ASSESSMENT OF THE IMPACT OF RURAL ROAD TRANSPORT ON SOCIO-ECONOMIC DEVELOPMENT.

(A CASE STUDY: TULLA - KENERA - YAYE ROAD SECTION)

MSc THESIS

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ASSESMENT OF THE IMPACT OF RURAL ROAD TRANSPORT ON SOCIO-ECONOMIC DEVELOPMEN

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ADVISORS’ APPROVAL SHEET

This is to certify that the thesis entitled **“Assessment of the Impact of Rural Road Transport on Socio-Economic Development”** Submitted in partial fulfilment of the requirements for the degree of **Masters of Science** with specialization in **Road and Transport Engineering,** the Graduate Program of the **School of Civil Engineering**, and has been carried out by **Mr. Ararsa Bekele,** Id. No **PGRo/004/10** under our supervision.

Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the School/department.

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We, the undersigned, members of the Board of Examiners of the final open defence by Ararsa Bekele have read and evaluated his thesis entitled “Assessment of The Impact of Rural Road Transport on Socio-Economic Development”, and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree.

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DECLARATION

I hereby declare that this MSc thesis entitled **“Assessment of The impact of Rural Road Transport on Socio-Economic Development”** Specialty or equivalent thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

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ABBREVIATIONS

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Official
EIA	Environmental Impact Assessment
ERA	Ethiopian Roads Authority
ERR	Economic Rate of Return
HCM	Highway Capacity Model
HDM-4	Highway Development and Management Model
IDA	International Development Association
IRI	International Roughness Index
IRR	Internal Rate of Return
MCA	Multi-Criteria Analysis
NPV	Net Present Value
RED	Roads Economic Decision Model
RSDP	Road Sector Development Programme
RUC	Road User Cost
VOC	Vehicle Operating Cost
WHO	World Health Organisation
WIDP	Woreda Integrated Development Plans

Abstract

Roads are the dominant mode of transportation in Ethiopia but it has been neglected to a large extent in the past, Socio-economic development and subsequent economic growth on the country is hampered by several limiting factors, including the lack of adequate roads infrastructure. Investment in transport infrastructure plays a significant role in stimulating development. An increased interest in rural roads investment potential has developed in recent years. This is mainly due to the need for development of rural as well as the positive impact that road investment could generate on rural communities, should they have an adequate support roads infrastructure network that is sustained over the long term. Due to improvement in transportation network, reduction in transportation costs can be realized in numerous ways, such as reduction in travel time, decrease in vehicle operating costs, increased safety and reduction in the level of air and noise pollution. In addition to reduction in transportation cost, it also increase comfort to passengers and also enhancing land value. Economic analysis is a critical component of a comprehensive project evaluation methodology that considers all key quantitative and qualitative impacts of road. The scope of present study consists of evaluating the impact on rural road investment and checking economic viability of the project. Maintaining and upgrading for two lanes with gravel shoulder of flexible pavement road namely, Tulla Kenera Yaye Section of TKY is taken as a case study. In spite of heavy initial investment in maintaining and upgrading to two lane with gravel shoulder of flexible pavement, economic analysis carried out using HDM-IV and RED model results indicates that there is great saving towards Vehicle Operating cost (VOC) and Travel Time cost (TTC) after maintenance. The paper also indicates the benefits of rural road investments as well as the type of mechanisms used in practice to estimate its impact.

Keywords: *road sector development, socio-economic growth, agricultural production, social service, market access, RED model and HDM -4 models.*

CHAPTER ONE

INTRODUCTION

1.1 General

Transportation occupies high space in modern life. Advancement in all spheres of life has been to a large extent influenced by transportation facility. Transportation is best thought of as a tool to transport goods and peoples from one place to another. Investment in highways or other facilities generates benefit in the form of lowering the transportation cost for making movement and also enhances the level of Gross Domestic Product (GDP) through mobilization of unemployed factors of production thus enabling economic growth and development. The bulk of passengers and goods movement in Ethiopia takes place by roads, which are facilitated through an extensive road network. Roads provide mobility and accessibility to the people. Roads build the country. For any nation, road transport is very important for economic growth. The construction of road brings a variety of benefits that is enjoyed by all sectors of the economy.

Rural road investment is one of the main priorities of Governments in Africa as a mechanism towards reducing poverty. It is also an important aspect considered by the development community in the poverty alleviation process and the provision of more equitable opportunities for rural citizens. Currently several factors, including the lack of adequate road infrastructure, are hampering socio-economic development and subsequent economic growth on the African continent. Against this background it is appropriate to state that investment in rural transport infrastructure in Africa plays a significant role in socio-economic development and economic growth of the continent. However, to be able to state that investment in rural transport infrastructure contributes to socio-economic development and economic growth, methodologies are required to estimate the extent of the impact of such investments on socio-economic development and economic growth.

In most African countries, road transport network and road density measured as per person and per square kilometre of land area is very low compared to the global average. Yet road transport sector is the dominant means of transport in the continent carrying around 80 to 90 percent of passenger and freight traffic; and most rural communities are accessible only through roads (Gwilliam, 2011). Recently countries in the continent are making huge progress in allocating funds and building road infrastructure, but still rural road accessibility remains to be one of the challenges to eradicate extreme poverty and achieve the sustainable development goals (SDGs).Poor rural accessibility and poverty are extremely linked; when people are isolated, they are unable to harness the economic and social opportunities within a wider geographic region. Poor accessibility also makes diffusion of new technologies difficult, contributes to high transaction and production costs, and limits access to health, education and other social infrastructure (Hajj and Pendakur, 2000). It also hinders household mobility to access inputs and supplies their produce to the market. Such poor physical accessibility often compounds the effects of poverty and deprivation (Porter, 2007). And a recent study by Alkire et al (2014) also shows that 85 percent of the poor (measured using Multidimensional Poverty Index) in105 countries reside in rural areas where the pattern of higher incidence and intensity of poverty in rural areas than in urban ones is consistent across the different regions in the developing world. Thus, those in acute poverty are mostly concentrated in rural areas. Hence improvements in transport infrastructure particularly of rural roads are critical to support sustainable economic growth and reduce poverty.

Cognizant of the importance of roads, the government of Ethiopia has embarked on massive investment on road construction by formulating the Comprehensive Road Sector Development Program (RSDP) in 1997. Since then, the RSDP has been implemented in four separate phases, and as part of the fourth RSDP, a Universal Rural Roads Access Program (URRAP) envisaged to connect rural kebeles by standard rural roads has been set out and implemented. Previous empirical works conducted in various countries show that rural roads infrastructure development reduced poverty and improved the quality of life, especially for the poor and narrowed down the income gap between citizens (Calderon and Serven, 2010; 2014; ADB,2012). Infrastructure can also have a strong impact on the incidence and depth of poverty by supporting inclusive growth, i.e., economic growth that can facilitate a meaningful and sustainable poverty reduction (World Bank, 2009).But better rural roads are not sufficient but necessary conditions to benefit the rural areas. The ability of the poor to make significant economic use of a road depends on their asset base and the entitlements to resources and opportunities that they can command. The poor benefit mainly through the indirect impacts of road improvements, of better access to state services and improved provision of services to the village, and of opportunities in alternative livelihood income streams where the preconditions for their development are right. The poor can also benefit broadly from improvements to the rural economy through increased opportunities for agricultural wage labour, but, again, these impacts are contingent on favourable preconditions being in place(Hettige, 2006).Besides socio economic conditions of the poor, distance of location of households from road also affects their ability to harness the direct and indirect benefits of roads. In the case of the study sites especially those connected by feeder roads, one road connects the tabia centre with the main road. Since settlement of rural households is highly spread, some households may travel hours on foot to reach the feeder roads. Households located close to a road may thus be affected differently from households located far from a road.

1.2 Research Background

Like many other economic and social activities that are intensive in infrastructure, the transport sector is an important component of the economy impacting on development and the welfare of the people (Rodrigue *et al*, 2011). When transport infrastructure is efficient, it provides various economic and social opportunities and benefits that result in positive multiplier effects such as better accessibility to markets, employment, education, health and additional investments (Oosterhaven and Knaap 2000).

Roads are viewed as a means of socioeconomic development because they link regions, places, people and economic activities. The expansion and improvement of a given road network would contribute to increases in accessibility and mobility, while reducing the distance to destinations, travel costs and travel time. However, these social and economic benefits, road networks are also perceived as cultural artefacts that lead to negative ecological effects (Patarasuk 2013). Particularly rural roads are somewhat typical in terms of their capacity to literally pave the way for various investments in social infrastructure sectors such as schools, health services, and security services. Roads also facilitate access to new technologies as well as the marketing of surplus produce that contribute to increase in agricultural productivity. In case of the agriculture sector, better roads can significantly reduce the cost of inputs such as fertilizers, seeds, and extension services (Dercon *et al* 2008). On the output side, better roads increase the scope of profitable trade, which in turn encourages on-farm investments to raising agricultural production (Binswanger *et al* 1993). This in turn raises rural incomes, lowers food prices (and hence raises disposable income in urban areas), reduces spatial inequality in food prices, and reduces dependence on food imports. If road infrastructure is well managed, it transforms the quality of life of citizens through dynamic externalities that its development often generates (Sengupta *et al*

2007:3). But when the system is deficient in terms of capacity or reliability, it can have an economic cost such as reduced or missed opportunities. Governments of developing countries, multilateral organizations such as the World Bank, the Asian Development Bank (ADB) and the International Fund for Agricultural Development (IFAD) emphasize the role of rural transport to increase access to- and participation in markets because markets contribute to division of labour and product specialization. According to Rural Poverty Report 2001 of IFAD "Distance to markets and the lack of roads is a central concern for rural communities throughout the developing world. The rural poor need access to competitive markets not just for their products but also for inputs, assets and technology, consumer goods, credit and labour." The poor and remote communities get larger benefits from a new road in several ways. On the one hand, road construction and maintenance might give employment opportunities for the local people; while on the other hand improved transport reduces the physical costs of access to resources and markets. Governments and donors, therefore, favour building new roads which allow easier transportation of all products from the rural and remote poor to ports and markets within and beyond country frontiers.

Totally, rural areas serve as the source and base for the production of food and raw materials which is the major sources of capital formation for a country, and a principal market for domestic manufactures (Olayiwola and Adeleye, 2005). In general terms, the rural areas engage in primary activities which form the foundation for any economic development Sustainable rural development is a function of a number of factors in which transportation is of importance. Efficient and effective rural transportation serves as one of the channels for the collection and exchange of goods and services, movement of people, dissemination of information and the promotion of rural economy. Along this line, Owen (1968) stated that "Immobility perpetrates poverty", effective transportation eases accessibility to inherent potentials of rural areas which could be harnessed for the development of its economy. In other words, rural transportation provision forms an intrinsic part of rural development strategies, serving as a mechanism and catalyst for rural transformation through there enforcement of rural development and contributes to poverty reduction by enhancing both equity and efficiency outcomes.

1.3 Research Problems Statement

In Ethiopia road transport is the dominant mode and accounts for 90 to 95 percent of motorized inter-urban freight and passenger movements. However, because of its limited road network, provision of infrastructure has remained one of the formidable challenges for Ethiopia in its endeavour towards socio-economic development and poverty reduction (ERA, 2011).

The low road density and seasonal state of road raises constraints to rural producers. Many people's live and produce far away from major roads, markets and to other socio-economic service centre. Consequently small holder agricultural producers face high transportation costs that raises prices of inputs, and impair further access to market, which leads to low productivity, health, education which in turn hinder economic growth in the area. It is generally believed that the improvements of transportation services in the study area have major implications for efforts to increase agricultural production, educational expansion, social provision and market access.

This condition makes delivery of services such as health, education, extension services very challenging and impede mass mobilization, marketing and general development interventions.

Although the evidence of impact studies has been broadly supportive of rural road investment, most studies tend to treat the topic as a ‘black box’, without identifying how, and in what circumstances, rural road investment is likely to have the most, or least, impact. Because of the lack of a consistent analysis, rural road impact studies have had very little influence on the planning and choice of standards for rural road investment.

For example, showing that rural road investment in general has an impact on rural development provides little or no guidance on exactly what engineering measures to take. In fact, there are a wide range of possible interventions, including, for example, spot improvements, basic access, gravel standard roads, low-cost sealed roads. In practice, the engineering measures chosen tend to be driven by a combination of available budgets, rules of thumb, crude prioritization indices and simple transport user cost analysis. In order to better inform decision makers we need to develop a more appropriate planning methodology from the evidence of impact studies through an appropriate theory of change. Thus, this study attempts to examine the contribution of road transportation to socioeconomic growth of Sidama Region.

1.4 Research Questions

- What is the contribution of rural road development on the provision of social services?
- What is the contribution of Road sector development to socio economic growth in the area?
- What is the role of road in the economic growth of the study area?

1.5 Objectives of the Study

1.5.1 General Objective

The general objective of this study is to assess the socioeconomic impacts of rural road infrastructure development on the surrounding communities and is to improve the understanding of the significance of the rural roads and the road conditions for people in the rural areas of the study areas and investigating their relationships, with specific reference to Tulla Yaye road project in Sidama Region.

1.5.2 Specific objectives of the study

- To assess the contribution of rural roads for economic growth and social services improvement in the study area.
- To analyze the economic viability of the case-study by HDM-4 software and RED model.
- Analyze the relationship of road accessibility with economic impact indicators such as: type of occupation of the household head, agricultural yield, income of individual household members, household asset, and expansion of trade activities and Social impact indicators like, poverty, education, health and gender.

1.6 Significance of the research

This study will be significant in the following ways: The findings of this study will inform the Government of Ethiopia on policy formulation in relation to roads and transportation management. It will also inform Regional administration leaders on the effects of transport interventions, including road management plans. In addition the findings will enable the region road management committee and Engineers to solicit funding for road maintenance and spot improvement.

1.7 Delimitation of the Study

The study confined itself to Sidama Region and within the variables of the study which are; sustainable Agriculture, Basic service provision, growth of business enterprises or trade and accessibility to employment opportunities. The findings will be applicable to road management especially when sourcing for road intervention and maintenance funds from the government and donors.

1.8 Limitation of the Study

It was not possible to control all variables especially the confounding variables. Also it was hard to show cause and effects relationships. Also data collected was at one point in time yet in natural situations, things kept on changing on day to day basis. The other major limitation of the study was the topic, rural transportation and socioeconomic development. Since the topic itself was very broad, it was difficult to examine all aspects of rural transportation in detail in a single study.

1.9 Definition of significant terms

Region according to this study it was a type of administrative division.

Effect means result or consequence of rural transport.

Rural refers to sparsely settled or agricultural country side.

Rural people are the persons dwelling in the sparsely settled or agricultural country side.

Socio-economic development was the process of social and economic development in a society.

CHAPTER TWO

LITERATURE REVIEW

2.1 General

Transportation is a rural community's essential connection to the nation and the world. Benson and Whitehead (1975) defined transport as "that part of economic activity which is concerned with increasing human satisfaction by changing the geographical position of goods or people". In other words, transport creates time and place utilities. Ogunsanya et al, (1993) observed that the need for transportation arises in any economy that is distributed over space, this need is particularly so in the context of community development where transportation is considered as the engine of growth of such economy. Transportation as one of the tools of development is important and without it the inherent potentialities of an area may not be realized.

Numerous studies have established the positive relationship between rural connectivity and development; rural roads provide vital links that foster effective access to and utilization of a host of important social and physical infrastructure. A multitude of benefits are attributed to rural road development, including increased agricultural production, better farm prices, growth of dairying, rural industrialization, better educational standards, and higher life expectancy resulting in balanced and faster development of rural areas.

Rural road development enhances access to markets for both inputs and outputs through a reduction in transaction and trade cost (transport and logistics cost). The greater availability of inputs increases their use by farmers. Consequently, agricultural productivity can increase. Rural Roads also enhances producers to achieve additional productive opportunities, leading to rise in production (Stifeland Minten, 2008). Jalan and Ravallion (2002) show that road density had a highly significant positive effect on consumption growth at the farm-household level in rural areas of Southern China from 1985 to 1990. Using household data in Ethiopia, Dercon and others (2008) find that the proximity of a road is a major factor in reducing poverty. Fan, Nyange, and Rao (2005) shows that each kilometre reduction in the distance to a public transportation facility reduces the probability of a household being poor by 0.22 to 0.33 percent in Uganda. It has been observed that there was a direct relationship between increase in acreage of export crop cultivation and the standard of roads and distance from main commercial centres. There is enhanced entrepreneurial activity, sharp decline in freight and passenger charges and improved services as a result of investment in rural roads (Bonney, 1964). While analysing the socio-economic impact of new roads on small and isolated village communities in Mexico, it was found that the roads created inflow and outflow generation of transportation, communication and modernization as well as migration, both into and out of the community (Elmondorf and Merrill, 1977).

Road Communication plays a crucial role in promoting economic, social and cultural development of a region. Improvement in road connectivity not only assures the development but also accelerates the process of development of a region. Thus, “road is one of the greatest fundamental institutions of mankind. Its beginnings are almost instructive with man's first quest in search of food, water, plunder or sheer adventure. It develops with man's advance; it retrogrades with the break-down of a social order.

In the modem world, roads have proved to yield profound economic and social significance. In fact, roads can rightly be regarded as barometers to measure the degree of economic advancement and civilization of a nation. In rural areas, the development of roads affects agriculture directly by enlarging the areas under cultivation. Road development also prompts a change in the type of agricultural production by diversion of cultivation of low cost crops to commercial crops. It encourages the production of protective foods of perishable nature, such as eggs, fruits, vegetables, milk and other dairy products. As these are best produced in rural areas, rapid and efficient transit is essential to ensure their availability in the nearby or far off market centres or urban markets in fresh and good condition in order to fetch remunerative prices. Paucity of good roads in rural areas compels the cultivators to dispose of their produce to the village trader or agent or money lender comparatively at cheap prices. Good roads would open up the urban markets to the cultivator, which would facilitate marketing of his product at higher prices. Thus, in the rural areas agricultural development goes hand in hand with expansion of roads. Apart from this, it breaks up the isolation of villages, helps in spreading education and creates a general sense of social awakening, promotion of health and various other social services.

2.2 Global perspective of transportation issues in rural Areas.

In the last few years, the research areas privileged by studies oriented to document, in an empirical way, the positive impact of larger and better access to rural road infrastructure have been related to two broad areas. On the economic side, privileged studies have been those quantifying time savings, transport costs reductions and transaction costs reductions associated to the articulation of rural households to product and factor markets, as well as those focusing on the impact that larger provision of this kind of infrastructure generates on rural job opportunities. On the social side, privileged studies have been those documenting the greater access to basic services –like health and education– that follow the construction or rehabilitation and maintenance of rural roads. Among the studies that focus their attention on quantifying time savings and the reduction of transport costs we can mention contributions like that of Lucas, Davis and Rikard (1996), who assess the impacts of a rural roads reconstruction and rehabilitation program in Tanzania, after seven years, by documenting traffic increases, passenger and freight cost reductions and time savings to access markets. It could also be mentioned here Guimaraes and Uhl (1997) who assess how transport mode, quality of the road and distance to markets affect agricultural production costs in the federal state of Pará, Brazil; or Liu (2000) who carries out a study of production and transport costs comparing villages with permanent access to roads to those with only seasonal access, in the state of Andhra Pradesh, in India. In addition, among studies interested on assessing relations between access to different types of road infrastructure and transaction costs, Escobal (2000)compares, for the case of Peru, two geographic areas with different degree inaccessibility, one connected to markets via motorized rural roads while the other is connected to the same markets via non-motorized rural roads. Escobal measures the transaction costs associated with marketing the main product of these areas potato, and finds that such costs are substantially higher at areas connected to markets by non-motorized roads than those observed at areas connected by motorized roads

Different studies have documented the importance of road infrastructure in expanding rural labour markets. Smith, Gordon, Meadows and Zwick (2001) show that, for the case of Uganda, the rehabilitation of road infrastructure fostered the expansion of job opportunities in the service sector. Lanjouw, Quizon and Sparrow (2001) also find rehabilitated non-agricultural job opportunities in Tanzania due to rehabilitated road infrastructure. However, Barret (2001) acknowledges that this kind of studies has not been able to estimate accurately the profitability of rehabilitated access to labour markets provided by such infrastructure improvement, in terms of new job opportunities as well as better job opportunities than those existing before the intervention. In addition, several studies such as those by Corral and Reardon (2001) in Nicaragua, de Janvry and Sadoulet (2001) in México, and Escobal (2001) in Peru, have found significant relations between different road indicators and non-agricultural rural job opportunities both in self-employment and waged activities. These studies have shown that road access might even compensate the absence of other public and private assets. What is happening with households' wealth and welfare? The impacts of rehabilitated road infrastructure on accessibility to product markets and new and better job opportunities, referred above, should though might not is generating wealth or welfare gains. However, there is not much work done in this research area. We can only mention the work of Jacoby (2000), who shows, using data from Nepal, that there is a negative relation between farmland value and its distance to agricultural markets. As indicated by this author, if farmland behaves like any asset, its price would equal the net present value of the benefits its cultivation generates, and therefore this relation between farmland value and distance to agricultural markets– is an indicator of the capital gains generated by the improvement of road infrastructure. In addition, Jacoby (2000) identifies a significant but weak relation between agricultural wages and distance to the market. This suggests that benefits of better articulation to labour markets are the result of changes in time allocation between self-employment and waged activities, rather than the result of increased wages due to rehabilitated rural roads.

Amongst the studies that have privileged the analysis of social impacts of rural road infrastructure, we can mention those by Windle and Cramb (1996) and Porter (2002). Windle and Cramb (1996) compare three areas in Malaysia with different degree of accessibility and verify the positive impacts of rehabilitated road infrastructure in maternal healthcare, nutrition and access to school; while Porter (2002) focuses on the impacts of road access over rural poor population of Sub-Saharan Africa, showing the significant negative impacts of road deterioration on accessing health services. A common criticism of most of the studies referred above is related to their methodological designs, which prevents them from assessing clear causal links between road construction, rehabilitation and maintenance and the different impact indicators. Frequently, these studies just show associations between greater provision of transport infrastructure and reduced transport costs, increased access to markets and public services, or even greater economic growth and lower poverty rates, without controlling properly for other covariates that might be having an effect on the linkages under analysis. In some other cases, control variables are incorporated, but this is not done systematically enough to allow the construction of a counterfactual scenario, required by any serious causal study seeking to make such causal claims.

Only a few studies have moved forward in the direction of constructing counterfactual scenarios. Ahmed and Hossain (1990) carried out the first study that sought to systematically control for the most important covariates in order to estimate the impact of rehabilitated rural infrastructure. With a sample of129 villages in Bangladesh, this study finds that villages with better road access have greater agricultural output, greater total incomes and better indicators of access to health services, in particular in the case of women. This study also finds evidence that suggests that roads would have increased wage income opportunities, especially for those who have no farmland.

The study by Binswanger, Khandker and Rosenzweig (1993) is also pioneering in this effort of constructing counterfactual scenarios to study the welfare impact of rural infrastructure. Using time series information in a random sample of 85 districts from 13 States in India, it shows that road infrastructure investment fostered agricultural output growth, higher usage of fertilizers and a larger credit supply. This study presents a conceptual framework that is helpful to overcome simultaneity problems created when assessing the causal relations between infrastructure investment and other variables of interest. To avoid the correlation of non-observable variables with each district's infrastructure endowment –which would bias impact estimates– Binswanger, Khandker and Rosenzweig (1993) implicitly construct a counterfactual scenario based on a random selection of districts.

Levy (1996) carried out another study in the same line, assessing the socioeconomic impacts of road rehabilitation based on a sample of four rural roads in Marruecos, comparing pre-existing and post-rehabilitation conditions. To control for context covariates, different to rehabilitation itself, which could have affected the outcome, Levy (1996) compares the data on the performance of these four rehabilitated rural roads with that of two non-rehabilitated roads. From this 'before-after' and 'with-without' comparison, the study finds that the impacts from rural road rehabilitation were much more important than the expected reduction in transport costs, showing significant increases in agricultural output as well as important changes in the crops portfolio and usage of inputs and technologies. In addition, the study identifies very clear causal linkages between rehabilitated road infrastructure and access to education, particularly for girls, as well as a substantial increase in the use of public health services. Although this is a case study, which does not pretend to be representative of a wider area, in methodological terms it does manage construct sufficiently solid counterfactual scenarios to move forward in establishing causal relations between rural roads investment and key variables associated with rural household's welfare.

2.3 Ethiopia transportation issues in rural Areas.

Ethiopia is with a population of above 110 million the second most populous Sub-Saharan African country. More than 81 percent of the total population are living in rural areas, (World Bank, 2020). Developing the road sector by boosting the size and quality of the road networks is one the main strategic pillars of the Growth and Transformation Plan 2010-2015 for Ethiopia. The performance of the road sector plays a vital role in the growing economy of the country and is therefore considered as really important and priority policy. In 1997, the Ethiopian Government developed the Road Sector Development Program (RSDP), to increase quality and quantity of the road network. After implementing several phases of the RSDP in the past years, many goals are accomplished. The total road network almost doubled from 26,550 km in 1997 to almost 50,000 km in 2011 (Ethiopian Roads Authority, 2013). There remains a critical need to provide rural communities with permanent accessibility to social and government services, economic and business services, and better opportunities for employment and generating income. Because of these mentioned reasons, the government has developed a sub-program of the RSDP: the Universal Rural Road Access Program (URRAP). This program is especially developed to improve the rural accessibility (Ethiopian Roads Authority, 2012). URRAP will connect all kebele's and tabia's by roads of a standard that provides all-weather, year round access, meets the needs of the locals are maintainable. The URRAP is designed to improve rural livelihoods by reducing their isolation and to provide year round access to their markets and other social services.

The Ethiopian Roads Authority wants to expand and improve the feeder road network by:

- Introducing sustainable road maintenance regimes on improved road networks;
- Developing and strengthening small and medium scale private enterprises (SMEs) working in support of the road sector;

- Creating massive employment opportunities for the community and for middle-level professionals; and
- Instituting and strengthening an appropriate institutional set-up at Woreda level that can manage the feeder roads under its jurisdiction.

URRAP is an employment intensive program and will therefore use labour based actions to build and in the long term maintain the roads, and so using employment as first step out of poverty. The program is generally geared towards making the rural population beneficiaries of infrastructure facilities connecting all kebles together. Hence it could facilitate transportation access, create better market link and also employment opportunities for rural youth. Beyond its very essence of promoting rural road coverage, the program also provides a great deal of opportunities for local private sector to upscale their project execution capacity.

According to the evaluation of the Ministry of Transport (MoT), the execution of URRAP in Southern Nations, Nationalities and Peoples' State has shown a reduced achievement when compared to others. Coupled with different rationales, the disagreement broke out among the main actors of the project including, state's bureau of transport, contractors and consultants has adversely affected the pace and quality of project execution. Taining to this issue, MoT had recently organized a field trip to assess the execution of tasks at the project sites. As soon as we (particularly crew of journalists) set our feet on the project sites, almost all consultancy and contractors' associations started criticizing the transport bureau for failing to pay them operational payment for about one year and three months.

2.4 Rural transportation problem in Ethiopia

The condition of rural transportation has frustrated rural development efforts in the country and this has resulted into series of challenges such as the cutting off of many rural areas in the country from neighbouring larger settlements from which they could access higher order socio-economic services, low productivity, low income and a fall in the standard of living of rural residents and high rate of poverty. Rural transportation problem in Ethiopia relates generally to the provision of access to natural resources like minerals, agriculture, forestry and the provision of access for the rural population so that they can access services at affordable rate. Rural transportation problem is accentuated by the dispersed spatial derivation of traffic, this is conditioned by the nature of rural environment and economy, bulkiness and perishable nature of rural product, imbalance in inflow and outflow, and marked variability in demand for transport.

Demand for rural transport is subject to three dimensions of traffic variation and fluctuations and these are diurnal, short term, and seasonal (Ovubude, 2000). The volume and direction of rural transport is influenced by the cyclic market system in rural areas. Hence, in most cases, traffic between main urban centre and dependent villages varies in volume depending on the cycle of the periodic markets in the area concerned. The cycle of rural transport demand also appears to correspond with the seasonal pattern of local agricultural and forest products availability. The condition of most rural roads in the country is very poor compared to inter-urban and intra-urban roads in the country. During rainy season, most rural roads deteriorate and become impassable; this poses a threat to sustainability of rural socio-economic development. Motorized transport cost become very high during rainy season as public transport operator hike up their fares because of the increased vehicle running costs often occasioned by the prevalent very bad road conditions. Rural travel and transport in most rural areas in Ethiopia still take place with great difficulties thereby compounding and worsening the problem of rural productivity and rural poverty.

2.5 The Role of Transport Policy

It is relatively rare for a government to prepare a separate rural transport policy or strategy document. The topic is usually covered within national transport policy and strategy documents. A good example is the Rural Transport Strategy prepared for South Africa (Republic of South Africa, Department of Transport, 2007) and rural transport policy and strategy statements have also been recently prepared for Nigeria (Federal Ministry of Agriculture and Rural Development, 2013), Uganda(Republic of Uganda, Ministry of Works and Transport, 2013) and Tanzania (See below). Advice on the preparation of a rural transport policy is given by Banjo and Robinson (1999). Important government policy statements may also be found in other documents, particularly in Poverty Reduction Strategy Papers (PRSP).

An Example of National Transport Policy Statements
The Vision:
"To have an efficient and cost effective domestic and international transport services to all segments of the population and sectors of the national economy with maximum safety and minimum environmental degradations."
The Mission:
"To develop safe, reliable, effective, efficient and fully integrated transport infrastructure and operations which will best meet the needs of travel and transport at improving levels of service at lower costs in a manner, which supports government strategies for socio-economic development, whilst being economically sustainable".
Source: *Ministry of Transport and communications, United Republic of Tanzania, National Transport Policy 2002.*

Within many government papers, the terms 'transport policy' and 'transport strategy' are often used interchangeably to cover the same material. When distinction is made, the term *policy* covers goals and objectives as well as overall guiding principles while the term *strategy* provides details on specific measures can also cover an action timetable and may outline which institutions and departments are responsible for implementation. General advice on the preparation of a National Transport Strategy is given by Lee and Hine (2008).

Although it may be possible to plan very common interventions (like rural roads) without a policy or strategy, this is extremely difficult for other types of interventions. It is important to understand the detailed objectives of the government, as well as the institutional structure and the legal framework. Many interventions (e.g. those relating to commercial transport services) may require changes in legislation to implement.

2.6 Connections between Rural Transport and Poverty Reduction

Before further developing an approach to planning, it is necessary to understand the nature of the problem. A systematic problem diagnosis can help with designing the most appropriate package of interventions that can address the key constraints.

Effective rural transport planning, particularly when addressing service issues but also the wider aspects of infrastructure planning, requires a great deal of background data and information to assess priorities but also to provide a measure of the scale of interventions required. To help with the planning process, this section explores the connections between rural transport and poverty reduction, and provides and discusses a range of data and issues relating to the rural population and their use of and interaction with different forms of transport.

Isolation is a strong contributor to poverty (Stifel and Minton, 2008). Good access to markets and basic services is essential for its eradication. Because of the high proportion of the poorest sections of the population living in rural areas, Poverty Reduction Strategy Papers often articulate the need to increase rural livelihoods through a range of measures including improving rural accessibility. They also usually stress the need to meet the Millennium Development Goals (MDGs) However; none of the MDGs directly mention transport, even if in most instances it would be impossible to achieve the goals without an extensive and relatively efficient rural transport system.

2.7 Overview of Road Network in Ethiopia

2.7.1 Road Investment

For a long time, roads infrastructure had been the major bottleneck in Ethiopia on doing business especially in rural parts of the country. Fig. 1 shows the road network development by road type in Ethiopia between1974 and 2014. During the imperial regime, road coverage mainly concentrated in urban areas. In the early 1950s, total road network both the asphalt and gravel roads in Ethiopia was6400 km. In 1974 the total road network increased to 9,260 km of which only 36 percent was asphalted and the remaining was gravel roads. By 1991, the total road network rose to 19,017km. Cognizant of the challenges the sector pose for the economy as a whole, recently the Government of Ethiopia (GoE) has shown greater commitment for road sector development by formulating the comprehensive Road Sector Development Programme (RSDP) in 1997 to address the constraints the road sector faced for long. Since then the RSDP has been implemented in four separate phases as follows:

- RSDP I - Period from July 1997 to June 2002 (5 year plan)
- RSDP II - Period July 2002 to June 2007 (5 year plan)
- RSDP III - Period July 2007 to June 2010 (3 year plan)
- RSDP IV - Period July 2010 to June 2015 (5 year plan).

RSDP IV was aligned with the Growth and Transformation Plan I (GTP). As part of the RSDP-IV, the GoE embarked on the Universal Rural Road Access Program (URRAP) that sets out to connect all kebele by roads of a standard that provides all-weather, year round access, meets the needs of the rural communities, are affordable and maintainable. It is mainly designed to improve rural mobility by reducing isolation for rural populations and to provide year round access to their markets, social and other services (ERA, 2013)

During the period of the RSDP until 2014, the government constructed around 72,972 km new additional roads of all type (asphalt, gravel, rural and community level roads). In 1997, the total road network was 26,550 km and reached at 99,522 km in 2014. During the last phase of RSDP (in 2010-2014), the total road network grew on average by a staggering 17 percent annually.

Table 2.1 Road Network and Investment in Ethiopia. (Source: ERA, 2013)

Program	Road Physical Works (km)Performance			Financial Performance		
	Plan	Accomplish	%ofAccomplish	Plan	Accomplish	% ofAccomplish
RSDP I (1997-2002)	8,908	8709	98	9812.9	7284.5	74
RSDP II (2002-2007)	8,486	11,589	141	15,985.9	18,112.9	113
RSDP III (2007-2010)	14,686	12,395	93	34,643.9	34,957.8	101
RSDP IV (2010-2015)	97,517	85,859	88	125,409.1	157,082.8	125
Total/Average	**129,597**	**118,969**	**92**	**185,851.8**	**217,438.0**	**117**

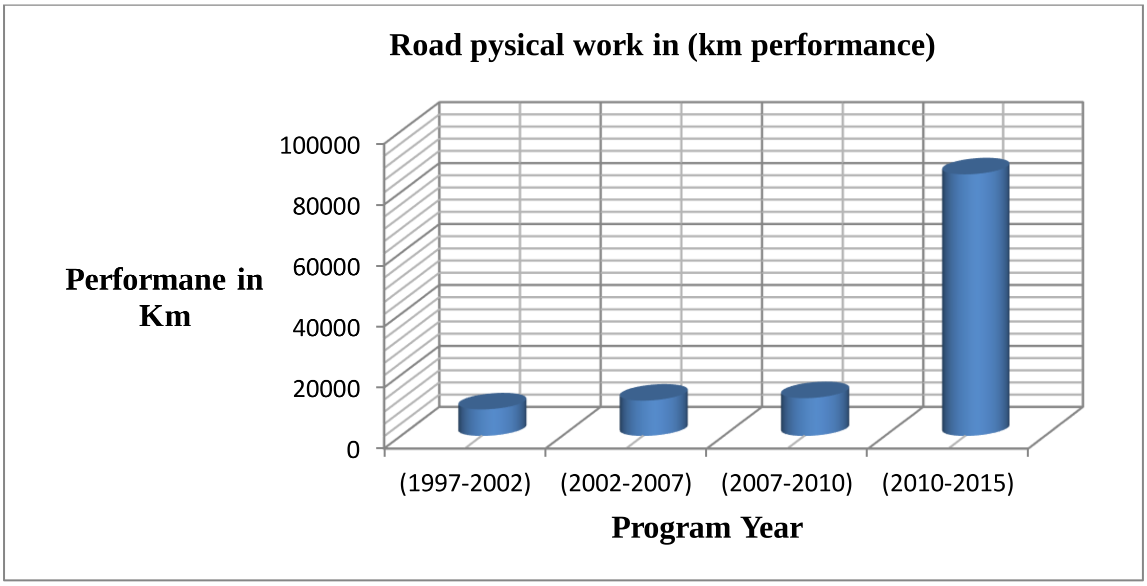


Figure 2.1 Road Network in Ethiopia by Road Type (in km) (Source: ERA, 2013)

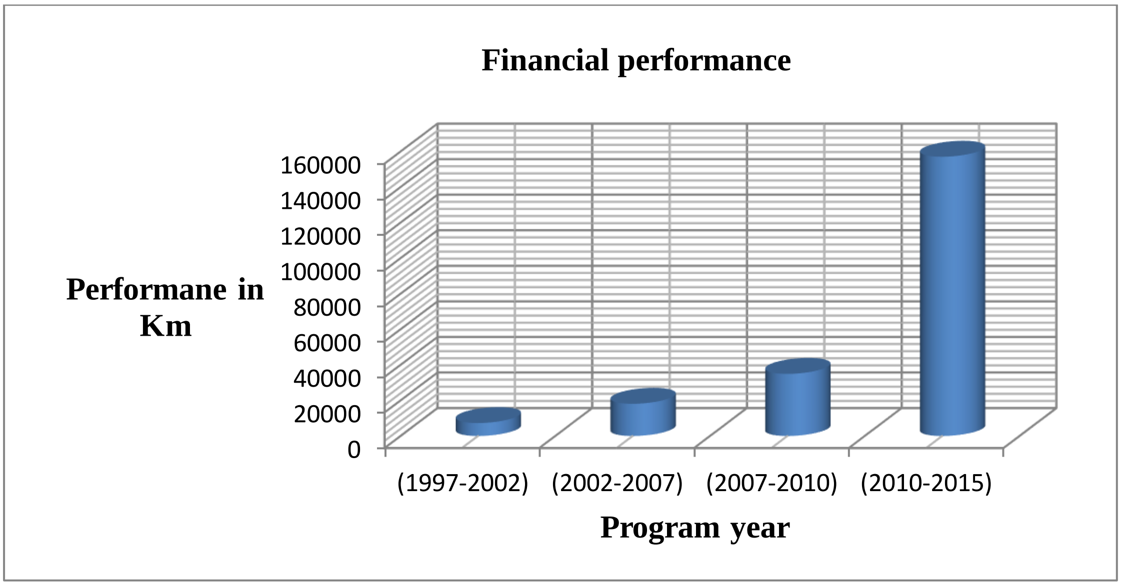


Figure 1.2 Road Investments in Ethiopia by Road Type (in km) (Source: ERA, 2013)

In 2014, the total stock of road network reached nearly 100,000 km of which majority are either rural or Woreda level roads constituting around 73 percent; while asphalt roads constituted only 13 percent. Since 2011, there has been huge Woreda and rural road construction indicating government emphasis on rural road.

2.7.2 Road Accessibility

In 2017/18, annual average distance from all-weather roads declined by 6.5percent from 4.6 km in 2016/17 to 4.3km. Similarly, the proportion of area more than 5km from all-weather roads dropped to 31.6 percent from 33.5percent last year.

Table 1.2 Road Accessibility,(Source: ERA, 2013)

Indicator	2016/17	2017/18	Percentage change
Proportion of area more Than 5 km from all-weather road	33.1	31.6	**-5.7**
Average distance from all- Weather roads	33.5	31.6	**-6.5**

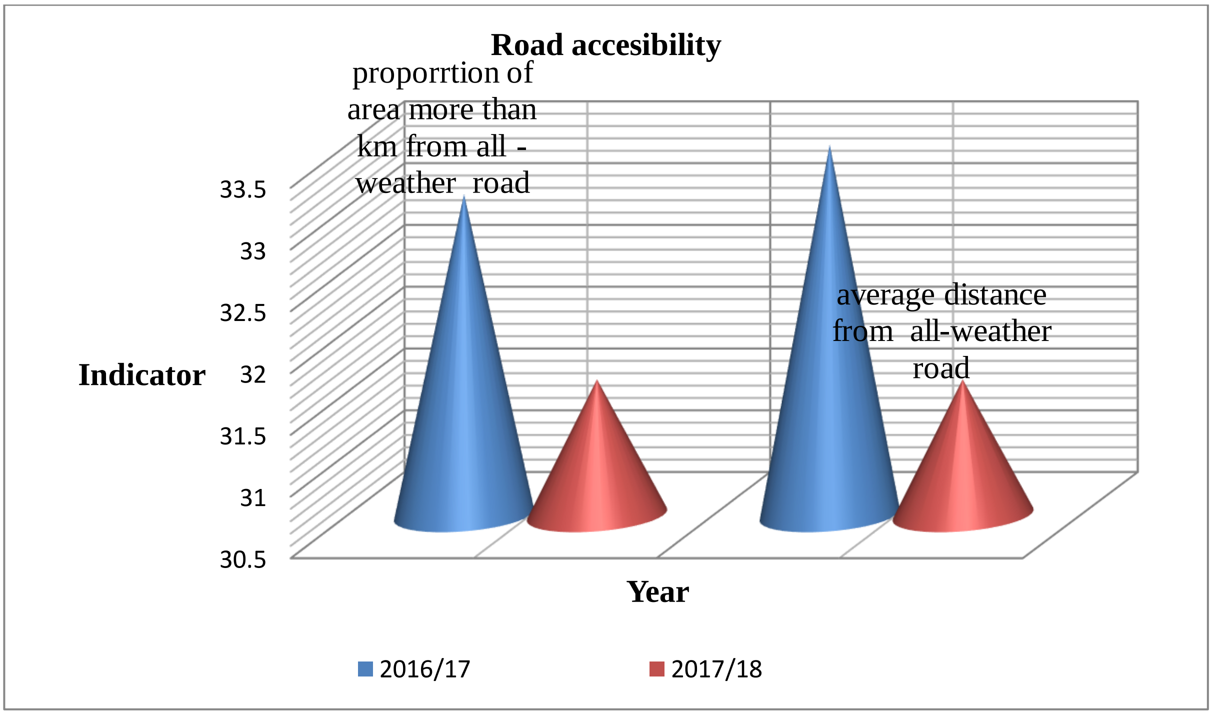


Figure 2.2 Road Accessibility Indicator (Source: ERA, 2013)

2.7.3 Road Density

At the end of 2017/18, road density per1, 000 square Km increased to 115.2 km from 109.2 km a year ago depicting a 5.5percent improvement over the previous year. Meanwhile, road density per 1,000populations was 1.27 km which shows slightly down ward movement by 1.6percent when compared with 1.29 km a year ago.

Table 2.3 Road Density, (Source: ERA, 2013)

Year	Road Density /1000 person	Road density /1000 sq.km
2004/05	0.50	33.70
2005/06	0.53	35.90
2006/07	0.55	38.60
2007/08	0.56	40.30
2008/09	0.57	42.60
2009/10	0.60	44.40
2010/11	0.65	48.30
2011/12	0.75	57.30
2012/13	1.00	78.20
2013/14	1.10	90.50

2014/15	1.20	100.40
2015/16	1.23	102.80
2016/17	1.29	109.20
2017/2018	1.27	115.20
Growth rate	-1.6	5.5

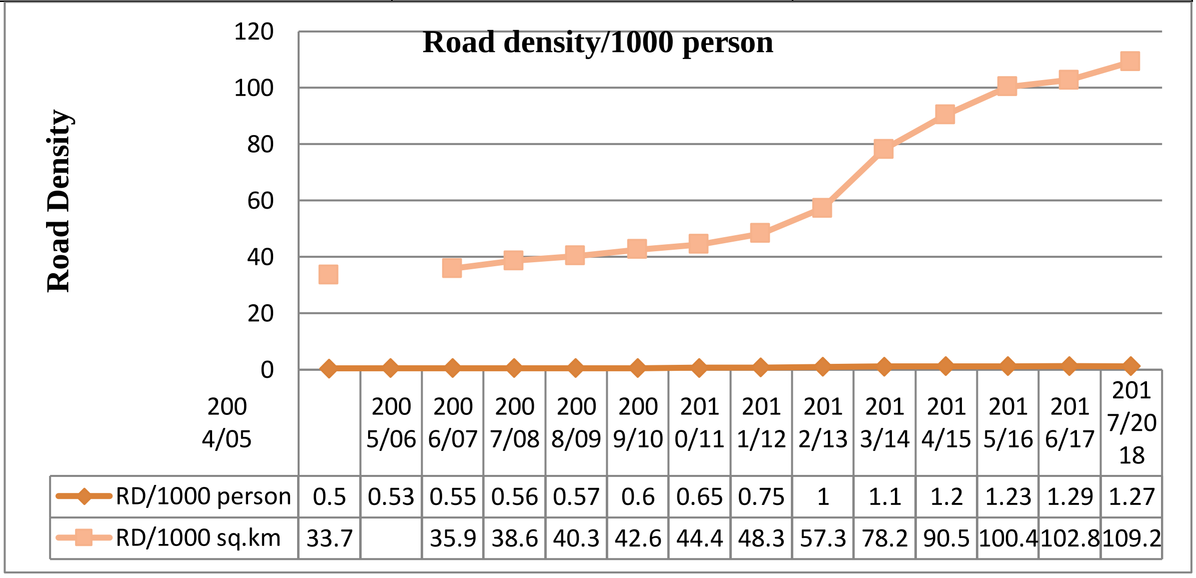


Figure 2.3 Road Density /1000 person,(Source: ERA, 2013)

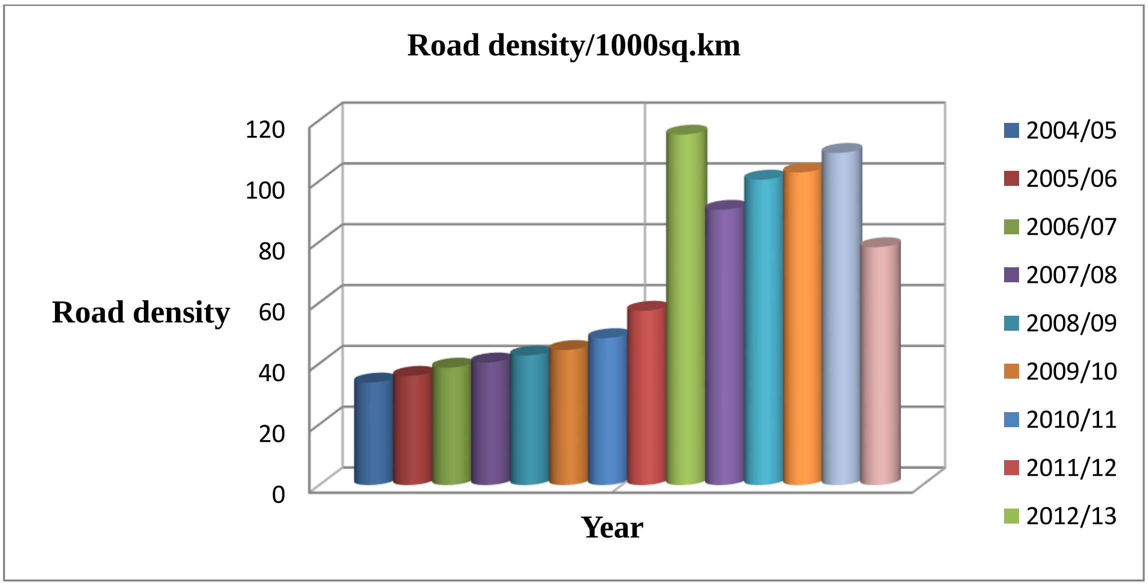


Figure 2.4 Road density /1000 sq.km,(Source: ERA, 2013)

2.7.4 Impact of Rural Roads

The impact of rural roads on income, poverty reduction, economic growth, employment, agricultural output and sales, education, health, traffic volume, transport services and costs within the rural areas are reported in the following sub-sections.

a. Income

The evidences presented in Table below suggest a positive impact of rural roads on income and household consumption of grains and non-food items.

b. Poverty reduction

Rural roads are seen to have an important impact on poverty reduction, particularly for areas in less developed counties that did not previously have access to transport infrastructure, such as Ethiopia and Nepal. For example in Ethiopia, the presence of rural roads reduced the chance of households becoming even poorer due to calamities such as droughts.

c. Employment

The studies presented in Table 4 suggest that rural roads have a positive impact on the choice of occupation and on job creation. Apart from the study by Wagale et al. (2019) it was also found that access to rural roads results in an increased and waged jobs and mobility of labour from rural to urban areas and from agriculture to non-farm employment. These impacts were most significant among households without land. The studies in Table 4 confirm the findings from the systematic review by Hine et al. (2016), that investment in rural roads consistently promotes and increase in non-agricultural employment.

d. Agricultural output and sales

The studies given in Table 5 show a diversity of effects on agriculture from better access and reduced transport costs. For Ethiopia (Nakamura et al. 2019) improved roads and reduced transport costs were shown to have an important positive effect on increasing agricultural production.

h. Transport costs

Rural roads were found in the studies identified to benefit rural households by reducing the transport costs of both passengers (of up to 65%) between and goods (up to 35%).

i. Economic indicators

The studies reported in the Table below suggest positive impacts of rural roads on a variety of economic indicators, although the Asher and Novosad (2018) suggest relatively weak returns compared with the costs.

Table 2.2 Impact of Rural Roads, (Source: Weisbrod 2000)

Impact of rural roads on income		
Country	**Study**	**Effect of rural roads**
Ethiopia	Nakamura *etal.* (2019)	While average household consumption increased between 2012 and 2016 by 16.1%, the increase was larger amongst remote communities' at., 27.9%.
Impact of rural road on poverty		
Ethiopia	Nakamura *et al.* (2019)	Results suggested that when connected to rural roads, rural residents were about 10.4 percent less likely to fall into or remain in poverty between 2012 and 2016. Moreover, rural roads households with rural roads exposed to the 2015/16 drought lowered their chance of becoming poor by around 14.4%.
Impact of rural road on employment		
Ethiopia	Nakamura *et al.* (2019)	Access to rural roads increased the share of household members with waged jobs by 2.8%. The impacts were particularly large among women (+2.6%) and the youth (+7.5%) in remote areas.
Impact of rural road on agricultural output		
Ethiopia	Nakamura *et al.* (2019)	Rural households were 3.6% more likely to use fertilizer when provided with access to a rural road resulting in an average 32.2% increase in the amount of crops sold by rural household. In remote areas, households were 16.1% more likely to sell crops when connected to rural roads.

Impact of rural road on transport costs		
Ethiopia	Stifel *et al.* (2016)	The study showed that a hypothetical rural road project that reduces the transport cost for each household by 50 US$/m ton would benefit household consumption by around 35%, with a range of 15% to 54%.
Impact of rural road on economic indicators		
Ethiopia	Stifel *et al.* (2016)	It was estimated that internal rates of return for hypothetical gravel roads was is the range of 12% to 35%.

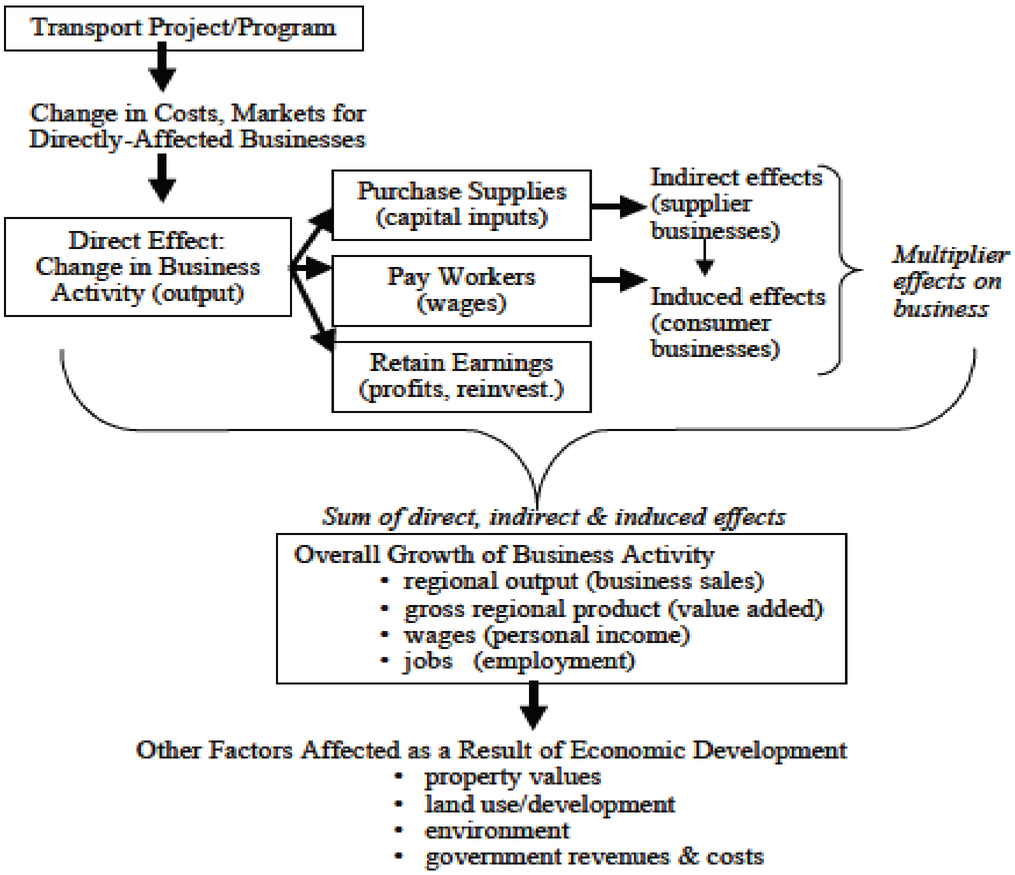


Figure 2.5 A Flowchart Identifying the Economic Impacts Due to Transportation Investments (Weisbrod 2000)

2.8 Socio-economic Evaluation

Economic feasibility studies analyse the relation between the costs and benefits of a project. But cost-benefit analysis (CBA) is only one aspect of economic evaluation. The evaluation should ask broader questions to address socio-economic impacts overall. The socio-economic analysis should assess the rationale for public intervention and whether the intervention is the most appropriate means of addressing that rationale. On the issue of institutional arrangements, the evaluation should focus heavily on assessing whether the various agents involved have the proper incentives to realize the desired outcomes.

The main purpose of project socio-economic evaluation is to help design and select projects that contribute to the welfare of a country. It is most useful when applied early in the project cycle and of very limited use when employed once the project is committed.

2.8.1 The nature of economic costs and benefits

For most infrastructure projects, annual operating and maintenance costs will relate to the capital cost of the project. Other costs will include land costs and environmental and social mitigation costs including resettlement costs. Some costs are difficult to quantify and some costs are not quantifiable such as the impact on the landscape. For most transport projects, the major economic benefits are derived from vehicle operating cost (VOC) savings, computed and valued in compliance with the road user (consumer) surplus theory. Benefits for road users may also include reduced driving time, reduced driving costs, fewer accidents, and environmental improvements.

The comparison of traffic volumes, with and without the project, constitutes the basic principle of the analysis. However, in the case of low-traffic roads it may be necessary to consider additional benefits related, for instance, to development of agriculture, improved access to water supply, health or education (see also below “specific issues concerning rural roads”).

There are also three main “intangibles” for which market valuations are not always directly available and which the subject of debate as to their quantification is therefore. These are:

- Time savings
- Accident savings
- Environmental Impact

In developing countries, there has been a tendency in the past to treat transport project savings related to operating costs as more “real” than savings in travel time. Rates of return have therefore sometimes been estimated initially excluding time values, and enhanced rates including time valuation given as an extra. To justify a project without recourse to time savings was viewed as a test of robustness. This attitude is changing and time savings are often accepted as a legitimate element of benefit. As a compromise, sometimes only working time savings are only fully valued by relating to wage rates with non-working time valued much less.

In developed economies, time savings are usually the main economic benefit of a new infrastructure. In some countries standard values of time shall be used in evaluation. Using standard values of time savings in a country promotes equity among different regions and different socio-economic categories.

The valuation of accident savings has been even more controversial, and in particular the question of valuing of pain and grief, including the loss of life. Increasingly, there is a requirement that safety audits be performed on project designs. This may have the effect of incorporating the costs of accident prevention measures within the overall project costs, without considering the counterpart benefits resulting from these safety improvements as project benefits, hence understating the true rate of return.

According to World Bank practice (other international donors have a similar approach),all projects are pre-classified according to whether they have zero, small or large environmental impacts. Those with non-zero impacts are required to have environmental impact assessments (EIA), and to contain mitigation measures to counter any adverse effects. This mandatory requirement covers the more obvious, immediate, consequences of projects. It does not, however, deal with more subtle effects, either positive or negative, associated with traffic generation or modal shift effects. However there is no objection in principle to the inclusion of such environmental effects in the economic evaluation, and it is increasingly done, and always in cases which are primarily viewed as environmental projects. This partly reflects the absence of adequate data on the physical impacts of specific interventions, as well as the absence of evaluation conventions.

For low traffic roads, user cost and time savings may be small and therefore accident and environmental benefits can be significant and again are increasingly included in the economic evaluation of highway investment.

2.8.2 The Impact of Socio-Economic

Usually when talking about socio-economic impact in relation to road condition we are looking at costs for road users and road managers. The road user costs are related to the road conditions. A road with high roughness and rutting causes bigger costs than an even road. To keep a road in good condition will cause costs for the road manager like rehabilitation costs and costs for normal and routine maintenance. The road managers are aiming for minimising the total costs, which are the sum of the road user costs and the road manager costs. This can be done by using different types of socio-economic models dealing with **cost-benefit analyses** (CB-analyses). Most of these models are working on road network level and are not suited to the low volume roads. In the Northern Periphery of Europe we are dealing in most cases with low volume roads in rural areas and in cold climate, so the currently available models will not be useful to give good road conditions. Therefore there is a need to look at other complementary methods and models to justify a good road standard also on low volume roads. In this case there is a need to lay stress upon the social benefits of keeping roads in rural areas in good condition. The social benefits though are often very difficult to measure in monetary terms.

Different policies and strategies can be used to keep roads in a proper condition. One policy can be to introduce minimum road condition levels on different parameters like roughness and rutting, sometimes called “shame levels”. These levels can be defined from comfort considerations and road user costs. They can also be defined locally from social considerations for people living in rural areas. They normally have a long way to go for public services, cultural events and all other needs. If the roads are in bad condition travel will be both long and uncomfortable. The levels can also be defined from professional drivers’ work environment requirements. The levels can be included in the Pavement Management Systems and be used to select maintenance candidates. They can also be included in the road maintenance codes and in the routine maintenance contracts.

Depending on the reasons mentioned above we will give the concept **socio-economic impact** a wider meaning in this report. I will examine the prevailing methods and models used today in the literature and in the member countries and try to sort out the good parts, which promote my aims.

2.8.3 Description of the problems justifying the Task

Bad road conditions will create big problems and costs for the society but it is not so easy to show the magnitude of these costs compared to other needs in the society. The budgets for road maintenance and rehabilitation will be allocated in competition with other sectors in the society like medical attendance, education and social welfare. The budgets also have to compete with other budgets for other transportation alternatives like railway and air transportation. When it comes to low volume roads it is very difficult to find economic motives to justify good road conditions. In the budget competition they have to fight the resource need for maintenance of high- and medium trafficked roads in urban and rural areas.

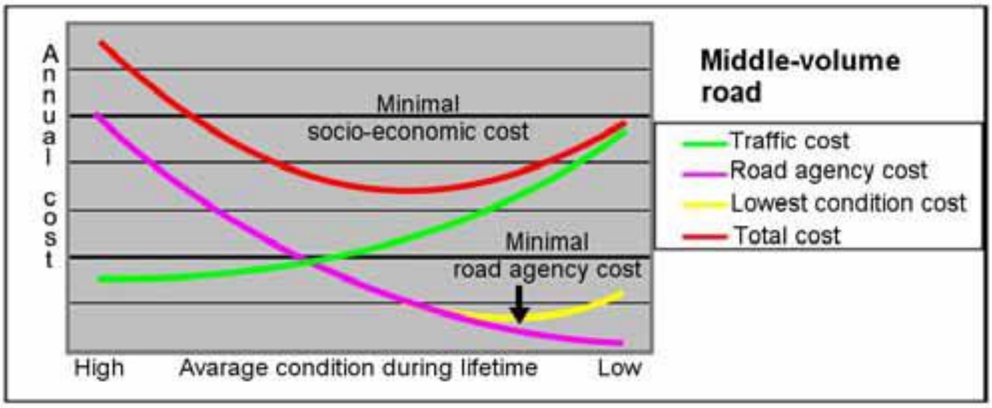


Figure 2.6 Principles for minimizing the socio-economic costs for road maintenance,(Source: Weir and McCabe 2012)

In rural areas the road network is in most cases the only possibility to move goods and people from one place to another. It is the vital nerve for many people in the Northern periphery. If the road does not work properly it will affect many urgent things in the society, like

- Business profitability
- Investments
- Tourism
- Service levels
- The social life.

The road condition will also have a great impact on the road user in action. It will affect his behaviour on the road e g make him change speed, force him to do turning movements or even make him take another road if possible. It will also have impact on his economy. A road in bad condition will increase vehicle cost, increase travel time and might even give damage to the carried loads. It will also influence the accident rate and the comfort for the road users. This means that there are many reasons why the socio economic consequences should be taken into consideration when allocating budgets for low volume roads, when selecting roads for maintenance and rehabilitation and when choosing maintenance strategies for the selected roads.

2.8.4 Factors affecting socio-economic impacts

There are many factors on road networks, which are affecting the socio-economic impacts for areas, people and the society. There are for instance:

- The road condition
    - Roughness
    - Rutting
- Friction
    - Cracking
    - Bearing capacity
    - Edge deformation
- The road alignment
    - Horizontal curves
    - Vertical curves
- The road width
- Amount of traffic
- Load restrictions
    - Permanent restrictions
    - Periodical restrictions
- Speed limits
- Environment

2.8.5 Why Economic Impact Analyses Are Conducted

Prediction and Evaluation EIAs are conducted to either

- **Predict** future changes in the economy in response to changes in future infrastructure investments or policies (all EIAs completed for transportation projects also predict economic impacts), or
- **Evaluate** changes in the economy from a project or policy implementation, past or current.

Generally, highway widening projects, regardless of type, produce temporary negative effects on abutting businesses, residents, and property owners during the construction period. Businesses and tax revenues are the most negatively affected, especially for projects requiring considerable right-of-way. However, the local construction expenditures offset much of the negative effects (Buffington & Wildenthal 1998, p. 50).

Motivations

Three major motivations for predicting or evaluating economic impacts are to

- Satisfy regulatory requirements.
- Provide public information and planning guidance.

Develop research findings for policy development, academic study, and/or advancement of transportation economics

2.9 Estimation of Welfare Value

Changes in traveller welfare can be estimated using the Rule of Half (RoH).Figure 2.7 shows the gain in traveller welfare (surplus) when travel cost falls. The benefit to existing users equals Area 2, while the benefit to new users equals Area 1. The RoH assumes a linear demand function between before and after demand points for each origin-destination pair.

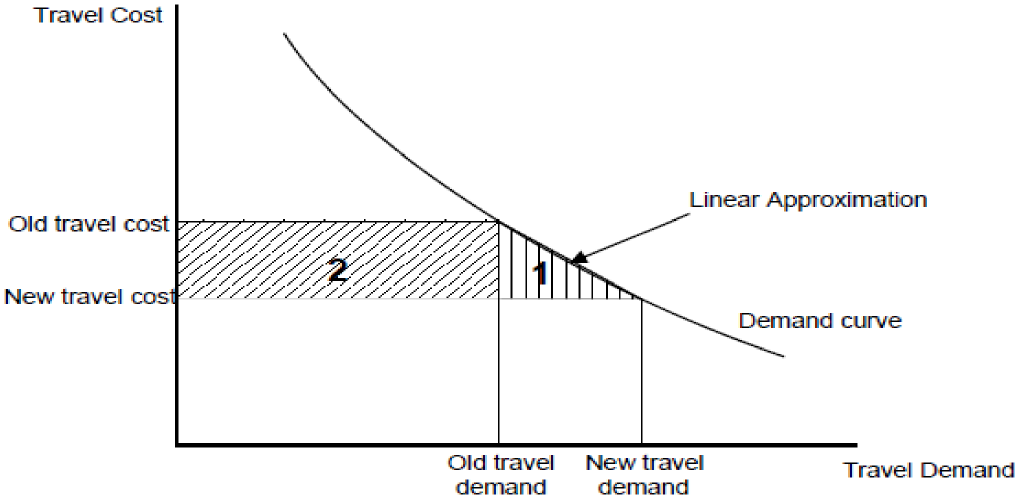


Figure 2.7 Estimation of Welfare Value, (Source: S-cool.co.uk, undated 2014)

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of the study area

The study area is located in Sidama Region which is one of the regional administrations which is found in the southern parts of Ethiopia. It is located in the north eastern part of the SNNP region and bounded by Oromiya in the Northeast and southeast, with Gedio Zone in the South, and Wolayta Zone in the west. Its geographic location lies between 60 14'and 70 18' North latitude and 370 92'and 390 14' East longitude. The total area of the Sidama Administration Region is about 6981.8 Sq.Km. It consists of 36 Woreda and 5 administrative towns (Socio-economic profile of Sidama Zone, 2011EC)

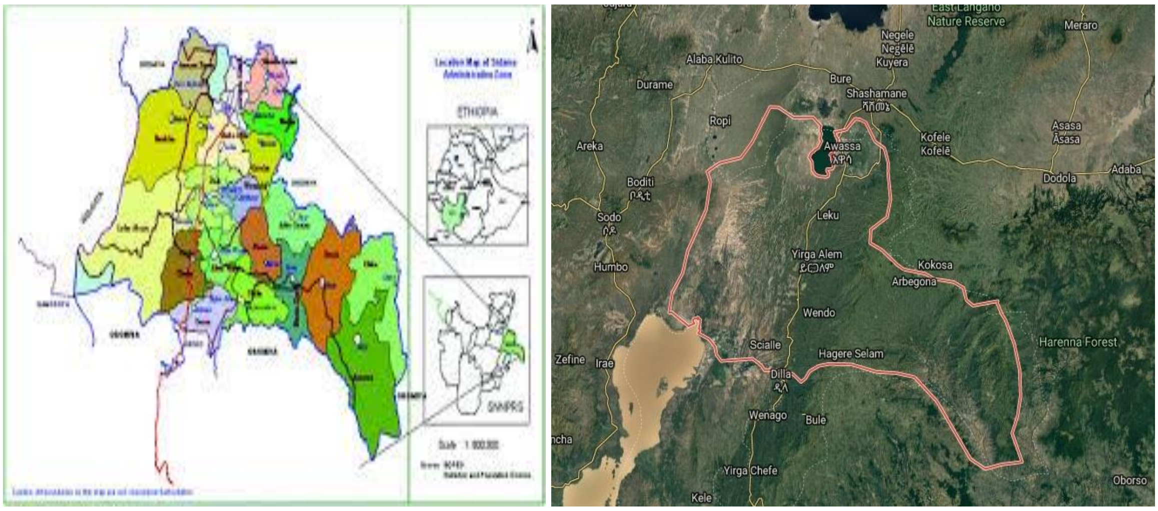


Figure 3.1 Map of Sidama Region showing the location of the Study Area and Sidama Region Administration Map (Source: Regional Administration of Sidama (2020).

3.2 Demographic Characteristics

A study of population can provide the basis to understand and to design the development needs such as infrastructure, health centres, educational institutions, etc. It is also important for the wise use of resources by matching with the size of population. For the year 2011, Sidama population was estimated to be about 3,277,078.The population of Sidama is highly distributed in areas where there is fertile land water and pasture. The Sidama Region is one of the most densely populated areas in the country. Even within the Region there is a great variation within the Woreda in population density.

According to the 2007 population census the annual population growth rate of Sidama administration is 2.8% per year in rural areas and 4.8% in urban areas (CSA, 2007).

3.3. Economic Sectors

Agriculture is the backbone of Ethiopia's Economy. It is also major and dominant economic sector in the Sidama Region. As it is economic base of all over the country, agricultural production is the pre-dominant activity of the region which encompasses crop and livestock production. However, due to cultural and environmental factors, peasants in the region mainly depend on enset and coffee for consumption as well as for cash income. Since the area is mainly known for its cash crop the contribution of rural road is so high in order to increase the economic value of coffee product (Socio-economic profile of Sidama Region, 2019EC).

3.3 Land Use/Land cover

The Sidama Region is among the potentially rich natural resource areas of the country. Intensive agriculture and livestock farming, and dense tropical forest areas characterize the land use feature of these areas. The Woreda traversed by the road are dominantly intensively cultivated and forest covered in the Sidama Region.

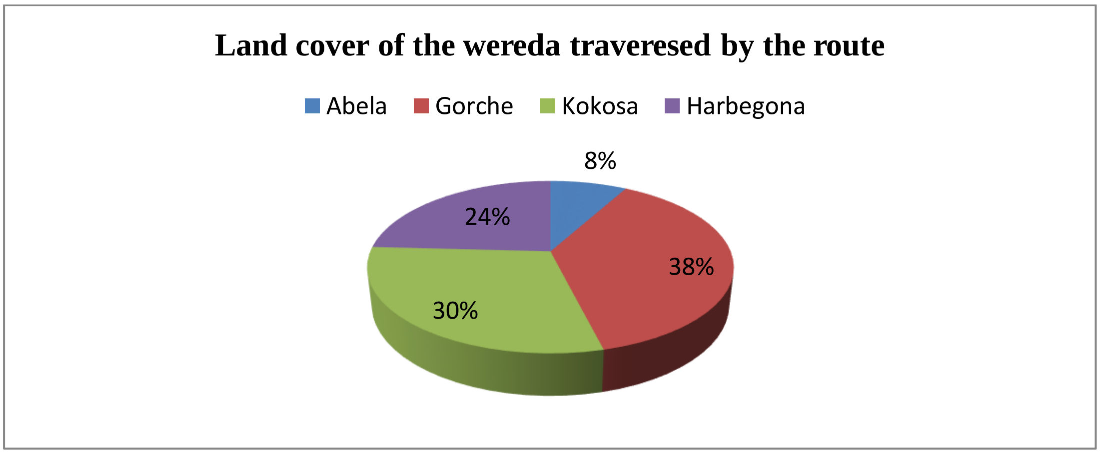


Figure 3.2 Land use/Land cover of the Woreda traversed by the road route, (Source: Harbegona Woreda Road and Transport Office)

3.4 Road Condition Surveys

Overall road condition data is often supplied by regional and district engineers on a regular basis using simple classifications of "very good, good, fair, poor, very poor" categories. However, it is well recognized that these subjective evaluations are very inconsistent, and may be influenced by the road agency's need to meet internationally set targets.

Road roughness is the key driver of vehicle operating costs and, overall it is critical for the assessment of overall road condition. Roughness data is useful for assessing the quality of different components of the rural network, for indicating when maintenance or investment should take place and to assist with road impact evaluations. However, roughness can change very quickly on unpaved roads with traffic, rainfall, and maintenance treatment. Nevertheless, it is recommended that objective roughness measurements be taken of the unpaved road network. It is very useful to know the frequency of grading and regravelling.

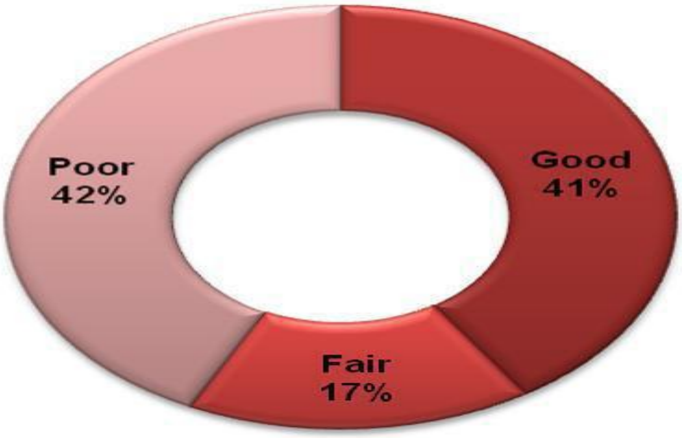


Figure 3.3 Road Condition Surveys throughout the route' (Source: Authors' Survey, 2021)

3.5 Transport Cost-Benefit Analysis

Conventional Cost-Benefit Analysis (CBA) is the most widely used procedure for planning road investment. The approach is adopted in the road planning modelsHDM-4 and RED. The main focus is to maximize economic welfare and perhaps its biggest strength is that it can discriminate between different projects and engineering designs on a rational basis. The main economic components of a Cost-Benefit Analysis (also common to other forms of CBA) are as follows:

- First round effects and secondary benefits
- Project and alternative case
- Planning time horizon, discounting and residual values
- Use of economic prices and inflation
- Road investment and maintenance costs
- Estimating traffic benefits (normal, diverted and generated traffic)
- Forecasting traffic
- Estimating generated traffic
- Vehicle Operating Costs
- Value of passenger time
- Accident rates and costs

- Economic decision criteria
- Strengths and weaknesses of transport – Cost-benefit analysis

3.5.1 First Round Effects and Secondary Benefits

Any procedure to analyse benefits should be designed to provide *maximum coverage of the costs and benefits* without *double-counting*. Transport Cost-benefit analysis focuses on the direct ‘*first round*’ effects of road investment on traffic and transport costs. The assumption is that these will broadly capture the costs and benefits of road investment without double counting. Because the approach measures benefits to the consumers of transport, it is sometimes referred to as the Consumers Surplus approach.

In contrast, road impact studies also include the wider *‘secondary benefits’* of road investment on the total economy. These are much more difficult to estimate, particularly ‘ex ante’, in advance of the investment. It would clearly be double counting to crudely add the primary traffic based benefits to an estimate of the overall secondary benefits. As an example, one approach of measuring secondary benefits is to estimate the rise in land values, or land rents, following a road investment. Because these arise as direct result of reduced transport costs, it would be double-counting to add transport cost savings to the rise in land values G.P. Ong et.al (2012).

3.5.2 The Project and Alternative Case

To carry out an economic evaluation it is necessary to identify a “*base” or “without investment” case* in order to make a comparison with different “*project”* or “*with investment” cases.* Different forecasts are prepared of both traffic volumes and transport costs and road maintenance costs to estimate net benefits.

In order for the economic analysis to be as realistic as possible the base case should include a level of road maintenance that is appropriate to the expected traffic volumes. It is sometimes easy to artificially inflate the value of a project case by assuming an unrealistically poor base case with little or no maintenance. Such practices should of course be avoided. Whatever base case is used it is important to include a “minimum do something” case, in other words, a case where the minimum of new investment or other measures are assumed, such as increased maintenance, to address the problem.

3.5.3 The Planning Time Horizon, Discounting and Residual Values

The Planning Time Horizon is the period over which the economic analysis is to be carried out. The choice of time horizon should reflect the economic lifetime of major assets in the investment. In general, main roads are evaluated over a 20 to 30 year period, while rural roads are more commonly evaluated over a 10 to 20-year period. Because of the nature of the way that costs and benefits are valued in the future (using an economic discount rate) those that occur in the distant future are valued less than those that occur in the near future. Using a 10.23% discount rate a dollar's worth of benefits occurring in the 25th year will only be valued at 0.066 percent, although for traffic benefits, this will be substantially mitigated by a high traffic growth rate.

Traditionally, the economic discount rate has been viewed as the opportunity cost of capital, which varies from country to country. The World Bank has used a 12 percent discount rate for most of its work, primarily to ration its funds. A lower rate can be used for projects particularly focused on the poorest sections of society. Residual values of major investments are sometimes used in an economic analysis. These should reflect the remaining economic life of an investment. In most instances because of discounting these values will usually have little impact on the outcome of the analysis?

3.5.4 The Use of Economic Prices and Inflation

To carry out an economic evaluation all costs and benefits need to be expressed in economic price terms (shadow prices). Prices should reflect the value that society places on the use of the resource excluding distortions resulting from taxation, subsidies, license fees, and legislation and other market imperfections.

Taxation and license fees do not represent a demand on real resources but transfer of spending power to the Government and hence in determining the economic price the taxation component should be subtracted from the market price. In contrast, an item that is subsidized is under-valued and hence the subsidy element should be added back in.

Depending on economic conditions, it is sometimes appropriate to make other adjustments to determine economic prices. When there is very substantial unemployment in the economy it is argued that the market price for unskilled labour does not properly reflect the true economic cost and hence the value should be adjusted downwards.

Other distortions can arise if the exchange rate between local and foreign currency is kept at an artificial level; hence, there may be a need to adjust the relative prices of imports and exports. Sometimes in feasibility studies, a very detailed *shadow pricing analysis* is carried out in which a range of adjustment factors are calculated and applied.

For most feasibility studies appropriate economic prices can be determined from adjusting market prices for taxation and subsidies. For many countries, *Standard Conversion Factors* are published to convert market prices to economic prices. In an economic analysis, all prices used throughout the analysis should be in *constant price* terms and refer to a given date. Hence, there is no reason to adjust future costs and benefits for forecast price inflation Shuo Li (2013).

3.5.5 Road Investment and Maintenance Costs

Investment and maintenance costs should be incorporated into the economic analysis using economic rather than market prices. The Standard Conversion Factors are particularly useful for converting construction and maintenance costs to market prices inroad appraisals. This will avoid a separate detailed study to achieve the same result.

The new investment and maintenance costs that are to be incurred in a project should be phased into the economic analysis at the time of their main economic consequences. The environmental appraisal will often identify measures that should be taken to minimize the effects of environmental disruption (e.g. sound barriers or tree planting).These costs should also be included within the investment costs of the project.

3.5.5.1 Maintenance Priorities

There is general broad agreement over which maintenance activities should take priority. The Transport Research Laboratory’s Overseas Road Note 1 (TRL Ltd, 2003) presents priorities based on a combination of treatment type and traffic volume. The heaviest trafficked roads have priority over lower trafficked roads. In terms of treatment, the highest priority task is emergency work, designed to keep the road open to It is interesting to note under this approach that recurrent pavement work has a higher priority than periodic work. This reinforces the results of an analysis using the road-planning model HDM-4. In general, the results suggest that unpaved road grading is extremely cost effective with high economic returns. In contrast regravelling, because of its high expense generally provides much lower economic returns and is often uneconomic for lower traffic volumes, if the alternative is to maintain a high grading frequency of an “earth” surface because the gravel is lost.

The importance of keeping roads open for traffic on very low traffic roads is graphically shown in Figure below. The curved line, showing the Marginal Productivity of Maintenance Expenditure, for earth or gravel roads initially in very bad condition, demonstrates that starting with very little expenditure the value of each dollar spent on maintenance rises quickly as access is established for around 95 percent of the year. It then falls as further access is established and flattens out as further maintenance is spent to achieve roughness reduction. The graph is useful in helping road organizations determine priorities if maintenance funding is limited. Following this is routine drainage work, routine pavement work and the periodic work such as regravelling and surface dressing.

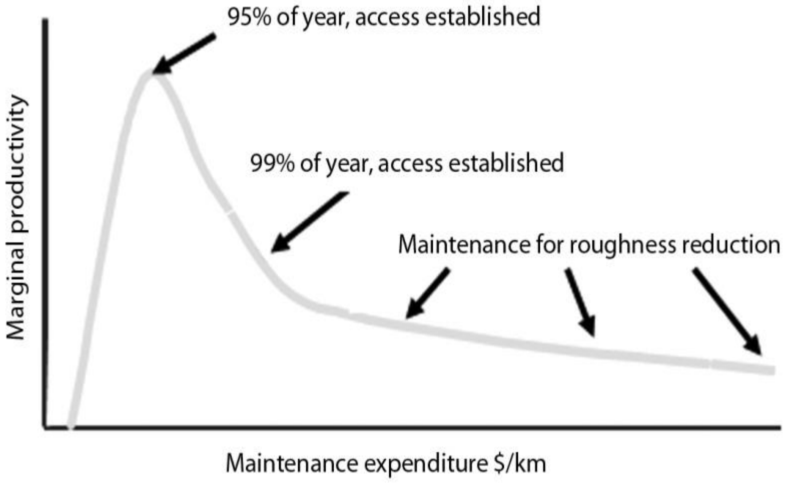


Figure 3.4 Marginal Productivity of Maintenance Expenditure on Low Traffic Roads (Source: S-cool.co.uk, undated, 2012)

3.5.5.2 Estimating Traffic Benefits

In order to evaluate traffic benefits, it is useful to separate traffic into the following categories:

a) Normal traffic. The traffic volume that is forecast to travel on the same route in both the base and project cases.

b) Diverted traffic. Traffic, travelling between the same origin and destination that is forecast to switch routes as a result of the investment.

c) Generated traffic. An increase in traffic volume that is forecast to arise, because of lower operating costs, directly as a result of the road investment.

Normal (and diverted) traffic benefits are valued in terms of the forecast traffic volume multiplied by the forecast change in transport costs. In Figure 10, as transport costs reduce from C1 to C2, normal traffic benefits are shown to be equivalent to the area C1, X, Y, and C2.

Generated Traffic is valued as the forecast traffic volume multiplied *by half the difference in operating costs*. This “rule of half” is based on the assumption that whilst some users would value the improved travel at virtually the full difference in transport costs for many other users the trip is only just worth making at the new lower cost. The assumption is that half the difference in operating costs represents a reasonable approximation for all generated traffic. Generated Traffic benefits are assumed to be half the difference in transport costs between the 'with' and 'without' cases, i.e. the triangular area X,Y, Z.

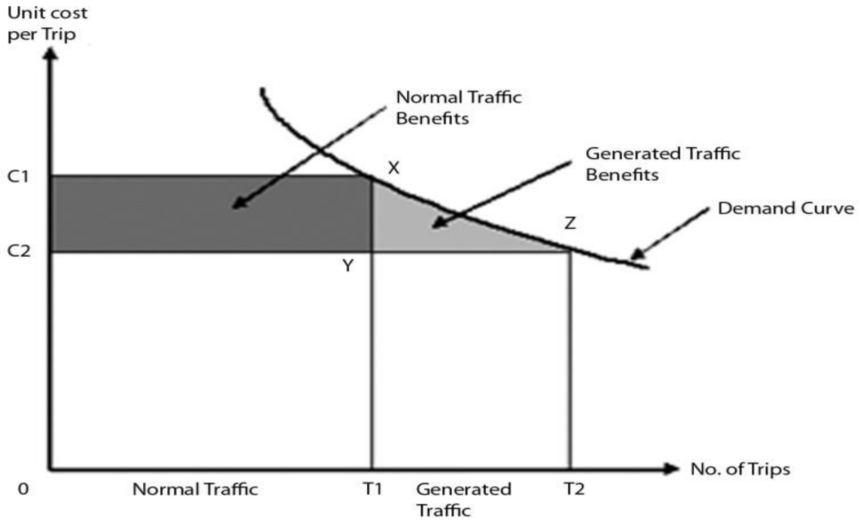


Figure 3.5 Normal and Generated Traffic Benefits Using the Consumers' Surplus Approach' (Source: Archondo Callao (2004)

3.5.5.3 Economic Decision Criteria

A range of decision criteria (such as Net Present Value, NPV and Internal Rate of Return, IRR) are used to help identify the best investment solution. Each has its particular strengths and weaknesses. With a cost-benefit analysis, a number of decision criteria can be established. Assuming an appropriate discount rate and all underlying assumptions are correct, *a project will be economically worthwhile if the NPV is greater than zero.* The higher the NPV, the greater the net benefits of the project. If there are no budgetary constraints and there is confidence in all underlying assumptions, then *the choice between two alternative projects should be based on the NPV*. Because discounted cost and benefit streams can be easily added or subtracted, the NPV approach is suitable for assessing projects built from separate components, such as when different minor projects are combined together, or when a road project is combined with another form of investment such an agricultural development scheme.

The ENPV is the sum of the differences between the discounted benefit and cost flows, and can be estimated as:

$$\mathrm{ENPV} = \sum_{t=1}^{n} \frac{\mathrm{B_{t-}C_t}}{(1+r)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \text{Equation (3.1)}$$

Where *Bt* is the gross economic benefit in year *t, Ct* is the sum of economic costs (including capital costs, operating maintenance costs, and negative terminal values)in year *t, r* is the required economic discount rate, and *n* is the project life.

The EIRR is the discount rate at which the ENPV becomes zero, and it can be estimated from the following:

$$\sum_{t=1}^{n} \frac{\mathrm{B_t}}{(1+r)^t} - \sum_{t=1}^{n} \frac{\mathrm{C_t}}{(1+)^t} = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \text{Equation (3.2)}$$

Where *r* is the EIRR, at which, the sum of the discounted stream of economic benefits equals that of the economic costs of a project.

The BCR is the ratio of the sum of the present value of the project benefits to the sum of the present value of the total project costs, and it can be estimated as:

$$\mathrm{BCR} = \sum_{t=1}^{n} \frac{\mathrm{B_t}}{(1+r)^t} \div \sum_{t=1}^{n} \frac{\mathrm{C_t}}{(1+)^t} = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \text{Equation (3.3)}$$

However, when project costs *Ct* include only fixed investment cost and exclude operation and maintenance costs, this is called the net BCR.

When there is only one project option and there are no alternatives to compare with and choose from, the ENPV, the EIRR, and the BCR should yield the same result: accept the project when its ENPV calculated using a minimum required discount rate is positive, or when the EIRR is greater than the minimum required discount rate, or when the BCR calculated using the minimum required discount rate is greater than 1. However, when an investment has several alternative project options that are mutually exclusive, the ENPV, the EIRR, and the BCR may or may not yield the same result. In such cases, the use of the ENPV is recommended.

The CER is the ratio of the present value of a project's investment and operating costs to the present value of the project output or outcome. The CER is mainly used for selecting the best project option when project benefits cannot be adequately valued and economic viability requires selecting the option with the least cost per unit of output or outcome. The CER is also useful in situations where project benefits can be valued and project alternatives have the same benefit flows so that investment decisions involve two steps, with the first step choosing the project option with the lowest CER; and the second testing whether the ENPV at the minimum required discount rate is positive or the EIRR is greater than the minimum required discount rate. The CER can be calculated as follows:

$$\mathrm{CER} = \sum_{t=1}^{n} \frac{\mathrm{C_t}}{(1+r)^t} \div | \sum_{t=1}^{n} \frac{\mathrm{O_t}}{(1+)^t} = 0 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \text{Equation (3.4)}$$

3.6 HDM-4 Economic Analysis Methodology

For all of the analysis options discussed in the prior section, the methodology used to perform the economic analysis in the HDM-4 software requires a high level of comprehension and in-depth knowledge of network constraints from the user. Information such as present value unit costs of M&R treatments are required to perform an accurate analysis. Past treatment history, as well as the usual minimum treatment applied, play a role in accurately forecasting the condition treatment recommendations. The remainder of this section provides an in-depth description of each of the three analysis options introduced before.

The project analysis of the HDM-4 software is not restricted to any type of M&R treatments. That is, it is capable of evaluating treatments from routine works to higher impact projects such as road reconstruction, road widening and introduction of new road segments. Primary candidates for project analysis consist of M&R plans that will be implemented to fewer pavement sections; this type of analysis is primarily made available to address unexpected M&R, such as new construction within a city.

The project analysis can then be evaluated in two ways, either through analysis by section or analysis by project. Tables 3.1 and 3.2 are excerpts from The Highway and Management Series Collection (Morosiuk et al., 2006) which illustrate the capabilities of project analysis. The alternatives in the tables below are chosen and entered into the software by the user in terms of available resources.

Table 3.1 Analysis by Section (Morosiuk et al., 2006)

Road Section	Section Alternative				
	1 Base Alternative	2	3	4	5
Section A	Routine Maintenance	Resealing	Overlay		
Section B	Routine Maintenance	Overlay	Reconstruction	Widening	
Section C	Routine Maintenance	Resealing	Rehabilitation	Lane addition	Realignment
Section D	Grading 1/year	Regravelling	paving		

The program analysis is applicable when a budgetary constraint is present and a defined set of roads are prioritized for M&R treatment within a year or a multi-year program. As stated earlier, the program analysis is begun by selecting candidate road segments section by section.

Table 3.2 Analysis by Project (Morosiuk et al., 2006)

Road Section	Project Alternative			
	1 Base Alternative	2	3	4
Section A	Routine Maintenance	Resealing	Reconstruction	Realignment
Section B	Routine Maintenance	Overlay	Mill & replace	Widening
Section C	Routine Maintenance	Inlay	Reconstruction	Lane addition
Section D	Grading 1/year	Regravelling	Widening	Upgrading
∑Project NPV	0	∑ NPV	∑ NPV	∑ NPV

Usually the candidate roads are those that may require maintenance for safety issues or are in dire need of rehabilitation or reconstruction. There are two methods to execute the program analysis within the software, the life cycle cost analysis and the multi-year forward program, both of which add to the comparative power of the software in terms of economic analysis. For both cases the "prioritization method employs the incremental NPV/cost ratio as the index, which provides an efficient and robust index for prioritization purposes" (Morosiuk et al., 2006).

The life cycle cost is applicable when current budgetary constraints are known between a year and 2 years in the future with high certainty, (typically for most local governments budgetary constraints are known on an annual basis). These constraints help prepare a detailed plan for each year and the ability to invest current budgets in pavement sections that may be in critical condition and address the removal of backlog. This analysis provides the results of implementing M&R treatments to road sections with a constrained budget. If the budget limit does not allow for M&R treatment it is pushed forward to the next year. Table 3.3 illustrates an example of a life cycle analysis plan.

Table 3.3 Program Analyses - Life Cycle Analysis (Morosiuk et al., 2006)

Section Alternative	**Assignments**	**Year**
Base Alternative	Minimum Maintenance	From year 1
Year 1 - Periodic Maintenance	Periodic Maintenance	From year 1
Year 2 - Periodic Maintenance	Minimum Maintenance	From year 1
	Periodic Maintenance	From year 2
Year 3 - Periodic Maintenance	Minimum Maintenance	From year 1
etc	Periodic Maintenance	From year 3
	Etc	etc

The multi-year forward plan is designed for agencies that have a significant knowledge of what their budgetary restrictions are for future years. This allows the capability of applying substantial efforts of M&R to a pavement network until the year's budget is consumed, leaving pending work to roll into the next year. For this analysis "economic calculations are done by comparing investments made within the budget period against deferring the action to the first year after the budget period" (Morosiuk et al., 2006). Alternatives for the multi-year forward plan can be selected by the user in terms of IRI condition, and be set to engage when a pavement section reaches a specific threshold.

Treatment Alternative Specifications (Morosiuk et al., 2006)

Reseal	When 3 < Roughness < 4 IRI
Overlay	When 4 < Roughness < 6 IRI
Reconstruct.	When Roughness > 6 IRI

For both of the life-cycle and multi-year forward program, the final step consists of budget optimization. The final optimization selects treatment options resulting in higher NPV/C ratio as the recommended treatments.

Table 3.4 Multi-Year Forward Program for Three Years (Morosiuk et al., 2006)

Section	Programme Period Alternative 1			Deferred works Alternative 2
	Year 1	**Year 2**	**Year 3**	**Year 4**
S1	Reseal			Overlay
S2	Overlay			Reconstruct
S3		Reseal		Overlay
S4			Reseal	Reseal

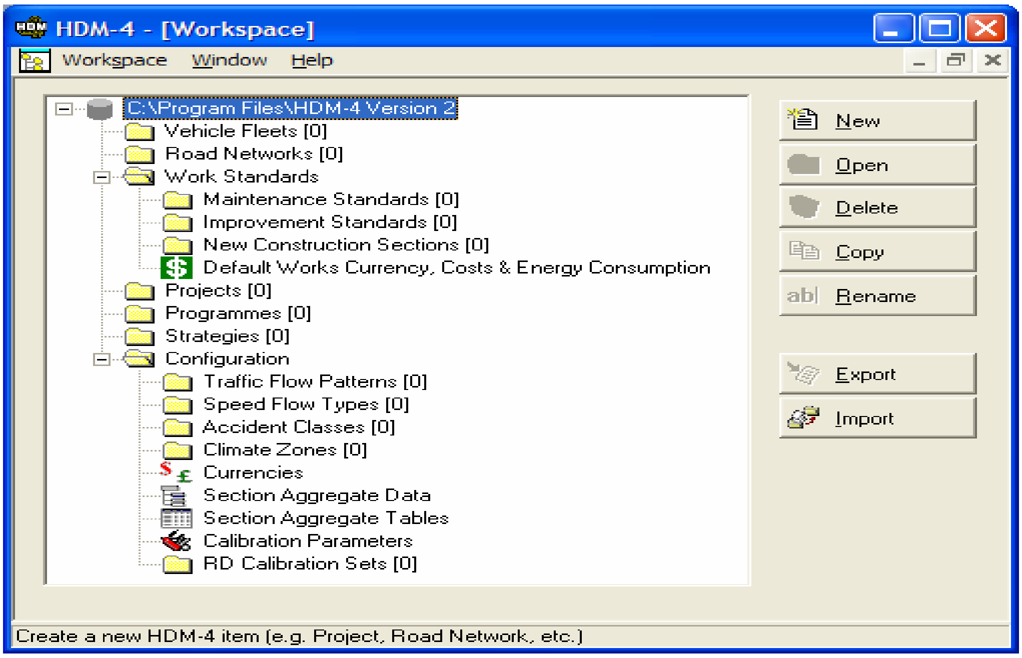
Strategy analysis is conducted to evaluate the entire pavement network. The purpose of this type of analysis is to achieve either one of two goals. The first is to determine how much funding is required, or will be required to maintain the pavement network at an agency defined "good" level of service. The second goal is to determine how the network will perform with a set budgetary constraint already in place. This is conducted through three optimization models that are available within HDM-4.

Objective Function	**Constraint**
Maximize benefit (NPV)	Financial agency costs
Maximize improvement in network Condition(roughness)	Financial agency costs
Minimize agency costs	Target network condition (roughness)

In essence, the HDM4 software has the following 5 main modules (refer to FIGURE 3.6):

- Vehicle Fleet
- Road Network
- Works Standards
- Analysis module (Projects, Programmes and Strategies)
- Configuration

Pertinent aspects of the HDM4 workspace will be discussed below under headings corresponding to the above modules. The discussions that follow are in no way meant to be exhaustive.



Create a new HDM-4 item (e.g. Project, Road Network, etc.)

Figure 3.6 HDM4 software modules showing an "empty" workspace.(Source: Rena Shukla (2005))

3.7 Functions and cycles

When considering the HDM-4 applications, it is convenient to view the highway management process in terms of the following functions (Robinson et al, 1997):

- Planning
- Programming
- Preparation
- Operations

3.8 Management functions

The above functions are normally carried out as a sequence of activities referred to as the *management cycle*. These are described in the following sections.

3.8.1 Planning

This involves an analysis of the road system as a whole, typically requiring the preparation of long term, or strategic, planning estimates of expenditure for road development and preservation under various budgetary and economic scenarios. Predictions may be made of expenditure under selected budget heads, and forecasts of highway conditions in terms of key indicators, under a variety of funding levels.

The physical highway system is usually characterised at the planning stage by lengths of road, or percentages of the network, in various categories defined by parameters such as road class or hierarchy, traffic flow/capacity, pavement and physical condition. The results of the planning exercise are of most interest to senior policy makers in the road sector, both political and professional. Work will often be undertaken by a planning or economics unit within a road agency.

3.8.2 Programming

This involves the preparation, under budget constraints, of multi-year road works and expenditure programmes in which those sections of the network likely to require maintenance, improvement, or new construction, are identified in a tactical planning exercise. Ideally, cost-benefit analysis should be undertaken to determine the economic feasibility of each set of works. The physical road network is normally considered at the programming stage on a link-by-link basis, with each link characterised by pavement sections and geometric segments, defined by their physical attributes. The programming activity produces estimates of expenditure, under different budget heads, for different treatment types and for different years for each road section. Budgets are typically constrained, and a key aspect of programming is to prioritise works to find the best value for money in the case of a constrained budget. Typical applications are the preparation of a budget for an annual or rolling multi-year work programme for a road network, or sub-network.

Programming activities are normally undertaken by managerial-level professionals within a road agency, perhaps in a planning or a maintenance department.

3.8.3 Preparation

This is the short-term planning stage where road schemes are packaged for implementation. At this stage, designs are refined and prepared in more detail; bills of quantities and detailed costing are made, together with work instructions and contracts. Detailed specifications and costing are likely to be drawn up, and any cost-benefit analysis may be revised to confirm the feasibility of the final scheme. Works on adjacent road sections may be combined into a package of a size that is cost-effective for work execution. Typical preparation activities are: the detailed design of an overlay scheme; the detailed design of major works, such as a junction or alignment improvement, lane addition, etc. For these activities, budgets will normally already have been approved.

Preparation activities are normally undertaken by relatively junior professional staff and technicians in a technical department of a road agency, and by contracts and procurement staff.

3.8.4 Operations

These activities cover the on-going operation of a road agency. Decisions about the management of operations are made typically on a daily or weekly basis, including the scheduling of work to be carried out, monitoring in terms of labor, equipment and materials, the recording of work completed, and the use of this information for monitoring and control. Activities are normally focused on individual road sections with measurements often being made at a relatively detailed level. Operations are normally managed by sub-professional staff, including works supervisors, technicians, clerks of works, and others.

3.9 Definition of cases

Two hypothetical futures exist in any CBA process: the future with a project (project case) and the future without a project (base case). A successful CBA is dependent on the accurate and complete definition of both hypothetical cases within the model.

The base and project cases provide a comparison for calculating costs of capital investments and as such, the difference between them measures the change in total surplus attributable to an investment. The first hypothetical case is the base case, which has previously been described as the world without a project. The base case should represent all future programmed and required investment based on the current level of service (business as usual). For example, when defining the base case of a highway upgrade project, it would not be accurate to exclude programmed maintenance. It is more likely that in the absence of a project the road would deteriorate to such a point where maintenance would be required. If maintenance were to be omitted, it is likely that the CBA would distort the results of a project.

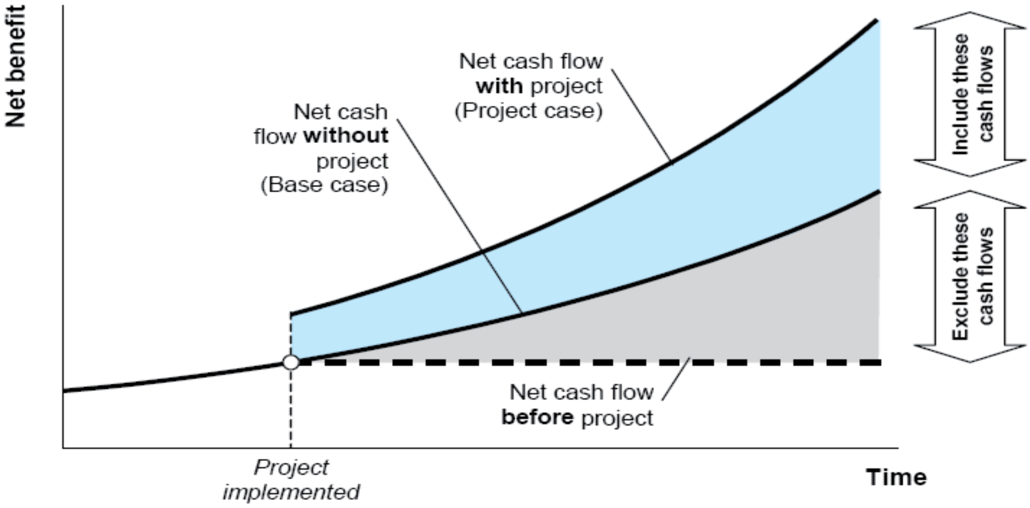


Figure 3.7 Base Case Definitions. (Source: Austroads (2005))

The project case is often more easily specified than the base case due to the amount of planning involved, and represents the future with a project. Accurate definition of the project case is required for an accurate CBA. In practice, inaccurate CBA is often the result of incomplete, incorrect or inaccurate specifications of the evaluation cases. Therefore, it is necessary to ensure that the base case and project case specifications are a true reflection of the hypothetical worlds. Any incorrect specification of these cases can lead to misleading results either understating or overstating the net worth of a project. As the purpose of the CBA is to provide decision makers with enhanced information sets with which to make allocation choices, misleading results must be avoided.

3.9.1 Optimization

To reach the optimum the aim is to minimize the socio-economic costs for the road manager, the road user and the rest of the society. In road maintenance this means to aim for the lowest sum of these costs as shown in a sketch in figure 10. If the budgets are too small the roads will deteriorate and the road user costs will increase.

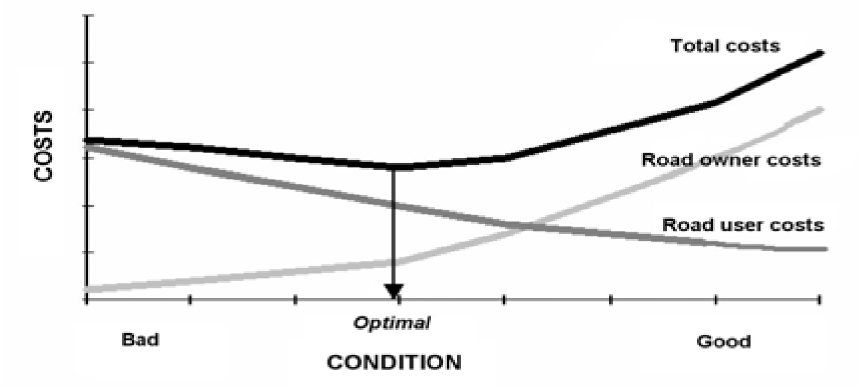


Figure 3.8 Principle sketch of an optimal road network condition.(Source: Sangwan SS, (2010)).

3.9.2 Costs-effectiveness

Cost-effectiveness or value for money stands at the core of any sound investment programme. It is also fully embedded in the procedures and structure of the cohesion policy of the Commission in which cost-benefit assessments of proposed projects are standard procedure. Also EIB applies CBA as standard assessment methodology before granting new loans.

The cost-effectiveness criterion is especially important if budget resources are limited. In this case cost-benefit analyses can be used to phase foreseen transport investment in time or to seek alternatives with a similar functionality that offer a higher value for money. Costs differ strongly per type of investment projects.

3.9.3 Strengths and Weaknesses of Transport – Cost-benefit analysis

The biggest strength of a Transport Cost-benefit analysis is that it can discriminate between different transport projects and different engineering designs on a rational basis. However, there are still major problems with valuing many of the components, including vehicle operating cost savings. Its main weaknesses, based on transport costs, are that it is not so good at dealing with:

- poverty and income inequality issues
- externalities (environment, national security and integration)
- social and economic issues relating to major changes in accessibility (e.g. dealing with new vehicle access or seasonally impassable roads)
- procedure, where there are major uncertainties with forecasting outcomes

3.10 RED Model

Traditional methods of economic appraisal are generally not suitable for the appraisal of low volume roads. However improved appraisal methods are increasingly able to capture the social benefits arising from the provision of adequate road infrastructure (Pinard2004). As rural roads are most often characterized by low traffic volumes appraisal should ideally be done with a tool specifically designed for low volume roads. The need for the RED Model was based on the fact that the HDM-4 model mainly focuses on higher volume roads, where the VPD are more than 200. For these purposes the Roads Economic Decision Model (RED) was developed by the World Bank (World Bank2003).

By adopting appraisal methods that are able to capture the non-economic benefits of low-volume road provision, e.g. the Roads Economic Decision (RED) Model, the socio-economic impact of rural road investment can be determined. This model is specifically aimed at improving the decision-making process for the development and maintenance of low-volume roads and can perform an economic evaluation of road investment options. The RED Model is aimed at improving the decision-making process for the development and maintenance of low-volume roads. The model performs an economic evaluation of road investment options. Benefits are calculated for the respective traffic components (i.e. normal, generated, induced and diverted traffic) and are also expressed mainly in terms of savings in vehicle operating costs, travel time and accident costs.

RED address the following main concerns related to low-volume roads:

- Reduce the input requirements;
- Takes into consideration the higher uncertainty related to the inputs;
- Allows for the incorporation of induced / development traffic;
- It computes internally the generated traffic due to the decrease in transport costs based on a defined price elasticity of demand;
- Quantifies the economic costs associated with the days-per-year when the passage of vehicles is further disrupted by a highly deteriorated road condition;
- Optionally, it use vehicle speed as a substitute parameter to road roughness to define the level of service of low-volume roads (vehicle speeds and possibility);
- Includes road safety benefits;

- Includes in the analysis other benefits (or costs) such as those related to non-motorized traffic, social service delivery and environmental impacts, if they are computed separately;
- It allows the use of MCA indicators to assist in the ranking of individual projects

Once you have used the Main Economic Evaluation Module to evaluate a given road, you can then use the Risk Analysis Module, which performs risk analysis using triangular distributions for the main inputs. The Risk Analysis Module interacts with the Main Economic Evaluation Module evaluating hundreds of what-if scenarios to yield the corresponding risk analysis results. The figure below presents the interaction between these RED modules.

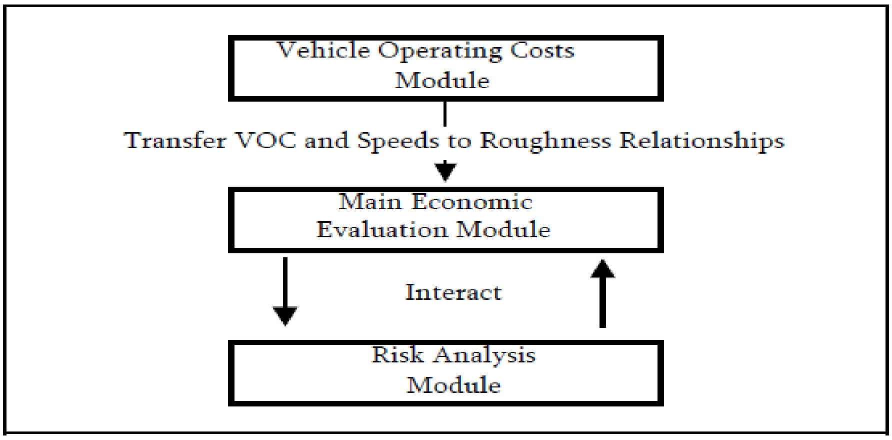


Figure 3.9 The interaction between these RED modules.(Source: RED User & Case Studies (Version 3.2)).

If you are evaluating many roads, you have two options:

a) Use the Main Economic Evaluation Module for evaluating each road one at a time, including risk analysis if necessary; or

b) Use the Program Evaluation Module to evaluate many roads at once and obtain the corresponding program results.

The RED workbooks can be located on any Windows folder and can be renamed if necessary. It is recommended that you make copies of the original workbooks and keep the originals in a safe place. You can then work on copies of the original workbooks, giving to them, if necessary, and unique workbook names. To print any of the worksheets, use the print commands of Excel.

Main Economic Evaluation Module

The Main Economic Evaluation Module is the main module and performs the economic evaluation of up to three project-alternatives for a given road. You define the current road characteristics and traffic and the features of four possible maintenance or improvement cases, one being the without project case and the other three being possible project-alternatives. The model evaluates the total transport costs of all four cases and computes the net benefits of the three project-alternatives compared with the without project case.

The names of the seven available input worksheets are given below. On these worksheets, you enter your inputs on all cells having a yellow background.

- Control and Setup
- Unit VOC and Speeds
- Time and Accidents
- Traffic
- Multi-Criteria Indicators
- Project-Alter. Main Features
- Project-Alter. Other Benefits

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Data Inputs for HDM-4 Analysis

The HDM-4 programme requires extensive data inputs. However the data types are structured into sensitivity classes and information quality levels in terms of the magnitude of impacts and the level of detail required for each application level. The details of the data sensitivity classes, the data quality levels, as well as the data collection and processing methods used are discussed in the following paragraphs and the framework of presentation is illustrated in Figure 4.1.

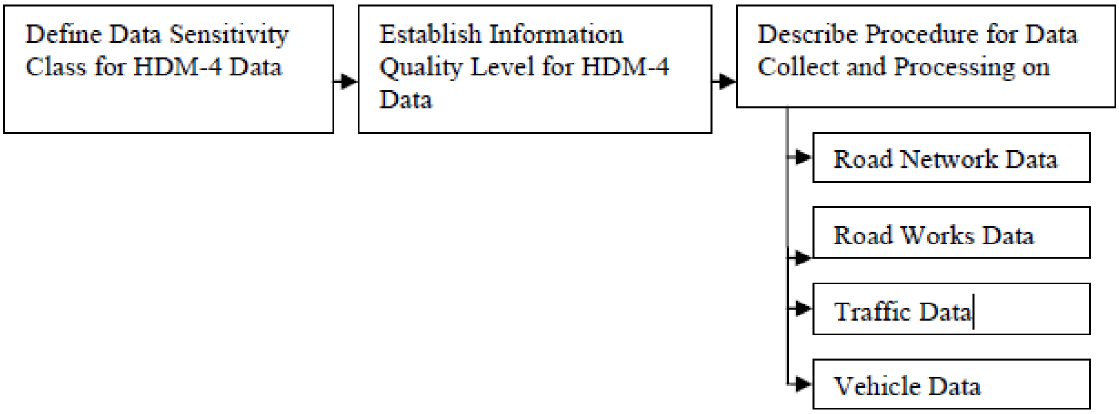


Figure 4.1 data collection procedure. (Source: Robinson et al (1998))

4.2 Traffic Count

The main objective of a traffic count is usually to obtain an accurate estimate of the Average Annual Daily Traffic (AADT), which can then be used, for example, for an economic road appraisal. In general, the lower the traffic volume the greater the daily variability. Hence, because of the low traffic volumes in rural areas, it is important that the traffic count be conducted over sufficient time to smooth out factors such as market days, peak harvest time, public holidays, religious festivals and weekends. It is often recommended that a seven day count be carried out, covering market and non-market days for the 12 daylight hours, with two days covering 24 hours to help estimate night time movements. Motorized traffic usually falls in the wet season and so, if possible, the counts should be taken twice per year to cover wet and dry seasons.

Table 4.1 ERA Vehicle Classification. (Source: High way Capacity Manual HCM 2010)

Vehicle classification	Description
1. Passenger Vehicles	
1.1. Cars	Small automobiles
1.2. Land Rovers	4WD and utility vehicles
1.3. Small Bus	Buses up to 25 passenger seats
1.4. Medium Bus	Buses with 25 up to 45 passenger seats
1.5. Large Bus	Buses with over 45 passenger seats.
2. Freight Vehicles	
2.1. Small Truck	Trucks of capacity up to 3.5 tons load.
2.2. Medium Truck	Trucks of capacity 3.5 up to 7.5 tons load.
2.3. Heavy Truck	Trucks of capacity over 7.5 tons load.
2.4. Truck and Trailer	Articulated Trucks and tanker trailers of capacity over 12 tons load.

The traffic count data collected on a directional basis for the road. That is, there are four traffic data collected from Tulla to Kenera and Kenera to Yaye taking into account the traffic in both directions.

The traffic count data is summarized and presented in the tables below.

Table 4.2 Traffic Count Data for Tulla Kenera Direction. (Source: Authors' Survey, 2021)

Day	SC	MC	4WD	LB	MB	LT	HT	TT	Total
16/01/2021	38	46	59	61	40	68	35	8	355
17/01/2021	27	40	51	49	33	65	33	6	304
18/01/2021	20	44	56	56	39	57	38	7	317
19/01/2021	24	38	53	47	41	70	29	8	310
20/01/2021	23	42	48	51	37	61	43	5	310
***20/01/2021**	12	22	25	40	21	55	47	2	224
21/01/2021	34	42	47	53	42	56	40	6	320
***21/01/2021**	8	17	25	37	18	45	35	4	189
22/01/2021	45	48	51	44	35	63	32	8	326

Table 4.3 Traffic Count Data for Kenera Yaye Direction.(Source: Authors' Survey, 2021)

Day	SC	MC	4WD	LB	MB	LT	HT	TT	Total
16/01/2021	35	41	52	63	33	72	31	7	334
17/01/2021	23	35	48	41	30	61	34	5	277
18/01/2021	18	40	51	53	36	50	39	6	293
19/01/2021	25	41	49	50	34	62	43	5	309
20/01/2021	23	42	45	51	37	61	43	5	307
***20/01/2021**	10	18	21	44	23	47	48	3	214
21/01/2021	47	48	54	44	35	65	34	9	336
***21/01/2021**	7	15	22	30	24	38	36	3	175
22/01/2021	33	42	47	53	45	44	50	5	319

4.2.1 Determination of Annual Average Daily Traffic

The annual average daily traffic (AADT) of the project road was determined based on the traffic count data from counting stations by considering the night and seasonal adjustment factors in to consideration. Night factors were applied to convert the 12 hour count data to an equivalent 24 hour count data, ADT. The night factor for each vehicle type is obtained by taking the ratio of the number of vehicles for the 24 hour counts to the corresponding 12 hour counts on the days when 24 hour counts were conducted. To get reasonable values of night factors, the average values of the two days 24 hour counts were used.

The annual average daily traffic (AADT) of the project road by the year 2012 is computed by multiplying the ADT of the count period with seasonal adjustment factors. The seasonal adjustment factor is calculated by reviewing past traffic data.

The tables below will show the Average day (12 hrs) traffic data obtained from the traffic count, the night factor, seasonal correction factor and the AADT.

Table 4.4 Adjusted Average Daily Traffic for Tulla Kenera Direction. (Source: Authors' Survey and calculation, 2021)

	SC	MC	4WD	LB	MB	LT	HT	TT	Total
Average of 12hr Data	30	43	52	52	38	63	36	7	321
Night Factor	1.35	1.46	1.5	1.7	1.5	1.85	2	1.5	
Seasonal Factor	0.83	0.91	1.01	0.81	0.76	0.91	0.91	0.87	
AADT 2021	**34**	**57**	**79**	**72**	**43**	**106**	**66**	**9**	**466**

Table 4.5 Adjusted Average Daily Traffic for Kenera Yaye Direction. (Source: Authors' Survey and calculation, 2021)

	SC	MC	4WD	LB	MB	LT	HT	TT	Total
Average of 12hr Data	29	41	49	51	36	59	39	6	310
Night Factor	1.2	1.4	1.4	1.8	1.6	1.7	2.1	1.4	
Seasonal Factor	0.83	0.91	1.01	0.81	0.76	0.91	0.91	0.87	
AADT 2021	**29**	**52**	**69**	**74**	**44**	**91**	**75**	**7**	**441**

4.2.3 Traffic Forecasting

A general traffic forecasting approach is considered for the project road compared to a road specific projection. In general, traffic or transport demand is a derived demand driven by growth in population, the economy and personal incomes. Forecasts of these factors are therefore required to make accurate traffic forecasts. Traffic growth can also be related to the growth in fuel consumption and vehicle fleet; therefore trends are also developed for these parameters. Moreover, estimates of income elasticity, relating traffic growth directly to forecast changes in national income, are often applied in making forecasts.

4.3 Road network

Defines the physical characteristics of road sections in a network or sub-network to be analyzed. The road network data includes both the functional condition and the structural condition. The obtained raw data was processed using the software's provided and validated by the equipment manufacturers. The secondary data like the details of earlier M&R works were collected from SRA. All the data obtained are compiled to the format, which is specified by HDM–4 input standards. The road network is shown in Table below.

Table 4.6 Road Network data. (Source: Authors' Survey, 2021)

ID	Section Name	Road Class	Road Type	Length (km)	Width (m)	AADT Year
TKRS	Tulla Kenera	Secondary	Gravel	30	6	2021
KYRS	Kenera Yaye	Secondary	Gravel	23	6	2021

4.4 Vehicle Fleet Data

This includes the parameters of the representative vehicles, which are considered to be playing in the study road network. The representative vehicles were considered based upon the classified traffic volume study. The raw survey data was obtained and was corrected by considering appropriate correction factors to obtain the corresponding Annual Average Daily Traffic (AADT). The economics of the standard vehicles are worked out and is shown in Table below.

Table 4.7 Basic characteristics of vehicle fleet.(Source: ARRB Group Ltd adapted from Austroads (2015)).

Base Type	Tire Type	Annual Km	Annual Working Hours	Average Life in Years
Car Small	Radial Ply	18000	500	10
Car Medium	Radial Ply	35000	1100	9
4WD	Radial Ply	80000	2000	9
Light Bus	Radial Ply	80000	2000	9
Medium Bus	Radial Ply	80000	2000	9
Light Truck	Radial Ply	50000	1300	9
Heavy Truck	Radial Ply	50000	1800	10
Articulated Truck	Radial Ply	70000	2000	10

4.5 Cost Data

The various M&R works and the vehicles have a cost attached to it and also the Vehicle operation costs and the cost of time of the passengers and goods which are carried are an important component in calculating the economics of the road network and help in selecting the best M&R strategy so that best economic outcomes are obtained. The cost data in this study are calculated based on the schedule of rates and also the various taxes and other costs are calculated and considered.

4.6 Economic versus financial analysis

Often the differences between economic and financial analysis are not thoroughly understood. The purpose of economic evaluation is to provide a view on the feasibility of investment from the national, resource viewpoint. It differs from financial analysis which provides information on the direct financial implications of investment including profitability. Economic evaluation, therefore, considers only resource costs and excludes transfers such as taxes and subsidies. It also takes into account the price of local (non-traded) inputs which may be overpriced or under-priced relative to market conditions. Minimum wages may overprice labour relative to its market value and subsidies, say for fuel or water, may under-priced inputs. Shadow pricing i.e. adjusting for market imperfections and transfers is the mechanism by which these market defects are overcome, and all economic costs and benefits brought to the same yardstick.

Therefore the general equation is:

Economic price (cost) = (market price – taxes + subsidies) * Opportunity cost of local inputs

This means that after subtracting monetary transfers, the local factor inputs such as labour, materials, transport etc. are valued at their opportunity (or market) cost. Imports are usually priced at market levels. A further important difference is that in an economic evaluation the situation “with project” is compared with the one “without project” i.e. we are only concerned with the difference. By contrast, in a financial analysis, only the return on investment of the ‘with’ project is considered.

The financial analysis consists in comparing revenue and expenses (investment, maintenance and operation costs) recorded by the concerned economic agents in each project alternative (if applicable) and in working out the corresponding financial return ratios.

Unlike the economic analysis, the financial analysis is only concerned with the direct financial costs and revenues of a scheme or project and also only the impacts on the specific organizations concerned not to the country. Usually tolls are not directly included in the economic evaluation to compute total benefits(except in the case of generated traffic) they nevertheless constitute a key factor of the economic analysis, as the level of tolls are likely to affect the transport demand and hence the economic worth of the project (in particular the economic rate of return).

Table 4.8 Financial cost characteristics of vehicle fleet. (Source: ERA, 2011)

Name	New Vehicle	Tire Cost	Fuel (per liter)	Lubricating Oil(per Liter)	Crew Wages (per hr)	Maintenance(birr/ hour)	Interest rate (%)
Car Small	1,316,000	1996	18.6	78.00	19.17	41.54	10.23
Car Medium	1,650,000	4250	17.75	73.21	37.50	42.63	10.23
4WD	1,650,000	2900	17.75	73.21	42.00	41.27	10.23
Light Bus	1,929,000	8000	17.75	73.21	59.22	48.35	10.23
Medium Bus	2,650,000	14600	17.75	73.21	37.33	34.00	10.23
Light Truck	1,644,000	14600	17.75	73.21	43.00	39.68	10.23
Heavy Truck	3,581,727	14600	17.75	73.21	65.50	45.80	10.23
Articulated Truck	4,300,000	14600	17.75	73.21	89.00	47.51	10.23

Table 4.9 Economical cost characteristics of vehicle fleet. (Source: ERA, 2011)

Name	New Vehicle	Tire Cost	Fuel (per liter)	Lubricating Oil(per Liter)	Crew Wages (per hr)	Maintenance(birr/hour)	Interest rate (%)
Car Small	590135	1495	15.00	60.00	17.42	37.76	10.23
Car Medium	1674085	3542	14.40	55.00	34.09	38.76	10.23
4WD	733460	2417	15.00	60.00	38.18	36.18	10.23
Light Bus	1285063	6667	14.40	55.00	57.14	37.52	10.23
Medium Bus	2070313	12167	14.40	55.00	53.84	43.95	10.23
Light Truck	1284175	6042	14.40	55.00	33.94	30.99	10.23
Heavy Truck	2798225	12167	14.40	55.00	59.55	41.64	10.23
Articulated Truck	3359375	12167	14.40	55.00	80.91	43.19	10.23

4.7 Solution for RED Model

In the analysis of RED Model the first step in the analysis process is t collect data from reliable sources in respect of Economic Costs, Utilization and Loading to be used in RED HDM- 4 VOC Version (3.2) Module to produce the required information for use in RED - Main Version (3.2). So, current vehicle, maintenance, operational and crew economic costs were studied. Data on rate of utilization and loading were also collected from various sources in the international market via internet. To get reliable data on different car costs; information from sales offices, importers, international market prices, vehicle driver's experiences and gas stations were exhaustively reviewed. These interviews and researches were then compiled and aggregated to a give an overall picture on economic costs, utilization and Loading data of the different vehicle types.

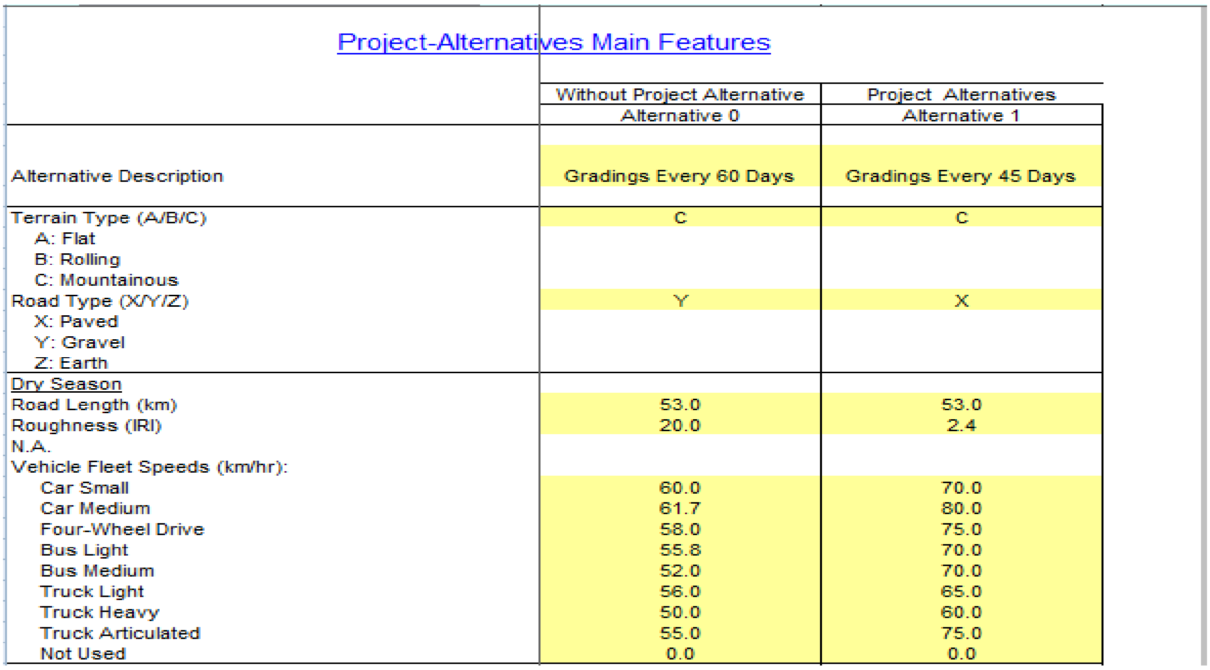
RED - Main Version (3.2) - Main Economic Evaluation Module

This Module is the main module that performs the economic evaluation of one road at a time with a maximum three project alternatives.

Note: in this paper some assumption was used accordingly

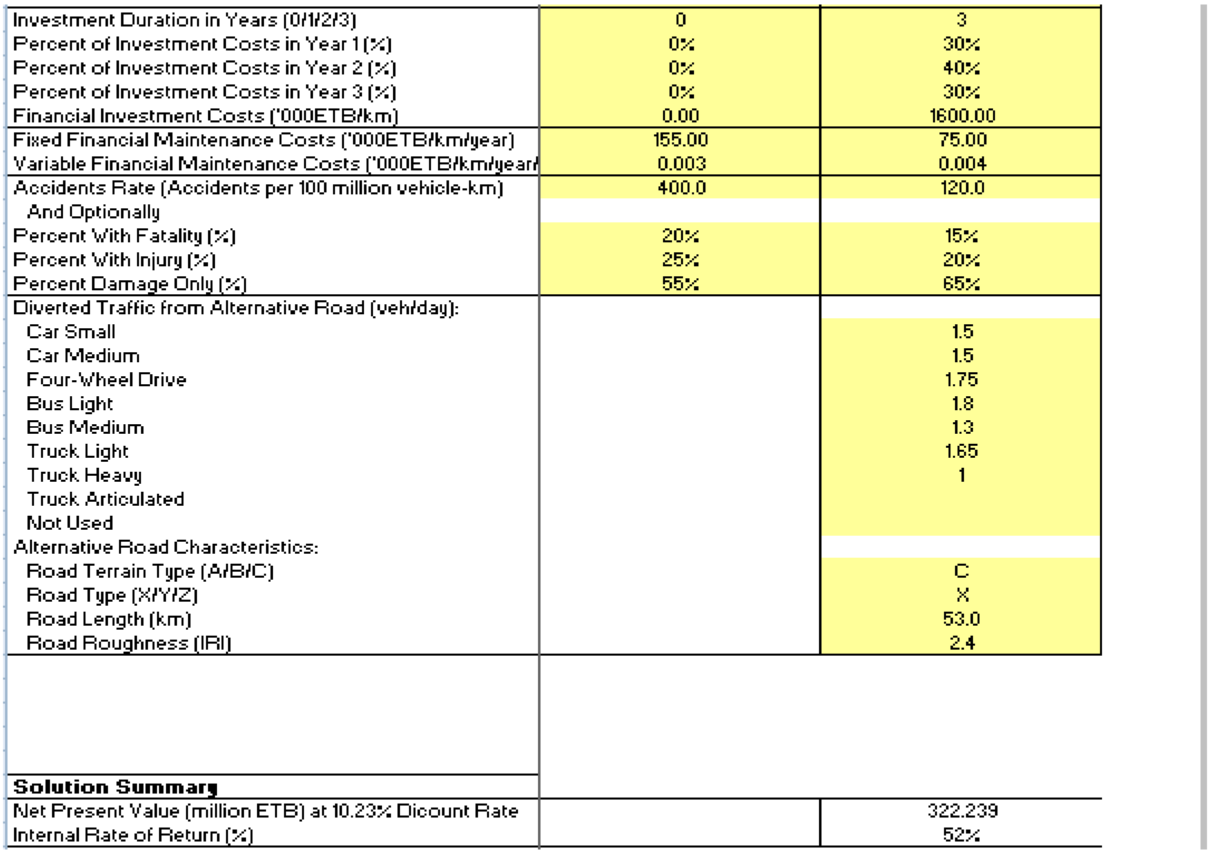
Project-Alter, Main Features - Main Version Module

Project-Alternatives Main Features



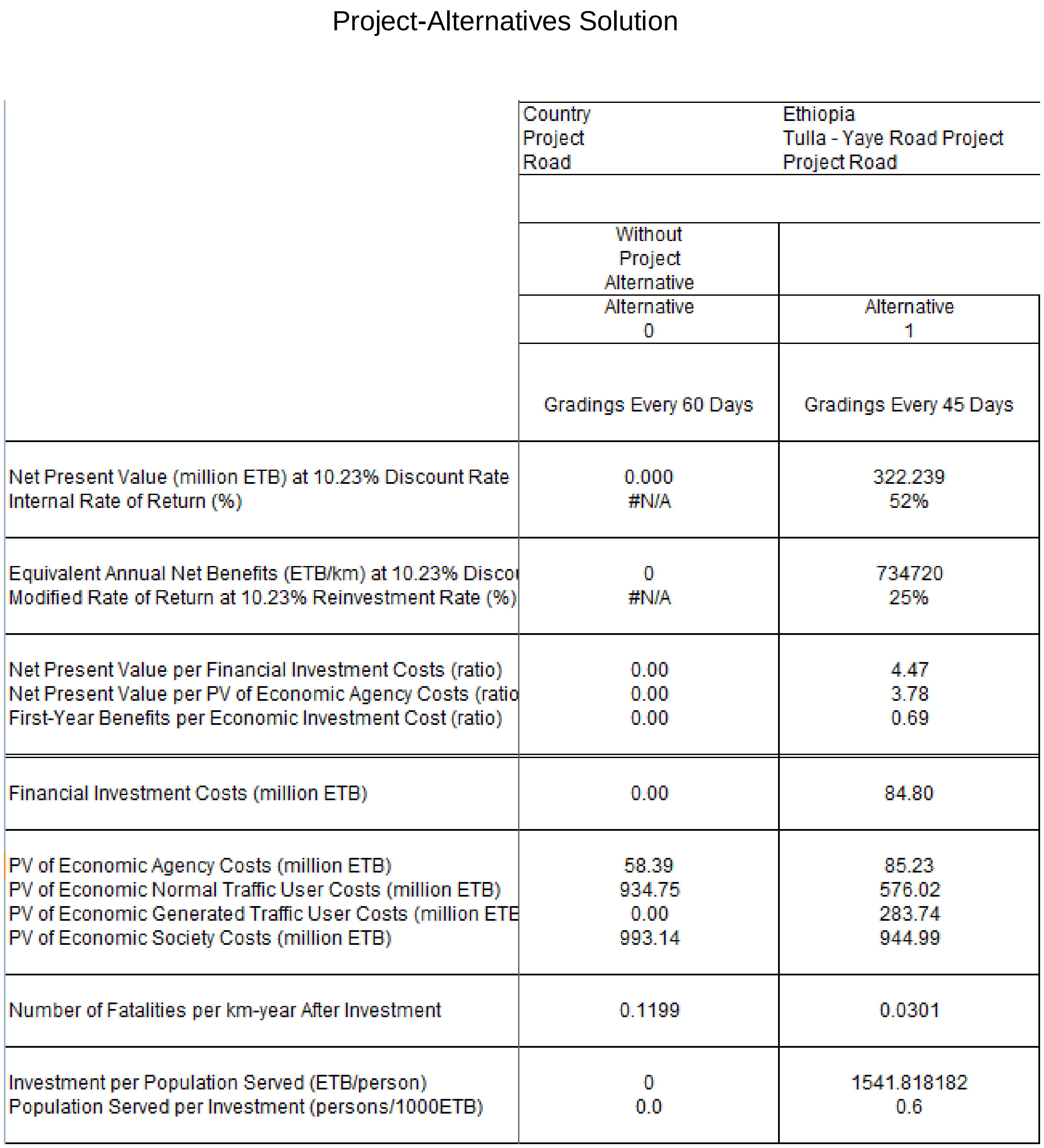
Project-Alternatives Main Features

	Without Project Alternative Alternative 0	Project Alternatives Alternative 1
Alternative Description	Gradings Every 60 Days	Gradings Every 45 Days
Terrain Type (A/B/C)	C	C
A: Flat		
B: Rolling		
C: Mountainous		
Road Type (X/Y/Z)	Y	X
X: Paved		
Y: Gravel		
Z: Earth		
Dry Season		
Road Length (km)	53.0	53.0
Roughness (IRI)	20.0	2.4
N.A.		
Vehicle Fleet Speeds (km/hr):		
Car Small	60.0	70.0
Car Medium	61.7	80.0
Four-Wheel Drive	58.0	75.0
Bus Light	55.8	70.0
Bus Medium	52.0	70.0
Truck Light	56.0	65.0
Truck Heavy	50.0	60.0
Truck Articulated	55.0	75.0
Not Used	0.0	0.0



Investment Duration in Years (0/1/2/3)	0	3
Percent of Investment Costs in Year 1 (%)	0%	30%
Percent of Investment Costs in Year 2 (%)	0%	40%
Percent of Investment Costs in Year 3 (%)	0%	30%
Financial Investment Costs ('000ETB/km)	0.00	1600.00
Fixed Financial Maintenance Costs ('000ETB/km/year)	155.00	75.00
Variable Financial Maintenance Costs ('000ETB/km/year/	0.003	0.004
Accidents Rate (Accidents per 100 million vehicle-km)	400.0	120.0
And Optionally		
Percent With Fatality (%)	20%	15%
Percent With Injury (%)	25%	20%
Percent Damage Only (%)	55%	65%
Diverted Traffic from Alternative Road (veh/day):		
Car Small		1.5
Car Medium		1.5
Four-Wheel Drive		1.75
Bus Light		1.8
Bus Medium		1.3
Truck Light		1.65
Truck Heavy		1
Truck Articulated		
Not Used		
Alternative Road Characteristics:		
Road Terrain Type (A/B/C)		C
Road Type (X/Y/Z)		X
Road Length (km)		53.0
Road Roughness (IRI)		2.4
Solution Summary		
Net Present Value (million ETB) at 10.23% Dicount Rate		322.239
Internal Rate of Return (%)		52%

Project-Alter, Solution from the Main Version Module

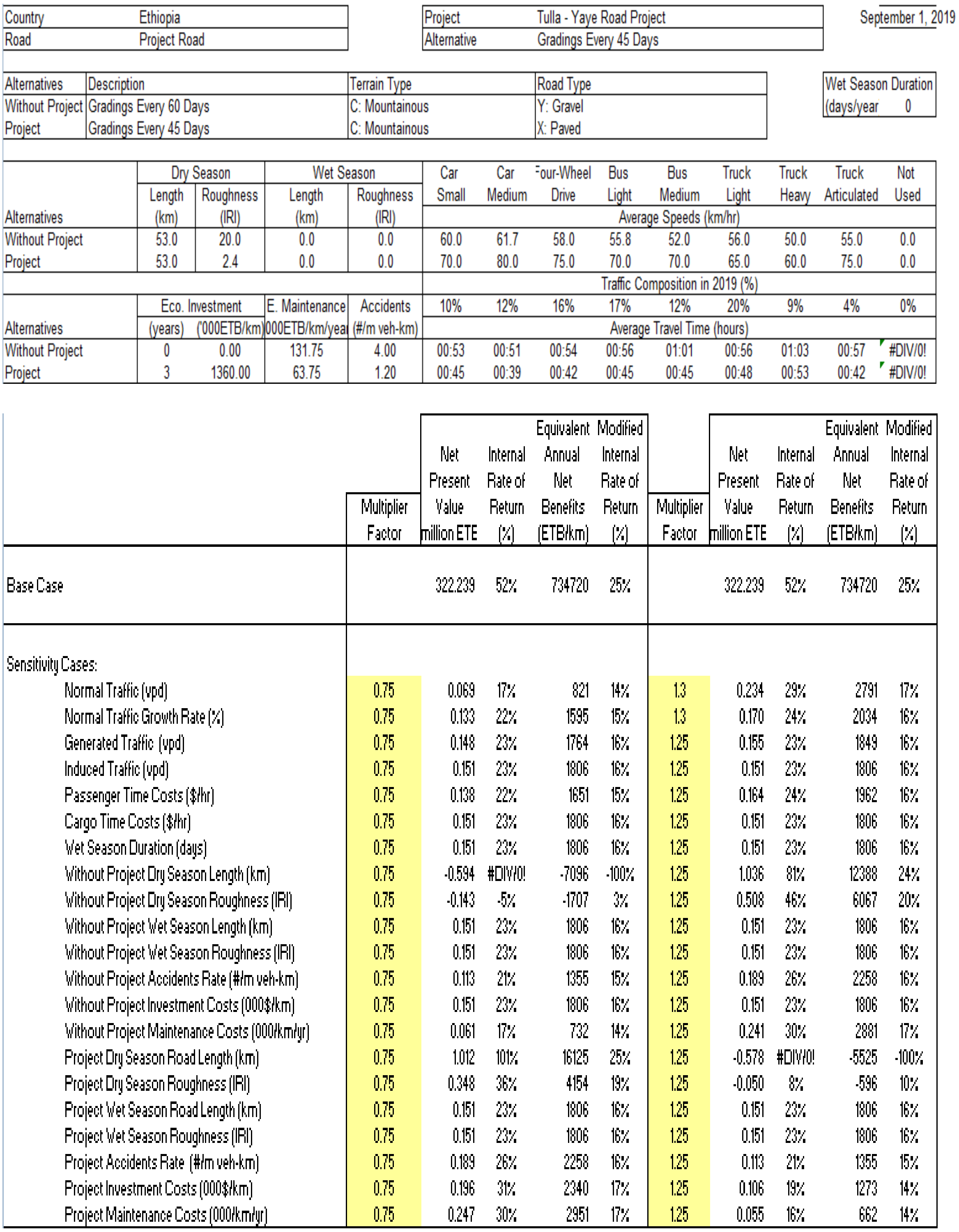


Project-Alternatives Solution

	Country	Ethiopia
	Project	Tulla - Yaye Road Project
	Road	Project Road
	Without Project Alternative	
	Alternative 0	Alternative 1
	Gradings Every 60 Days	Gradings Every 45 Days
Net Present Value (million ETB) at 10.23% Discount Rate	0.000	322.239
Internal Rate of Return (%)	#N/A	52%
Equivalent Annual Net Benefits (ETB/km) at 10.23% Disco	0	734720
Modified Rate of Return at 10.23% Reinvestment Rate (%)	#N/A	25%
Net Present Value per Financial Investment Costs (ratio)	0.00	4.47
Net Present Value per PV of Economic Agency Costs (ratio	0.00	3.78
First-Year Benefits per Economic Investment Cost (ratio)	0.00	0.69
Financial Investment Costs (million ETB)	0.00	84.80
PV of Economic Agency Costs (million ETB)	58.39	85.23
PV of Economic Normal Traffic User Costs (million ETB)	934.75	576.02
PV of Economic Generated Traffic User Costs (million ET	0.00	283.74
PV of Economic Society Costs (million ETB)	993.14	944.99
Number of Fatalities per km-year After Investment	0.1199	0.0301
Investment per Population Served (ETB/person)	0	1541.818182
Population Served per Investment (persons/1000ETB)	0.0	0.6

Sensitivity Analysis

Sensitivity: Upgrading to Asphalt concrete Road



Country	Ethiopia	Project	Tulla - Yaye Road Project	September 1, 2019
Road	Project Road	Alternative	Gradings Every 45 Days	

Alternatives	Description	Terrain Type	Road Type
Without Project	Gradings Every 60 Days	C: Mountainous	Y: Gravel
Project	Gradings Every 45 Days	C: Mountainous	X: Paved

Wet Season Duration	
(days/year	0

	Dry Season		Wet Season		Car	Car	Four-Wheel	Bus	Bus	Truck	Truck	Truck	Not
	Length	Roughness	Length	Roughness	Small	Medium	Drive	Light	Medium	Light	Heavy	Articulated	Used
Alternatives	(km)	(IRI)	(km)	(IRI)	Average Speeds (km/hr)								
Without Project	53.0	20.0	0.0	0.0	60.0	61.7	58.0	55.8	52.0	56.0	50.0	55.0	0.0
Project	53.0	2.4	0.0	0.0	70.0	80.0	75.0	70.0	70.0	65.0	60.0	75.0	0.0
					Traffic Composition in 2019 (%)								
	Eco. Investment		E. Maintenance	Accidents	10%	12%	16%	17%	12%	20%	9%	4%	0%
Alternatives	(years)	('000ETB/km)	000ETB/km/year	(#/m veh-km)	Average Travel Time (hours)								
Without Project	0	0.00	131.75	4.00	00:53	00:51	00:54	00:56	01:01	00:56	01:03	00:57	#DIV/0!
Project	3	1360.00	63.75	1.20	00:45	00:39	00:42	00:45	00:45	00:48	00:53	00:42	#DIV/0!

	Multiplier Factor	Net Present Value million ETB	Internal Rate of Return (%)	Equivalent Annual Net Benefits (ETB/km)	Modified Internal Rate of Return (%)	Multiplier Factor	Net Present Value million ETB	Internal Rate of Return (%)	Equivalent Annual Net Benefits (ETB/km)	Modified Internal Rate of Return (%)
Base Case		322.239	52%	734720	25%		322.239	52%	734720	25%
Sensitivity Cases:										
Normal Traffic (vpd)	0.75	0.069	17%	821	14%	1.3	0.234	29%	2791	17%
Normal Traffic Growth Rate (%)	0.75	0.133	22%	1595	15%	1.3	0.170	24%	2034	16%
Generated Traffic (vpd)	0.75	0.148	23%	1764	16%	1.25	0.155	23%	1849	16%
Induced Traffic (vpd)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Passenger Time Costs ($/hr)	0.75	0.138	22%	1651	15%	1.25	0.164	24%	1962	16%
Cargo Time Costs ($/hr)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Wet Season Duration (days)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Without Project Dry Season Length (km)	0.75	-0.594	#DIV/0!	-7096	-100%	1.25	1.036	81%	12388	24%
Without Project Dry Season Roughness (IRI)	0.75	-0.143	-5%	-1707	3%	1.25	0.508	46%	6067	20%
Without Project Wet Season Length (km)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Without Project Wet Season Roughness (IRI)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Without Project Accidents Rate (#/m veh-km)	0.75	0.113	21%	1355	15%	1.25	0.189	26%	2258	16%
Without Project Investment Costs (000$/km)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Without Project Maintenance Costs (000/km/yr)	0.75	0.061	17%	732	14%	1.25	0.241	30%	2881	17%
Project Dry Season Road Length (km)	0.75	1.012	101%	16125	25%	1.25	-0.578	#DIV/0!	-5525	-100%
Project Dry Season Roughness (IRI)	0.75	0.348	36%	4154	19%	1.25	-0.050	8%	-596	10%
Project Wet Season Road Length (km)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Project Wet Season Roughness (IRI)	0.75	0.151	23%	1806	16%	1.25	0.151	23%	1806	16%
Project Accidents Rate (#/m veh-km)	0.75	0.189	26%	2258	16%	1.25	0.113	21%	1355	15%
Project Investment Costs (000$/km)	0.75	0.196	31%	2340	17%	1.25	0.106	19%	1273	14%
Project Maintenance Costs (000/km/yr)	0.75	0.247	30%	2951	17%	1.25	0.055	16%	662	14%

Table 4.10 Sensitivity Analysis (From the above result)

Sensitivity case	Multiplier Factor	NPV	EIRR	MIRR	Multiplier Factor	NPV	EIRR	MIRR
Normal Traffic (vpd)	0.75	0.069	17%	14%	1.3	0.234	29%	17%
Normal Traffic Growth Rate (%)	0.75	0.133	22%	15%	1.3	0.170	24%	16%

Since, the feasibility of the project was not altered under this sensitivity factor as shown in the above table. So, the project is not sensitive.

Sensitivity of the Vehicle Operating Costs

The following figure illustrates how the vehicle operating cost varies according to the Roughness of the roads for a medium truck on a paved flat road

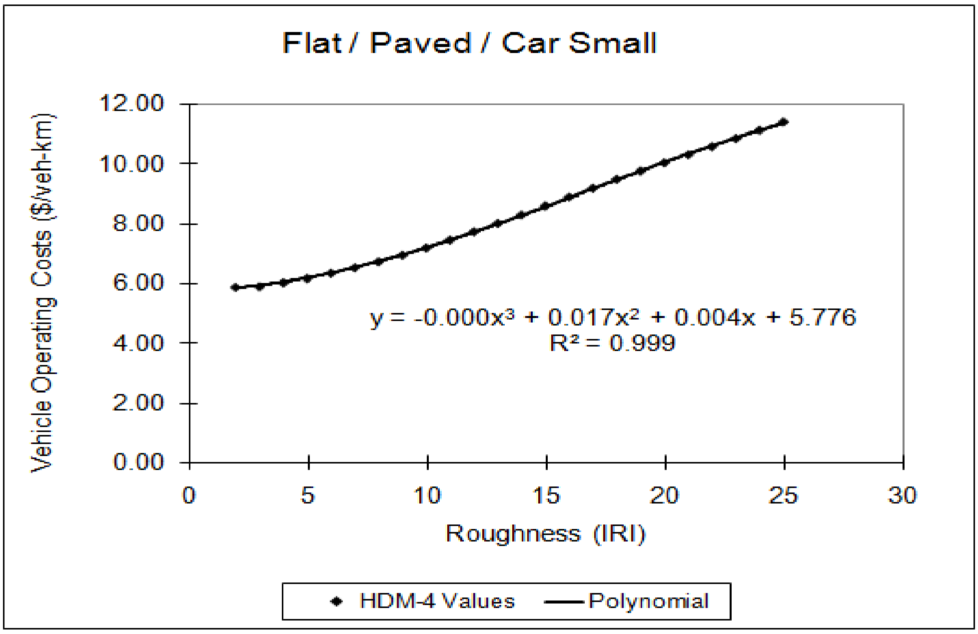


Figure 4.2 Variation of VOC Sale in relation with Roughness of the road

Subsequent figure shows the relation between the roughness of the road and the vehicle speed, the detail presented vide Annexure 2.

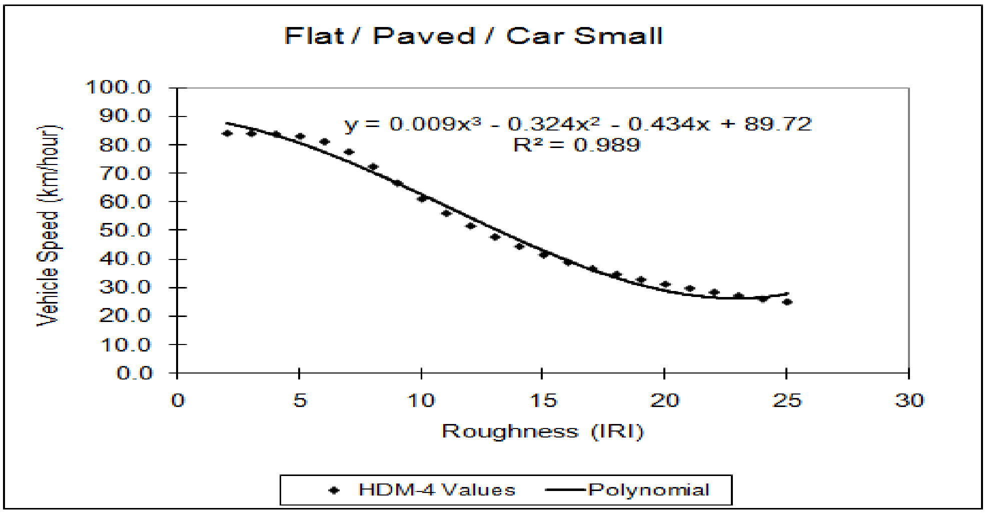


Figure 4.3 Variation of truck speed in relation with Roughness of the road

- **Is the Project feasible? Why?**

From the above analysis results, it can be seen that the project (upgrade to paved road) has a positive NPV (+322.239) and an EIRR (52%) which is greater than the opportunity cost of capital (10.23%). Therefore, the results brief that the project is feasible to undertake.

4.8 After analyzing the data using HDM-4 the following output was produced

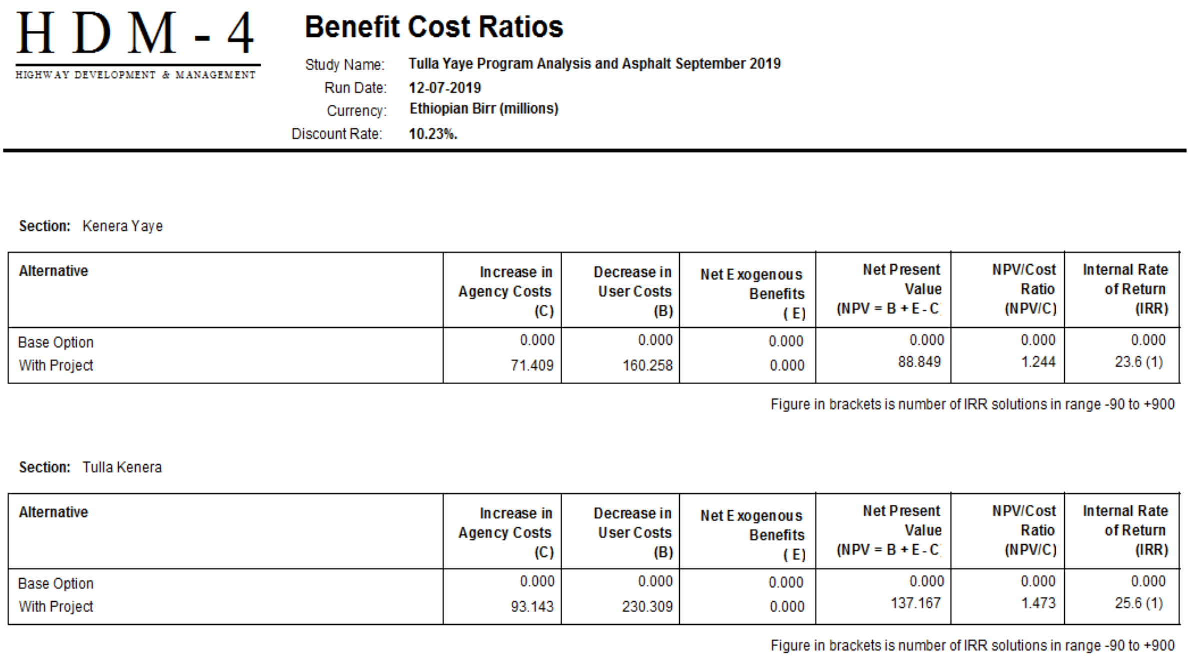
4.8.1 Program Analysis

The Programme analysis as it is termed is the analysis for doing the yearly maintenance programme or for the multi-year rolling programme. The programme analysis tool has been incorporated in HDM-4 for easy analysis of the whole road network for identifying the candidate road sections for the maintenance for a particular budget period. For the constraint budget, the economic criteria for selecting the candidate road are the maximisation of NPV/Cost.

By doing the program analysis one can get the following:

- Identify the candidate road sections for maintenance,
- Determine the alternative improvements,
- Optimization of the program in case of budget constraints,
- Obtain the optimized list of projects for the budget period

Table 4.11 Benefit Cost Ratio form program Analysis by section



HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: **Tulla Yaye Program Analysis and Asphalt September 2019**
Run Date: **12-07-2019**
Currency: **Ethiopian Birr (millions)**
Discount Rate: **10.23%.**

Section: Kenera Yaye

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E - C	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
Base Option	0.000	0.000	0.000	0.000	0.000	0.000
With Project	71.409	160.258	0.000	88.849	1.244	23.6 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Section: Tulla Kenera

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E - C	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
Base Option	0.000	0.000	0.000	0.000	0.000	0.000
With Project	93.143	230.309	0.000	137.167	1.473	25.6 (1)

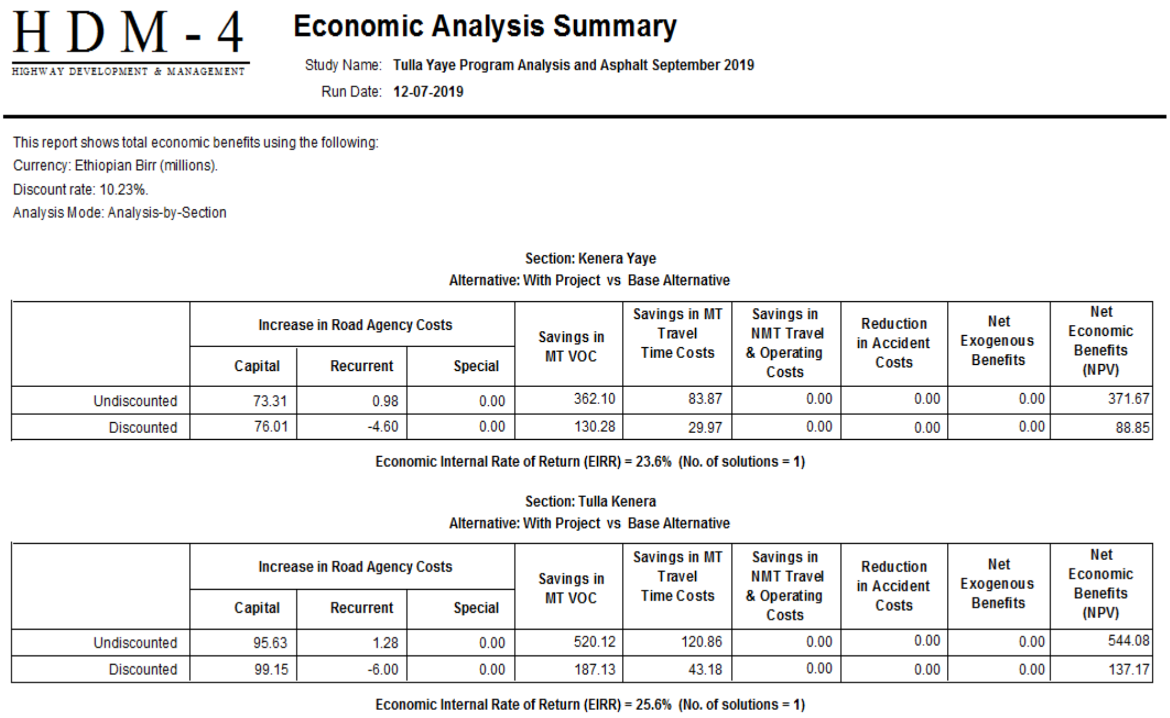
Figure in brackets is number of IRR solutions in range -90 to +900

Economic Analysis

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. It is therefore important that decisions about investments in roads are made on objective judgments and therefore, Economic appraisal has been carried out for each traffic homogenous section of entire Project road. The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the proposed study is worthy of investment keeping in view the benefits to the society. The Proposal for project road is i.e. maintenance and up gradation of Tulla - Yaye section, TYS. In order to assess the benefits accrued to the society; both the options of „Without Improvement" and „With Improvement" has to be compared. For this purpose, the entire existing road has been considered along with its proposed maintenance and improvement proposals. In general, in case of economic analysis is also recommended that analysis period should not be long as it may lead to erroneous results. However, in order to be able to draw the conclusions on common platform Economic Analysis have also been carried out for 15 years of analysis period. The summary of Economic internal rate of return (EIRR) worked out, for construction option based on life cycle cost analysis is presented below. HDM-4 output of discounted Net Benefit Cost Ratios is presented vide Annexure 2 and HDM-4 output of undiscounted Net Benefit Cost Ratios is presented vide Annexure 3

Economic Analysis Summary by Section

Table 4.12 Economic Analysis Summary for program Analysis by Section



Economic Analysis Summary

Study Name: **Tulla Yaye Program Analysis and Asphalt September 2019**
Run Date: **12-07-2019**

This report shows total economic benefits using the following:
Currency: Ethiopian Birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Section

Section: Kenera Yaye
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	73.31	0.98	0.00	362.10	83.87	0.00	0.00	0.00	371.67
Discounted	76.01	-4.60	0.00	130.28	29.97	0.00	0.00	0.00	88.85

Economic Internal Rate of Return (EIRR) = 23.6% (No. of solutions = 1)

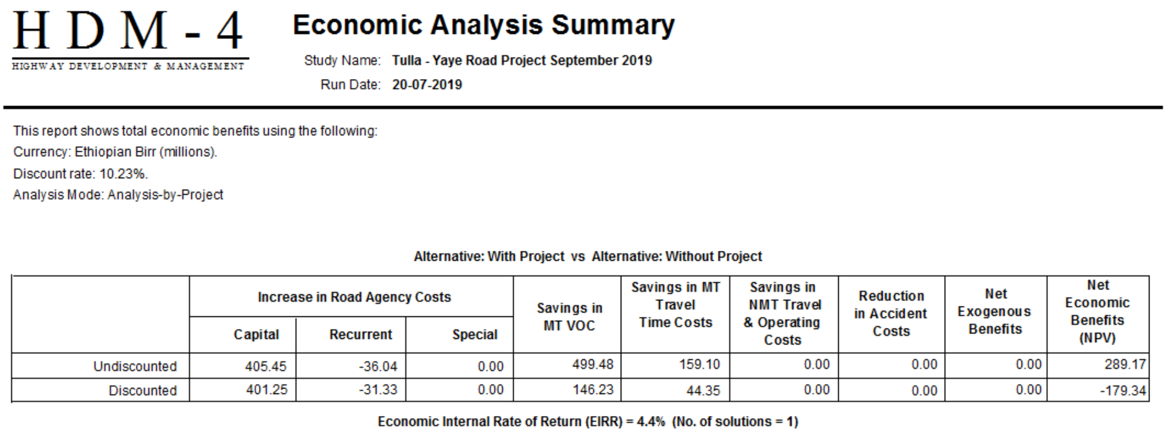
Section: Tulla Kenera
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	95.63	1.28	0.00	520.12	120.86	0.00	0.00	0.00	544.08
Discounted	99.15	-6.00	0.00	187.13	43.18	0.00	0.00	0.00	137.17

Economic Internal Rate of Return (EIRR) = 25.6% (No. of solutions = 1)

Economic Analysis Summary by Project

Table 4.13 Economic Analysis Summary for Program Analysis by Project



Economic Analysis Summary

Study Name: **Tulla - Yaye Road Project September 2019**
Run Date: **20-07-2019**

This report shows total economic benefits using the following:
Currency: Ethiopian Birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Project

Alternative: With Project vs Alternative: Without Project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	405.45	-36.04	0.00	499.48	159.10	0.00	0.00	0.00	289.17
Discounted	401.25	-31.33	0.00	146.23	44.35	0.00	0.00	0.00	-179.34

Economic Internal Rate of Return (EIRR) = 4.4% (No. of solutions = 1)

4.8.2 Project Analysis

Project analysis allows the users to assess the physical, functional and economic feasibility of specified project alternatives by comparison against a base case (do nothing). The key issues are:

✓ **Life cycle prediction of deterioration, maintenance effects & costs:**

For the particular traffic loading, HDM-4 is able to calculate the deterioration of the road structure and the surface for each year of the analysis period. If the user provides the maintenance option then HDM-4 can apply the maintenance, calculates the cost of maintenance and the effects thereof.

✓ **Road user costs and benefits:**

The road user costs consist of the Vehicle Operating Costs (VOC), the Travel Time Cost (TTC) and the Accident Cost (AC). If no maintenance is done (do nothing option) the road user costs will be high but if any maintenance is applied such as overlay (do something option), the road user costs will be reduced to a great extent. If the Road user costs of the above two options are compared then it will be seen that a benefit will be obtained by doing the maintenance.

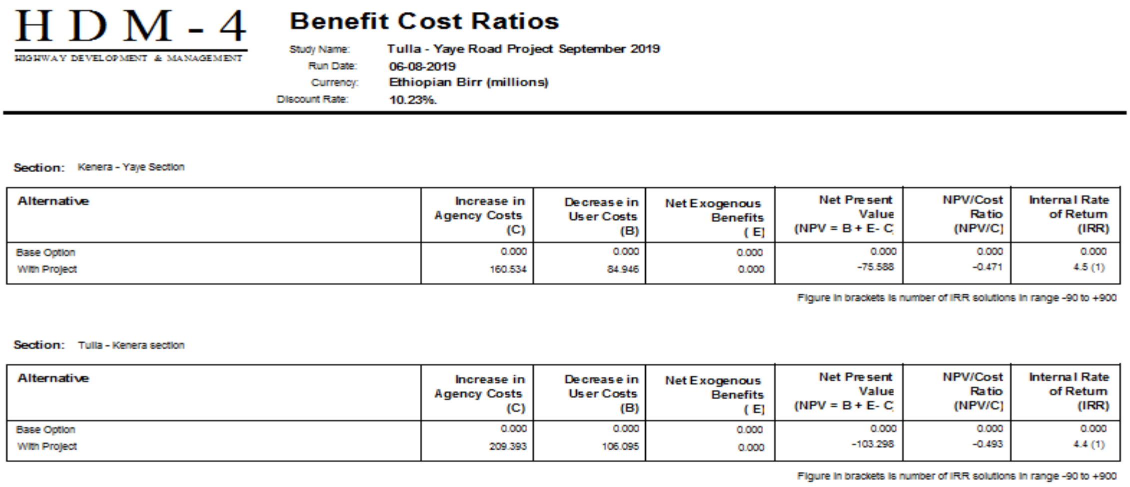
✓ **Economic comparison of project alternatives:**

For the maintenance of the road, the user might have various maintenance strategies. HDM can calculate the economic indicators like NPV, IRR etc. for every option of the maintenance strategies for the projected analysis period. The most beneficial maintenance option will be one that gives the maximum economic return.

✓ **Road structural performance**:

The Road is generally designed to carry the load of traffic that runs over it. If the structure of the road is not strong enough to withstand the traffic loading then the road structure will fail. HDM has the analytical model that can calculate the structural strength of the Road for the traffic running over it.

Table 4.14 Benefit Cost Ratio from Project Analyses by Project



H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Tulla - Yaye Road Project September 2019
Run Date: 06-08-2019
Currency: Ethiopian Birr (millions)
Discount Rate: 10.23%.

Section: Kenera - Yaye Section

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
Base Option	0.000	0.000	0.000	0.000	0.000	0.000
With Project	160.534	84.946	0.000	-75.588	-0.471	4.5 (1)

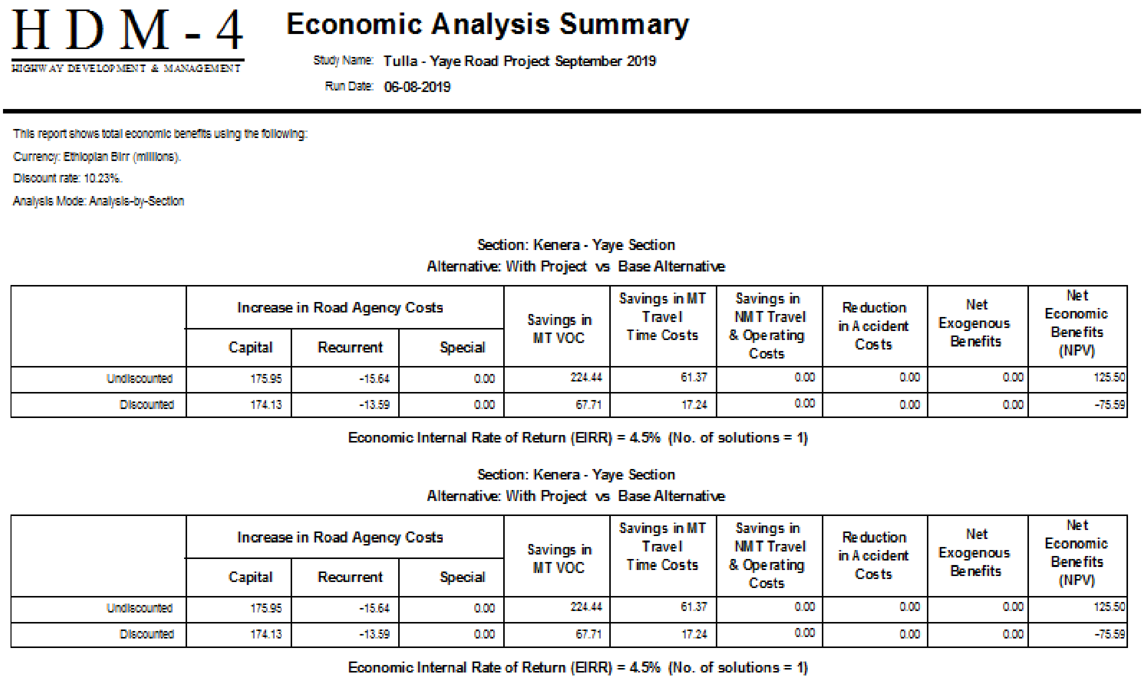
Figure in brackets is number of IRR solutions in range -90 to +900

Section: Tulla - Kenera section

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
Base Option	0.000	0.000	0.000	0.000	0.000	0.000
With Project	209.393	106.095	0.000	-103.298	-0.493	4.4 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Table 4.15 Economic Analysis Summary from Project Analyses by Project



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HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Tulla - Yaye Road Project September 2019
Run Date: 06-08-2019

This report shows total economic benefits using the following:
Currency: Ethiopian Birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Section

Section: Kenera - Yaye Section
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	175.95	-15.64	0.00	224.44	61.37	0.00	0.00	0.00	125.50
Discounted	174.13	-13.59	0.00	67.71	17.24	0.00	0.00	0.00	-75.59

Economic Internal Rate of Return (EIRR) = 4.5% (No. of solutions = 1)

Section: Kenera - Yaye Section
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	175.95	-15.64	0.00	224.44	61.37	0.00	0.00	0.00	125.50
Discounted	174.13	-13.59	0.00	67.71	17.24	0.00	0.00	0.00	-75.59

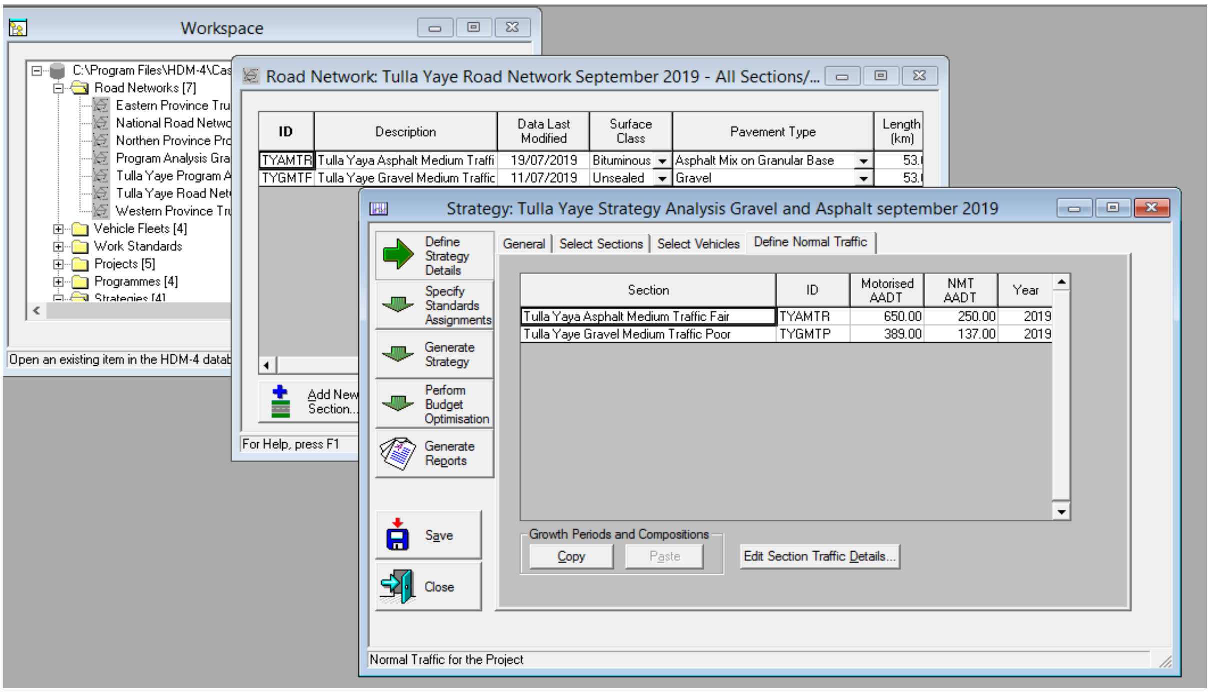
Economic Internal Rate of Return (EIRR) = 4.5% (No. of solutions = 1)

4.8.3 Strategic Analysis

For strategically Analysis consider the two given alternative road project

- Gravel Road with Medium Traffic in Fair Condition, 53km length
- Paved Road with High Traffic in Fair Condition, 53km length

Since, the traffic on gravel road is medium consider AADT of 387and take 650AADT on the Paved road. Others input data also inserted accordingly in the HDM-4software.For road network.

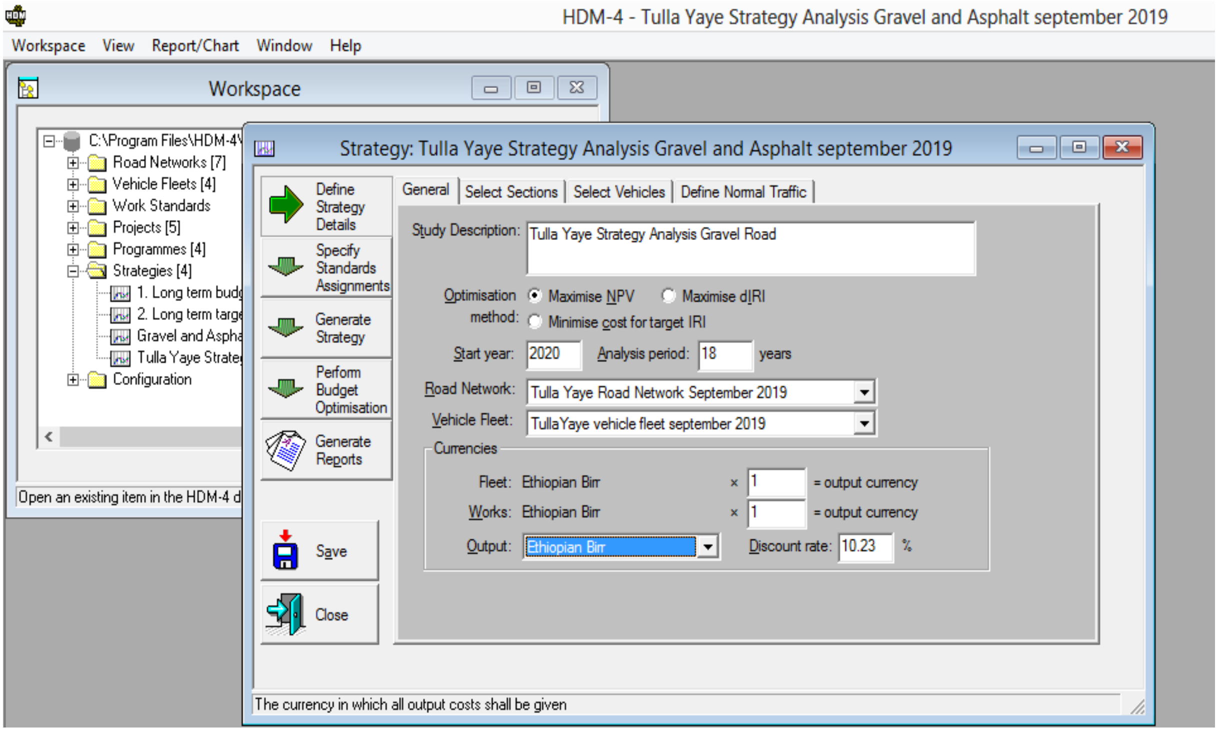


ID	Description	Data Last Modified	Surface Class	Pavement Type	Length (km)
TYAMTR	Tulla Yaya Asphalt Medium Traffi	19/07/2019	Bituminous	Asphalt Mix on Granular Base	53.
TYGMTF	Tulla Yaye Gravel Medium Traffic	11/07/2019	Unsealed	Gravel	53.

Section	ID	Motorised AADT	NMT AADT	Year
Tulla Yaya Asphalt Medium Traffic Fair	TYAMTR	650.00	250.00	2019
Tulla Yaye Gravel Medium Traffic Poor	TYGMTP	389.00	137.00	2019

Figure 4.4 Data input for Strategy Analysis from HDM-4 Software

The strategic analysis has been carried out for the selected road network. The analysis is carried out to maximize the NPV or minimize the costs to achieve a desirable target IRI, which means the maximum IRI at or below which the network is to be kept. The project period has been considered. Used the “Maximum NPV” for optimization during defining strategic detail others input data also inserted accordingly in the HDM-4 software. For strategic analysis.



Study Description: Tulla Yaye Strategy Analysis Gravel Road

Optimisation method: ● Maximise NPV ○ Maximise dIRI ○ Minimise cost for target IRI

Start year: 2020 Analysis period: 18 years

Road Network: Tulla Yaye Road Network September 2019

Vehicle Fleet: TullaYaye vehicle fleet september 2019

Currencies

Fleet: Ethiopian Birr × 1 = output currency

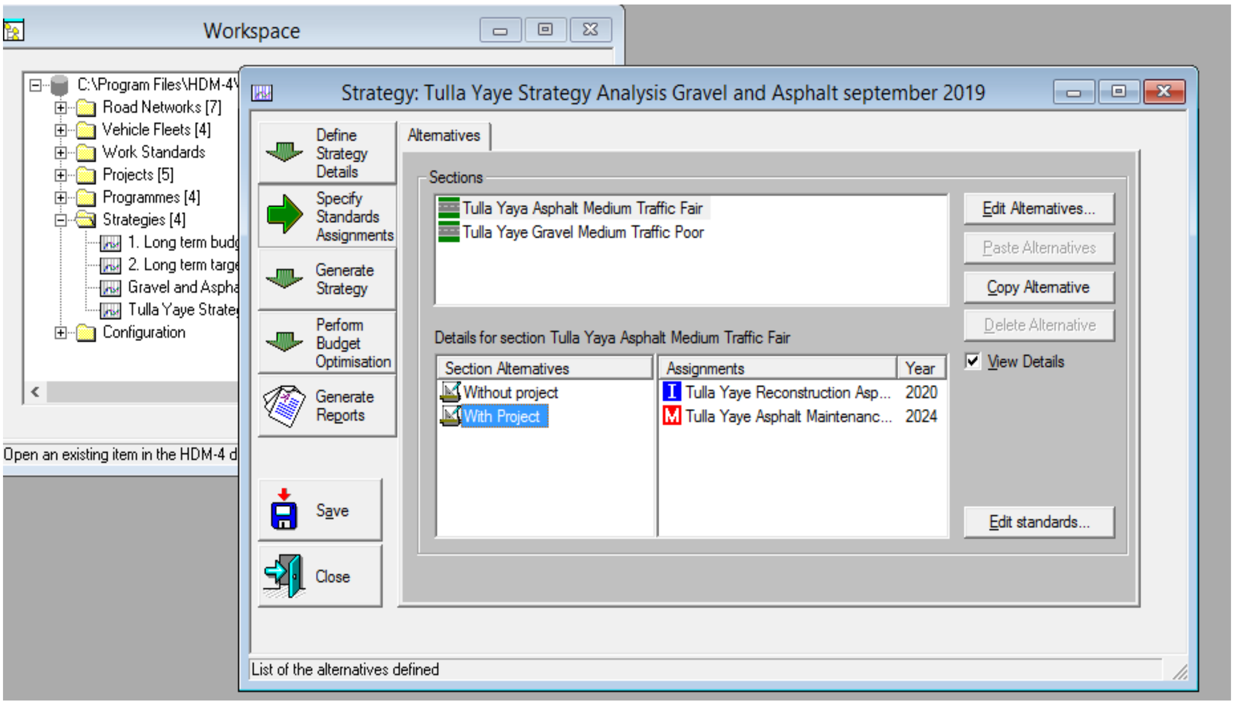
Works: Ethiopian Birr × 1 = output currency

Output: Ethiopian Birr Discount rate: 10.23 %

The currency in which all output costs shall be given

Figure 4.5 Defining the Strategy Details from the HDM-4 software

Considered the without project and with project option analysis for both roads.



Sections

Tulla Yaya Asphalt Medium Traffic Fair

Tulla Yaye Gravel Medium Traffic Poor

Details for section Tulla Yaya Asphalt Medium Traffic Fair

☑ View Details

Section Alternatives

Without project

With Project

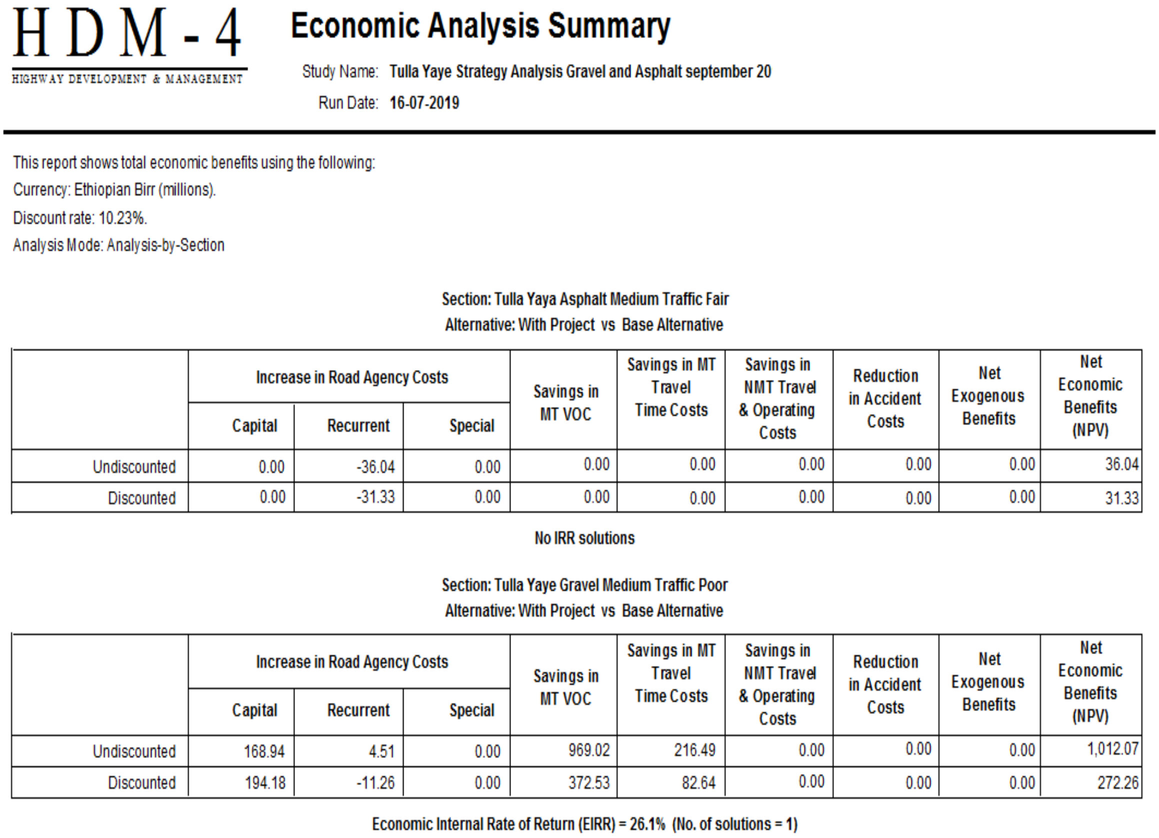
Assignments	Year
I Tulla Yaye Reconstruction Asp...	2020
M Tulla Yaye Asphalt Maintenanc...	2024

List of the alternatives defined

Figure 4.6 Section Alternatives (With or Without Project) for Strategy Analysis from HDM-4 Software

At the end the HDM-4 software produce the following strategies output.

Table 4.16 Economic Analysis Summary from Strategy Analysis



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HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Tulla Yaye Strategy Analysis Gravel and Asphalt september 20**
Run Date: **16-07-2019**

This report shows total economic benefits using the following:
Currency: Ethiopian Birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Section

Section: Tulla Yaya Asphalt Medium Traffic Fair
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-36.04	0.00	0.00	0.00	0.00	0.00	0.00	36.04
Discounted	0.00	-31.33	0.00	0.00	0.00	0.00	0.00	0.00	31.33

No IRR solutions

Section: Tulla Yaye Gravel Medium Traffic Poor
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	168.94	4.51	0.00	969.02	216.49	0.00	0.00	0.00	1,012.07
Discounted	194.18	-11.26	0.00	372.53	82.64	0.00	0.00	0.00	272.26

Economic Internal Rate of Return (EIRR) = 26.1% (No. of solutions = 1)

- Net Present Value (NPV) for Gravel Road with Medium Traffic in Fair Condition is 272.26.
- Net Present Value (NPV) for Paved Road with High Traffic in Fair Condition is 31.33

Since, the NPV of Gravel Road with Medium Traffic in Fair Condition is greater than NPV of Paved Road with Medium Traffic in Fair Condition. That mean, 272.26 >31.33

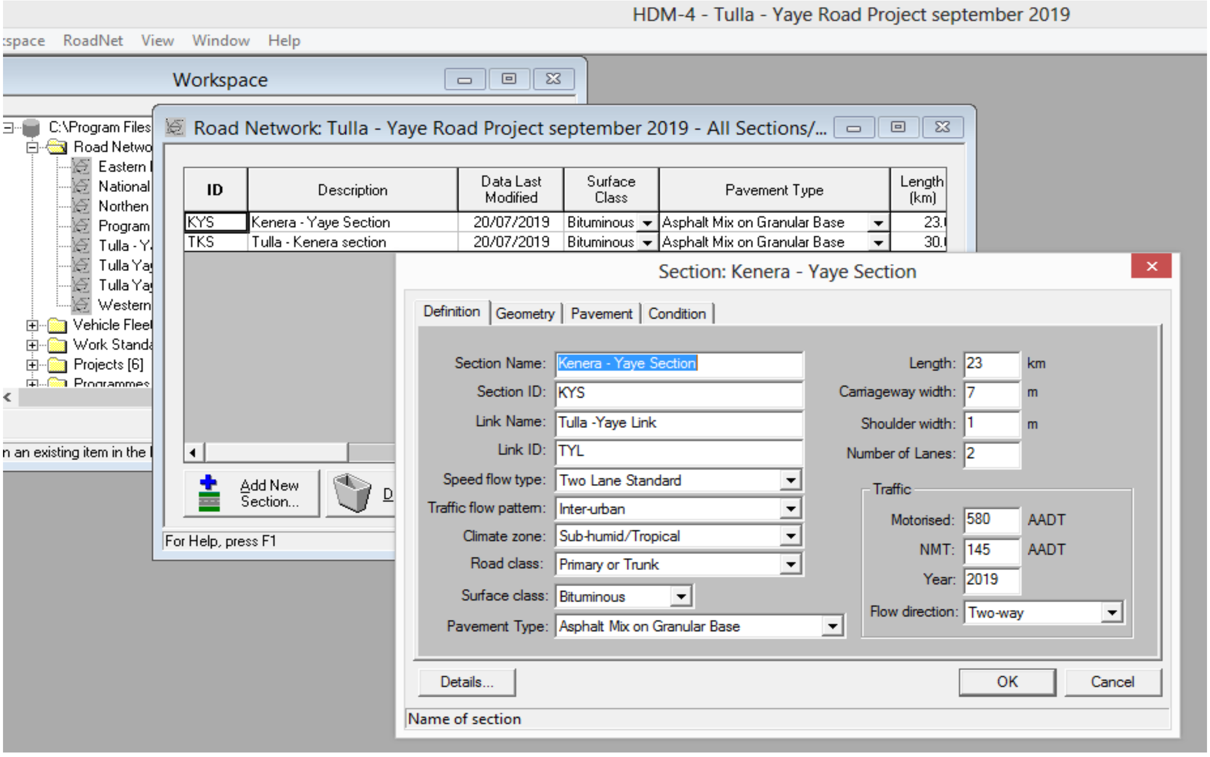
So, use the section of Gravel Road with Medium Traffic in Fair Condition for Program Analysis.

From The Program Analysis

Since, Gravel Road with Medium Traffic in Poor Condition in 53km length has Maximum Net Present Value (NPV) then takes this road section for Program Analysis. By dividing 53km Gravel road in to two sections, each section has its own Homogenous characteristics:

- Kenera-Yaye Section has23km length
- Tulla-Kenera Section has 30km length and

As shown below in the figure below



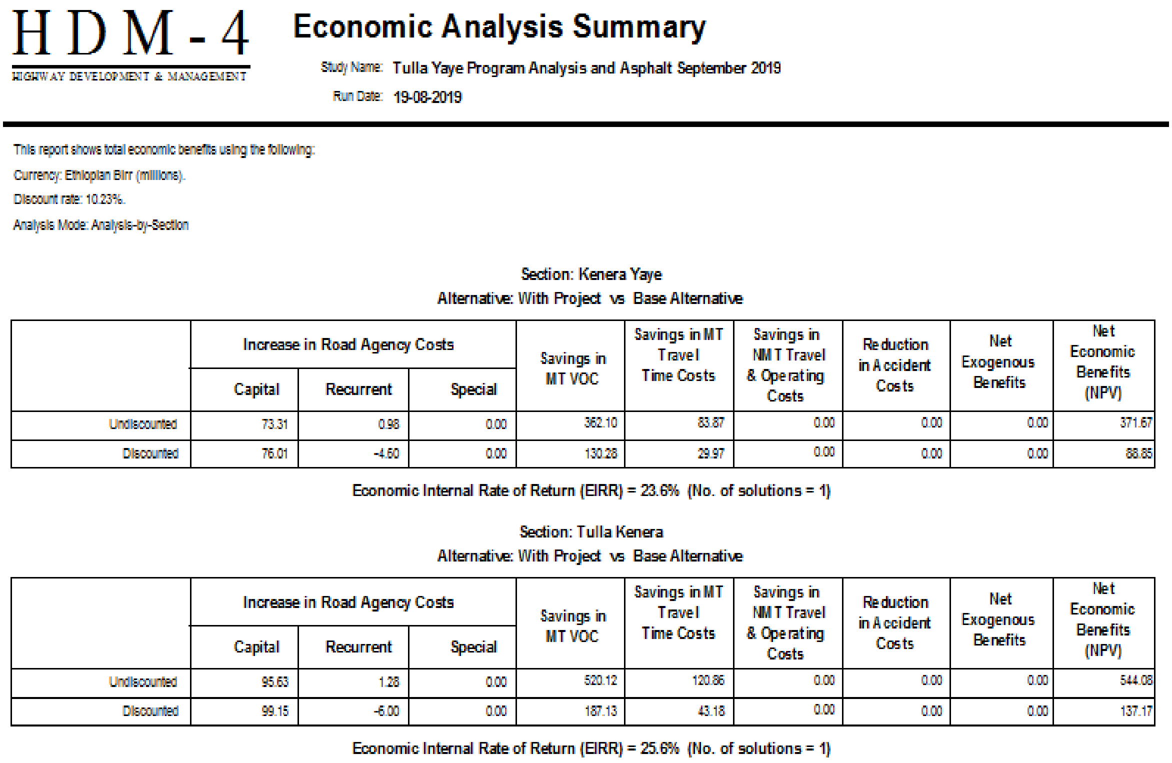
ID	Description	Data Last Modified	Surface Class	Pavement Type	Length (km)
KYS	Kenera - Yaye Section	20/07/2019	Bituminous	Asphalt Mix on Granular Base	23.
TKS	Tulla - Kenera section	20/07/2019	Bituminous	Asphalt Mix on Granular Base	30.

Section Name: Kenera - Yaye Section
Section ID: KYS
Link Name: Tulla -Yaye Link
Link ID: TYL
Speed flow type: Two Lane Standard
Traffic flow pattern: Inter-urban
Climate zone: Sub-humid/Tropical
Road class: Primary or Trunk
Surface class: Bituminous
Pavement Type: Asphalt Mix on Granular Base
Length: 23 km
Carriageway width: 7 m
Shoulder width: 1 m
Number of Lanes: 2
Traffic
Motorised: 580 AADT
NMT: 145 AADT
Year: 2019
Flow direction: Two-way

Figure 4.7 defining the Road Network from the HDM-4 software

Finally, the HDM-4 software produces the following output in the program analysis of the road sections.

Table 4.17 Economic Analysis Summary from Program Analysis



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HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Tulla Yaye Program Analysis and Asphalt September 2019
Run Date: 19-08-2019

This report shows total economic benefits using the following:
Currency: Ethiopian Birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Section

Section: Kenera Yaye
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	73.31	0.98	0.00	362.10	83.87	0.00	0.00	0.00	371.67
Discounted	76.01	-4.60	0.00	130.28	29.97	0.00	0.00	0.00	88.85

Economic Internal Rate of Return (EIRR) = 23.6% (No. of solutions = 1)

Section: Tulla Kenera
Alternative: With Project vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	95.63	1.28	0.00	520.12	120.86	0.00	0.00	0.00	544.08
Discounted	99.15	-6.00	0.00	187.13	43.18	0.00	0.00	0.00	137.17

Economic Internal Rate of Return (EIRR) = 25.6% (No. of solutions = 1)

4.9 Measuring externalities

An externality occurs when a transaction takes place and causes an impact on a third party that was not directly involved in the transaction. Put another way, externalities exist when the actions of one group affect the welfare of another group without compensation being made. Externalities are the indirect consequences of transport by road users. In economic terms, externalities exist when the marginal cost to the firm is not equal to the marginal costs for the community. Therefore prices of these goods and services do not reflect the true economic cost, which results in excess or shortage of supply in the market depending on the nature of the externality. Externalities may be positive (where a third party incurs benefits from the transaction) or negative (where a third party incurs costs from the transaction). For example a positive externality may occur when a third party benefits from improved medical research, while a negative externality may occur when a third party suffers the impact of pollution generated by a factory. Transport systems have generally been associated with negative externalities, impacting the environment and human health. The most significant of these externalities in terms of scale include air pollution, greenhouse gas emissions, noise, water pollution and ecological impacts. To accurately reflect the impact of a proposed activity it is necessary to include as many externalities as possible into the CBA. Inclusion of these externalities into the evaluation (that is, by internalising the externality) ensures decision makers will be better able to assess the likely economic impacts of a proposed activity. The incorporation of externalities into the evaluation is achieved by estimating its monetary value. In theory, this monetary value is the financial cost that would be incurred by those that benefit from the externality, to compensate those that incur the impact of the externality. In the case of a transport-related evaluation, the preferred treatment for externalities is to internalise these costs by calculating a monetary value expressed per VKT for inclusion in the CBA. To achieve this, externalities must be quantified and measured. There are different methodologies to value externalities. The complexity of the effects and the large number of diverse stakeholders involved make it very difficult to develop a homogenous method for the evaluation of transport externalities.

To simplify the valuation of externalities with respect to transport, HDM-4 has produced a standardised set of default values for various categories of externalities associated with road projects. The methodology and valuation technique used by HDM4 is based on research conducted in a variety of jurisdictions. These references are used as sources of externalities default values in cases where externalities costs are not critical to the overall project evaluation. When externalities are significant, a specific quantification and valuation has to be under taken as the default values may not necessarily reflect the actual externality values involved. This can be done using techniques such as hedonic pricing which estimates the price of a commodity based on its characteristics which yield utility/disutility, for example estimating noise costs (characteristic of disutility) by estimating changes in house (commodity) prices based on volume of noise. Where externalities cannot be quantified, a qualitative evaluation using an evaluation summary table should be included in the analysis.

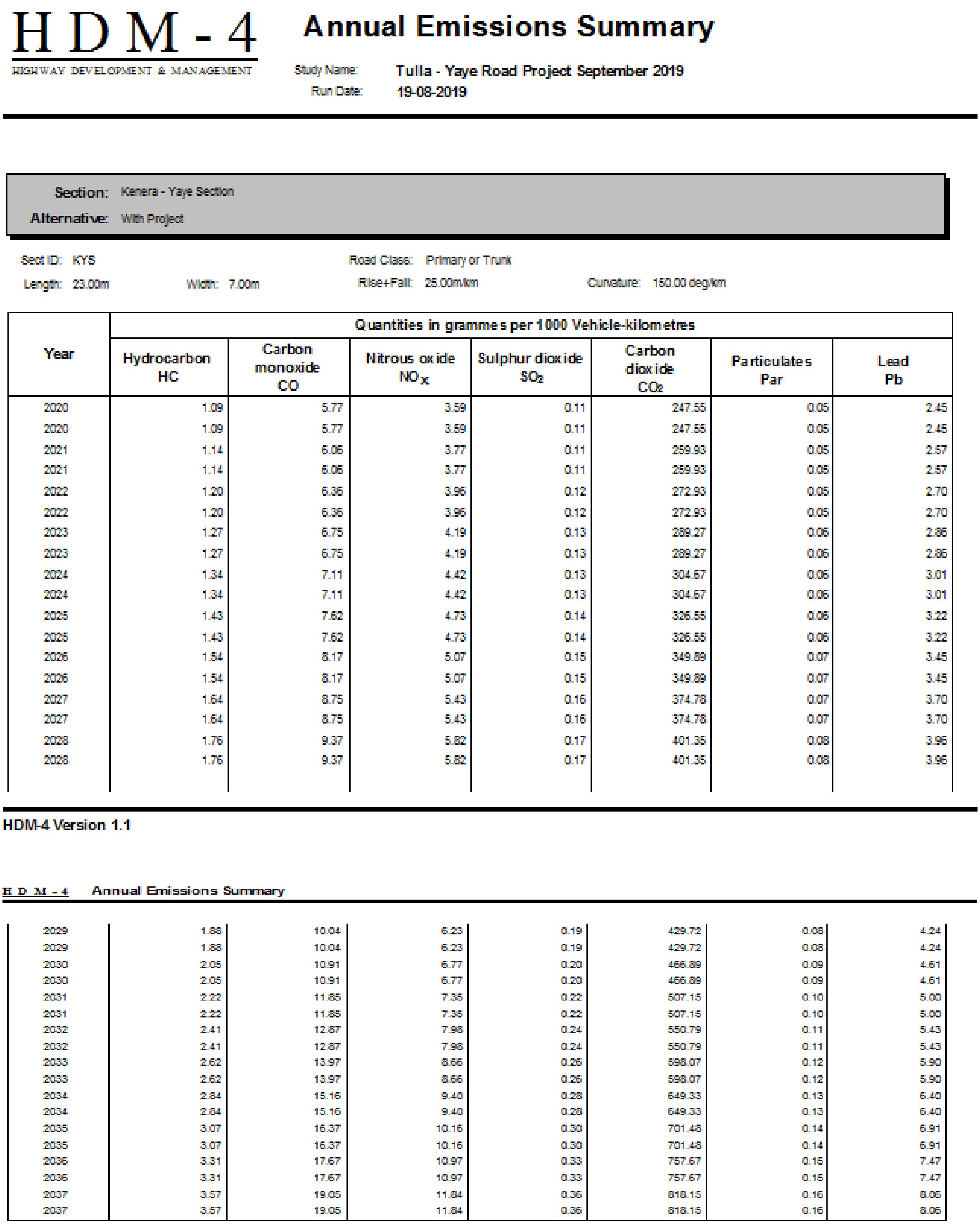
Externalities that are valued in transport evaluation include:

- air pollution
- greenhouse gas emissions
- noise
- water
- nature and landscape
- urban separation
- Downstream effects.

Default externality unit values are presented in Table below for cars and buses in an urban and rural environment. Generally urban externalities will impact a larger number of third parties and are therefore valued higher than externalities that occur in a rural setting.

Types of emissions generated by the HDM 4 are: Hydrocarbon (HC); Carbon Monoxide (CO0; Nitrous Oxide (NO_x); Sulphur Dioxide (SO_2); Carbon Dioxide (CO_2); Particulates (Par); and Lead (P_b).

Table 4.18 Annual Emissions Summary from the HDM-4 software



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HIGHWAY DEVELOPMENT & MANAGEMENT

Annual Emissions Summary

Study Name: Tulla - Yaye Road Project September 2019
Run Date: 19-08-2019

Section: Kenera - Yaye Section
Alternative: With Project

Sect ID: KYS
Road Class: Primary or Trunk
Length: 23.00m
Width: 7.00m
Rise+Fall: 25.00m/km
Curvature: 150.00 deg/km

Year	Quantities in grammes per 1000 Vehicle-kilometres						
	Hydrocarbon HC	Carbon monoxide CO	Nitrous oxide NO_x	Sulphur dioxide SO_2	Carbon dioxide CO_2	Particulates Par	Lead Pb
2020	1.09	5.77	3.59	0.11	247.55	0.05	2.45
2020	1.09	5.77	3.59	0.11	247.55	0.05	2.45
2021	1.14	6.06	3.77	0.11	259.93	0.05	2.57
2021	1.14	6.06	3.77	0.11	259.93	0.05	2.57
2022	1.20	6.36	3.96	0.12	272.93	0.05	2.70
2022	1.20	6.36	3.96	0.12	272.93	0.05	2.70
2023	1.27	6.75	4.19	0.13	289.27	0.06	2.86
2023	1.27	6.75	4.19	0.13	289.27	0.06	2.86
2024	1.34	7.11	4.42	0.13	304.67	0.06	3.01
2024	1.34	7.11	4.42	0.13	304.67	0.06	3.01
2025	1.43	7.62	4.73	0.14	326.55	0.06	3.22
2025	1.43	7.62	4.73	0.14	326.55	0.06	3.22
2026	1.54	8.17	5.07	0.15	349.89	0.07	3.45
2026	1.54	8.17	5.07	0.15	349.89	0.07	3.45
2027	1.64	8.75	5.43	0.16	374.78	0.07	3.70
2027	1.64	8.75	5.43	0.16	374.78	0.07	3.70
2028	1.76	9.37	5.82	0.17	401.35	0.08	3.96
2028	1.76	9.37	5.82	0.17	401.35	0.08	3.96
2029	1.88	10.04	6.23	0.19	429.72	0.08	4.24
2029	1.88	10.04	6.23	0.19	429.72	0.08	4.24
2030	2.05	10.91	6.77	0.20	466.89	0.09	4.61
2030	2.05	10.91	6.77	0.20	466.89	0.09	4.61
2031	2.22	11.85	7.35	0.22	507.15	0.10	5.00
2031	2.22	11.85	7.35	0.22	507.15	0.10	5.00
2032	2.41	12.87	7.98	0.24	550.79	0.11	5.43
2032	2.41	12.87	7.98	0.24	550.79	0.11	5.43
2033	2.62	13.97	8.66	0.26	598.07	0.12	5.90
2033	2.62	13.97	8.66	0.26	598.07	0.12	5.90
2034	2.84	15.16	9.40	0.28	649.33	0.13	6.40
2034	2.84	15.16	9.40	0.28	649.33	0.13	6.40
2035	3.07	16.37	10.16	0.30	701.48	0.14	6.91
2035	3.07	16.37	10.16	0.30	701.48	0.14	6.91
2036	3.31	17.67	10.97	0.33	757.67	0.15	7.47
2036	3.31	17.67	10.97	0.33	757.67	0.15	7.47
2037	3.57	19.05	11.84	0.36	818.15	0.16	8.06
2037	3.57	19.05	11.84	0.36	818.15	0.16	8.06

HDM-4 Version 1.1

H D M - 4 Annual Emissions Summary

Section: Kenera - Yaje Section

Alternative: Without Project

Sect ID: KYS Road Class: Primary or Trunk

Length: 23.00m Width: 7.00m Rise+Fall: 25.00m/km Curvature: 150.00 deg/km

Year	Quantities in grammes per 1000 Vehicle-kilometres						
	Hydrocarbon HC	Carbon monoxide CO	Nitrous oxide NO_X	Sulphur dioxide SO_2	Carbon dioxide CO_2	Particulates Par	Lead Pb
2020	1.09	5.77	3.59	0.11	247.55	0.05	2.45
2020	1.09	5.77	3.59	0.11	247.55	0.05	2.45
2021	1.14	6.08	3.78	0.11	260.78	0.05	2.58
2021	1.14	6.08	3.78	0.11	260.78	0.05	2.58
2022	1.21	6.42	3.99	0.12	275.01	0.05	2.71
2022	1.21	6.42	3.99	0.12	275.01	0.05	2.71
2023	1.27	6.77	4.20	0.13	290.15	0.06	2.86
2023	1.27	6.77	4.20	0.13	290.15	0.06	2.86
2024	1.34	7.13	4.43	0.13	306.20	0.06	3.02
2024	1.34	7.13	4.43	0.13	306.20	0.06	3.02
2025	1.43	7.59	4.75	0.14	327.72	0.06	3.23
2025	1.43	7.59	4.75	0.14	327.72	0.06	3.23
2026	1.52	7.99	5.08	0.15	350.13	0.07	3.47
2026	1.52	7.99	5.08	0.15	350.13	0.07	3.47
2027	1.61	8.24	5.47	0.17	373.32	0.07	3.74
2027	1.61	8.24	5.47	0.17	373.32	0.07	3.74
2028	1.72	8.31	5.97	0.18	401.90	0.08	4.10
2028	1.72	8.31	5.97	0.18	401.90	0.08	4.10
2029	1.87	8.34	6.68	0.20	443.41	0.09	4.63
2029	1.87	8.34	6.68	0.20	443.41	0.09	4.63
2030	2.08	8.73	7.58	0.23	499.13	0.10	5.32
2030	2.08	8.73	7.58	0.23	499.13	0.10	5.32
2031	2.27	9.36	8.33	0.25	547.21	0.11	5.87
2031	2.27	9.36	8.33	0.25	547.21	0.11	5.87
2032	2.46	10.11	9.00	0.27	590.99	0.11	6.34
2032	2.46	10.11	9.00	0.27	590.99	0.11	6.34
2033	2.65	10.92	9.72	0.30	638.27	0.12	6.85
2033	2.65	10.92	9.72	0.30	638.27	0.12	6.85
2034	2.87	11.79	10.49	0.32	689.33	0.13	7.39
2034	2.87	11.79	10.49	0.32	689.33	0.13	7.39
2035	3.08	12.68	11.28	0.34	741.03	0.14	7.95
2035	3.08	12.68	11.28	0.34	741.03	0.14	7.95
2036	3.31	13.63	12.13	0.37	796.60	0.15	8.54
2036	3.31	13.63	12.13	0.37	796.60	0.15	8.54
2037	3.56	14.65	13.03	0.40	856.35	0.17	9.18
2037	3.56	14.65	13.03	0.40	856.35	0.17	9.18

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Pertaining to the main research question of "Assessment of the impact of rural road on socio economic development*",* two subsequent questions were presented as a foundation to address the main question:

- What contribution do rural roads have on economic growth and social services improvement within the study area?
- Analyzing and checking the economic viability of the proposed road project using HDM-4 software and RED model.

The Rural transport infrastructure is an important element towards economic growth, ensuring mobility for people, efficiency and effectiveness in the distribution of resources. An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the regional and national economy. It is therefore important that decisions about investments in roads are made on objective judgments and therefore, Economic appraisal has been carried out for each traffic homogenous section of entire Project road. The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the proposed study is worthy of investment keeping in view the benefits to the society. The Proposal for project road is i.e. maintenance and up gradation to two lanes with gravel shoulders of Tulla Kenera Yaye Section TKY. In order to assess the benefits accrued to the society; both the options of „Without Improvement‟ and „With Improvement‟ has to be compared. For this purpose, the entire existing road has been considered along with its proposed maintenance and improvement proposals. In general, in case of economic analysis is also recommended that analysis period should not be long as it may lead to erroneous results. However, in order to be able to draw the conclusions on common platform Economic Analysis have also been carried out for 15 years of analysis period. Maintaining the road section which is taken as a case study, economic analysis carried out using HDM-IV and RED model results indicates that there is great saving towards Vehicle Operating cost (VOC) and Travel Time cost (TTC) after maintenance. Therefore, it can be concluded that the transport CBA has to be used very carefully for assessing the benefits of policy actions on transport and there impacts on growth.

Recommendations

This study has examined the impact of road transportation on rural development in Sidama Region Local Government area.

- BCA is an appropriate methodology for evaluating the net value, or net return, of a transportation investment.
- Analysts need to consider the full range of benefits and costs to the society at large in applying BCA. Analysts must also be aware of the measurement issues when estimating the economic benefits.
- In addition to the direct impacts, a comprehensive BCA must also incorporate the wider economic benefits, such as agglomeration, competitiveness, and improved labor supply. These wider economic benefits are generally produced as estimates from BCA.
- This also points to the need for including BCA in the modeling toolbox that is used by the analysts, so that the potential economic development due to a transportation investment can be accurately analyzed.
- A road-maintenance policy and strategy are needed for primary and rural roads..
- A comprehensive RMS is necessary for any road authority, which entails regular data collection, database, use of the RED model and HDM-4 model, programming and implementation.
- Rehabilitation (structural overlay) design needs to be considered along with the current maintenance practices in the country.
- MCA may be introduced to prioritized rural roads for maintenance after obtaining economic results from HDM-4. The MCA may be based on social, economic, political, and environmental and job-creation factors.
- Adequate and timely road-maintenance funding is essential, therefore, Ethiopia may consider establishing a Road Fund dedicated for maintenance. Road-user charges are a useful source for ensuring maintenance funding.
- Optimum Road-maintenance standards and strategies using the HDM-4 model need to be set for the whole road network of Ethiopia.

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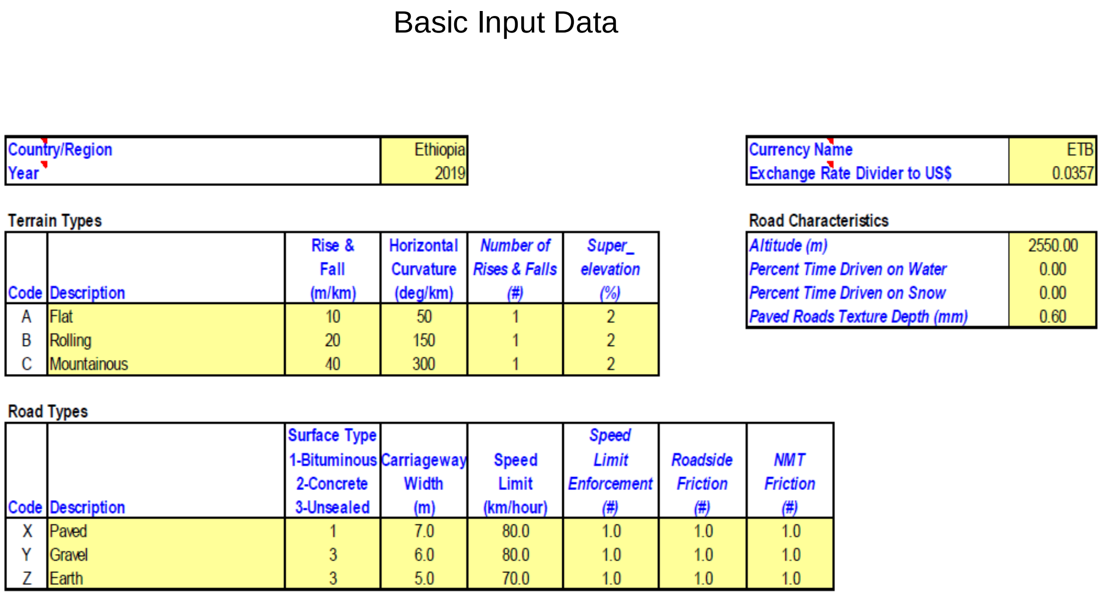
Appendix 1

Basic Input Data Sheet - HDM 4 Module.



Basic Input Data

Country/Region	Ethiopia
Year	2019

Currency Name	ETB
Exchange Rate Divider to US$	0.0357

Terrain Types

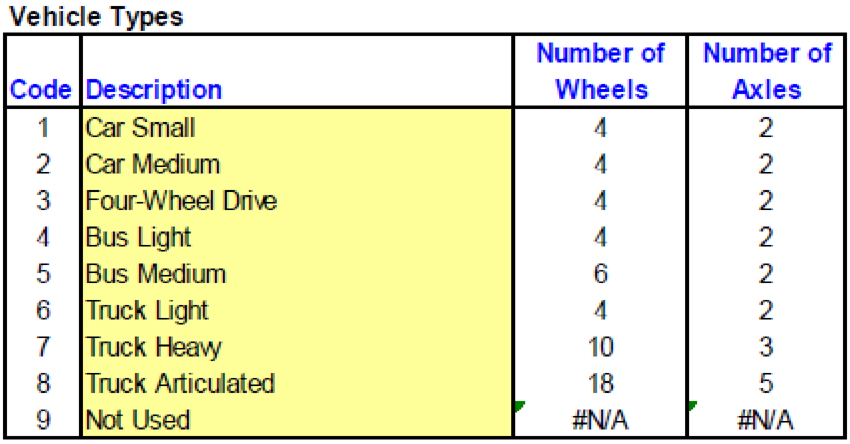
Code	Description	Rise & Fall (m/km)	Horizontal Curvature (deg/km)	*Number of Rises & Falls (#)*	*Super_ elevation (%)*
A	Flat	10	50	1	2
B	Rolling	20	150	1	2
C	Mountainous	40	300	1	2

Road Characteristics

Altitude (m)	2550.00
Percent Time Driven on Water	0.00
Percent Time Driven on Snow	0.00
Paved Roads Texture Depth (mm)	0.60

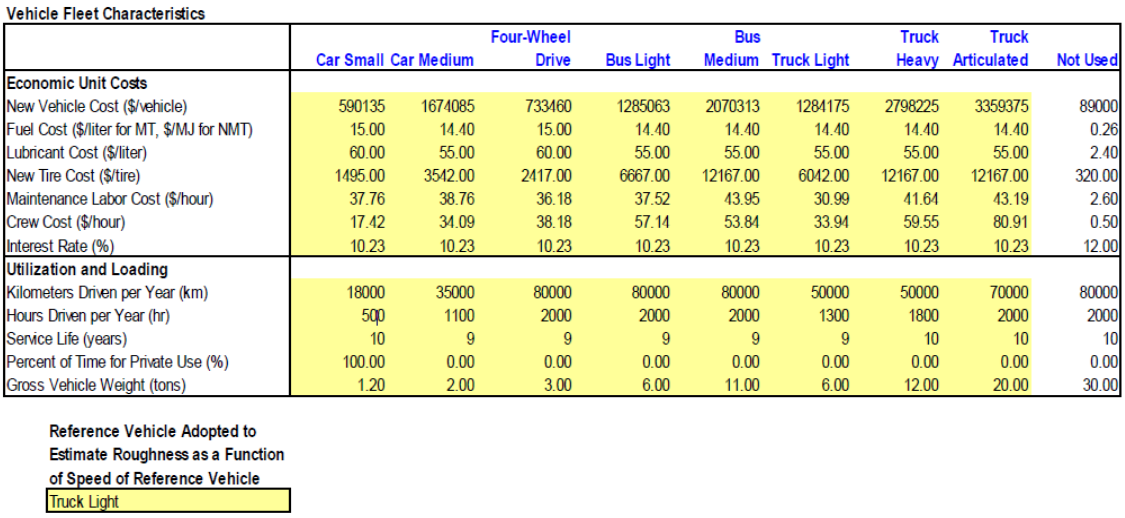
Road Types

Code	Description	Surface Type 1-Bituminous 2-Concrete 3-Unsealed	Carriageway Width (m)	Speed Limit (km/hour)	*Speed Limit Enforcement (#)*	*Roadside Friction (#)*	*NMT Friction (#)*
X	Paved	1	7.0	80.0	1.0	1.0	1.0
Y	Gravel	3	6.0	80.0	1.0	1.0	1.0
Z	Earth	3	5.0	70.0	1.0	1.0	1.0



Vehicle Types

Code	Description	Number of Wheels	Number of Axles
1	Car Small	4	2
2	Car Medium	4	2
3	Four-Wheel Drive	4	2
4	Bus Light	4	2
5	Bus Medium	6	2
6	Truck Light	4	2
7	Truck Heavy	10	3
8	Truck Articulated	18	5
9	Not Used	#N/A	#N/A



Vehicle Fleet Characteristics

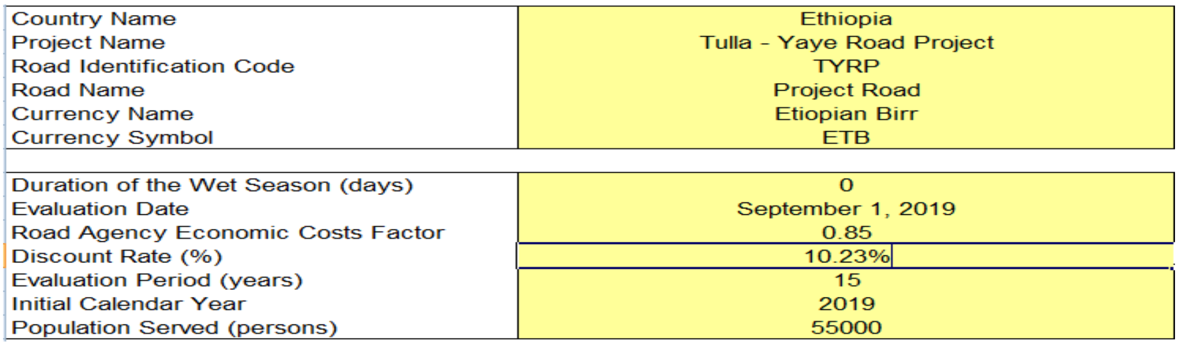
	Car Small	Car Medium	Four-Wheel Drive	Bus Light	Bus Medium	Truck Light	Truck Heavy	Truck Articulated	Not Used
Economic Unit Costs									
New Vehicle Cost ($/vehicle)	590135	1674085	733460	1285063	2070313	1284175	2798225	3359375	89000
Fuel Cost ($/liter for MT, $/MJ for NMT)	15.00	14.40	15.00	14.40	14.40	14.40	14.40	14.40	0.26
Lubricant Cost ($/liter)	60.00	55.00	60.00	55.00	55.00	55.00	55.00	55.00	2.40
New Tire Cost ($/tire)	1495.00	3542.00	2417.00	6667.00	12167.00	6042.00	12167.00	12167.00	320.00
Maintenance Labor Cost ($/hour)	37.76	38.76	36.18	37.52	43.95	30.99	41.64	43.19	2.60
Crew Cost ($/hour)	17.42	34.09	38.18	57.14	53.84	33.94	59.55	80.91	0.50
Interest Rate (%)	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23	12.00
Utilization and Loading									
Kilometers Driven per Year (km)	18000	35000	80000	80000	80000	50000	50000	70000	80000
Hours Driven per Year (hr)	500	1100	2000	2000	2000	1300	1800	2000	2000
Service Life (years)	10	9	9	9	9	9	10	10	10
Percent of Time for Private Use (%)	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Vehicle Weight (tons)	1.20	2.00	3.00	6.00	11.00	6.00	12.00	20.00	30.00

Reference Vehicle Adopted to Estimate Roughness as a Function of Speed of Reference Vehicle

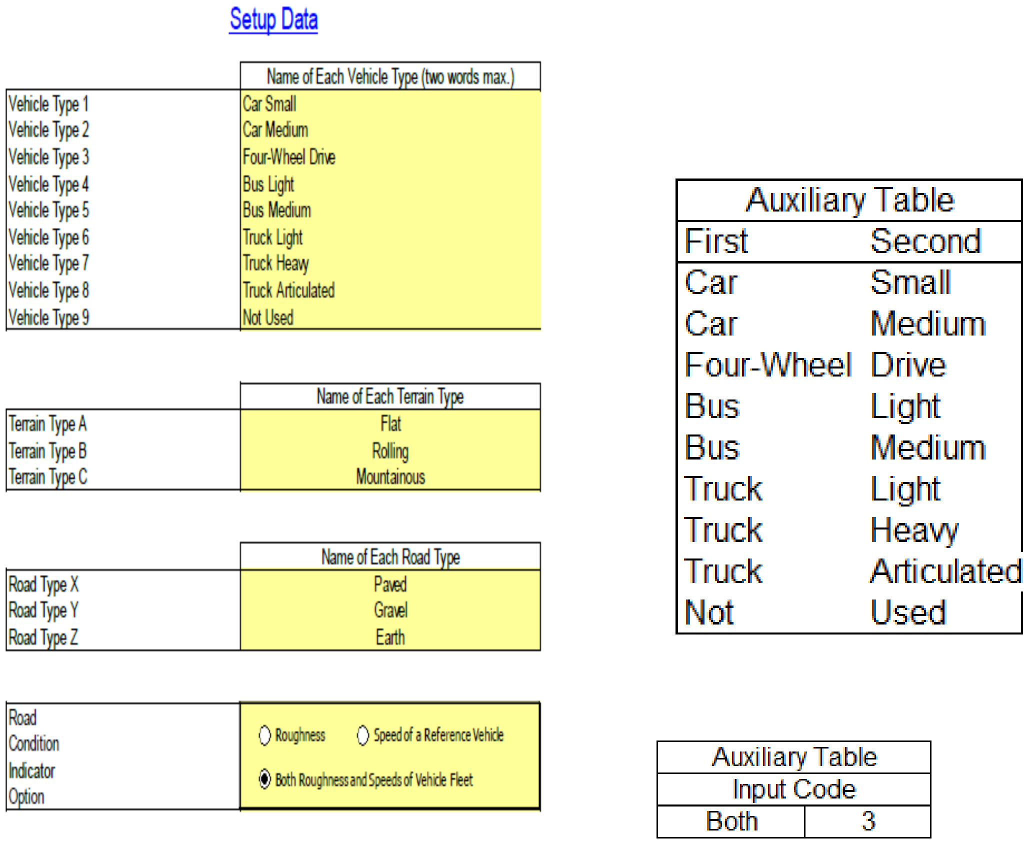
Truck Light

- **Completed Control Data Sheet.**

Control Data



Country Name	Ethiopia
Project Name	Tulla - Yaye Road Project
Road Identification Code	TYRP
Road Name	Project Road
Currency Name	Etiopian Birr
Currency Symbol	ETB
Duration of the Wet Season (days)	0
Evaluation Date	September 1, 2019
Road Agency Economic Costs Factor	0.85
Discount Rate (%)	10.23%
Evaluation Period (years)	15
Initial Calendar Year	2019
Population Served (persons)	55000



Setup Data

	Name of Each Vehicle Type (two words max.)
Vehicle Type 1	Car Small
Vehicle Type 2	Car Medium
Vehicle Type 3	Four-Wheel Drive
Vehicle Type 4	Bus Light
Vehicle Type 5	Bus Medium
Vehicle Type 6	Truck Light
Vehicle Type 7	Truck Heavy
Vehicle Type 8	Truck Articulated
Vehicle Type 9	Not Used

	Name of Each Terrain Type
Terrain Type A	Flat
Terrain Type B	Rolling
Terrain Type C	Mountainous

	Name of Each Road Type
Road Type X	Paved
Road Type Y	Gravel
Road Type Z	Earth

Road Condition Indicator Option	○ Roughness ○ Speed of a Reference Vehicle ● Both Roughness and Speeds of Vehicle Fleet

Auxiliary Table	
First	Second
Car	Small
Car	Medium
Four-Wheel	Drive
Bus	Light
Bus	Medium
Truck	Light
Truck	Heavy
Truck	Articulated
Not	Used

Auxiliary Table	
Input Code	
Both	3

Note that for mountainous terrain the option of entering both roughness and speeds of vehicle fleet is recommended because, in that case, the speeds of all vehicles are not a function of road roughness but function of the road geometry.

Appendix2

Sensitivity analysis

The Excel sheet named "Analysis" permits to implement sensitivity analysis dynamically. This tool allows testing what are the main factors which influence costs and prices?

The following figure illustrated how the analysis works:

- Road characteristics and truck type has to be chosen.
- The independent variable taken from a list has to be selected it will be the value put in x axis on the graph. The independent variable is chosen among the basic input data. This may be for example, the percentage of empty mileage, the load rate, the fuel financial costs

- Range value for the independent variable has to entered (from … to …)
- The dependent variable has to be selected also from a list. This variable will constitute y axis of the graph.

As a result, it is possible to test different factors and see what their impact on the transport is Costs and prices. Some of the figure which illustrated the present report has been made using this tool.

Sensitivity analysis permits to observe clearly that some factors such as:

- condition of the road (IRI) ;
- diminution of empty backhaul ;
- improvement of vehicle loading ;

Have a great influence in the setting up of transport costs and prices and may permit the improvement of revenue for transport carriers.

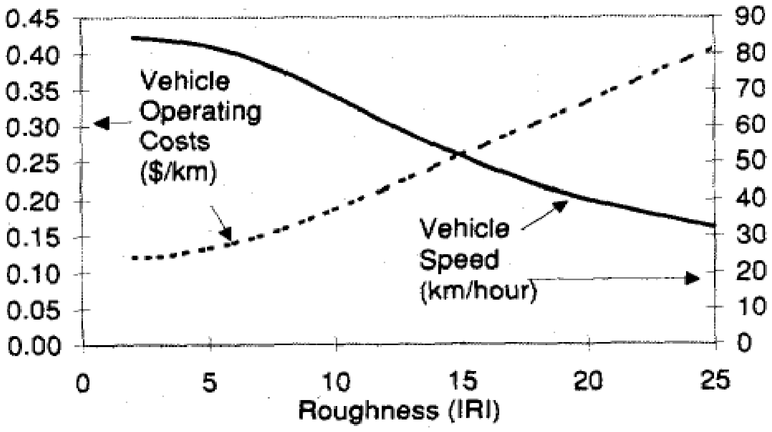


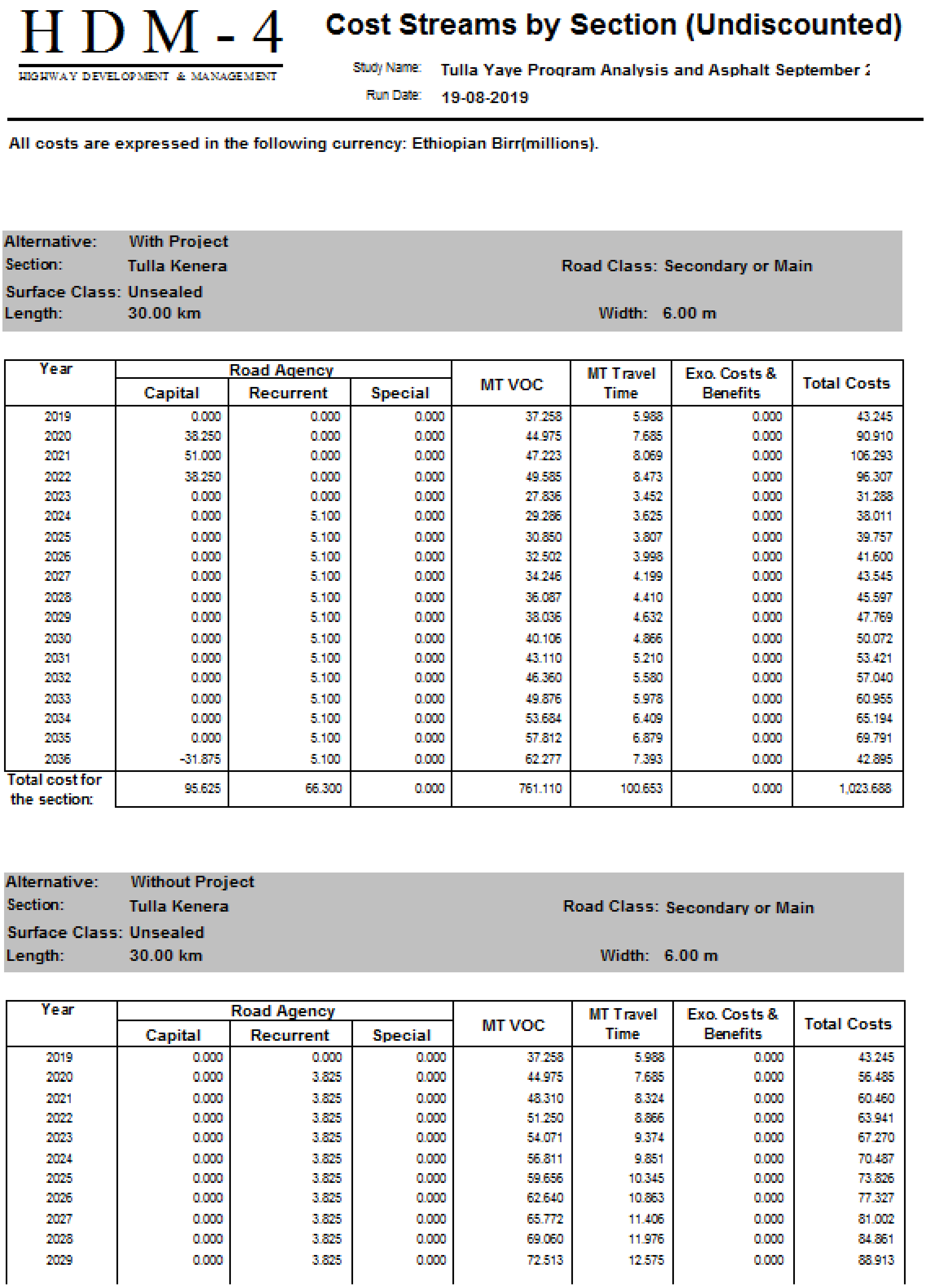
Figure 2. Typical VOC and speed relationships

Passenger Car / Flat Terrain / Two-Lane Road

proper presentation of the results with the capability for sensitivity, switching values and stochastic risk analyses; and have the evaluation model on a spreadsheet, such as Excel, in order to capitalize on built-in features and tools such as goal seek, scenarios, solver, data analysis, and additional analytical add-ins.

To calculate vehicle operating costs and speeds for a given level of service, the relationships between vehicle operating costs and speeds to road roughness must be defined, using cubic polynomials, for up to nine vehicle types; three terrain types and three road types (see the Figure above).

Appendix 2



H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Cost Streams by Section (Undiscounted)

Study Name: Tulla Yaye Program Analysis and Asphalt September :
Run Date: 19-08-2019

All costs are expressed in the following currency: Ethiopian Birr(millions).

Alternative: With Project
Section: Tulla Kenera
Road Class: Secondary or Main
Surface Class: Unsealed
Length: 30.00 km
Width: 6.00 m

Year	Road Agency			MT VOC	MT Travel Time	Exo. Costs & Benefits	Total Costs
	Capital	Recurrent	Special				
2019	0.000	0.000	0.000	37.258	5.988	0.000	43.245
2020	38.250	0.000	0.000	44.975	7.685	0.000	90.910
2021	51.000	0.000	0.000	47.223	8.069	0.000	106.293
2022	38.250	0.000	0.000	49.585	8.473	0.000	96.307
2023	0.000	0.000	0.000	27.836	3.452	0.000	31.288
2024	0.000	5.100	0.000	29.286	3.625	0.000	38.011
2025	0.000	5.100	0.000	30.850	3.807	0.000	39.757
2026	0.000	5.100	0.000	32.502	3.998	0.000	41.600
2027	0.000	5.100	0.000	34.246	4.199	0.000	43.545
2028	0.000	5.100	0.000	36.087	4.410	0.000	45.597
2029	0.000	5.100	0.000	38.036	4.632	0.000	47.769
2030	0.000	5.100	0.000	40.106	4.866	0.000	50.072
2031	0.000	5.100	0.000	43.110	5.210	0.000	53.421
2032	0.000	5.100	0.000	46.360	5.580	0.000	57.040
2033	0.000	5.100	0.000	49.876	5.978	0.000	60.955
2034	0.000	5.100	0.000	53.684	6.409	0.000	65.194
2035	0.000	5.100	0.000	57.812	6.879	0.000	69.791
2036	-31.875	5.100	0.000	62.277	7.393	0.000	42.895
Total cost for the section:	95.625	66.300	0.000	761.110	100.653	0.000	1,023.688

Alternative: Without Project
Section: Tulla Kenera
Road Class: Secondary or Main
Surface Class: Unsealed
Length: 30.00 km
Width: 6.00 m

Year	Road Agency			MT VOC	MT Travel Time	Exo. Costs & Benefits	Total Costs
	Capital	Recurrent	Special				
2019	0.000	0.000	0.000	37.258	5.988	0.000	43.245
2020	0.000	3.825	0.000	44.975	7.685	0.000	56.485
2021	0.000	3.825	0.000	48.310	8.324	0.000	60.460
2022	0.000	3.825	0.000	51.250	8.866	0.000	63.941
2023	0.000	3.825	0.000	54.071	9.374	0.000	67.270
2024	0.000	3.825	0.000	56.811	9.851	0.000	70.487
2025	0.000	3.825	0.000	59.656	10.345	0.000	73.826
2026	0.000	3.825	0.000	62.640	10.863	0.000	77.327
2027	0.000	3.825	0.000	65.772	11.406	0.000	81.002
2028	0.000	3.825	0.000	69.060	11.976	0.000	84.861
2029	0.000	3.825	0.000	72.513	12.575	0.000	88.913

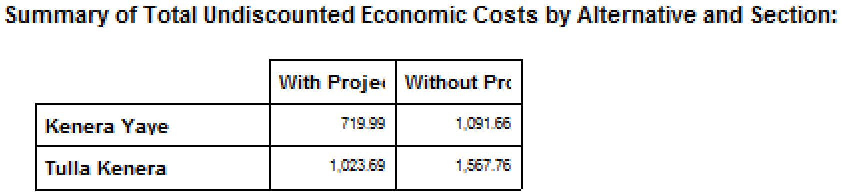
2030	0.000	3.825	0.000	76.139	13.204	0.000	93.167
2031	0.000	3.825	0.000	81.469	14.128	0.000	99.421
2032	0.000	3.825	0.000	87.171	15.117	0.000	106.113
2033	0.000	3.825	0.000	93.273	16.175	0.000	113.273
2034	0.000	3.825	0.000	99.803	17.307	0.000	120.935
2035	0.000	3.825	0.000	106.789	18.519	0.000	129.132
2036	0.000	3.825	0.000	114.264	19.815	0.000	137.904
Total cost for the section:	0.000	65.025	0.000	1,281.223	221.517	0.000	1,567.765

Alternative: With Project
Section: Kenera Yaye **Road Class:** Secondary or Main
Surface Class: Unsealed
Length: 23.00 km **Width:** 6.00 m

Year	Road Agency			MT VOC	MT Travel Time	Exo. Costs & Benefits	Total Costs
	Capital	Recurrent	Special				
2019	0.000	0.000	0.000	26.102	4.222	0.000	30.324
2020	29.325	0.000	0.000	31.094	5.310	0.000	65.729
2021	39.100	0.000	0.000	32.649	5.576	0.000	77.324
2022	29.325	0.000	0.000	34.281	5.855	0.000	69.461
2023	0.000	0.000	0.000	19.234	2.392	0.000	21.627
2024	0.000	3.910	0.000	20.234	2.512	0.000	26.657
2025	0.000	3.910	0.000	21.314	2.638	0.000	27.862
2026	0.000	3.910	0.000	22.454	2.771	0.000	29.134
2027	0.000	3.910	0.000	23.657	2.910	0.000	30.477
2028	0.000	3.910	0.000	24.927	3.056	0.000	31.894
2029	0.000	3.910	0.000	26.272	3.210	0.000	33.392
2030	0.000	3.910	0.000	27.699	3.372	0.000	34.981
2031	0.000	3.910	0.000	29.770	3.610	0.000	37.291
2032	0.000	3.910	0.000	32.011	3.866	0.000	39.787
2033	0.000	3.910	0.000	34.435	4.142	0.000	42.487
2034	0.000	3.910	0.000	37.060	4.440	0.000	45.410
2035	0.000	3.910	0.000	39.905	4.764	0.000	48.578
2036	-24.438	3.910	0.000	42.984	5.118	0.000	27.574
Total cost for the section:	73.313	50.830	0.000	526.082	69.763	0.000	719.988

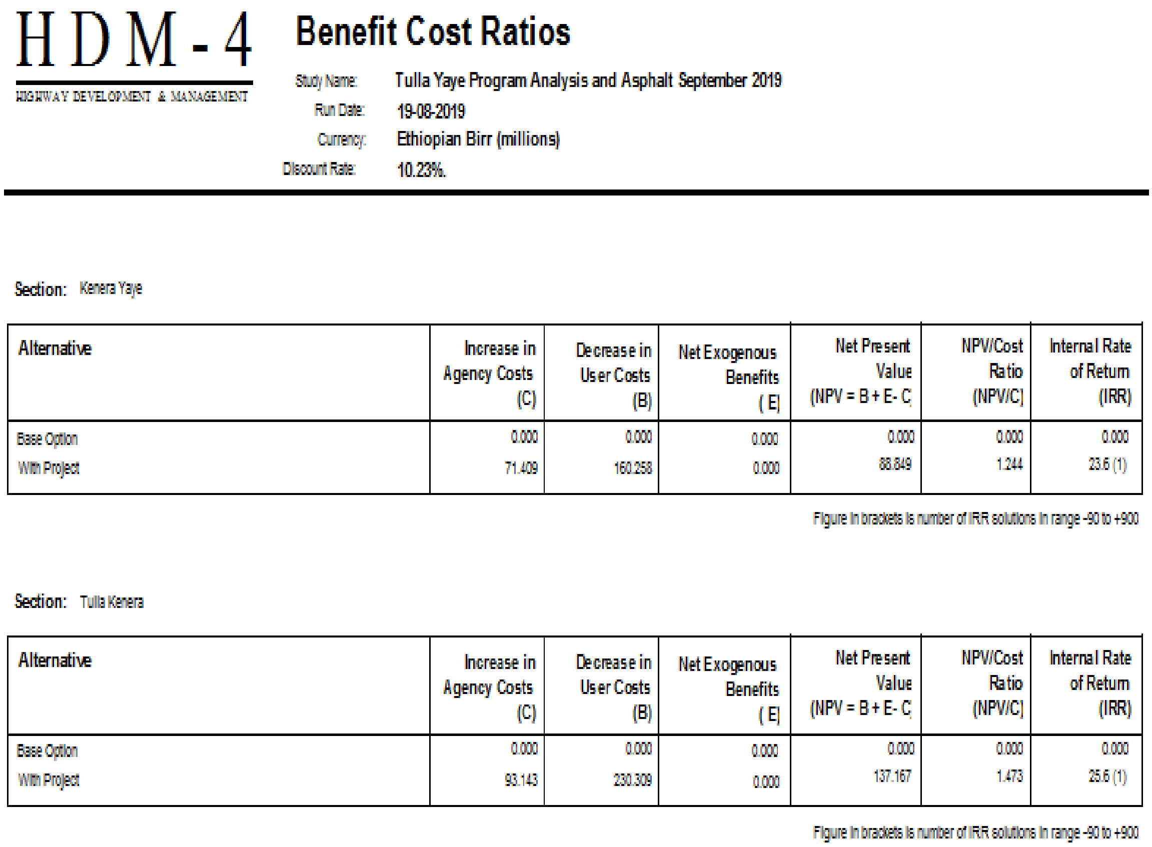
Alternative: Without Project
Section: Kenera Yaye **Road Class:** Secondary or Main
Surface Class: Unsealed
Length: 23.00 km **Width:** 6.00 m

Year	Road Agency			MT VOC	MT Travel Time	Exo. Costs & Benefits	Total Costs
	Capital	Recurrent	Special				
2019	0.000	0.000	0.000	26.102	4.222	0.000	30.324
2020	0.000	2.933	0.000	31.094	5.310	0.000	39.337
2021	0.000	2.933	0.000	33.445	5.763	0.000	42.141
2022	0.000	2.933	0.000	35.501	6.142	0.000	44.576
2023	0.000	2.933	0.000	37.469	6.497	0.000	46.899
2024	0.000	2.933	0.000	39.375	6.830	0.000	49.138



Summary of Total Undiscounted Economic Costs by Alternative and Section:

	With Proje	Without Pr
Kenera Yaye	719.99	1,091.66
Tulla Kenera	1,023.69	1,567.76



HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Tulla Yaye Program Analysis and Asphalt September 2019
Run Date: 19-08-2019
Currency: Ethiopian Birr (millions)
Discount Rate: 10.23%.

Section: Kenera Yaye

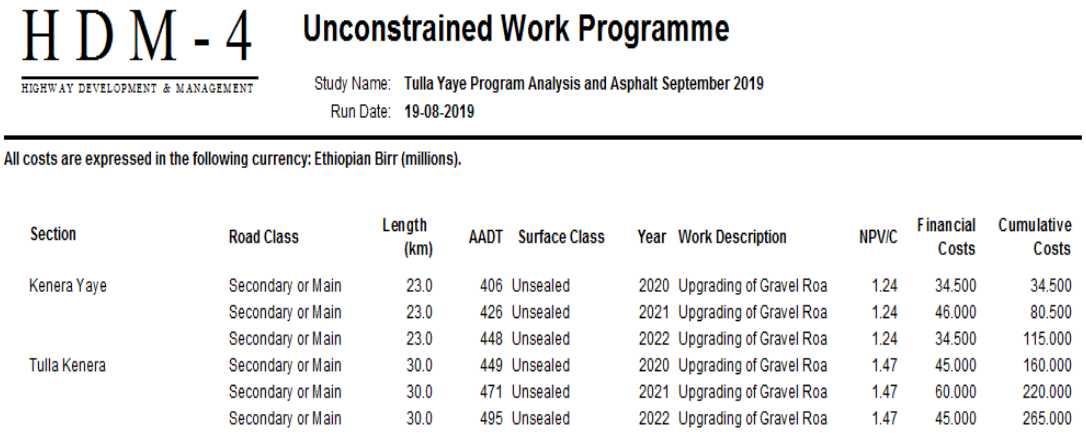
Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
Base Option	0.000	0.000	0.000	0.000	0.000	0.000
With Project	71.409	160.258	0.000	88.849	1.244	23.6 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Section: Tulla Kenera

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
Base Option	0.000	0.000	0.000	0.000	0.000	0.000
With Project	93.143	230.309	0.000	137.167	1.473	25.6 (1)

Figure in brackets is number of IRR solutions in range -90 to +900



HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Unconstrained Work Programme

Study Name: Tulla Yaye Program Analysis and Asphalt September 2019
Run Date: 19-08-2019

All costs are expressed in the following currency: Ethiopian Birr (millions).

Section	Road Class	Length (km)	AADT	Surface Class	Year	Work Description	NPV/C	Financial Costs	Cumulative Costs
Kenera Yaye	Secondary or Main	23.0	406	Unsealed	2020	Upgrading of Gravel Roa	1.24	34.500	34.500
	Secondary or Main	23.0	426	Unsealed	2021	Upgrading of Gravel Roa	1.24	46.000	80.500
	Secondary or Main	23.0	448	Unsealed	2022	Upgrading of Gravel Roa	1.24	34.500	115.000
Tulla Kenera	Secondary or Main	30.0	449	Unsealed	2020	Upgrading of Gravel Roa	1.47	45.000	160.000
	Secondary or Main	30.0	471	Unsealed	2021	Upgrading of Gravel Roa	1.47	60.000	220.000
	Secondary or Main	30.0	495	Unsealed	2022	Upgrading of Gravel Roa	1.47	45.000	265.000

For section 1

- Net Present Value, NPV = 88.849
- Economical Internal rate of Return (EIRR) = 23.6%
- Benefit Cost Ratio (B-CR)

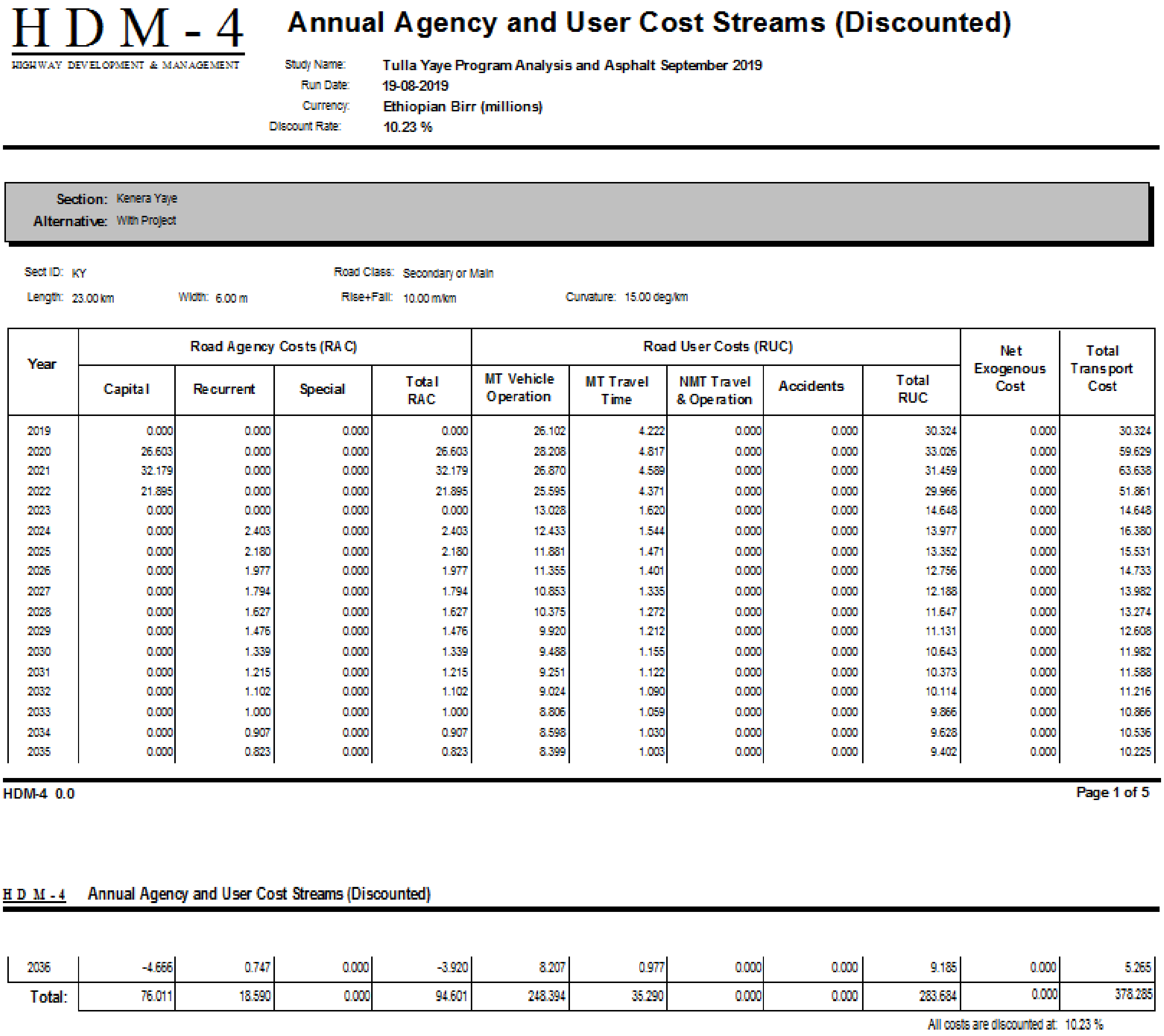
  B-CR = B/C = 160.258/71.409 = 2.24

For section 2

- Net Present Value, NPV = 137.167
- Economical Internal rate of Return (EIRR) = 25.6%
- Benefit Cost Ratio (B-CR)

  B-CR = B/C = 230.309/93.143 = 2.47

Appendix 3



HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Annual Agency and User Cost Streams (Discounted)

Study Name: Tulla Yaye Program Analysis and Asphalt September 2019
Run Date: 19-08-2019
Currency: Ethiopian Birr (millions)
Discount Rate: 10.23 %

Section: Kenera Yaye
Alternative: With Project

Sect ID: KY
Road Class: Secondary or Main
Length: 23.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	26.102	4.222	0.000	0.000	30.324	0.000	30.324
2020	26.603	0.000	0.000	26.603	28.208	4.817	0.000	0.000	33.026	0.000	59.629
2021	32.179	0.000	0.000	32.179	26.870	4.589	0.000	0.000	31.459	0.000	63.638
2022	21.895	0.000	0.000	21.895	25.595	4.371	0.000	0.000	29.966	0.000	51.861
2023	0.000	0.000	0.000	0.000	13.028	1.620	0.000	0.000	14.648	0.000	14.648
2024	0.000	2.403	0.000	2.403	12.433	1.544	0.000	0.000	13.977	0.000	16.380
2025	0.000	2.180	0.000	2.180	11.881	1.471	0.000	0.000	13.352	0.000	15.531
2026	0.000	1.977	0.000	1.977	11.355	1.401	0.000	0.000	12.756	0.000	14.733
2027	0.000	1.794	0.000	1.794	10.853	1.335	0.000	0.000	12.188	0.000	13.982
2028	0.000	1.627	0.000	1.627	10.375	1.272	0.000	0.000	11.647	0.000	13.274
2029	0.000	1.476	0.000	1.476	9.920	1.212	0.000	0.000	11.131	0.000	12.608
2030	0.000	1.339	0.000	1.339	9.488	1.155	0.000	0.000	10.643	0.000	11.982
2031	0.000	1.215	0.000	1.215	9.251	1.122	0.000	0.000	10.373	0.000	11.588
2032	0.000	1.102	0.000	1.102	9.024	1.090	0.000	0.000	10.114	0.000	11.216
2033	0.000	1.000	0.000	1.000	8.806	1.059	0.000	0.000	9.866	0.000	10.866
2034	0.000	0.907	0.000	0.907	8.598	1.030	0.000	0.000	9.628	0.000	10.536
2035	0.000	0.823	0.000	0.823	8.399	1.003	0.000	0.000	9.402	0.000	10.225
2036	-4.666	0.747	0.000	-3.920	8.207	0.977	0.000	0.000	9.185	0.000	5.265
Total:	76.011	18.590	0.000	94.601	248.394	35.290	0.000	0.000	283.684	0.000	378.285

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HDM-4 Annual Agency and User Cost Streams (Discounted)

All costs are discounted at: 10.23 %

Section: Kenera Yaye
Alternative: Without Project

Sect ID: KY
Road Class: Secondary or Main
Length: 23.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	26.102	4.222	0.000	0.000	30.324	0.000	30.324
2020	0.000	2.660	0.000	2.660	28.208	4.817	0.000	0.000	33.026	0.000	35.686
2021	0.000	2.413	0.000	2.413	27.526	4.743	0.000	0.000	32.268	0.000	34.682
2022	0.000	2.189	0.000	2.189	26.506	4.586	0.000	0.000	31.092	0.000	33.281
2023	0.000	1.986	0.000	1.986	25.379	4.401	0.000	0.000	29.780	0.000	31.766
2024	0.000	1.802	0.000	1.802	24.195	4.197	0.000	0.000	28.392	0.000	30.194
2025	0.000	1.635	0.000	1.635	23.050	3.999	0.000	0.000	27.048	0.000	28.683
2026	0.000	1.483	0.000	1.483	21.957	3.809	0.000	0.000	25.766	0.000	27.249
2027	0.000	1.345	0.000	1.345	20.915	3.628	0.000	0.000	24.543	0.000	25.889
2028	0.000	1.221	0.000	1.221	19.923	3.456	0.000	0.000	23.379	0.000	24.599
2029	0.000	1.107	0.000	1.107	18.977	3.292	0.000	0.000	22.269	0.000	23.376
2030	0.000	1.004	0.000	1.004	18.077	3.136	0.000	0.000	21.213	0.000	22.217
2031	0.000	0.911	0.000	0.911	17.547	3.044	0.000	0.000	20.591	0.000	21.502
2032	0.000	0.827	0.000	0.827	17.033	2.955	0.000	0.000	19.988	0.000	20.814
2033	0.000	0.750	0.000	0.750	16.534	2.868	0.000	0.000	19.402	0.000	20.152
2034	0.000	0.680	0.000	0.680	16.050	2.784	0.000	0.000	18.834	0.000	19.514
2035	0.000	0.617	0.000	0.617	15.579	2.703	0.000	0.000	18.282	0.000	18.899
2036	0.000	0.560	0.000	0.560	15.122	2.623	0.000	0.000	17.746	0.000	18.306

Total:	0.000	23.192	0.000	23.192	378.680	65.263	0.000	0.000	443.942	0.000	467.135

All costs are discounted at: 10.23 %

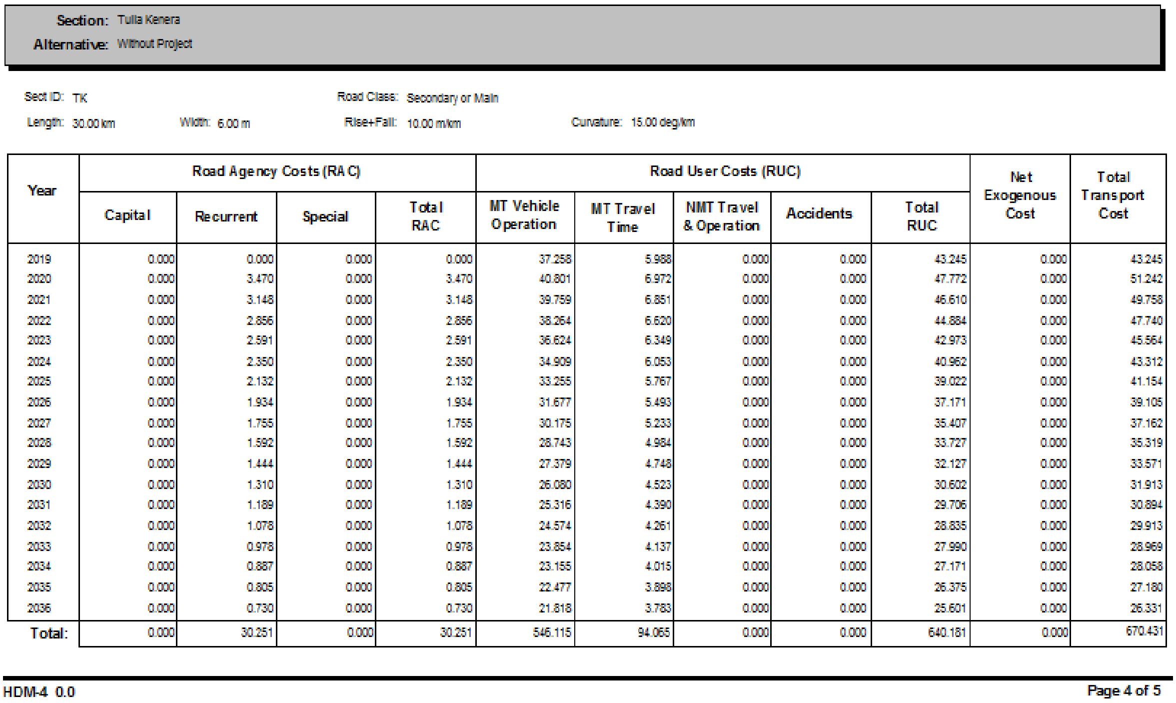
Section: Tulla Kenera
Alternative: With Project

Sect ID: TK
Road Class: Secondary or Main
Length: 30.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	37.258	5.988	0.000	0.000	43.245	0.000	43.245
2020	34.700	0.000	0.000	34.700	40.801	6.972	0.000	0.000	47.772	0.000	82.472
2021	41.973	0.000	0.000	41.973	38.865	6.641	0.000	0.000	45.506	0.000	87.479
2022	28.558	0.000	0.000	28.558	37.021	6.326	0.000	0.000	43.347	0.000	71.905
2023	0.000	0.000	0.000	0.000	18.854	2.338	0.000	0.000	21.192	0.000	21.192
2024	0.000	3.134	0.000	3.134	17.995	2.227	0.000	0.000	20.223	0.000	23.357
2025	0.000	2.843	0.000	2.843	17.197	2.122	0.000	0.000	19.319	0.000	22.162
2026	0.000	2.579	0.000	2.579	16.437	2.022	0.000	0.000	18.458	0.000	21.037
2027	0.000	2.340	0.000	2.340	15.711	1.926	0.000	0.000	17.638	0.000	19.977
2028	0.000	2.123	0.000	2.123	15.019	1.835	0.000	0.000	16.855	0.000	18.977
2029	0.000	1.926	0.000	1.926	14.361	1.749	0.000	0.000	16.110	0.000	18.036
2030	0.000	1.747	0.000	1.747	13.738	1.667	0.000	0.000	15.404	0.000	17.151
2031	0.000	1.585	0.000	1.585	13.396	1.619	0.000	0.000	15.015	0.000	16.600
2032	0.000	1.438	0.000	1.438	13.069	1.573	0.000	0.000	14.642	0.000	16.080
2033	0.000	1.304	0.000	1.304	12.755	1.529	0.000	0.000	14.284	0.000	15.589
2034	0.000	1.183	0.000	1.183	12.455	1.487	0.000	0.000	13.942	0.000	15.126
2035	0.000	1.073	0.000	1.073	12.168	1.448	0.000	0.000	13.616	0.000	14.690
2036	-6.086	0.974	0.000	-5.112	11.891	1.412	0.000	0.000	13.303	0.000	8.190

Total:	99.145	24.248	0.000	123.393	358.992	50.881	0.000	0.000	409.873	0.000	533.266

All costs are discounted at: 10.23 %



Section: Tulla Kenera
Alternative: Without Project

Sect ID: TK
Road Class: Secondary or Main
Length: 30.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	37.258	5.988	0.000	0.000	43.245	0.000	43.245
2020	0.000	3.470	0.000	3.470	40.801	6.972	0.000	0.000	47.772	0.000	51.242
2021	0.000	3.148	0.000	3.148	39.759	6.851	0.000	0.000	46.610	0.000	49.758
2022	0.000	2.856	0.000	2.856	38.264	6.620	0.000	0.000	44.884	0.000	47.740
2023	0.000	2.591	0.000	2.591	36.624	6.349	0.000	0.000	42.973	0.000	45.564
2024	0.000	2.350	0.000	2.350	34.909	6.053	0.000	0.000	40.962	0.000	43.312
2025	0.000	2.132	0.000	2.132	33.255	5.767	0.000	0.000	39.022	0.000	41.154
2026	0.000	1.934	0.000	1.934	31.677	5.493	0.000	0.000	37.171	0.000	39.105
2027	0.000	1.755	0.000	1.755	30.175	5.233	0.000	0.000	35.407	0.000	37.162
2028	0.000	1.592	0.000	1.592	28.743	4.984	0.000	0.000	33.727	0.000	35.319
2029	0.000	1.444	0.000	1.444	27.379	4.748	0.000	0.000	32.127	0.000	33.571
2030	0.000	1.310	0.000	1.310	26.080	4.523	0.000	0.000	30.602	0.000	31.913
2031	0.000	1.189	0.000	1.189	25.316	4.390	0.000	0.000	29.706	0.000	30.894
2032	0.000	1.078	0.000	1.078	24.574	4.261	0.000	0.000	28.835	0.000	29.913
2033	0.000	0.978	0.000	0.978	23.854	4.137	0.000	0.000	27.990	0.000	28.969
2034	0.000	0.887	0.000	0.887	23.155	4.015	0.000	0.000	27.171	0.000	28.058
2035	0.000	0.805	0.000	0.805	22.477	3.898	0.000	0.000	26.375	0.000	27.180
2036	0.000	0.730	0.000	0.730	21.818	3.783	0.000	0.000	25.601	0.000	26.331
Total:	0.000	30.251	0.000	30.251	546.115	94.065	0.000	0.000	640.181	0.000	670.431

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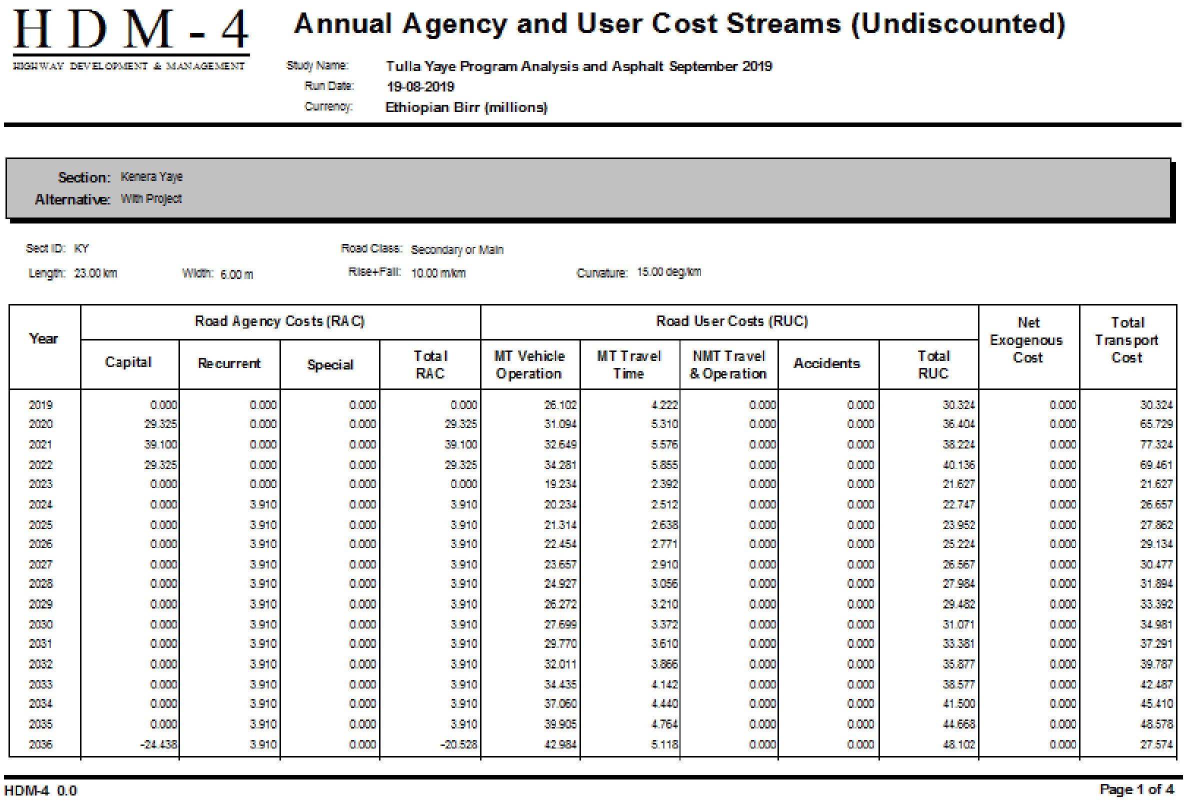

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Annual Agency and User Cost Streams (Undiscounted)

Study Name: **Tulla Yaye Program Analysis and Asphalt September 2019**
Run Date: **19-08-2019**
Currency: **Ethiopian Birr (millions)**

Section: Kenera Yaye
Alternative: With Project

Sect ID: KY
Road Class: Secondary or Main
Length: 23.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	26.102	4.222	0.000	0.000	30.324	0.000	30.324
2020	29.325	0.000	0.000	29.325	31.094	5.310	0.000	0.000	36.404	0.000	65.729
2021	39.100	0.000	0.000	39.100	32.649	5.576	0.000	0.000	38.224	0.000	77.324
2022	29.325	0.000	0.000	29.325	34.281	5.855	0.000	0.000	40.136	0.000	69.461
2023	0.000	0.000	0.000	0.000	19.234	2.392	0.000	0.000	21.627	0.000	21.627
2024	0.000	3.910	0.000	3.910	20.234	2.512	0.000	0.000	22.747	0.000	26.657
2025	0.000	3.910	0.000	3.910	21.314	2.638	0.000	0.000	23.952	0.000	27.862
2026	0.000	3.910	0.000	3.910	22.454	2.771	0.000	0.000	25.224	0.000	29.134
2027	0.000	3.910	0.000	3.910	23.657	2.910	0.000	0.000	26.567	0.000	30.477
2028	0.000	3.910	0.000	3.910	24.927	3.056	0.000	0.000	27.984	0.000	31.894
2029	0.000	3.910	0.000	3.910	26.272	3.210	0.000	0.000	29.482	0.000	33.392
2030	0.000	3.910	0.000	3.910	27.699	3.372	0.000	0.000	31.071	0.000	34.981
2031	0.000	3.910	0.000	3.910	29.770	3.610	0.000	0.000	33.381	0.000	37.291
2032	0.000	3.910	0.000	3.910	32.011	3.866	0.000	0.000	35.877	0.000	39.787
2033	0.000	3.910	0.000	3.910	34.435	4.142	0.000	0.000	38.577	0.000	42.487
2034	0.000	3.910	0.000	3.910	37.060	4.440	0.000	0.000	41.500	0.000	45.410
2035	0.000	3.910	0.000	3.910	39.905	4.764	0.000	0.000	44.668	0.000	48.578
2036	-24.438	3.910	0.000	-20.528	42.984	5.118	0.000	0.000	48.102	0.000	27.574

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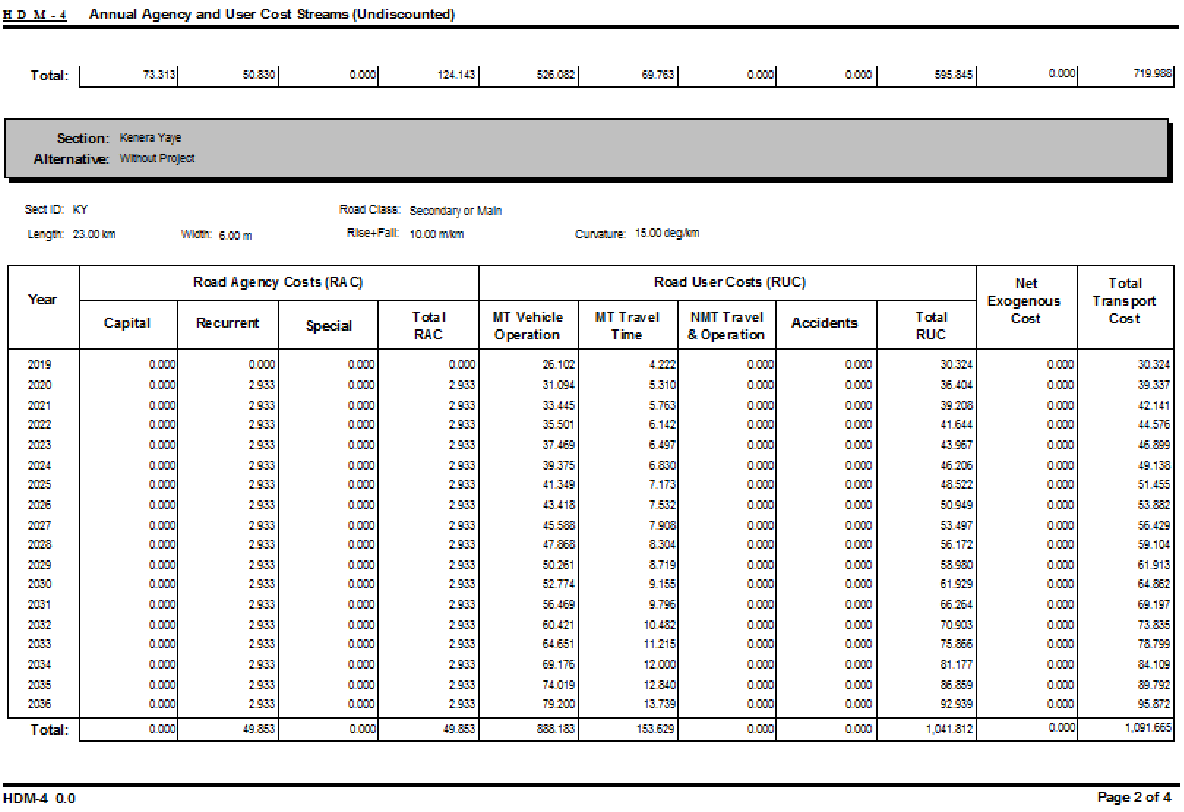

HDM-4 Annual Agency and User Cost Streams (Undiscounted)

Total:	73.313	50.830	0.000	124.143	526.082	69.763	0.000	0.000	595.845	0.000	719.988

Section: Kenera Yaye
Alternative: Without Project

Sect ID: KY
Road Class: Secondary or Main
Length: 23.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	26.102	4.222	0.000	0.000	30.324	0.000	30.324
2020	0.000	2.933	0.000	2.933	31.094	5.310	0.000	0.000	36.404	0.000	39.337
2021	0.000	2.933	0.000	2.933	33.445	5.763	0.000	0.000	39.208	0.000	42.141
2022	0.000	2.933	0.000	2.933	35.501	6.142	0.000	0.000	41.644	0.000	44.576
2023	0.000	2.933	0.000	2.933	37.469	6.497	0.000	0.000	43.967	0.000	46.899
2024	0.000	2.933	0.000	2.933	39.375	6.830	0.000	0.000	46.206	0.000	49.138
2025	0.000	2.933	0.000	2.933	41.349	7.173	0.000	0.000	48.522	0.000	51.455
2026	0.000	2.933	0.000	2.933	43.418	7.532	0.000	0.000	50.949	0.000	53.882
2027	0.000	2.933	0.000	2.933	45.588	7.908	0.000	0.000	53.497	0.000	56.429
2028	0.000	2.933	0.000	2.933	47.868	8.304	0.000	0.000	56.172	0.000	59.104
2029	0.000	2.933	0.000	2.933	50.261	8.719	0.000	0.000	58.980	0.000	61.913
2030	0.000	2.933	0.000	2.933	52.774	9.155	0.000	0.000	61.929	0.000	64.862
2031	0.000	2.933	0.000	2.933	56.469	9.796	0.000	0.000	66.264	0.000	69.197
2032	0.000	2.933	0.000	2.933	60.421	10.482	0.000	0.000	70.903	0.000	73.835
2033	0.000	2.933	0.000	2.933	64.651	11.215	0.000	0.000	75.866	0.000	78.799
2034	0.000	2.933	0.000	2.933	69.176	12.000	0.000	0.000	81.177	0.000	84.109
2035	0.000	2.933	0.000	2.933	74.019	12.840	0.000	0.000	86.859	0.000	89.792
2036	0.000	2.933	0.000	2.933	79.200	13.739	0.000	0.000	92.939	0.000	95.872
Total:	0.000	49.853	0.000	49.853	888.183	153.629	0.000	0.000	1,041.812	0.000	1,091.665

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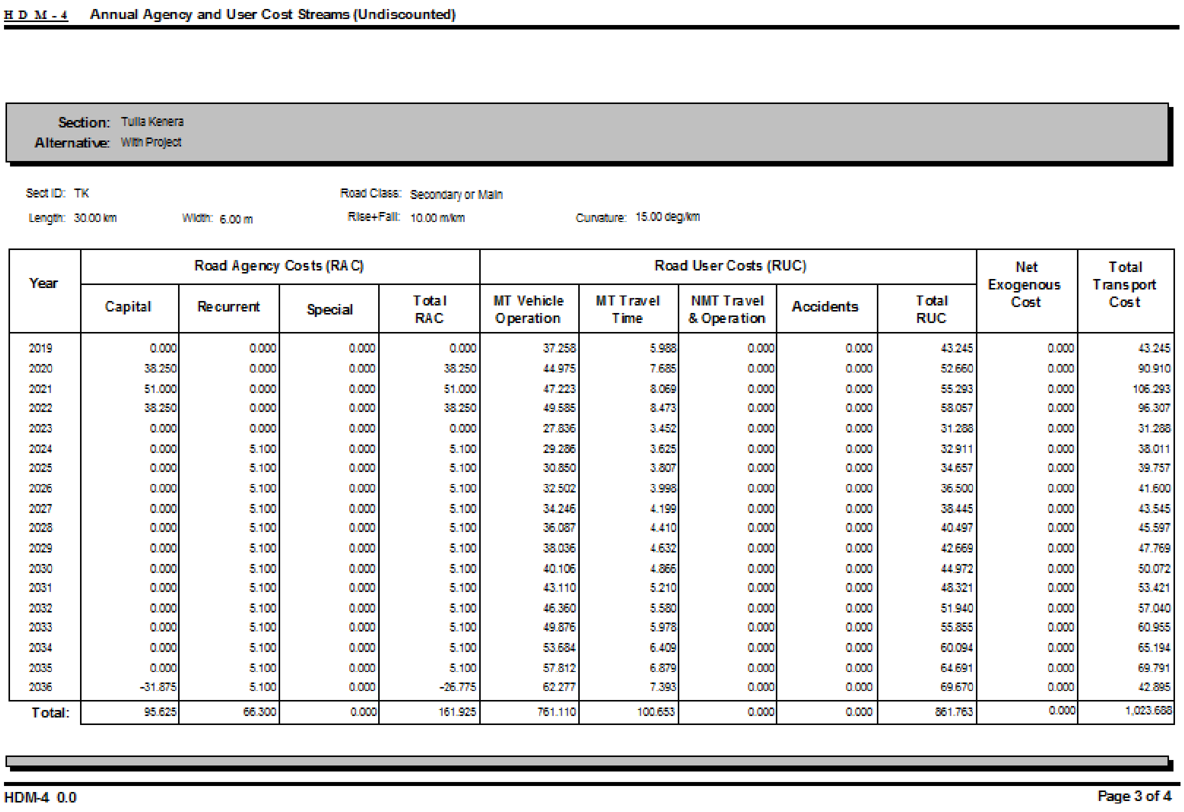

HDM-4 Annual Agency and User Cost Streams (Undiscounted)

Section: Tulla Kenera
Alternative: With Project

Sect ID: TK
Road Class: Secondary or Main
Length: 30.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	37.258	5.988	0.000	0.000	43.245	0.000	43.245
2020	38.250	0.000	0.000	38.250	44.975	7.685	0.000	0.000	52.660	0.000	90.910
2021	51.000	0.000	0.000	51.000	47.223	8.069	0.000	0.000	55.293	0.000	106.293
2022	38.250	0.000	0.000	38.250	49.585	8.473	0.000	0.000	58.057	0.000	96.307
2023	0.000	0.000	0.000	0.000	27.836	3.452	0.000	0.000	31.288	0.000	31.288
2024	0.000	5.100	0.000	5.100	29.286	3.625	0.000	0.000	32.911	0.000	38.011
2025	0.000	5.100	0.000	5.100	30.850	3.807	0.000	0.000	34.657	0.000	39.757
2026	0.000	5.100	0.000	5.100	32.502	3.998	0.000	0.000	36.500	0.000	41.600
2027	0.000	5.100	0.000	5.100	34.246	4.199	0.000	0.000	38.445	0.000	43.545
2028	0.000	5.100	0.000	5.100	36.087	4.410	0.000	0.000	40.497	0.000	45.597
2029	0.000	5.100	0.000	5.100	38.036	4.632	0.000	0.000	42.669	0.000	47.769
2030	0.000	5.100	0.000	5.100	40.106	4.866	0.000	0.000	44.972	0.000	50.072
2031	0.000	5.100	0.000	5.100	43.110	5.210	0.000	0.000	48.321	0.000	53.421
2032	0.000	5.100	0.000	5.100	46.360	5.580	0.000	0.000	51.940	0.000	57.040
2033	0.000	5.100	0.000	5.100	49.876	5.978	0.000	0.000	55.855	0.000	60.955
2034	0.000	5.100	0.000	5.100	53.684	6.409	0.000	0.000	60.094	0.000	65.194
2035	0.000	5.100	0.000	5.100	57.812	6.879	0.000	0.000	64.691	0.000	69.791
2036	-31.875	5.100	0.000	-26.775	62.277	7.393	0.000	0.000	69.670	0.000	42.895
Total:	95.625	66.300	0.000	161.925	761.110	100.653	0.000	0.000	861.763	0.000	1,023.688

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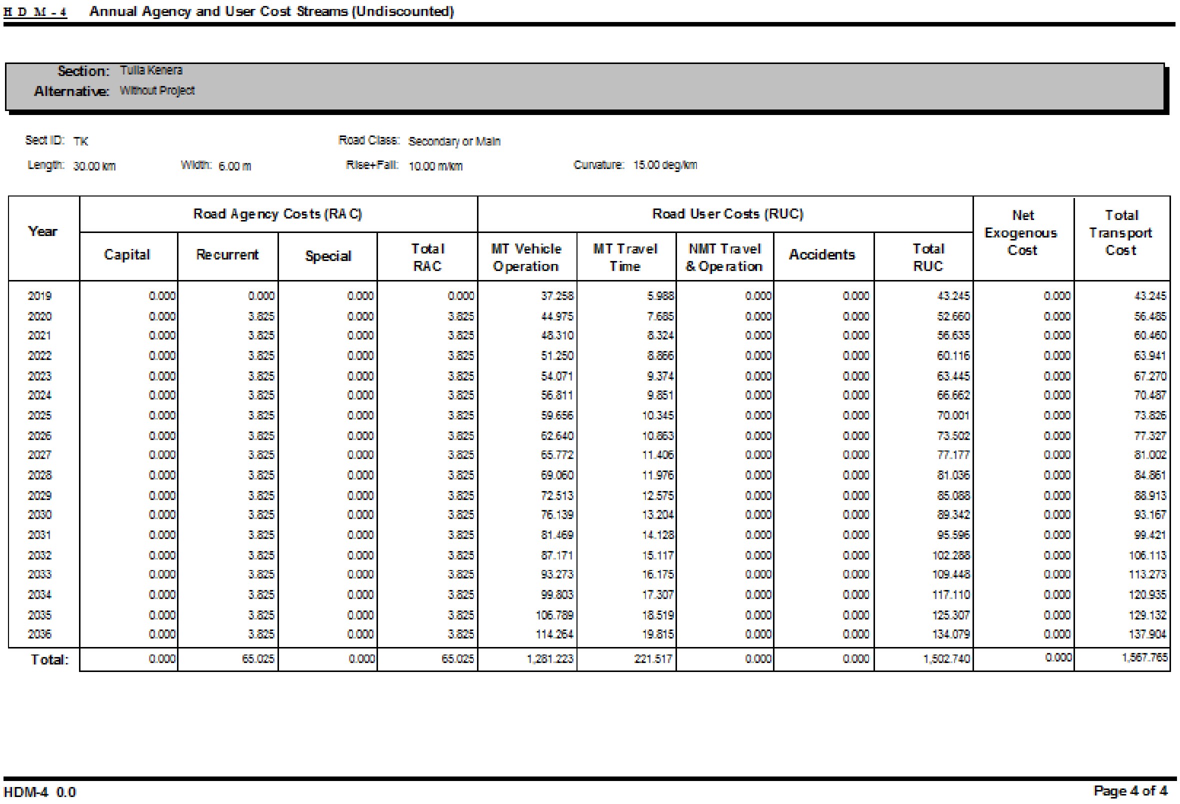

HDM-4 Annual Agency and User Cost Streams (Undiscounted)

Section: Tulla Kenera
Alternative: Without Project

Sect ID: TK
Road Class: Secondary or Main
Length: 30.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Road Agency Costs (RAC)				Road User Costs (RUC)					Net Exogenous Cost	Total Transport Cost
	Capital	Recurrent	Special	Total RAC	MT Vehicle Operation	MT Travel Time	NMT Travel & Operation	Accidents	Total RUC		
2019	0.000	0.000	0.000	0.000	37.258	5.988	0.000	0.000	43.245	0.000	43.245
2020	0.000	3.825	0.000	3.825	44.975	7.685	0.000	0.000	52.660	0.000	56.485
2021	0.000	3.825	0.000	3.825	48.310	8.324	0.000	0.000	56.635	0.000	60.460
2022	0.000	3.825	0.000	3.825	51.250	8.866	0.000	0.000	60.116	0.000	63.941
2023	0.000	3.825	0.000	3.825	54.071	9.374	0.000	0.000	63.445	0.000	67.270
2024	0.000	3.825	0.000	3.825	56.811	9.851	0.000	0.000	66.662	0.000	70.487
2025	0.000	3.825	0.000	3.825	59.656	10.345	0.000	0.000	70.001	0.000	73.826
2026	0.000	3.825	0.000	3.825	62.640	10.863	0.000	0.000	73.502	0.000	77.327
2027	0.000	3.825	0.000	3.825	65.772	11.406	0.000	0.000	77.177	0.000	81.002
2028	0.000	3.825	0.000	3.825	69.060	11.976	0.000	0.000	81.036	0.000	84.861
2029	0.000	3.825	0.000	3.825	72.513	12.575	0.000	0.000	85.088	0.000	88.913
2030	0.000	3.825	0.000	3.825	76.139	13.204	0.000	0.000	89.342	0.000	93.167
2031	0.000	3.825	0.000	3.825	81.469	14.128	0.000	0.000	95.596	0.000	99.421
2032	0.000	3.825	0.000	3.825	87.171	15.117	0.000	0.000	102.288	0.000	106.113
2033	0.000	3.825	0.000	3.825	93.273	16.175	0.000	0.000	109.448	0.000	113.273
2034	0.000	3.825	0.000	3.825	99.803	17.307	0.000	0.000	117.110	0.000	120.935
2035	0.000	3.825	0.000	3.825	106.789	18.519	0.000	0.000	125.307	0.000	129.132
2036	0.000	3.825	0.000	3.825	114.264	19.815	0.000	0.000	134.079	0.000	137.904
Total:	0.000	65.025	0.000	65.025	1,281.223	221.517	0.000	0.000	1,502.740	0.000	1,567.765

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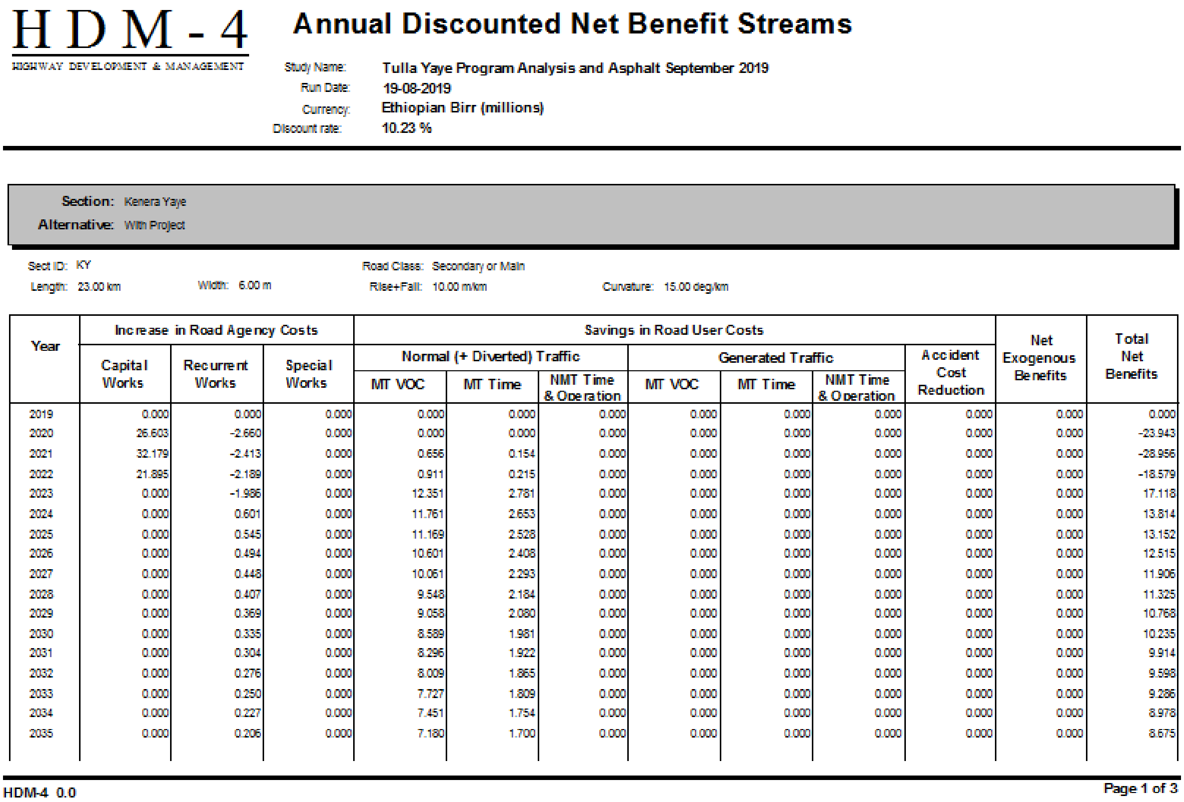

HDM-4

HIGHWAY DEVELOPMENT & MANAGEMENT

Annual Discounted Net Benefit Streams

Study Name: Tulla Yaye Program Analysis and Asphalt September 2019
Run Date: 19-08-2019
Currency: Ethiopian Birr (millions)
Discount rate: 10.23 %

Section: Kenera Yaye
Alternative: With Project

Sect ID: KY
Road Class: Secondary or Main
Length: 23.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Increase in Road Agency Costs			Savings in Road User Costs							Net Exogenous Benefits	Total Net Benefits
	Capital Works	Recurrent Works	Special Works	Normal (+ Diverted) Traffic			Generated Traffic			Accident Cost Reduction		
				MT VOC	MT Time	NMT Time & Operation	MT VOC	MT Time	NMT Time & Operation			
2019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	26.603	-2.660	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-23.943
2021	32.179	-2.413	0.000	0.656	0.154	0.000	0.000	0.000	0.000	0.000	0.000	-28.956
2022	21.895	-2.189	0.000	0.911	0.215	0.000	0.000	0.000	0.000	0.000	0.000	-18.579
2023	0.000	-1.986	0.000	12.351	2.781	0.000	0.000	0.000	0.000	0.000	0.000	17.118
2024	0.000	0.601	0.000	11.761	2.653	0.000	0.000	0.000	0.000	0.000	0.000	13.814
2025	0.000	0.545	0.000	11.169	2.528	0.000	0.000	0.000	0.000	0.000	0.000	13.152
2026	0.000	0.494	0.000	10.601	2.408	0.000	0.000	0.000	0.000	0.000	0.000	12.515
2027	0.000	0.448	0.000	10.061	2.293	0.000	0.000	0.000	0.000	0.000	0.000	11.906
2028	0.000	0.407	0.000	9.548	2.184	0.000	0.000	0.000	0.000	0.000	0.000	11.325
2029	0.000	0.369	0.000	9.058	2.080	0.000	0.000	0.000	0.000	0.000	0.000	10.768
2030	0.000	0.335	0.000	8.589	1.981	0.000	0.000	0.000	0.000	0.000	0.000	10.235
2031	0.000	0.304	0.000	8.296	1.922	0.000	0.000	0.000	0.000	0.000	0.000	9.914
2032	0.000	0.276	0.000	8.009	1.865	0.000	0.000	0.000	0.000	0.000	0.000	9.598
2033	0.000	0.250	0.000	7.727	1.809	0.000	0.000	0.000	0.000	0.000	0.000	9.286
2034	0.000	0.227	0.000	7.451	1.754	0.000	0.000	0.000	0.000	0.000	0.000	8.978
2035	0.000	0.206	0.000	7.180	1.700	0.000	0.000	0.000	0.000	0.000	0.000	8.675

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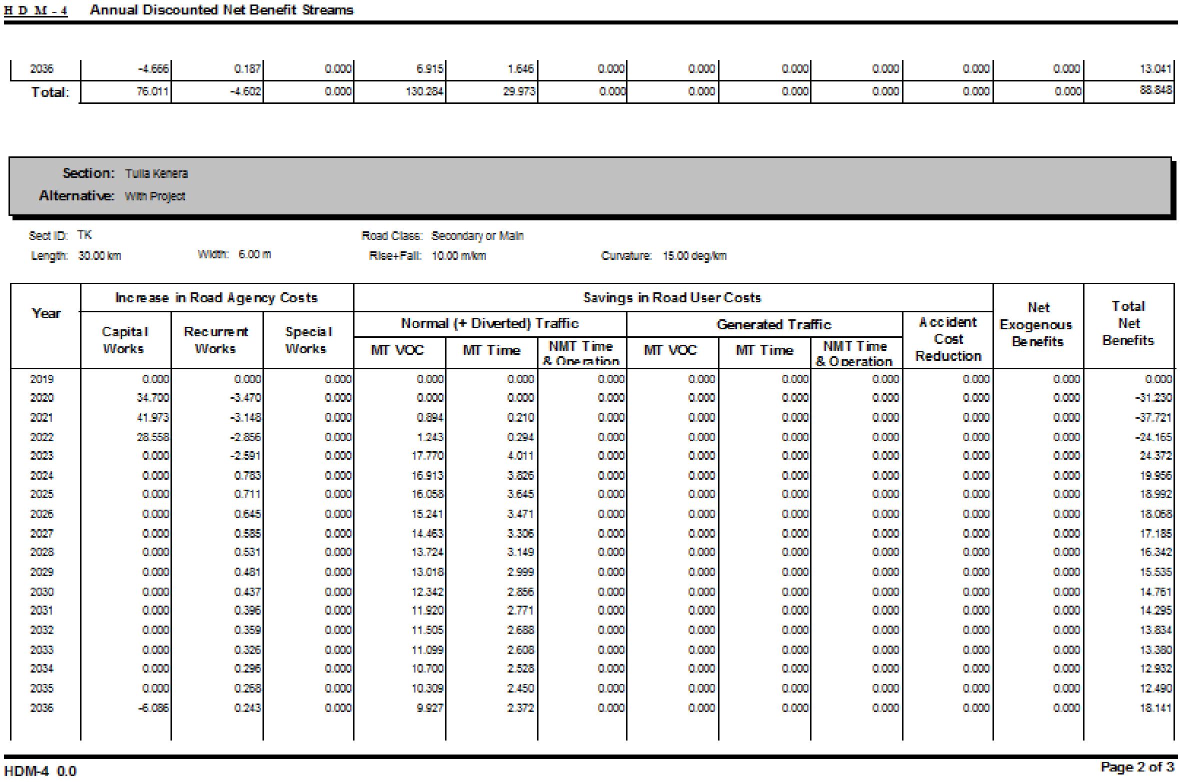

H D M - 4 Annual Discounted Net Benefit Streams

2036	-4.666	0.187	0.000	6.915	1.646	0.000	0.000	0.000	0.000	0.000	0.000	13.041
Total:	76.011	-4.602	0.000	130.284	29.973	0.000	0.000	0.000	0.000	0.000	0.000	88.848

Section: Tulla Kenera
Alternative: With Project

Sect ID: TK
Road Class: Secondary or Main
Length: 30.00 km
Width: 6.00 m
Rise+Fall: 10.00 m/km
Curvature: 15.00 deg/km

Year	Increase in Road Agency Costs			Savings in Road User Costs							Net Exogenous Benefits	Total Net Benefits
				Normal (+ Diverted) Traffic			Generated Traffic			Accident Cost Reduction		
	Capital Works	Recurrent Works	Special Works	MT VOC	MT Time	NMT Time & Operation	MT VOC	MT Time	NMT Time & Operation			
2019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	34.700	-3.470	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-31.230
2021	41.973	-3.148	0.000	0.894	0.210	0.000	0.000	0.000	0.000	0.000	0.000	-37.721
2022	28.558	-2.856	0.000	1.243	0.294	0.000	0.000	0.000	0.000	0.000	0.000	-24.165
2023	0.000	-2.591	0.000	17.770	4.011	0.000	0.000	0.000	0.000	0.000	0.000	24.372
2024	0.000	0.783	0.000	16.913	3.826	0.000	0.000	0.000	0.000	0.000	0.000	19.956
2025	0.000	0.711	0.000	16.058	3.645	0.000	0.000	0.000	0.000	0.000	0.000	18.992
2026	0.000	0.645	0.000	15.241	3.471	0.000	0.000	0.000	0.000	0.000	0.000	18.068
2027	0.000	0.585	0.000	14.463	3.306	0.000	0.000	0.000	0.000	0.000	0.000	17.185
2028	0.000	0.531	0.000	13.724	3.149	0.000	0.000	0.000	0.000	0.000	0.000	16.342
2029	0.000	0.481	0.000	13.018	2.999	0.000	0.000	0.000	0.000	0.000	0.000	15.535
2030	0.000	0.437	0.000	12.342	2.856	0.000	0.000	0.000	0.000	0.000	0.000	14.761
2031	0.000	0.396	0.000	11.920	2.771	0.000	0.000	0.000	0.000	0.000	0.000	14.295
2032	0.000	0.359	0.000	11.505	2.688	0.000	0.000	0.000	0.000	0.000	0.000	13.834
2033	0.000	0.326	0.000	11.099	2.608	0.000	0.000	0.000	0.000	0.000	0.000	13.380
2034	0.000	0.296	0.000	10.700	2.528	0.000	0.000	0.000	0.000	0.000	0.000	12.932
2035	0.000	0.268	0.000	10.309	2.450	0.000	0.000	0.000	0.000	0.000	0.000	12.490
2036	-6.086	0.243	0.000	9.927	2.372	0.000	0.000	0.000	0.000	0.000	0.000	18.141

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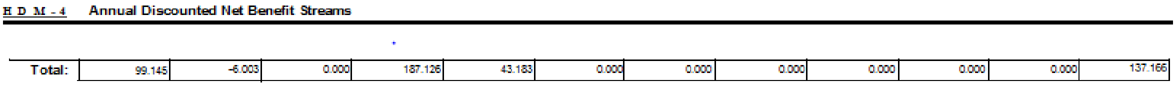
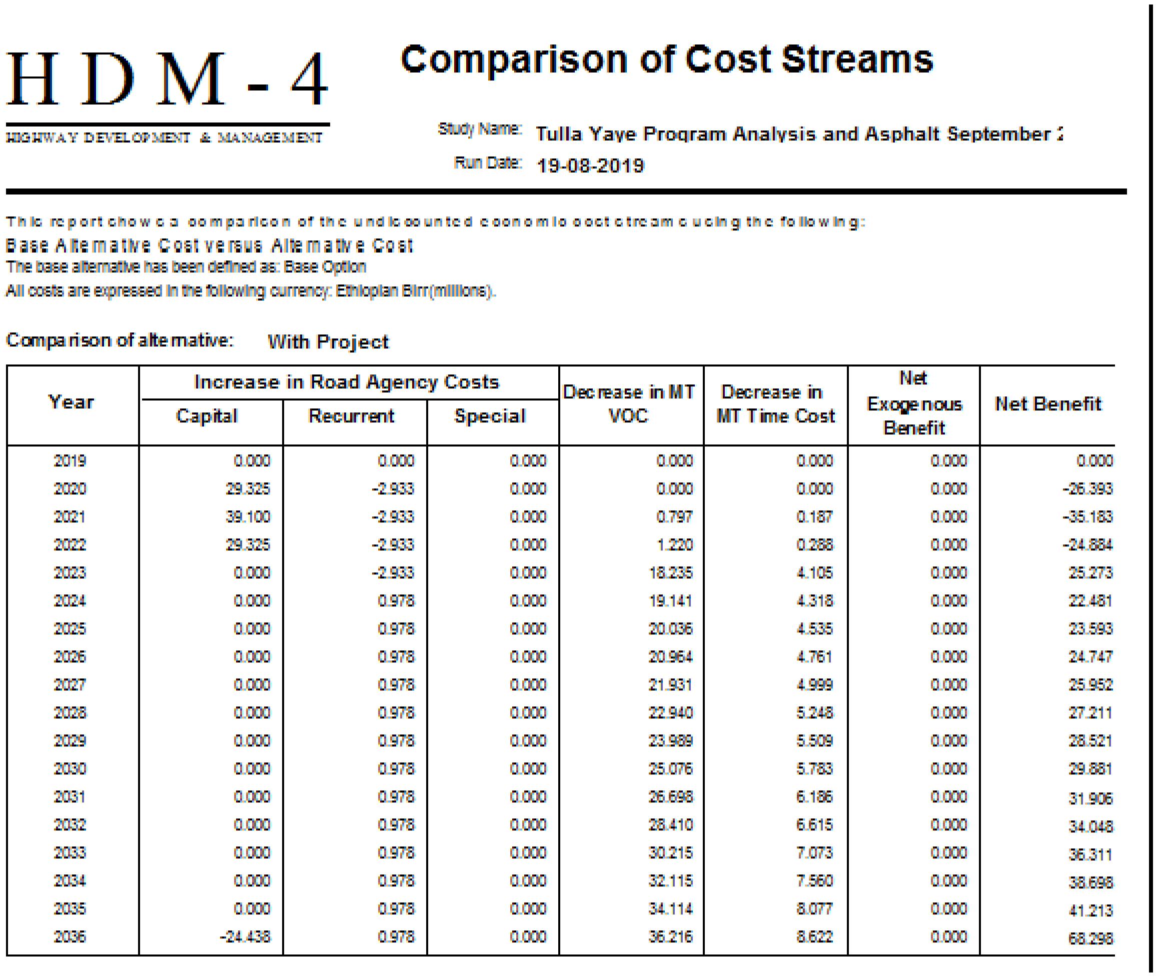


H D M - 4 Annual Discounted Net Benefit Streams

Total:	99.145	-6.003	0.000	187.126	43.183	0.000	0.000	0.000	0.000	0.000	0.000	137.166



H D M - 4

HIGHWAY DEVELOPMENT & MANAGEMENT

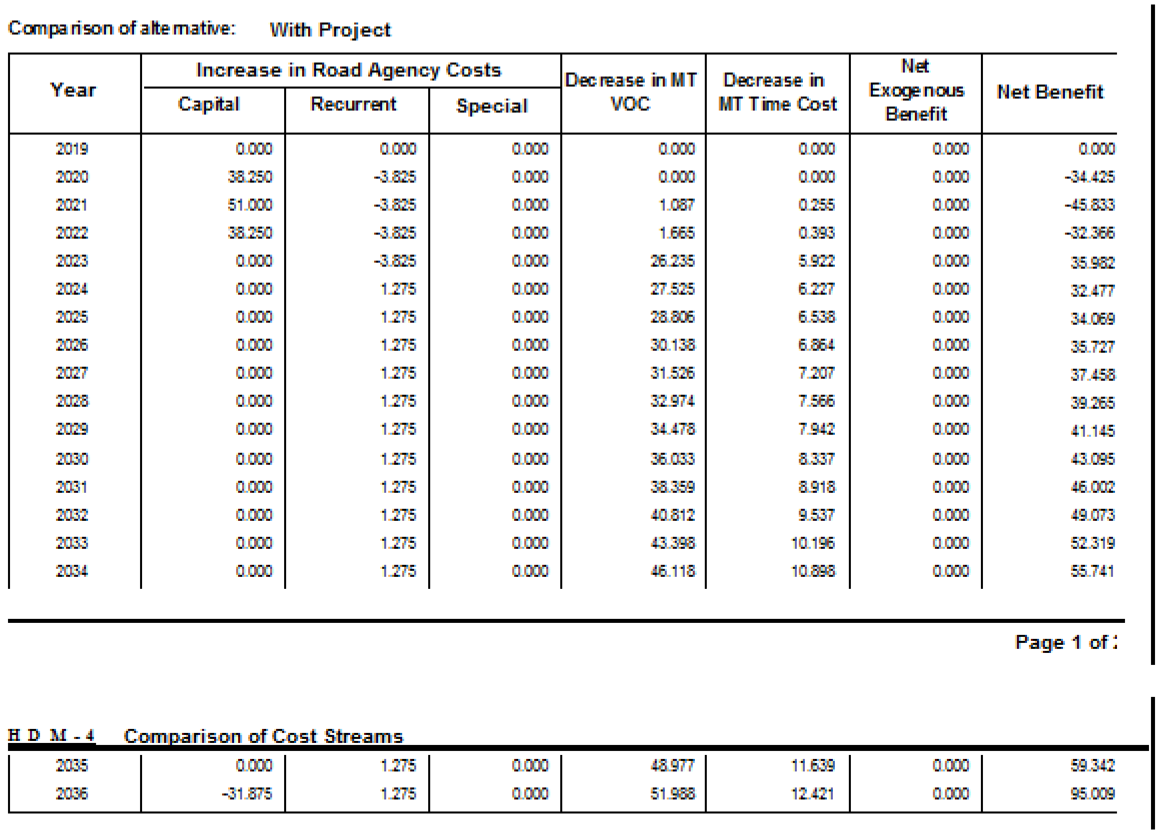
Comparison of Cost Streams

Study Name: **Tulla Yaye Program Analysis and Asphalt September**
Run Date: **19-08-2019**

This report shows a comparison of the undiscounted economic cost streams using the following:
Base Alternative Cost versus Alternative Cost
The base alternative has been defined as: Base Option
All costs are expressed in the following currency: Ethiopian Birr(millions).

Comparison of alternative: **With Project**

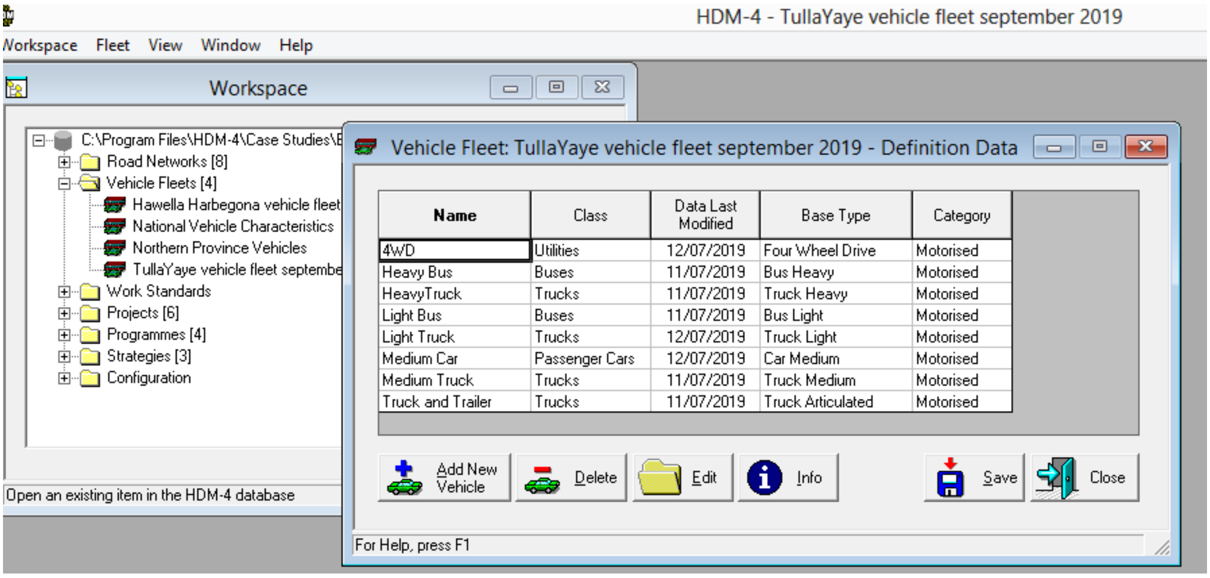
Year	Increase in Road Agency Costs			Decrease in MT VOC	Decrease in MT Time Cost	Net Exogenous Benefit	Net Benefit
	Capital	Recurrent	Special				
2019	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	29.325	-2.933	0.000	0.000	0.000	0.000	-26.393
2021	39.100	-2.933	0.000	0.797	0.187	0.000	-35.183
2022	29.325	-2.933	0.000	1.220	0.288	0.000	-24.884
2023	0.000	-2.933	0.000	18.235	4.105	0.000	25.273
2024	0.000	0.978	0.000	19.141	4.318	0.000	22.481
2025	0.000	0.978	0.000	20.036	4.535	0.000	23.593
2026	0.000	0.978	0.000	20.964	4.761	0.000	24.747
2027	0.000	0.978	0.000	21.931	4.999	0.000	25.952
2028	0.000	0.978	0.000	22.940	5.248	0.000	27.211
2029	0.000	0.978	0.000	23.989	5.509	0.000	28.521
2030	0.000	0.978	0.000	25.076	5.783	0.000	29.881
2031	0.000	0.978	0.000	26.698	6.186	0.000	31.906
2032	0.000	0.978	0.000	28.410	6.615	0.000	34.048
2033	0.000	0.978	0.000	30.215	7.073	0.000	36.311
2034	0.000	0.978	0.000	32.115	7.560	0.000	38.698
2035	0.000	0.978	0.000	34.114	8.077	0.000	41.213
2036	-24.438	0.978	0.000	36.216	8.622	0.000	68.298



Comparison of alternative: **With Project**

Year	Increase in Road Agency Costs			Decrease in MT VOC	Decrease in MT Time Cost	Net Exogenous Benefit	Net Benefit
	Capital	Recurrent	Special				
2019	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	38.250	-3.825	0.000	0.000	0.000	0.000	-34.425
2021	51.000	-3.825	0.000	1.087	0.255	0.000	-45.833
2022	38.250	-3.825	0.000	1.665	0.393	0.000	-32.366
2023	0.000	-3.825	0.000	26.235	5.922	0.000	35.982
2024	0.000	1.275	0.000	27.525	6.227	0.000	32.477
2025	0.000	1.275	0.000	28.806	6.538	0.000	34.069
2026	0.000	1.275	0.000	30.138	6.864	0.000	35.727
2027	0.000	1.275	0.000	31.526	7.207	0.000	37.458
2028	0.000	1.275	0.000	32.974	7.566	0.000	39.265
2029	0.000	1.275	0.000	34.478	7.942	0.000	41.145
2030	0.000	1.275	0.000	36.033	8.337	0.000	43.095
2031	0.000	1.275	0.000	38.359	8.918	0.000	46.002
2032	0.000	1.275	0.000	40.812	9.537	0.000	49.073
2033	0.000	1.275	0.000	43.398	10.196	0.000	52.319
2034	0.000	1.275	0.000	46.118	10.898	0.000	55.741
2035	0.000	1.275	0.000	48.977	11.639	0.000	59.342
2036	-31.875	1.275	0.000	51.988	12.421	0.000	95.009

Vehicle Fleet (input data from the software)

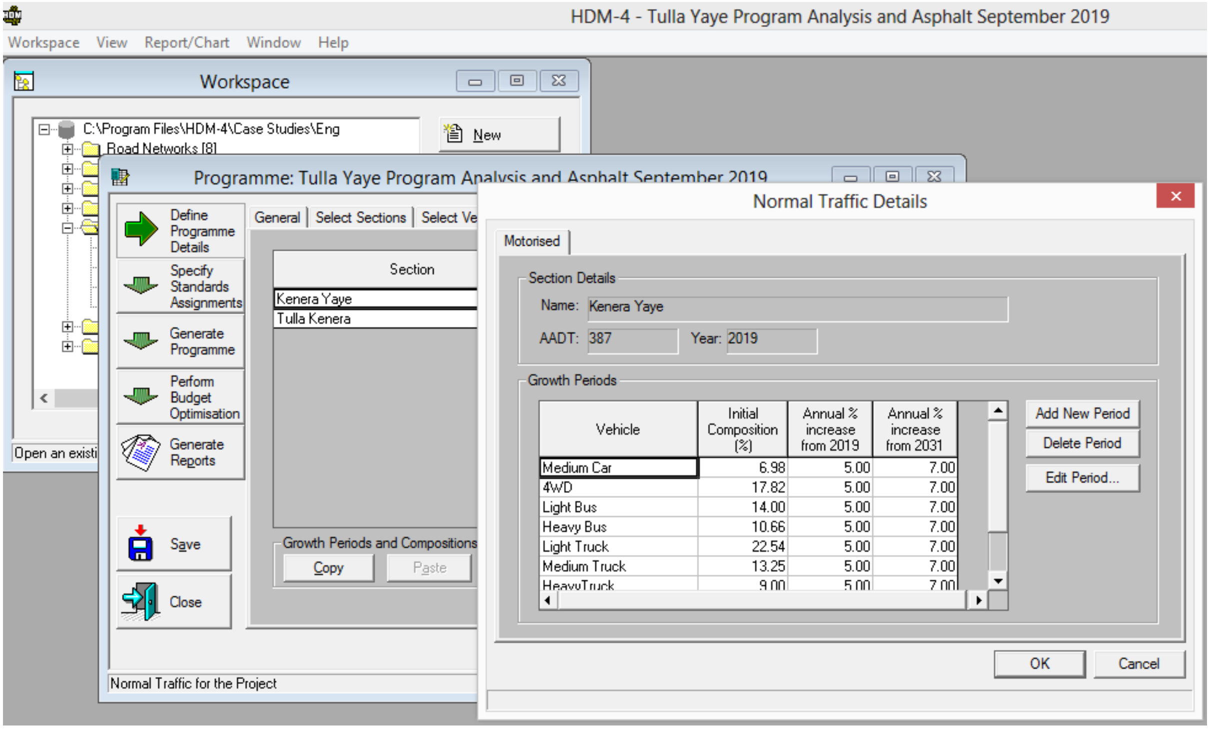


Name	Class	Data Last Modified	Base Type	Category
4WD	Utilities	12/07/2019	Four Wheel Drive	Motorised
Heavy Bus	Buses	11/07/2019	Bus Heavy	Motorised
HeavyTruck	Trucks	11/07/2019	Truck Heavy	Motorised
Light Bus	Buses	11/07/2019	Bus Light	Motorised
Light Truck	Trucks	12/07/2019	Truck Light	Motorised
Medium Car	Passenger Cars	12/07/2019	Car Medium	Motorised
Medium Truck	Trucks	11/07/2019	Truck Medium	Motorised
Truck and Trailer	Trucks	11/07/2019	Truck Articulated	Motorised

Open an existing item in the HDM-4 database

For Help, press F1

Percentage Composition of Vehicles (input data from the software)



Name: Kenera Yaye

AADT: 387 Year: 2019

Vehicle	Initial Composition (%)	Annual % increase from 2019	Annual % increase from 2031
Medium Car	6.98	5.00	7.00
4WD	17.82	5.00	7.00
Light Bus	14.00	5.00	7.00
Heavy Bus	10.66	5.00	7.00
Light Truck	22.54	5.00	7.00
Medium Truck	13.25	5.00	7.00
HeavyTruck	9.00	5.00	7.00

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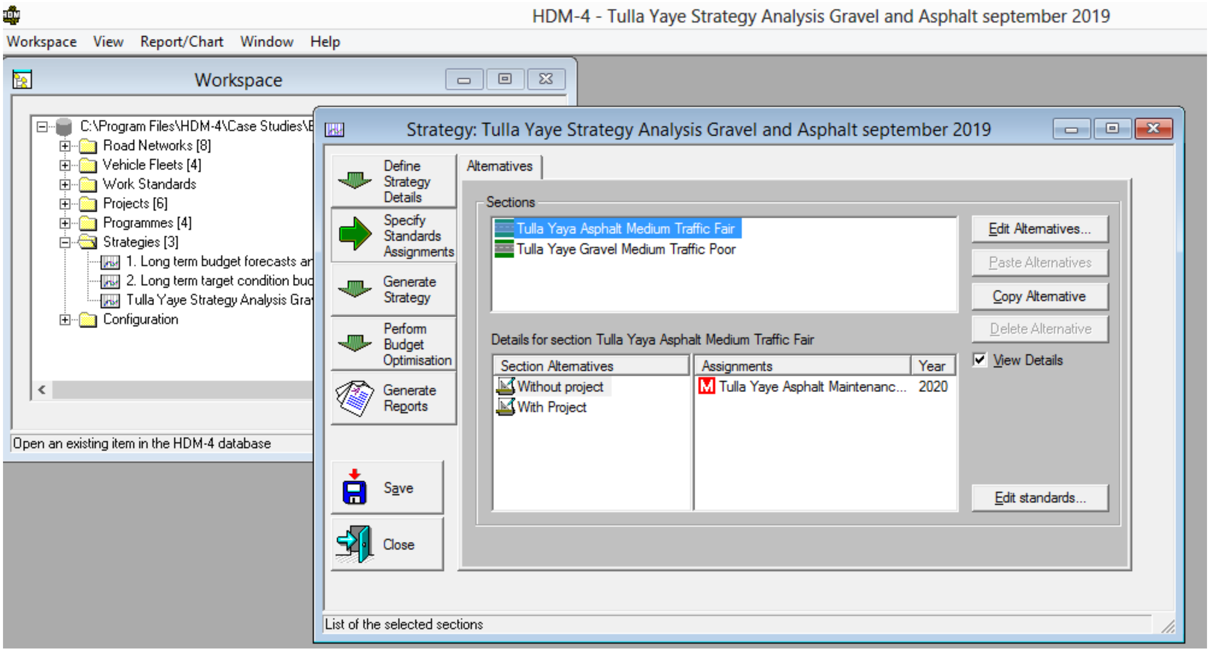
Normal Traffic for the Project

Specifying the Standard Assignments (Maintenance and Improvement)



Open an existing item in the HDM-4 database

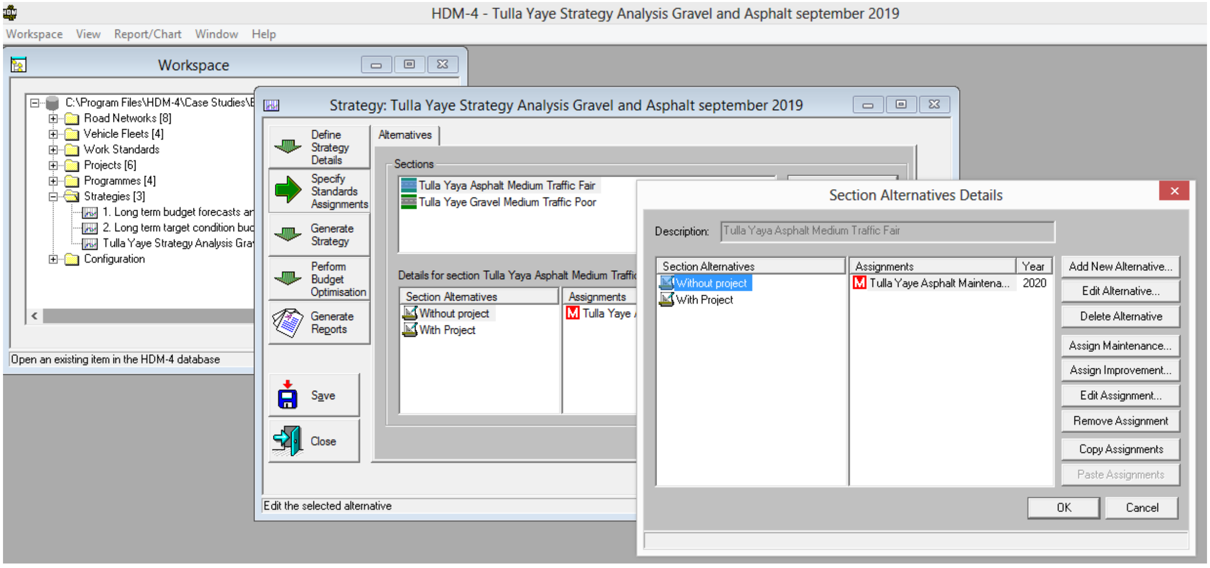
Sections:
Tulla Yaya Asphalt Medium Traffic Fair
Tulla Yaye Gravel Medium Traffic Poor

☑ View Details

Details for section Tulla Yaya Asphalt Medium Traffic Fair

Section Alternatives	Assignments	Year
Without project	Tulla Yaye Asphalt Maintenanc...	2020
With Project		

List of the selected sections



Open an existing item in the HDM-4 database

Description: Tulla Yaya Asphalt Medium Traffic Fair

Section Alternatives	Assignments	Year
Without project	Tulla Yaye Asphalt Maintena...	2020
With Project		

Edit the selected alternative