638.7083	1663.219	1643.3385	1618.673007	1778.761546	1699.658	1671.9745	4181.3553
Cumulative NPV	-6184.623	-4402.8186	-2689.5447	-1050.8364	612.3825	2255.721	3874.393973	5653.155519	7352.8135	9024.7879	**13,206.14**

Phase one ADD ONE Route second decision

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km** Initial Total Distance=656+430.3=**1086.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

1Km=2.8 million USD = 50 million ETB **Added Distance= 558.2 Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						5,000.00	5,500.00
Operation cost						526.38	500.00	575.00	575.25	625.00	377.00	600.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	526.38	500.00	575.00	575.25	625.00	5377.00	6100.00
Benefit Component												
Tariff						3,947.81	3,750.00	4,312.50	4,314.38	4,687.50	2,827.50	4,500.00
Salvage value												
Total Benefit	0	0	0	0	0	3947.81	3750	4312.5	4314.375	4687.5	2827.5	4500
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	3421.44	3250.00	3737.50	3739.13	4062.50	-2549.50	-1600.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	2704.01	2469.73	2730.95	2627.06	2744.48	-1656.11	-999.36
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-45464.58	-42994.85	-40263.89	-37636.83	-34892.36	-36548.46	-37547.82

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	6000	6750	4660									
Operation cost	380	472.5	497.5	642.5	787.5	950	1062.5	945	835	840	922.5	812.5
Total Cost	6380	7222.5	5157.5	642.5	787.5	950	1062.5	945	835	840	922.5	812.5
Benefit Component												
Tariff	2850	3543.75	3731.25	4818.75	5906.25	7125	7968.75	7087.5	6262.5	6300	6918.75	6093.75
Salvage value												
Total Benefit	2850	3543.75	3731.25	4818.75	5906.25	7125	7968.75	7087.5	6262.5	6300	6918.75	6093.75
Net Benefit	-3530	-3678.75	-1426.25	4176.25	5118.75	6175	6906.25	6142.5	5427.5	5460	5996.25	5281.25
PV of Net Benefit	-2120.027	-2124.3865	-791.946	2229.734	2627.829	3048.1536	3277.9992	2803.3568	2381.7694	2303.8764	2432.8365	2060.329
Cumulative NPV	-39667.84	-41792.23	-42584.176	-40354.442	-37726.61	-34678.459	-31400.46	-28597.103	-26215.334	-23911.457	-21478.621	-19418.292

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	950	960	960	956	998	1020	1040	1160	1154	1176	1200
Total Cost	950	960	960	956	998	1020	1040	1160	1154	1176	1200
Benefit Component											
Tariff	7125	7200	7200	7170	7485	7650	7800	8700	8655	8820	9000
Salvage value											20000
Total Benefit	7125	7200	7200	7170	7485	7650	7800	8700	8655	8820	29000
Net Benefit	6175	6240	6240	6214	6487	6630	6760	7540	7501	7644	27800
PV of Net Benefit	2316.346	2250.7008	2164.1354	2072.229	2080.066	2044.1528	2004.0713	2149.3369	2055.9804	2014.5922	7044.9501
Cumulative NPV	-17101.95	-14851.245	-12687.109	-10614.88	-8534.815	-6490.6617	-4486.5904	-2337.2535	-281.27314	1733.319	**8,778.27**

Phase one ADD TWO Route, Second Decision

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_mekele_ **558.2km**

Initial Total Distance=656+430.3=**1086.3km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

1Km=2.8 Million USD = 50 million ETB

Added Total Distance=558.2+272.8= 831 Km

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						7,750.00	8,000.00
Operation cost						526.38	500.00	575.00	575.25	625.00	377.00	600.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	526.38	500.00	575.00	575.25	625.00	8,127.00	8,600.00
Benefit Component												
Tariff						3,947.81	3,750.00	4,312.50	4,314.38	4,687.50	2,827.50	4,500.00
Salvage value												
Total Benefit	0	0	0	0	0	3947.81	3750	4312.5	4314.375	4687.5	2827.5	4500
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	3421.44	3250.00	3737.50	3739.13	4062.50	-5299.50	-4100.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	2704.01	2469.73	2730.95	2627.06	2744.48	-3442.45	-2560.85
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-45464.58	-42994.85	-40263.89	-37636.83	-34892.36	-38334.81	-40895.66

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	9000	8500	8300									
Operation cost	380	472.5	497.5	802.5	947.5	1110	1222.5	1105	995	1000	1082.5	972.5
Total Cost	9380	8972.5	8797.5	802.5	947.5	1110	1222.5	1105	995	1000	1082.5	972.5
Benefit Component												
Tariff	2850	3543.75	3731.25	6018.75	7106.25	8325	9168.75	8287.5	7462.5	7500	8118.75	7293.75
Salvage value												
Total Benefit	2850	3543.75	3731.25	6018.75	7106.25	8325	9168.75	8287.5	7462.5	7500	8118.75	7293.75
Net Benefit	-6530	-5428.75	-5066.25	5216.25	6158.75	7215	7946.25	7182.5	6467.5	6500	7036.25	6321.25
PV of Net Benefit	-3921.749	-3134.9679	-2813.1088	2784.99852	3161.737478	3561.52689	3771.62736	3277.99924	2838.15632	2742.71001	2854.79191	2466.0554
Cumulative NPV	-44817.41	-47952.374	-50765.483	-47980.484	-44818.7467	-41257.22	-37485.592	-34207.593	-31369.437	-28626.727	-25771.935	-23305.88

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1110	1120	1120	1116	1158	1180	1200	1320	1314	1336	1360
Total Cost	1110	1120	1120	1116	1158	1180	1200	1320	1314	1336	1360
Benefit Component											
Tariff	8325	8400	8400	8370	8685	8850	9000	9900	9855	10020	10200
Salvage value											17500
Total Benefit	8325	8400	8400	8370	8685	8850	9000	9900	9855	10020	27700
Net Benefit	7215	7280	7280	7254	7527	7670	7800	8580	8541	8684	26340
PV of Net Benefit	2706.4677	2625.81762	2524.82463	2419.04558	2413.54	2364.80	2312.39	2445.80	2341.04	2288.69	6674.96
Cumulative NPV	-20599.41	-17973.594	-15448.77	-13029.724	-10616.18	-8251.38	-5938.99	-3493.19	-1152.15	1136.54	**7,811.50**

Phase one ADD THREE, Second decisionat medium demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km** — Initial Total Distance=656+430.3=**1086.3km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**

1Km=2.8 Million USD = 50 million ETB — **Added Total Distance=558.2+272.8+587= 1,418 Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						12,750.00	14,000.00
Operation cost						526.38	500.00	575.00	575.25	625.00	377.00	600.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	526.38	500.00	575.00	575.25	625.00	13,127.00	14,600.00
Benefit Component												
Tariff						3,947.81	3,750.00	4,312.50	4,314.38	4,687.50	2,827.50	4,500.00
Salvage value												
Total Benefit	0	0	0	0	0	3947.81	3750	4312.5	4314.375	4687.5	2827.5	4500
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	3421.44	3250.00	3737.50	3739.13	4062.50	-10299.50	-10100.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	2704.01	2469.73	2730.95	2627.06	2744.48	-6690.36	-6308.43
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-45464.58	-42994.85	-40263.89	-37636.83	-34892.36	-41582.71	-47891.14

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	14,500.00	15,000.00	14,650.00									
Operation cost	380.00	472.50	497.50	1,002.50	1,147.50	1,310.00	1,422.50	1,305.00	1,195.00	1,200.00	1,282.50	1,172.50
Total Cost	14,880.00	15,472.50	15,147.50	1,002.50	1,147.50	1,310.00	1,422.50	1,305.00	1,195.00	1,200.00	1,282.50	1,172.50
Benefit Component												
Tariff	2850	3543.75	3731.25	7518.75	8606.25	9,825.00	10,668.75	9,787.50	8,962.50	9,000.00	9,618.75	8,793.75
Salvage value												
Total Benefit	2850	3543.75	3731.25	7518.75	8606.25	9825.00	10668.75	9787.5	8962.5	9000	9618.75	8793.75
Net Benefit	-12030.00	-11928.75	-11416.25	6516.25	7458.75	8515.00	9246.25	8482.50	7767.50	7800.00	8336.25	7621.25
PV of Net Benefit	-7224.91	-6888.56	-6339.04	3479.08	3829.12	4203.24	4388.66	3871.30	3408.64	3291.25	3382.24	2973.21
Cumulative NPV	-55116.05	-62004.61	-68343.64	-64864.57	-61035.44	-56832.20	-52443.54	-48572.23	-45163.59	-41872.34	-38490.11	-35516.89

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1,310.00	1,320.00	1,320.00	1,316.00	1,358.00	1,380.00	1,400.00	1,520.00	1,514.00	1,536.00	1,560.00
Total Cost	1,310.00	1,320.00	1,320.00	1,316.00	1,358.00	1,380.00	1,400.00	1,520.00	1,514.00	1,536.00	1,560.00
Benefit Component											
Tariff	9825	9900	9900	9870	10185	10,350.00	10,500.00	11,400.00	11,355.00	11,520.00	11,700.00
Salvage value											25000
Total Benefit	9825	9900	9900	9870	10185	10350.00	10500	11400	11355	11520	36700
Net Benefit	8515.00	8580.00	8580.00	8554.00	8827.00	8970.00	9100.00	9880.00	9841.00	9984.00	35140.00
PV of Net Benefit	3194.12	3094.71	2975.69	2852.57	2830.39	2765.62	2697.79	2816.37	2697.36	2631.30	8905.02
Cumulative NPV	-32322.77	-29228.06	-26252.37	-23399.81	-20569.42	-17803.80	-15106.01	-12289.64	-9592.28	-6960.97	**1,944.05**

<u>Phase one Initial Decision for Three route cons. AT medium demand</u>

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele **_430.3km** Initial Total Distance=656+430.3+558.2=**<u>1644.5km</u>**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

1Km=2.8 million USD = 50 million ETB

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00							
Operation cost						726.38	700.00	775.00	775.25	825.00	577.00	800.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	726.38	700.00	775.00	775.25	825.00	577.00	800.00
Benefit Component												
Tariff						5,447.81	5,250.00	5,812.50	5,814.38	6,187.50	4,327.50	6,000.00
Salvage value												
Total Benefit	0	0	0	0	0	5447.81	5250	5812.5	5814.375	6187.5	4327.5	6000
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	4721.44	4550.00	5037.50	5039.13	5362.50	3750.50	5200.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	3731.42	3457.63	3680.85	3540.42	3622.71	2436.25	3247.90
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-69264.01	-65806.39	-62125.53	-58585.11	-54962.40	-52526.14	-49278.24

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	580	672.5	697.5	642.5	787.5	950.00	1062.50	945.00	835.00	840.00	922.50	812.50
Total Cost	580.00	672.50	697.50	642.50	787.50	950.00	1,062.50	945.00	835.00	840.00	922.50	812.50
Benefit Component												
Tariff	4350	5043.75	5231.25	4818.75	5906.25	7,125.00	7,968.75	7,087.50	6,262.50	6,300.00	6,918.75	6,093.75
Salvage value												
Total Benefit	4350	5043.75	5231.25	4818.75	5906.25	7125.00	7968.75	7087.5	6262.5	6300	6918.75	6093.75
Net Benefit	3770.00	4371.25	4533.75	4176.25	5118.75	6175.00	6906.25	6142.50	5427.50	5460.00	5996.25	5281.25
PV of Net Benefit	2264.16	2524.29	2517.43	2229.73	2627.83	3048.15	3278.00	2803.36	2381.77	2303.88	2432.84	2060.33
Cumulative NPV	-47014.08	-44489.79	-41972.36	-39742.62	-37114.79	-34066.64	-30788.64	-27985.28	-25603.51	-23299.64	-20866.80	-18806.47

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	950	960	960	956	998	1020.00	1040.00	1160.00	1154.00	1176.00	1200.00
Total Cost	950.00	960.00	960.00	956.00	998.00	1,020.00	1,040.00	1160.00	1154.00	1176.00	1200.00
Benefit Component											
Tariff	7125	7200	7200	7170	7485	7,650.00	7,800.00	8,700.00	8,655.00	8,820.00	9,000.00
Salvage value											16000
Total Benefit	7125	7200	7200	7170	7485	7650.00	7800	8700	8655	8820	25000
Net Benefit	6175.00	6240.00	6240.00	6214.00	6487.00	6630.00	6760.00	7540.00	7501.00	7644.00	23800.00
PV of Net Benefit	2316.35	2250.70	2164.14	2072.23	2080.07	2044.15	2004.07	2149.34	2055.98	2014.59	6031.29
Cumulative NPV	-16490.13	-14239.43	-12075.29	-10003.06	-7923.00	-5878.84	-3874.77	-1725.43	330.55	2345.14	**8,376.43**

Phase one ADD ONE, Second decision for route three cons. At medium demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km** Initial Total Distance=656+430.3+558.2=**1,644.5km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

1Km=2.8 Million USD = 50 million ETB **Added Total Distance= 272.8Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00						2,500.00	2,890.00
Operation cost						726.38	700.00	775.00	775.25	825.00	577.00	800.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	726.38	700.00	775.00	775.25	825.00	3,077.00	3,690.00
Benefit Component												
Tariff						5,447.81	5,250.00	5,812.50	5,814.38	6,187.50	4,327.50	6,000.00
Salvage value												
Total Benefit	0	0	0	0	0	5447.81	5250	5812.5	5814.375	6187.5	4327.5	6000
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	4721.44	4550.00	5037.50	5039.13	5362.50	1250.50	2310.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	3731.42	3457.63	3680.85	3540.42	3622.71	812.30	1442.82
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-69264.01	-65806.39	-62125.53	-58585.11	-54962.40	-54150.10	-52707.28

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	2,500.00	2,750.00	3,000.00									
Operation cost	580.00	672.50	697.50	802.50	947.50	1,110.00	1,222.50	1,105.00	995.00	1,000.00	1,082.50	972.50
Total Cost	3,080.00	3,422.50	3,697.50	802.50	947.50	1,110.00	1,222.50	1,105.00	995.00	1,000.00	1,082.50	972.50
Benefit Component												
Tariff	4350	5043.75	5231.25	6018.75	7106.25	8,325.00	9,168.75	8,287.50	7,462.50	7,500.00	8,118.75	7,293.75
Salvage value												
Total Benefit	4350	5043.75	5231.25	6018.75	7106.25	8325.00	9168.75	8287.5	7462.5	7500	8118.75	7293.75
Net Benefit	1270.00	1621.25	1533.75	5216.25	6158.75	7215.00	7946.25	7182.50	6467.50	6500.00	7036.25	6321.25
PV of Net Benefit	762.73	936.23	851.64	2785.00	3161.74	3561.53	3771.63	3278.00	2838.16	2742.71	2854.79	2466.06
Cumulative NPV	-51944.55	-51008.32	-50156.68	-47371.68	-44209.94	-40648.42	-36876.79	-33598.79	-30760.63	-28017.92	-25163.13	-22697.08

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1,110.00	1,120.00	1,120.00	1,116.00	1,158.00	1,180.00	1,200.00	1,320.00	1,314.00	1,336.00	1,360.00
Total Cost	1,110.00	1,120.00	1,120.00	1,116.00	1,158.00	1,180.00	1,200.00	1,320.00	1,314.00	1,336.00	1,360.00
Benefit Component											
Tariff	8325	8400	8400	8370	8685	8,850.00	9,000.00	9,900.00	9,855.00	10,020.00	10,200.00
Salvage value											20000
Total Benefit	8325	8400	8400	8370	8685	8850.00	9000	9900	9855	10020	30200
Net Benefit	7215.00	7280.00	7280.00	7254.00	7527.00	7670.00	7800.00	8580.00	8541.00	8684.00	28840.00
PV of Net Benefit	2706.47	2625.82	2524.82	2419.05	2413.54	2364.80	2312.39	2445.80	2341.04	2288.69	7308.50
Cumulative NPV	-19990.61	-17364.79	-14839.97	-12420.92	-10007.38	-7642.57	-5330.18	-2884.39	-543.35	1745.34	**9,053.84**

Phase one ADD TWO, Second decision for route three cons.

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

Initial Total Distance=656+430.3+558.2=**1644.5km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**

1Km=2.8 Million USD = 50 million ETB

Added Total Distance=272.8+587= 859.8 Km

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00						8,500.00	8,240.00
Operation cost						726.38	700.00	775.00	775.25	825.00	577.00	800.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	726.38	700.00	775.00	775.25	825.00	9,077.00	9,040.00
Benefit Component												
Tariff						5,447.81	5,250.00	5,812.50	5,814.38	6,187.50	4,327.50	6,000.00
Salvage value												
Total Benefit	0	0	0	0	0	5447.81	5250	5812.5	5814.375	6187.5	4327.5	6000
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	4721.44	4550.00	5037.50	5039.13	5362.50	-4749.50	-3040.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	3731.42	3457.63	3680.85	3540.42	3622.71	-3085.18	-1898.78
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-69264.01	-65806.39	-62125.53	-58585.11	-54962.40	-58047.58	-59946.36

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	8,500.00	9,000.00	8,750.00									
Operation cost	580.00	672.50	697.50	1,002.50	1,147.50	1,310.00	1,422.50	1,305.00	1,195.00	1,200.00	1,282.50	1,172.50
Total Cost	9,080.00	9,672.50	9,447.50	1,002.50	1,147.50	1,310.00	1,422.50	1,305.00	1,195.00	1,200.00	1,282.50	1,172.50
Benefit Component												
Tariff	4350	5043.75	5231.25	7518.75	8606.25	9,825.00	10,668.75	9,787.50	8,962.50	9,000.00	9,618.75	8,793.75
Salvage value												
Total Benefit	4350	5043.75	5231.25	7518.75	8606.25	9825.00	10668.75	9787.5	8962.5	9000	9618.75	8793.75
Net Benefit	-4730.00	-4628.75	-4216.25	6516.25	7458.75	8515.00	9246.25	8482.50	7767.50	7800.00	8336.25	7621.25
PV of Net Benefit	-2840.72	-2672.99	-2341.13	3479.08	3829.12	4203.24	4388.66	3871.30	3408.64	3291.25	3382.24	2973.21
Cumulative NPV	-62787.07	-65460.06	-67801.19	-64322.12	-60492.99	-56289.75	-51901.09	-48029.78	-44621.14	-41329.89	-37947.66	-34974.44

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1,310.00	1,320.00	1,320.00	1,316.00	1,358.00	1,380.00	1,400.00	1,520.00	1,514.00	1,536.00	1,560.00
Total Cost	1,310.00	1,320.00	1,320.00	1,316.00	1,358.00	1,380.00	1,400.00	1,520.00	1,514.00	1,536.00	1,560.00
Benefit Component											
Tariff	9825	9900	9900	9870	10185	10,350.00	10,500.00	11,400.00	11,355.00	11,520.00	11,700.00
Salvage value											25000
Total Benefit	9825	9900	9900	9870	10185	10350.00	10500	11400	11355	11520	36700
Net Benefit	8515.00	8580.00	8580.00	8554.00	8827.00	8970.00	9100.00	9880.00	9841.00	9984.00	35140.00
PV of Net Benefit	3194.12	3094.71	2975.69	2852.57	2830.39	2765.62	2697.79	2816.37	2697.36	2631.30	8905.02
Cumulative NPV	-31780.32	-28685.61	-25709.92	-22857.36	-20026.97	-17261.35	-14563.56	-11747.19	-9049.83	-6418.52	**2,486.50**

Phase one Initial Decision for route two cons. At Low demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

1Km=2.8 million USD = 50 million ETB Total Distance=656+430.3=**1086.3km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00							
Operation cost						326.38	300.00	375.00	375.25	425.00	177.00	400.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	326.38	300.00	375.00	375.25	425.00	177.00	400.00
Benefit Component												
Tariff						2,447.81	2,250.00	2,812.50	2,814.38	3,187.50	1,327.50	3,000.00
Salvage value												
Total Benefit	0	0	0	0	0	2447.81	2250	2812.5	2814.375	3187.5	1327.5	3000
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	2121.44	1950.00	2437.50	2439.13	2762.50	1150.50	2600.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	1676.60	1481.84	1781.06	1713.70	1866.25	747.34	1623.95
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-46491.99	-45010.15	-43229.09	-41515.40	-39649.15	-38901.81	-37277.86

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	180	272.5	297.5	242.5	387.5	550.00	662.50	545.00	435.00	440.00	522.50	412.50
Total Cost	180.00	272.50	297.50	242.50	387.50	550.00	662.50	545.00	435.00	440.00	522.50	412.50
Benefit Component												
Tariff	1350	2043.75	2231.25	1818.75	2906.25	4,125.00	4,968.75	4,087.50	3,262.50	3,300.00	3,918.75	3,093.75
Salvage value												
Total Benefit	1350	2043.75	2231.25	1818.75	2906.25	4125.00	4968.75	4087.5	3262.5	3300	3918.75	3093.75
Net Benefit	1170.00	1771.25	1933.75	1576.25	2518.75	3575.00	4306.25	3542.50	2827.50	2860.00	3396.25	2681.25
PV of Net Benefit	702.67	1022.85	1073.74	841.57	1293.06	1764.72	2043.93	1616.75	1240.80	1206.79	1377.95	1046.01
Cumulative NPV	-36575.18	-35552.33	-34478.59	-33637.02	-32343.96	-30579.24	-28535.31	-26918.56	-25677.75	-24470.96	-23093.01	-22047.00

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	550	560	560	556	598	620.00	640.00	760.00	754.00	776.00	800.00
Total Cost	550.00	560.00	560.00	556.00	598.00	620.00	640.00	760.00	754.00	776.00	800.00
Benefit Component											
Tariff	4125	4200	4200	4170	4485	4,650.00	4,800.00	5,700.00	5,655.00	5,820.00	6,000.00
Salvage value											10000
Total Benefit	4125	4200	4200	4170	4485	4650.00	4800	5700	5655	5820	16000
Net Benefit	3575.00	3640.00	3640.00	3614.00	3887.00	4030.00	4160.00	4940.00	4901.00	5044.00	15200.00
PV of Net Benefit	1341.04	1312.91	1262.41	1205.19	1246.37	1242.52	1233.27	1408.19	1343.34	1329.36	3851.92
Cumulative NPV	-20705.96	-19393.05	-18130.64	-16925.45	-15679.08	-14436.55	-13203.28	-11795.09	-10451.76	-9122.40	**-5,270.48**

Phase one ADD ONE Route second decision At Low demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele **_430.3km** Initial Total Distance=656+430.3=**1086.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

1Km=2.8 million USD = 50 million ETB **Added Distance= 558.2 Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						5,000.00	5,500.00
Operation cost						326.38	300.00	375.00	375.25	425.00	177.00	400.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	326.38	300.00	375.00	375.25	425.00	5177.00	5900.00
Benefit Component												
Tariff						2,447.81	2,250.00	2,812.50	2,814.38	3,187.50	1,327.50	3,000.00
Salvage value												
Total Benefit	0	0	0	0	0	2447.81	2250	2812.5	2814.375	3187.5	1327.5	3000
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	2121.44	1950.00	2437.50	2439.13	2762.50	-3849.50	-2900.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	1676.60	1481.84	1781.06	1713.70	1866.25	-2500.56	-1811.33
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-46491.99	-45010.15	-43229.09	-41515.40	-39649.15	-42149.71	-43961.04

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	6,000.00	6,750.00	4,660.00									
Operation cost	180	272.5	297.5	402.5	547.5	710.00	822.50	705.00	595.00	600.00	682.50	572.50
Total Cost	6,180.00	7,022.50	4,957.50	402.50	547.50	710.00	822.50	705.00	595.00	600.00	682.50	572.50
Benefit Component												
Tariff	1350	2043.75	2231.25	3018.75	4106.25	5,325.00	6,168.75	5,287.50	4,462.50	4,500.00	5,118.75	4,293.75
Salvage value												
Total Benefit	1350	2043.75	2231.25	3018.75	4106.25	5325.00	6168.75	5287.5	4462.5	4500	5118.75	4293.75
Net Benefit	-4830.00	-4978.75	-2726.25	2616.25	3558.75	4615.00	5346.25	4582.50	3867.50	3900.00	4436.25	3721.25
PV of Net Benefit	-2900.77	-2875.10	-1513.79	1396.84	1826.97	2278.09	2537.56	2091.39	1697.19	1645.63	1799.90	1451.74
Cumulative NPV	-46861.82	-49736.92	-51250.71	-49853.87	-48026.91	-45748.81	-43211.26	-41119.86	-39422.67	-37777.05	-35977.14	-34525.40

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	710	720	720	716	758	780	800	920	914	936	960
Total Cost	710	720	720	716	758	780	800	920	914	936	960
Benefit Component											
Tariff	5325	5400	5400	5370	5685	5850	6000	6900	6855	7020	7200
Salvage value											16000
Total Benefit	5325	5400	5400	5370	5685	5850	6000	6900	6855	7020	23200
Net Benefit	4615	4680	4680	4654	4927	5070	5200	5980	5941	6084	22240
PV of Net Benefit	1731.164	1688.0256	1623.1015	1552.0042	1579.85	1563.1756	1541.5933	1704.6465	1628.3935	1603.4509	5635.96007
Cumulative NPV	-32794.24	-31106.215	-29483.113	-27931.109	-26351.26	-24788.084	-23246.491	-21541.844	-19913.451	-18310	**-12,674.04**

Phase one ADD TWO Route, Second Decision for low demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_mekele_ **558.2km**

Initial Total Distance=656+430.3=**1086.3km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

1Km=2.8 Million USD = 50 million ETB

Added Total Distance=558.2+272.8= 831 Km

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						7,750.00	8,000.00
Operation cost						326.38	300.00	375.00	375.25	425.00	177.00	400.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	326.38	300.00	375.00	375.25	425.00	7,927.00	8,400.00
Benefit Component												
Tariff						2,447.81	2,250.00	2,812.50	2,814.38	3,187.50	1,327.50	3,000.00
Salvage value												
Total Benefit	0	0	0	0	0	2447.81	2250	2812.5	2814.375	3187.5	1327.5	3000
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	2121.44	1950.00	2437.50	2439.13	2762.50	-6599.50	-5400.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	1676.60	1481.84	1781.06	1713.70	1866.25	-4286.91	-3372.82
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-46491.99	-45010.15	-43229.09	-41515.40	-39649.15	-43936.06	-47308.88

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	9,000.00	8,500.00	8,300.00									
Operation cost	180.00	272.50	297.50	502.50	647.50	810.00	922.50	805.00	695.00	700.00	782.50	672.50
Total Cost	9,180.00	8,772.50	8,597.50	502.50	647.50	810.00	922.50	805.00	695.00	700.00	782.50	672.50
Benefit Component												
Tariff	1350	2043.75	2231.25	3768.75	4856.25	6,075.00	6,918.75	6,037.50	5,212.50	5,250.00	5,868.75	5,043.75
Salvage value												
Total Benefit	1350	2043.75	2231.25	3768.75	4856.25	6075.00	6918.75	6037.5	5212.5	5250	5868.75	5043.75
Net Benefit	-7830.00	-6728.75	-6366.25	3266.25	4208.75	5265.00	5996.25	5232.50	4517.50	4550.00	5086.25	4371.25
PV of Net Benefit	-4702.50	-3885.69	-3534.95	1743.88	2160.66	2598.95	2846.07	2388.04	1982.43	1919.90	2063.63	1705.32
Cumulative NPV	-52011.38	-55897.06	-59432.02	-57688.14	-55527.48	-52928.53	-50082.45	-47694.41	-45711.98	-43792.08	-41728.46	-40023.14

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	810.00	820.00	820.00	816.00	858.00	880.00	900.00	1,020.00	1,014.00	1,036.00	1,060.00
Total Cost	810.00	820.00	820.00	816.00	858.00	880.00	900.00	1,020.00	1,014.00	1,036.00	1,060.00
Benefit Component											
Tariff	6075	6150	6150	6120	6435	6,600.00	6,750.00	7,650.00	7,605.00	7,770.00	7,950.00
Salvage value											17500
Total Benefit	6075	6150	6150	6120	6435	6600.00	6750	7650	7605	7770	25450
Net Benefit	5265.00	5330.00	5330.00	5304.00	5577.00	5720.00	5850.00	6630.00	6591.00	6734.00	24390.00
PV of Net Benefit	1974.99	1922.47	1848.53	1768.76	1788.27	1763.58	1734.29	1889.93	1806.55	1774.76	6180.80
Cumulative NPV	-38048.15	-36125.67	-34277.14	-32508.38	-30720.10	-28956.52	-27222.23	-25332.29	-23525.74	-21750.98	**-15,570.18**

Phase one ADD THREE, Second decisionat Low demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km** — Initial Total Distance=656+430.3=**1086.3km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**

1Km=2.8 Million USD = 50 million ETB — **Added Total Distance=558.2+272.8+587= 1,418 Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00						12,750.00	14,000.00
Operation cost						326.38	300.00	375.00	375.25	425.00	177.00	400.00
Total Cost	7,500.00	10,000.00	14,300.00	15,000.00	7,515.00	326.38	300.00	375.00	375.25	425.00	12,927.00	14,400.00
Benefit Component												
Tariff						2,447.81	2,250.00	2,812.50	2,814.38	3,187.50	1,327.50	3,000.00
Salvage value												
Total Benefit	0	0	0	0	0	2447.81	2250	2812.5	2814.375	3187.5	1327.5	3000
Net Benefit	-7500.00	-10000.00	-14300.00	-15000.00	-7515.00	2121.44	1950.00	2437.50	2439.13	2762.50	-11599.50	-11400.00
PV of Net Benefit	-7211.54	-9245.56	-12712.65	-12822.06	-6176.78	1676.60	1481.84	1781.06	1713.70	1866.25	-7534.81	-7120.41
Cumulative NPV	-7211.54	-16457.10	-29169.75	-41991.81	-48168.59	-46491.99	-45010.15	-43229.09	-41515.40	-39649.15	-47183.96	-54304.37

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	14,500.00	15,000.00	14,650.00									
Operation cost	180.00	272.50	297.50	742.50	887.50	1,050.00	1,162.50	1,045.00	935.00	940.00	1,022.50	912.50
Total Cost	14,680.00	15,272.50	14,947.50	742.50	887.50	1,050.00	1,162.50	1,045.00	935.00	940.00	1,022.50	912.50
Benefit Component												
Tariff	1350	2043.75	2231.25	5568.75	6656.25	7,875.00	8,718.75	7,837.50	7,012.50	7,050.00	7,668.75	6,843.75
Salvage value												
Total Benefit	1350	2043.75	2231.25	5568.75	6656.25	7875.00	8718.75	7837.5	7012.5	7050	7668.75	6843.75
Net Benefit	-13330.00	-13228.75	-12716.25	4826.25	5768.75	6825.00	7556.25	6792.50	6077.50	6110.00	6646.25	5931.25
PV of Net Benefit	-8005.65	-7639.27	-7060.88	2576.77	2961.52	3369.01	3586.52	3100.01	2667.01	2578.15	2696.56	2313.91
Cumulative NPV	-62310.02	-69949.30	-77010.18	-74433.41	-71471.88	-68102.87	-64516.35	-61416.35	-58749.33	-56171.19	-53474.63	-51160.72

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1,050.00	1,060.00	1,060.00	1,056.00	1,098.00	1,120.00	1,140.00	1,260.00	1,254.00	1,276.00	1,300.00
Total Cost	1,050.00	1,060.00	1,060.00	1,056.00	1,098.00	1,120.00	1,140.00	1,260.00	1,254.00	1,276.00	1,300.00
Benefit Component											
Tariff	7875	7950	7950	7920	8235	8,400.00	8,550.00	9,450.00	9,405.00	9,570.00	9,750.00
Salvage value											25000
Total Benefit	7875	7950	7950	7920	8235	8400.00	8550	9450	9405	9570	34750
Net Benefit	6825.00	6890.00	6890.00	6864.00	7137.00	7280.00	7410.00	8190.00	8151.00	8294.00	33450.00
PV of Net Benefit	2560.17	2485.15	2389.57	2288.99	2288.49	2244.56	2196.77	2334.62	2234.14	2185.90	8476.75
Cumulative NPV	-48600.55	-46115.40	-43725.83	-41436.84	-39148.36	-36903.80	-34707.02	-32372.40	-30138.26	-27952.36	**-19,475.61**

Phase one Initial Decision for Three route cons. AT Low demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Initial Total Distance=656+430.3+558.2=**1644.5km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**

1Km=2.8 million USD = 50 million ETB

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00							
Operation cost						486.38	460.00	535.00	535.25	585.00	337.00	560.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	486.38	460.00	535.00	535.25	585.00	337.00	560.00
Benefit Component												
Tariff						3,647.81	3,450.00	4,012.50	4,014.38	4,387.50	2,527.50	4,200.00
Salvage value												
Total Benefit	0	0	0	0	0	3647.81	3450	4012.5	4014.375	4387.5	2527.5	4200
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	3161.44	2990.00	3477.50	3479.13	3802.50	2190.50	3640.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	2498.53	2272.15	2540.98	2444.39	2568.83	1422.91	2273.53
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-70496.90	-68224.75	-65683.77	-63239.39	-60670.55	-59247.65	-56974.11

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost												
Operation cost	340	432.5	457.5	402.5	547.5	710.00	822.50	705.00	595.00	600.00	682.50	572.50
Total Cost	340.00	432.50	457.50	402.50	547.50	710.00	822.50	705.00	595.00	600.00	682.50	572.50
Benefit Component												
Tariff	2550	3243.75	3431.25	3018.75	4106.25	5,325.00	6,168.75	5,287.50	4,462.50	4,500.00	5,118.75	4,293.75
Salvage value												
Total Benefit	2550	3243.75	3431.25	3018.75	4106.25	5325.00	6168.75	5287.5	4462.5	4500	5118.75	4293.75
Net Benefit	2210.00	2811.25	2973.75	2616.25	3558.75	4615.00	5346.25	4582.50	3867.50	3900.00	4436.25	3721.25
PV of Net Benefit	1327.27	1623.43	1651.22	1396.84	1826.97	2278.09	2537.56	2091.39	1697.19	1645.63	1799.90	1451.74
Cumulative NPV	-55646.84	-54023.42	-52372.20	-50975.36	-49148.39	-46870.30	-44332.74	-42241.35	-40544.16	-38898.54	-37098.63	-35646.89

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	710	720	720	716	758	780.00	800.00	920.00	914.00	936.00	960.00
Total Cost	710.00	720.00	720.00	716.00	758.00	780.00	800.00	920.00	914.00	936.00	960.00
Benefit Component											
Tariff	5325	5400	5400	5370	5685	5,850.00	6,000.00	6,900.00	6,855.00	7,020.00	7,200.00
Salvage value											16000
Total Benefit	5325	5400	5400	5370	5685	5850.00	6000	6900	6855	7020	23200
Net Benefit	4615.00	4680.00	4680.00	4654.00	4927.00	5070.00	5200.00	5980.00	5941.00	6084.00	22240.00
PV of Net Benefit	1731.16	1688.03	1623.10	1552.00	1579.85	1563.18	1541.59	1704.65	1628.39	1603.45	5635.96
Cumulative NPV	-33915.73	-32227.70	-30604.60	-29052.60	-27472.75	-25909.57	-24367.98	-22663.33	-21034.94	-19431.49	**-13,795.53**

Phase one ADD ONE, Second decision for route three cons. At Low demand

Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**

Part of Route 3: Addis Ababa(Sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**

Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km** — Initial Total Distance=656+430.3+558.2=**1,644.5km**

Part of route 6 Weldia_ Mile_Djibouti_**272.8km**

1Km=2.8 Million USD = 50 million ETB — **Added Total Distance= 272.8Km**

UNIT=1million birr

Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00						2,500.00	2,890.00
Operation cost						486.38	460.00	535.00	535.25	585.00	337.00	560.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	486.38	460.00	535.00	535.25	585.00	2,837.00	3,450.00
Benefit Component												
Tariff						3,647.81	3,450.00	4,012.50	4,014.38	4,387.50	2,527.50	4,200.00
Salvage value												
Total Benefit	0	0	0	0	0	3647.81	3450	4012.5	4014.375	4387.5	2527.5	4200
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	3161.44	2990.00	3477.50	3479.13	3802.50	-309.50	750.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	2498.53	2272.15	2540.98	2444.39	2568.83	-201.05	468.45
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-70496.90	-68224.75	-65683.77	-63239.39	-60670.55	-60871.60	-60403.15

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	2,500.00	2,750.00	3,000.00									
Operation cost	340.00	432.50	457.50	502.50	647.50	810.00	922.50	805.00	695.00	700.00	782.50	672.50
Total Cost	2,840.00	3,182.50	3,457.50	502.50	647.50	810.00	922.50	805.00	695.00	700.00	782.50	672.50
Benefit Component												
Tariff	2550	3243.75	3431.25	3768.75	4856.25	6,075.00	6,918.75	6,037.50	5,212.50	5,250.00	5,868.75	5,043.75
Salvage value												
Total Benefit	2550	3243.75	3431.25	3768.75	4856.25	6075.00	6918.75	6037.5	5212.5	5250	5868.75	5043.75
Net Benefit	-290.00	61.25	-26.25	3266.25	4208.75	5265.00	5996.25	5232.50	4517.50	4550.00	5086.25	4371.25
PV of Net Benefit	-174.17	35.37	-14.58	1743.88	2160.66	2598.95	2846.07	2388.04	1982.43	1919.90	2063.63	1705.32
Cumulative NPV	-60577.32	-60541.95	-60556.52	-58812.64	-56651.98	-54053.03	-51206.96	-48818.91	-46836.48	-44916.59	-42852.96	-41147.64

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	810.00	820.00	820.00	816.00	858.00	880.00	900.00	1,020.00	1,014.00	1,036.00	1,060.00
Total Cost	810.00	820.00	820.00	816.00	858.00	880.00	900.00	1,020.00	1,014.00	1,036.00	1,060.00
Benefit Component											
Tariff	6075	6150	6150	6120	6435	6,600.00	6,750.00	7,650.00	7,605.00	7,770.00	7,950.00
Salvage value											20000
Total Benefit	6075	6150	6150	6120	6435	6600.00	6750	7650	7605	7770	27950
Net Benefit	5265.00	5330.00	5330.00	5304.00	5577.00	5720.00	5850.00	6630.00	6591.00	6734.00	26890.00
PV of Net Benefit	1974.99	1922.47	1848.53	1768.76	1788.27	1763.58	1734.29	1889.93	1806.55	1774.76	6814.34
Cumulative NPV	-39172.65	-37250.18	-35401.65	-33632.88	-31844.61	-30081.03	-28346.73	-26456.80	-24650.24	-22875.48	**-16,061.14**

Phase one ADD TWO, Second decision for route three cons. At Low demand												
Route 1 :Addis Ababa(Sebeta)_Mojo_Awash_ Dire Dawa_ Djibouti_**656km**												
Part of Route 3: Addis Ababa(sebeta)_ Ejaji_Seka_ Jimma_ Bedele _**430.3km**												
Part of route 5 Awash _ Kombolcha_Mekele_ **558.2km**						Initial Total Distance=656+430.3+558.2=**1644.5km**						
Part of route 6 Weldia_ Mile_Djibouti_**272.8km**												
Route 2 Mojo_ Shashemene_ Konso_ Woitu_**587km**												
1Km=2.8 Million USD	**=**	**50 million ETB**				**Added Total Distance=272.8+587= 859.8 Km**						
UNIT=1million birr												
Year	1	2	3	4	5	6	7	8	9	10	11	12
Cost component												
Construction cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00						8,500.00	8,240.00
Operation cost						486.38	460.00	535.00	535.25	585.00	337.00	560.00
Total Cost	12,500.00	15,500.00	20,300.00	21,750.00	12,175.00	486.38	460.00	535.00	535.25	585.00	8,837.00	8,800.00
Benefit Component												
Tariff						3,647.81	3,450.00	4,012.50	4,014.38	4,387.50	2,527.50	4,200.00
Salvage value												
Total Benefit	0	0	0	0	0	3647.81	3450	4012.5	4014.375	4387.5	2527.5	4200
Net Benefit	-12500.00	-15500.00	-20300.00	-21750.00	-12175.00	3161.44	2990.00	3477.50	3479.13	3802.50	-6309.50	-4600.00
PV of Net Benefit	-12019.23	-14330.62	-18046.63	-18591.99	-10006.96	2498.53	2272.15	2540.98	2444.39	2568.83	-4098.53	-2873.15
Cumulative NPV	-12019.23	-26349.85	-44396.48	-62988.47	-72995.43	-70496.90	-68224.75	-65683.77	-63239.39	-60670.55	-64769.08	-67642.23

Year	13	14	15	16	17	18	19	20	21	22	23	24
Cost component												
Construction cost	8,500.00	9,000.00	8,750.00									
Operation cost	340.00	432.50	457.50	742.50	887.50	1,050.00	1,162.50	1,045.00	935.00	940.00	1,022.50	912.50
Total Cost	8,840.00	9,432.50	9,207.50	742.50	887.50	1,050.00	1,162.50	1,045.00	935.00	940.00	1,022.50	912.50
Benefit Component												
Tariff	2550	3243.75	3431.25	5568.75	6656.25	7,875.00	8,718.75	7,837.50	7,012.50	7,050.00	7,668.75	6,843.75
Salvage value												
Total Benefit	2550	3243.75	3431.25	5568.75	6656.25	7875.00	8718.75	7837.5	7012.5	7050	7668.75	6843.75
Net Benefit	-6290.00	-6188.75	-5776.25	4826.25	5768.75	6825.00	7556.25	6792.50	6077.50	6110.00	6646.25	5931.25
PV of Net Benefit	-3777.61	-3573.85	-3207.35	2576.77	2961.52	3369.01	3586.52	3100.01	2667.01	2578.15	2696.56	2313.91
Cumulative NPV	-71419.84	-74993.69	-78201.04	-75624.26	-72662.74	-69293.73	-65707.21	-62607.20	-59940.19	-57362.04	-54665.49	-52351.58

Year	25	26	27	28	29	30	31	32	33	34	35
Cost component											
Construction cost											
Operation cost	1,050.00	1,060.00	1,060.00	1,056.00	1,098.00	1,120.00	1,140.00	1,260.00	1,254.00	1,276.00	1,300.00
Total Cost	1,050.00	1,060.00	1,060.00	1,056.00	1,098.00	1,120.00	1,140.00	1,260.00	1,254.00	1,276.00	1,300.00
Benefit Component											
Tariff	7875	7950	7950	7920	8235	8,400.00	8,550.00	9,450.00	9,405.00	9,570.00	9,750.00
Salvage value											25000
Total Benefit	7875	7950	7950	7920	8235	8400.00	8550	9450	9405	9570	34750
Net Benefit	6825.00	6890.00	6890.00	6864.00	7137.00	7280.00	7410.00	8190.00	8151.00	8294.00	33450.00
PV of Net Benefit	2560.17	2485.15	2389.57	2288.99	2288.49	2244.56	2196.77	2334.62	2234.14	2185.90	8476.75
Cumulative NPV	-49791.41	-47306.26	-44916.69	-42627.70	-40339.21	-38094.65	-35897.88	-33563.26	-31329.12	-29143.21	**-20,666.47**