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**Traffic Threshold for Upgrading Low Volume Roads Considering Different
Maintenance Strategies**

by

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ABSTRACT

The transport network is considered as the backbone of a society. The low volume roads in rural areas connect the people to their market and administrative centers. Upgrading and maintenance activities of these roads for all weather operation need huge resources. A proper economic decision tool is required for allocation of the scarce funds by prioritizing of roads for upgrading and maintenance.

The study is focused on finding the effects of maintenance activities on determining the threshold for upgrading low volume roads. During the economic analysis, HDM-4 is used as the tool to calculate the Net Present Value of a project alternative. The Net Present Value of a project alternative is the difference between the Present Value of Total Transportation Cost of base alternative and the project alternative. The traffic volume corresponding to the Zero Net Present Value gives the threshold value of the traffic volume for upgrading the road from base alternative to project alternative.

The contribution of road user cost in total transportation cost is about 86%. The traffic threshold (ADT) for upgrading the earthen road to gravel road, DBST road and asphalt road is 47, 73 and 88 respectively for Ideal Maintenance Scenario and 45, 66 and 85 for Minimal Maintenance Scenario. Similarly, traffic threshold (ADT) for upgrading the gravel road to DBST road and asphalt road is 104 and 128 respectively for Ideal Maintenance Scenario and 76 and 102 for Minimal Maintenance Scenario.

If proper maintenance is ensured, the threshold of upgrading road will increase. The observed value of AADT at which the upgrading of low volume road are being carried out and the theoretical AADT derived in the research are statistically indifferent.

Keywords: Low volume roads, Road Upgrading, Road Maintenance, Economic Analysis, Threshold, Road User Cost, Vehicle Operating Cost, IRI

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ABBREVIATIONS

AADT	Annual Average Daily Traffic
AC	Asphalt Concrete
ADT	Average Daily Traffic
CBR	California Bearing Ratio
CBS	Central Bureau of Statistics
DBST	Double Bituminous Surface Treatment
DHM	Department of Hydrology and Meteorology
DoLI	Department of Local Infrastructure
DoLIDAR	Department of Local Infrastructure and Agricultural Roads
DoR	Department of Roads
DoS	Department of Survey
DoTM	Department of Transport Management
DPR	Detail Project Report
HDI	Human Development Index
HDM	Highway Decision and Management Module
HMIS	Highway Management Information System
IM	Ideal Maintenance
IRC	Indian Road Congress
IRI	International Roughness Index
MM	Minimal Maintenance
NADA	Nepal Automobiles Dealers Association
NMT	Non-Motorised Traffic
NPV	Net Present Value
NRB	Nepal Rastra Bank
PSI	Present Serviceability Index
RCI	Roughness Condition Index
RED	Roads Economic Decision Model
RQI	Ride Quality Index
SR	Surface Rating
VOC	Vehicle Operating Cost

CHAPTER 1: INTRODUCTION

1.1 Background

A good transport network plays a vital role in achieving economic success in modern economics. The transport network ensures the connectivity within the country as well as with other countries by connecting people to jobs, linking products to markets, strengthening supply chain and logistics and fostering internal and external trade.(Eddington, 2006)

Out of 57,632.04 km of rural roads, only 3.5% (2,004.19 km) is black topped standard, 22.2% (12,823.00 km) is gravel standard and remaining 74.3% (42,804.85 km) is earthen standard. Out of them, length of all-weather road is only 25.7%(14,827.20 km) roads (DoLIDAR, 2016). These rural roads connect the people of rural areas to their market centres and the administrative centres. Therefore we need to upgrade these roads to make them all weather roads to ensure that the people living in rural parts of the country have excess to the market centres and administrative centres throughout the year. Upgrading and maintaining these roads to all weather roads need huge resources. Due to inadequacy of resources to upgrade all of these roads to all weather standard we need a proper economic decision making tool to mobilize the scare funds through prioritization on the basis of importance of these roads. The traffic threshold for upgrading the road can be an important indicator for prioritization of roads.

There is a trend to allocate a huge portion of budget towards construction of new roads and upgrading them to black top roads rather than maintenance of existing roads. It is partly due to the public demand for black top roads and partly due to lack of mindfulness among decision maker about the importance and benefit about the regular maintenance of existing roads. In lack of proper maintenance, these roads (mainly earthen and gravel roads) deteriorate and increase the vehicle operating cost. In long run a huge fund is required for rehabilitation of these roads to make them suitable for vehicle operation. So, the periodic and recurrent maintenance can greatly reduce the vehicle operation and road user cost especially for unpaved roads (Archondo-Callao, 2011a). If the benefit of regular maintenance work can be quantified, then it can support the allocation of economically justifiable fund for the maintenance of the rural roads.

At the initial stage there is a low volume of traffic but with the increase in economic activities after the penetration of road network, the traffic volume increases. The earthen roads provide good service for initial low volume roads. As traffic volume increases, the rate of deterioration of earthen road accelerate hence increasing the maintenance and operational cost of such road. As a result it won't be justifiable to operate high volume traffic in earthen roads. So, it needs to be upgraded to gravel. With further increase in traffic volume, gravel road need to be upgraded to sealed roads and so on.

1.2 Problem Statement

Although sealed roads have low operation cost and environmental benefit than unsealed roads, developing countries don't have enough funds to upgrade all unsealed roads to sealed roads. So, the planners require a tool to prioritize such roads for upgrading based on importance. A number of studies have been done on deriving the criteria and threshold for upgrading the rural low roads in Nepal, but the results are not sufficient enough to use them in planning process. Hence an in-depth study is required to determine the best alternative of the pavement for a given volume of traffic and determine the threshold for upgrading the low volume roads.

The regular maintenance of road is another major factor that influences the life, service level and operation of roads. The rural roads in Nepal don't have proper mechanism for regular maintenance mainly due to lack of fund and proper institutional mechanism for road maintenance work. Due to the lack of regular maintenance of these rural roads, the rate of deterioration of these roads increases and increases the road user cost. One of the reasons for low funding and attention in road maintenance is due to lack of understanding among the decision makers in Nepal about the importance of maintenance work. Hence an in-depth study is required to quantify the benefit of maintenance on roads and its impact on upgrading threshold of low volume roads.

1.3 Research Objectives

The main objective of this study is to determine the effects of road maintenance on determining the threshold for upgrading of low volume roads.

In order to achieve the main objective the following sub objectives are set out:

- To identify the relationship between vehicle operating cost and roughness of the road.
- To identify the influence of road maintenance in vehicle operating cost.
- To determine the suitable pavement for a given traffic condition.
- To determine the threshold for upgrading of low volume roads without maintenance.
- To determine the threshold for upgrading of low volume roads with maintenance.

1.4 Scope and Limitations of Study

The different low volume roads which are being upgraded will be the area of study. Due to the time constraints for measurement of deterioration of those roads a road deterioration prediction model of HDM-4 will be used to determine the roughness of the road during the evaluation period. The corresponding road user cost is calculated based on the predicted deterioration. The frequency and nature of maintenance work is determined based on the predicted deterioration. The result of the study greatly depends on the accuracy of the prediction model. Due to the lack of data accident cost is not considered during the evaluation. As HDM-4 doesn't have the provision for prediction of diverted and induced vehicle due to change in level of service, they are not considered during this research.

1.5 Significance of the study

The outcome of this research will be helpful for the planners and decision makers to prioritize the low volume roads for efficient allocation of limited resource for upgrading of these roads. The threshold for upgrading of low volume road can be used by planners and decision makers as the argument and justification for upgrading a road. The quantification of effect of road maintenance on road user cost will can be used for computation of economically justifiable investment of maintenance of existing roads.

CHAPTER 2:LITRATURE REVIEW

Transportation is considered the “infrastructure” of infrastructures. Transport is considered as prerequisite for all 15 sectors for investment to graduate from least developed countries by 2022 by National Planning commission. (GoN, 2014). Although development of transportation is vital for overall development of a country, they require a huge investment for construction, maintenance and upgrading. In order to utilize the scare resource efficiently we need an evaluation framework for prioritizing the road projects.

Low volume rural roads are different from trunk roads in terms of construction and operation. As length of the road to be covered to serve same number of population is higher for rural roads than urban roads, the per capita cost of rural road is more than urban roads. In spite of having high per capita cost, government need to invest in rural roads for poverty reduction and improvement of access.(Bhandari et al., 2016)

Traffic is one of the reasons for deterioration of road. The deterioration of the road increases the vehicle operation cost so road needs the regular maintenance to maintain the desired level of service. The rate deterioration of road with increase of traffic is higher for unpaved road than paved roads ultimately causing the maintenance of unpaved roads costlier than paved roads. So, above certain traffic volume, upgrading of unpaved road to paved roads will be economically efficient than maintaining unpaved road.

2.1 Road Construction and Upgrading

Construction of new roads can have several reasons. It can be a result of increase in demand of existing roads, need for improving a regional and national connectivity or for a strategic need. The road infrastructure requires a huge investment for survey, design, land acquisition, road construction and maintenance. The rural roads are mostly constructed for improving the connectivity. These roads usually have very low traffic volume during the construction period so construction of low cost roads i.e. earthen, gravel standard is economically justifiable. As the economic activities increases with improvement in connectivity of rural area with other parts, the traffic volume increase. So, to address the increase in demand the rural roads are upgraded to better roads i.e. paved roads which reduces the vehicle operation cost, increases the level of service and road capacity.

2.2 Road Maintenance

Road maintenance is the series of interdependent activities carried out on and off the road surface with a view to preserve the assets and to maintain its serviceability. If more than 25 percentage of the road length need to be rebuilt it is considered as rehabilitation rather than maintenance. Based on the nature and timing of maintenance works maintenance work can be broadly grouped into three categories:

- a. Routine Maintenance which consist of minor works carried out in regular basis to assure passage and safety of the roads in short run and prevent early deterioration of the roads.
- b. Periodic Maintenance which consists of relatively large scale works carried out in relatively long interval to preserve the structural integrity of the road and requires specialized equipment and skilled manpower.
- c. Urgent Maintenance is the immediate repairs works which are carried out in response to any unforeseen disturbances.

(Burningham & Stankevich, 2005)

The construction of large spread rural network has greatly improved the connectivity of developing countries. Although rural roads are relatively cheap to construct but it is much more difficult for the concerned authority to maintain these roads in serviceable condition. Due to lack of timely maintenance and poor road condition, the vehicle operating cost and the risk of accident is high. The rate of deterioration of rural roads is high so after a certain period of start of deterioration, the rehabilitation or reconstruction is unavoidable. In order to avoid the huge cost of rehabilitation and reconstruction, there is an urgent need of a rational strategy for resource allocation for timely maintenance of rural roads based on the prioritization. (P.K. et al., 2017)

2.3 Pavement Deterioration

As stated in Discussion Paper on Road Pavement Management (MRCU, 1995) the deterioration of pavement is continuous process irrespective of design and construction standards and is influenced by several factors such as environment(terrain), traffic(volume and axle load) and construction(design and construction standards and quality of materials and workmanship).

The pavement deterioration reduces the serviceability of road and increases the road user cost and maintenance cost. The loss of serviceability increases the discomfort and travel time which further increases the road user cost. This increase in road user cost justifies the road agency's investment to minimize the deterioration. For traffic levels above 250 ADT, the vehicle operating costs constitute around 75% to 95% of total road transport cost (MRCU, 1995). For an efficient pavement management system,

$$M_c \ll (VOC_1 - VOC_2) \text{ where,}$$

M_c = the discounted costs per km of the measures adopted to provide a serviceable road over time "t";

VOC_1 = the discounted vehicle operating costs per km on the road over time "t" without the measures;

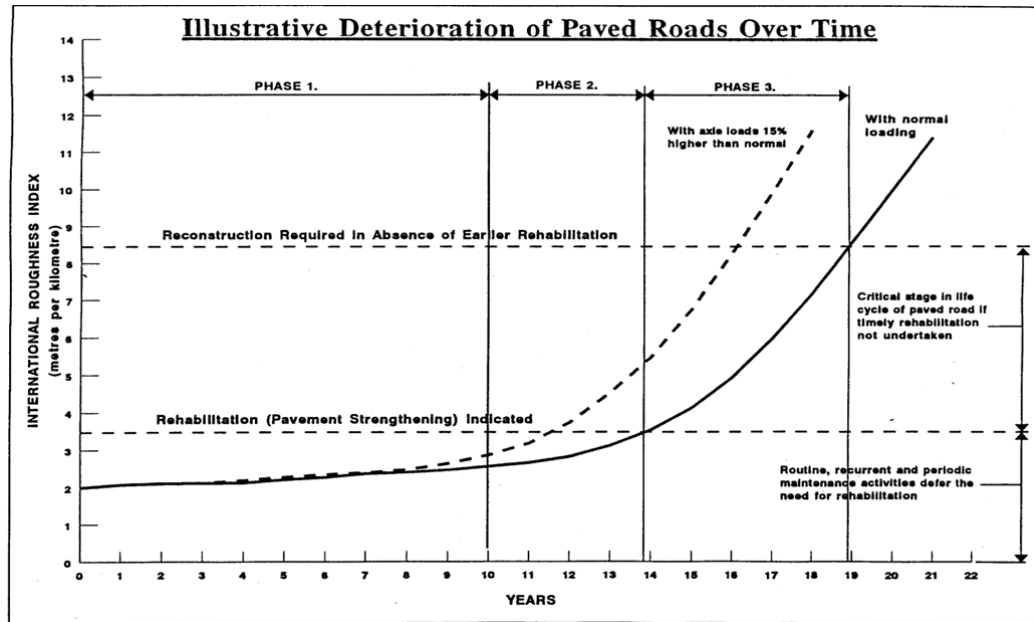
VOC_2 = the discounted vehicle operating costs per km on the road over time "t" with the measures;

In order to achieve the above criteria road agency must always work to minimize VOC_2 which maximizes the $(VOC_1 - VOC_2)$ i.e. vehicle operation cost savings.

2.4 Pavement Deterioration Characteristics

As per Road Deterioration in Developing Countries (Harral & Faiz, 1988), a World Bank policy study, in absence of road maintenance unpaved roads deteriorate rapid but rather uniform rate throughout their life cycle. Meanwhile, paved roads when operated unmaintained deteriorate in a non liner pattern. As illustrated in the figure below the deterioration is low during the initial two thirds part of the life cycle. Beyond that period the deterioration is much more rapid causing the pavement to deteriorate from good condition to fair condition just within few years. Within next few years the pavement undergoes a radical structural failure. During the initial phase maintaining paved roads in good condition requires fairly inexpensive routine maintenance. When pavement deteriorates to fair condition as in phase two maintaining road to good condition requires a resurfacing incurring a moderate cost.

Beyond this phase the pavement requires a huge cost for maintenance or even requires a reconstruction.



Source: (Harral & Faiz, 1988)

Figure 2-1 Illustrative Deterioration of Paved Roads Over Time

2.5 Pavement Condition Measurement Parameters (MRCU, 1995)

The road deterioration can be quantified by following measures of pavement condition. The commonly used measures of pavement condition are

- a. **Surface roughness** measures the irregularity on the pavement surface and expressed in terms of International Roughness Index (IRI) in meter/km. It can be related with the Vehicle Operation Cost (VOC) during the analysis as VOC increases with increase in surface roughness
- b. **Surface distress** measure the pavement deterioration and represented as a numerical index (0=good and 5=poor) determined through visual examination.
- c. **Structural Capacity** measures the ability of pavement to carry the design load. It is represented by Structural Number (SN) which is related to CBR value and thickness of individual pavement layers and pavement deflection.
- d. **Pavement texture (friction)** measures the ability of pavement to provide skid resistance which is measured in terms of Sideways Force Coefficient(SFC) and Sensor Measured Texture Depth (SMTD).

2.6 Economic Evaluation

Road economic evaluation is a process where the cost and benefits from a scheme are quantified over a evaluation period and evaluated using a common yardstick. It is also known as Benefit-Cost analysis.(IRC, 2009)

The economic evaluation of road projects is basically a comparison of transport cost components calculated for at least two alternatives of road constructions, usually one being with project alternatives and another being without project alternatives.(Adler, 1971)

2.6.1 Criteria for Upgrading and Prioritization

The economic evaluation for determination of criteria for investment for upgrading and maintenance of road is a well-established technique(Archondo-Callao, 2011b). Economic evaluations measure the benefit of project using surplus in road user costs (consumer surplus method) or surplus of producer (producer surplus method). With the consumer surplus method, the present value of road agency cost and road user cost is calculated over a period of time at fixed discount rate and compared between the alternative with the desired upgrading and the alternative without the upgrading. The alternative with lowest present value of total transportation cost is the best alternative for given scenario. The economic evaluation for upgrading a road mainly depends on construction and maintenance costs, traffic volume, road user costs, and the deterioration of the with and without the upgrade, which is influenced by the level of maintenance applied.

A number of research has been done in past to evaluate the threshold for upgrading the roads. (Devkota, 2013) determined that Traffic threshold for rural road up gradation from earth to bituminous premix carpet is 133 AADT. RED was used as the for the analysis.

(Neupane, 2015) derived the threshold for upgrading the pavement to DBST to be 200 AADT for hills and 395 AADT for plain. HDM-4 was used for the analysis.

The threshold traffic for upgrading the roads was determined by (Department of Roads, 2007) as in Table 2-1. HDM-4 was used for the analysis.

Table 2-1 Threshold Traffic for Upgrading of Roads

Activity	Threshold Traffic	
	Hill	Terai
Upgrading Aerth to Gravel	42	37
Upgrading Grvaeal to Paved	102	84

(Archondo-Callao, 2011b) carried out the study to find the impact of maintenance on Economic evaluation of upgrading unsealed roads. The study suggested that maintenance affects the roughness of the road. The roughness of road affects the road user cost and the economic justification of a road investment depends on the road user cost. It also suggests that the traffic needed to rationalize the investment for upgrading a road depends on the maintenance standard desired over the evaluation period i.e. 97 vehicles per day required for justifying the upgrading of gravel road to DST if full maintenance is assumed whereas 70 vehicles per day required for justifying the upgrading of gravel road to DST if zero maintenance is assumed which is 27 % less traffic

2.6.2 Highway Development and Management Model (HDM-4)

Out of various tools for economic evaluation of road investments, Highway Development and Management Model (HDM-4) which is developed by International Study of Highway Development and Management Tools, has a good framework for economic evaluation of investment in road construction and maintenance (Veeraragavan & Reddy, 2003). This model is widely used for the economic and technical evaluation of road networks. Moreover, HDM-4 provides the performance models bituminous, concrete and unsealed roads which can be used to predict the deterioration pattern for given scenario. The model HDM-4 needs to be adjusted by certain calibration factors in reference to the specific conditions of the country or region in order to use it for pavement management activities. (Thube, 2013) The road under evaluation is modelled using these parameters so as to represent the actual scenario. The result hugely depends upon the extent to which model represent the real scenario. The model is then evaluated under various scenarios to evaluate the performance of the road under such scenario.

2.6.2.1 HDM-4 Analytical Framework

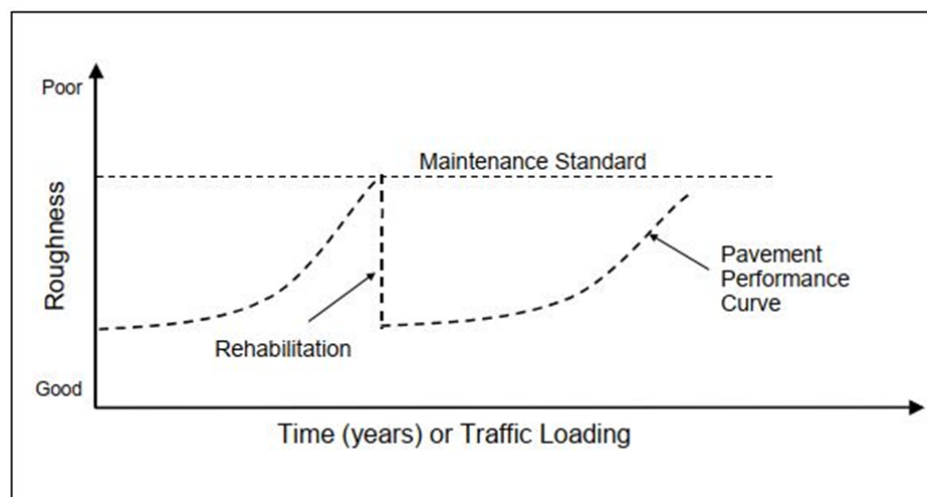
The HDM-4 analytical framework is built on the idea of pavement life cycle analysis where following effects are predicted usually over a period of 15 to 40 years.(Kerali, 2000)

- **Road deterioration:** Predicts road deterioration for paved and unpaved roads.
- **Road work effects:** Determine the cost and effect of road works activities i.e. construction or maintenance
- **Road user effects:** Determines costs and effect of travel time, vehicle operation and road accidents.
- **Socio - Economic and Environmental effects:** Determines effects of pollutions, and forecasts numbers of road accidents.

During the road operation, several factors cause the road to deteriorate. Some of the major factors are.

- **Vehicle Load**
- **Environmental weathering**
- **Insufficient drainage systems**

The frequency and standard of maintenance and initial design and construction standards greatly influence the rate of deterioration of pavement. Figure 2-2 illustrates the expected pavement performance presented in terms of the international roughness index (IRI). When the deterioration reaches a defined threshold for maintenance standard, the maintenance work is carried out to lower the roughness and maintaining the desired standards. So, the total road agency cost depends of the total road construction cost and the maintenance and improved standards desired for the road.



Source: (Kerali, 2000)

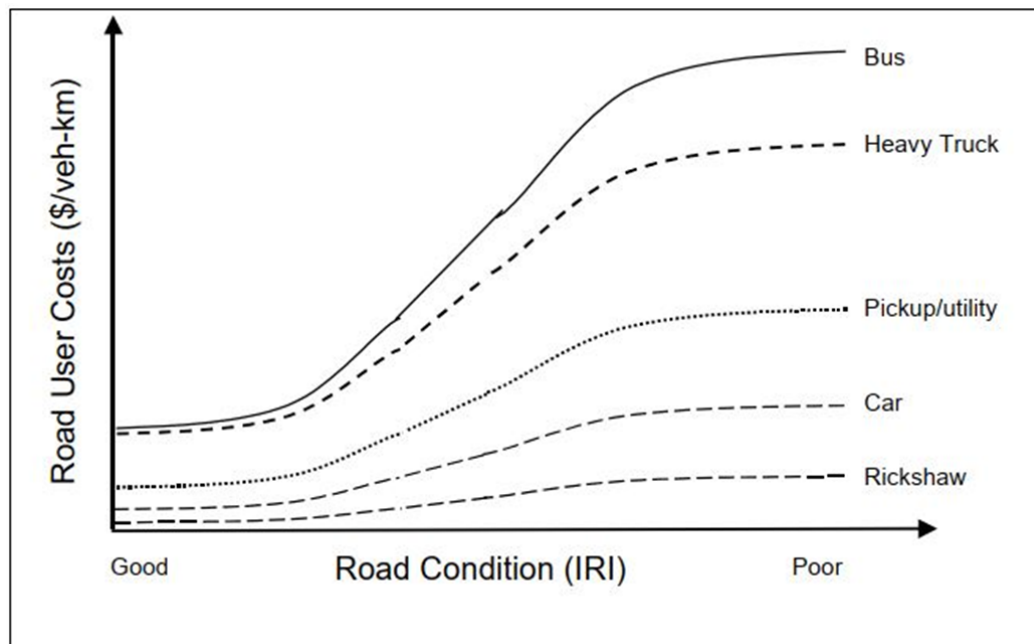
Figure 2-2 Concept of Life-cycle analysis in HDM-4

The effects of the road condition, on road users are quantified in terms of road user costs, and other social and environmental effects. Road user costs includes:(Kerali, 2000)

- **Vehicle operation costs** (fuel, tyres, oil, spare parts consumption; vehicle depreciation and utilization, etc.),
- **Travel time cost-** for both passengers and freight, and
- **Road accidents Cost** (that is, loss of life, injury to road users, damage to vehicles and other roadside objects).

The social and environmental effects includes vehicle emissions, energy consumption, pollutions and other welfare benefits to the population served by the roads.

In HDM-4, road user effects can be calculated for both motorized and non-motorised transport. The Figure 2-3 shows the impact of road conditions on cost of different modes of transport.



Source: (Kerali, 2000)

Figure 2-3 Effect of Road Condition on Vehicle Operating Costs for Rolling Terrain

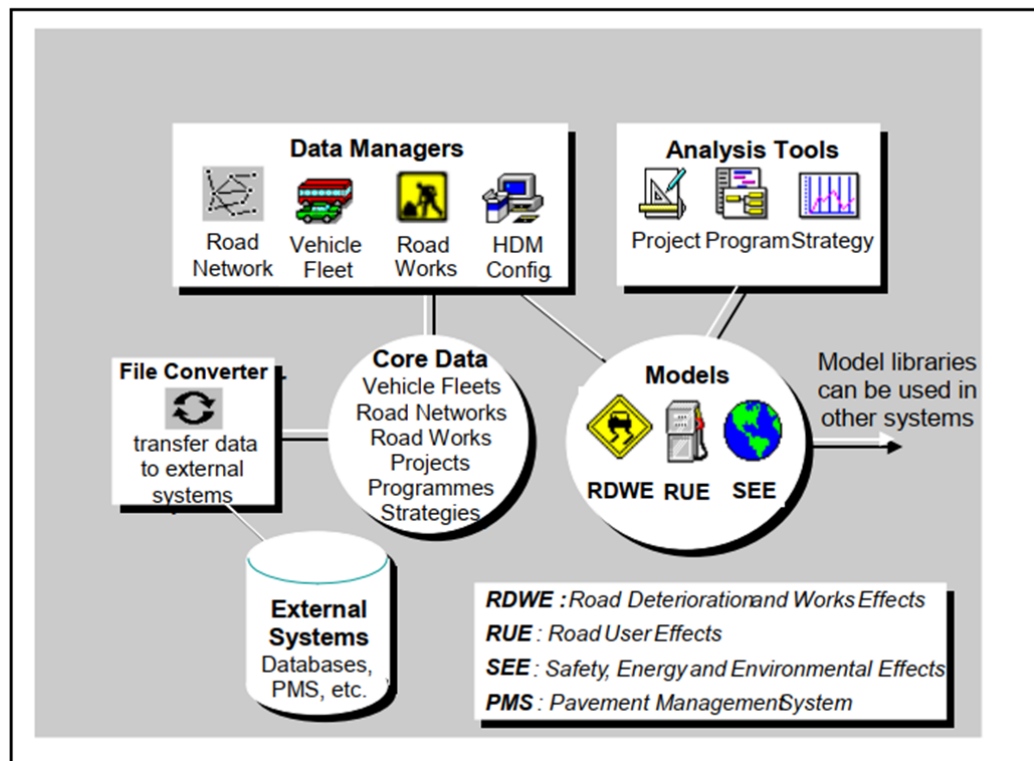
Road User Costs in HDM-4 are calculated by forecasting resource consumption and multiplying it with their unit costs. Economic benefits from road works activity are then determined by comparing the present value of various road works against a base case (without project or do minimum) alternative, usually where minimum standard of routine maintenance is carried out. HDM-4 is designed to compare different

investment options. HDM-4 estimates the cost of various alternatives for a given number of period and these costs are discounted to a specific bas year to compare among the alternatives..

2.6.2.2 Overview of HDM-4

An overview of the HDM-4 data flow is given in following Figure. This shows the major input data required for analysis and major output that we obtain after the analysis. The analysis procedure is shown in Source: (Kerali, 2000)

Figure 2-4



Source: (Kerali, 2000)

Figure 2-4 HDM-4 Flow diagram

2.6.2.3 Input data

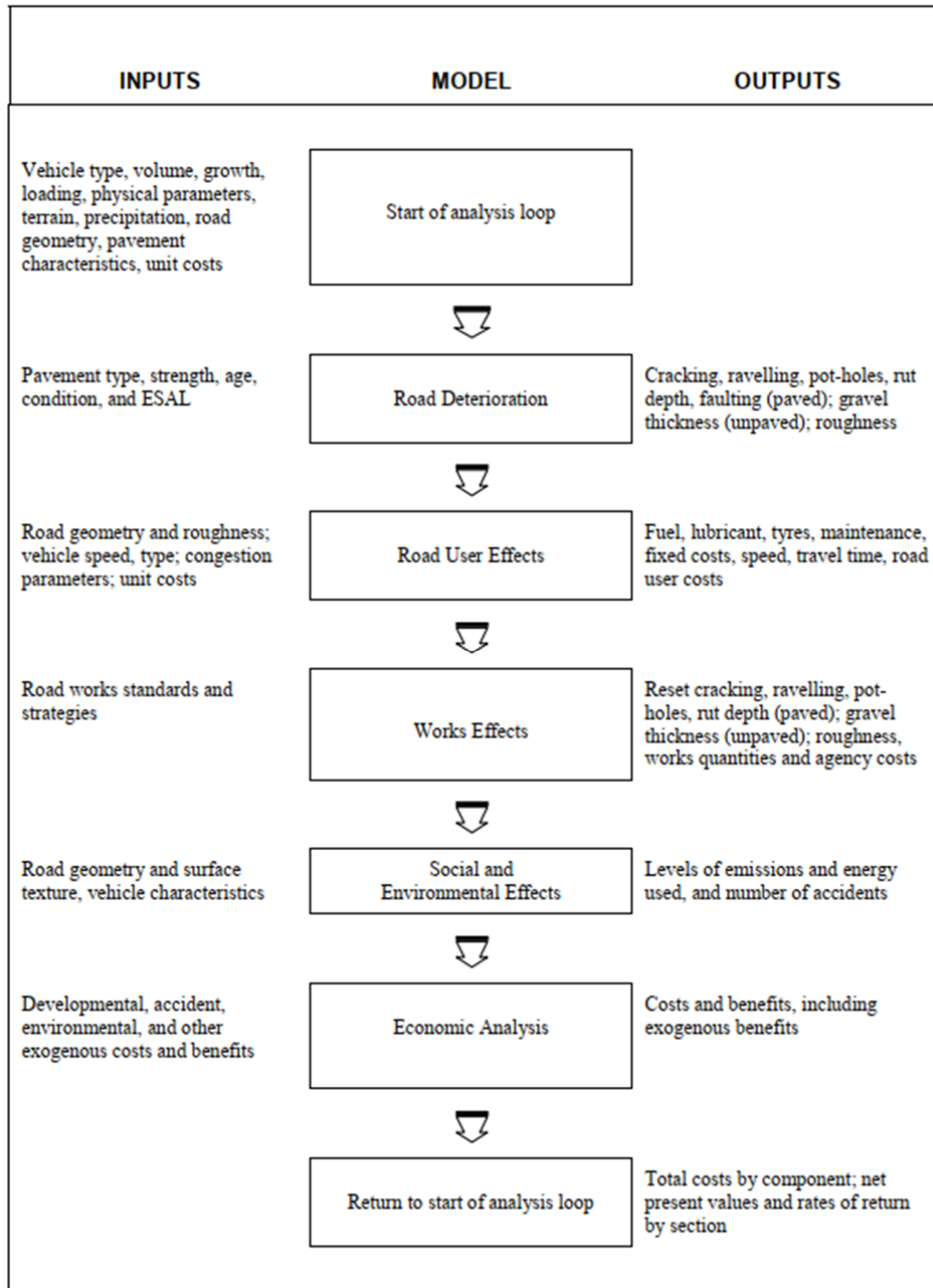
The input data can be grouped in four category:

- **Road Network:** Contains data of the road network.
- **Vehicle Fleet:** Contains the characteristics of the vehicle fleet under operation
- **Road Works:** Contains the standards for maintenance and improvement of road sections.

- **HDM Configuration:** Contains the default used by the system for analysis unless otherwise specified.

2.6.2.4 Life cycle analysis

The basic methodology of HDM-4 is similar for each of project, programme or strategy analysis. In each case, HDM-4 simulates total life cycle conditions and costs over an analysis period under the circumstances defined by user. The total cost during the analysis include mainly construction cost, maintenance cost, vehicle operation cost and travel time cost. The conception of the life cycle analysis is presented in Figure 2-5



Source: (Kerali, 2000)

Figure 2-5 Life-cycle analysis using HDM-4

The following models are contained within HDM-4(Kerali, 2000):

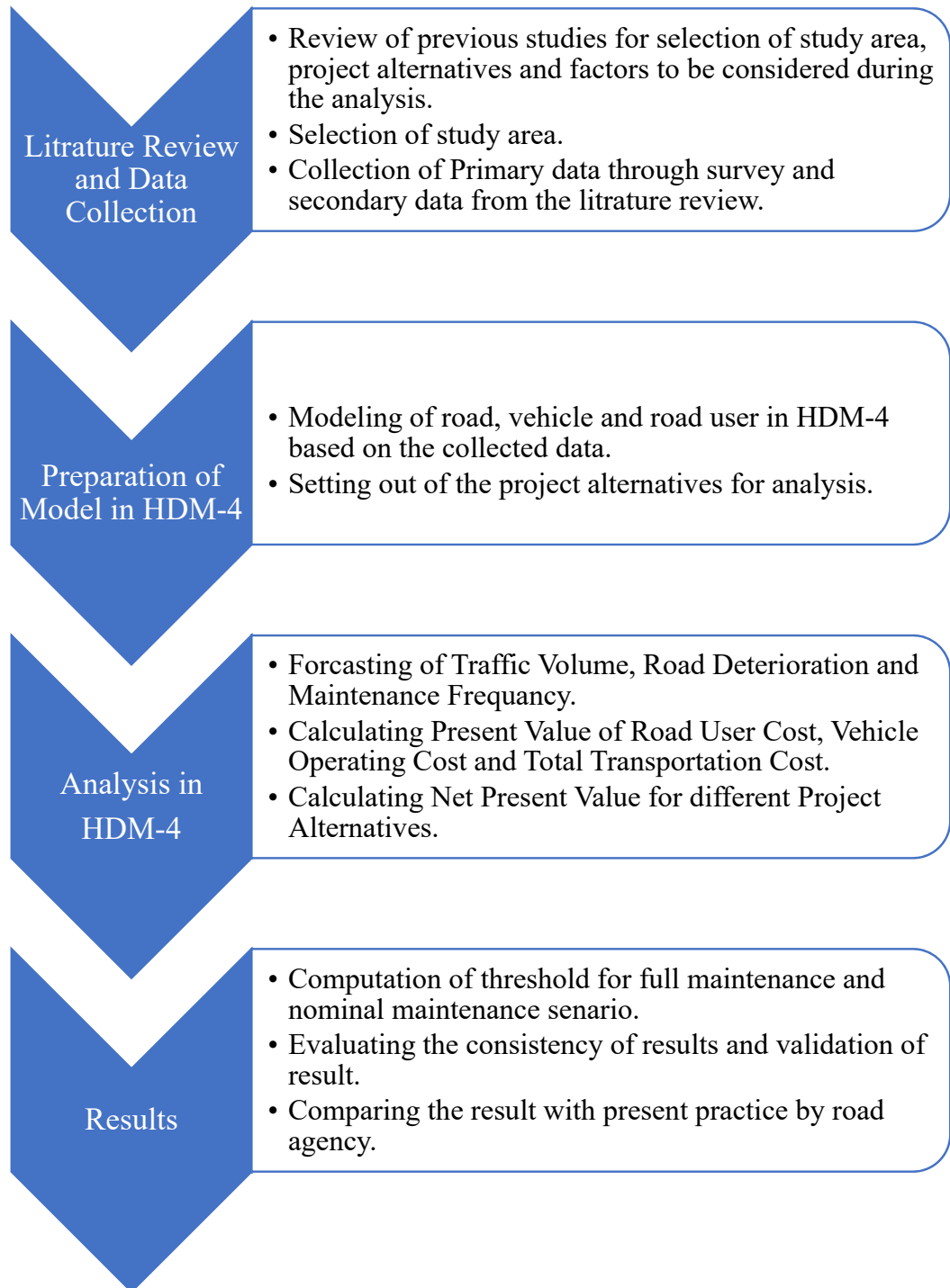
- **Road Deterioration (RD):** Predicts pavement deterioration for paved and unpaved roads.

- **Works Effects (WE):** Determine the cost and effect of road works activities i.e. construction or maintenance
- **Road User Effects (RUE):** Determines costs and effect of travel time, vehicle operation and road accidents.
- **Social and Environmental Effects (SEE):** Determines effects of pollutions, and forecasts numbers of road accidents.

CHAPTER 3: METHODOLOGY

3.1 Methodology Framework

The research methodology follows basic steps as shown in following diagram



3.2 Study Area

Armadi- Banau Road of Parbat district is selected for evaluation. It is being upgraded to Asphalt Concrete standard by Rural Connectivity Improvement Project (RCIP) under Department of Local Infrastructure (DoLI). The Length of road is 12.80 km. The salient features of this road is listed in Table 3-1

Table 3-1 Salient Feature of Armadi- Banau Road

1.	Name of Project	:	Armadi - Banau Road
2.	Location		
	Province	:	IV
	District	:	Parbat
	VDC	:	Khurkot, Pang, Nanglibang and Banau
3	Major Settlements	:	Armadi, Bagaicha, Bhatebari, Tatarkot, Banaubazar
4	Terrain	:	Hilly
5	Classification of Road		
	Classification	:	District Core Road Network
	Existing Surface	:	Earthen
	Proposed Standard	:	Blacktopped
7	Road Alignment		
	Starting Point	:	Armadi of Pokhara - Baglung Highway
	Ending Point	:	Banau Bazaar of Banau VDC
	Length	:	12.802 km
	DTMP Code	:	44A006R
8	Cross Section		
	Right of Way	:	8m
	Formation Width	:	6.25 m including drain
	Roadway Wdth	:	5.25 m
	Carriageway Width	:	3.75 m
	Shoulder Width	:	0.75 m either Side

(RCIP, 2017)

3.3 Collection of Data

The secondary data was obtained from the Detail Project Report of these roads prepared by Rural Connectivity Improvement Project (RCIP). This include the alignment and geometry of the road, traffic data during the design, population served, economic status of the road users, CBR value of the subgrade etc.

The primary data regarding the condition of road i.e. road roughness, rise and fall, length etc. was collected using the mobile application “Roadroid” which is one of the widely used application for estimation and tacking of road condition (Gamage et al., 2016),(Johnston, 2013). For collecting the data using “Roadroid”, the smartphone with the software is mounted on front screen of vehicle. The vehicle is then moved along the road with speed 20 km/hr or higher. During this process the software records Latitude, Longitude, Distance (m), Speed (km/h), Altitude (m) using the GPS of the smartphone and estimates the IRI using the accelerometer. This data is then analyzed to estimate the IRI and other parameters for the road as shown in APPENDIX 3.

The data regarding the maintenance cost and the upgrading cost was obtained from the Norms from Department of Roads (DoR) and Department of Local Infrastructure (DoLI). This includes the construction cost for graveling of road, construction of DBST and Asphalt Concrete and the cost of maintenance work in these roads. The data required for calculating the Vehicle operating cost i.e. cost of fuel, lubricant, tire, labour, vehicle utilization, vehicle service life was obtained from market survey.

Highway Development and Management Model (HDM-4) requires a number of data to prepare a model to represent the actual field scenario and evaluate the performance of the model under different alternatives. The accuracy of model on representation of actual scenario depends on the accuracy and adequacy of data. Table 3-2 summarizes the data required for evaluation and respective source and method on obtaining these data. The data used for model preparation is presented in APPENDIX-1.

Table 3-2 List of Data with corresponding source and Method

S.N.	Data	Source/ Method
1	Alignment/ Geometry of road <ul style="list-style-type: none">• Road length• Road roughness	DPR of roads, Field Survey

S.N.	Data	Source/ Method
	<ul style="list-style-type: none"> • Gradient • Horizontal and Vertical Curves 	
2	Topological Information	DPR of roads
3	Climate and Weather	DHM, DPR of roads
4	Discount Rate and Interest rate	NRB, Market Survey
5	Population Served	CBS, DPR of roads
6	Construction, Maintenance and Upgrading Cost	DoR and DoLI, Rate Analysis and Norms
7	Vehicle Cost	NADA, Market Survey
8	Vehicle Operating Cost <ul style="list-style-type: none"> • Fuel • Lubricant • Tire • Labour • Vehicle utilization • Vehicle Service Life 	NADA, Market Survey
9	Externalities <ul style="list-style-type: none"> • Social Cost and Benefits 	DoTM, Literature review
10	Traffic Data <ul style="list-style-type: none"> • Traffic Volume • Average Speed • Vehicle Characteristics • Road User Characteristics • Vehicle Distribution • Travel time 	DOTM and DPR of roads, Field Survey
11	Design Parameters <ul style="list-style-type: none"> • Road Alignment Alternatives • Road Pavement Alternatives • Road Maintenance Alternatives 	Road Standards

3.4 Calibration of HDM-4

HDM-4 is designed to be used in a wide range of conditions. HDM-4 allows us to customize a number of parameters, so as to reflect the conditions and environment under study.

Calibration of HDM-4 is intended to improve the accuracy of predicted pavement performance and vehicle resource consumptions. The default equations in HDM-4 if used without calibration, would predict pavement and vehicle performance that may not accurately represent the actual performance on specific road sections.

(Bennett & Paterson, 2000) suggest that the HDM-4 may be calibrated for Level -1 calibration during analysis of road for planning purpose. Hence the HDM-4 is calibrated using the calibration factors suggested by (Bennett & Paterson, 2000) for Nepal. For calibrating a model in Level-1 calibration following input data should be determined (Bennett & Paterson, 2000):

- Unit costs (RUE and RDWE)
- Certain characteristics of representative vehicles
- Economic analysis data (discount rates and analysis period)
- Pavement characteristics (RDWE studies)
- Traffic composition and growth rates
- Regional climatic type

The data used during calibration of HDM-4 for this analysis as suggested by (Bennett & Paterson, 2000) is summarized in APPENDIX 2.

3.5 Setting the Project Alternatives for Analysis

Most of the roads under consideration are earthen roads. For the further analysis of performance of road in different conditions, the following 10 alternatives i.e. existing earthen road, upgrade gravel, upgrade to DBST and upgrade to Asphalt Concrete of 50 mm along with minimal and ideal maintenance for all above conditions were formulated. It can be summarized as below:

Table 3-3 Project Alternatives for Evaluation

Alt No.	Alternative Code	Initial Investment	Maintenance Policy
1	ETH-MM	Earthen Road	Minimal Maintenance
2	ETH-IM	Earthen Road	Ideal Maintenance
3	GRA-MM	Upgrade to Gravel	Minimal Maintenance
4	GRA-IM	Upgrade to Gravel	Ideal Maintenance
5	DST-MM	Upgrade to DBST	Minimal Maintenance
6	DST-IM	Upgrade to DBST	Ideal Maintenance
7	AC-MM	Upgrade to Asphalt Concrete 50 mm	Minimal Maintenance
8	AC-IM	Upgrade to Asphalt Concrete 50 mm	Ideal Maintenance

The upgrading standards are defined based on the Nepal Roads Standards and Nepal Rural Road Standards and the alternatives are defined based on those upgrading standard.

3.6 Forecasting the Traffic volume, Road Deterioration and Road Maintenance Frequency

The traffic growth rate was calculated using the traffic data during the design year (in DPR) and the present traffic data from field survey. The traffic growth rate was used to forecast the traffic volume for evaluation period i.e. 20 years. The traffic volume is used to calculate the Road deterioration using HDM-4 VOC module and represented in terms of International Roughness Index (IRI) which is used to determine the frequency of maintenance. The minimal maintenance include only the routine maintenance whereas the ideal maintenance policy for different road types is as below which is subject to modification with further research and desired level of service defined by Nepal Roads Standards and Nepal Rural Road Standards.

- For gravel road Ideal maintenance includes annual maintenance, one heavy grading per year, and re-graveling when the gravel thickness reaches 50 mm
- For DBST Ideal maintenance includes annual routine maintenance, patching of all potholes, resealing of the pavement if the area of the damaged surface is

greater than 20% and the IRI value of roughness is greater than 6.0 m/km, and a 50-mm asphalt mix overlay is placed when the roughness reaches 6.5 m/km

- For the road with asphalt mix placement, Ideal maintenance includes annual routine maintenance, patching of all potholes, and a 50-mm overlay is placed when the roughness reaches 4.0 m/km.

(Archondo-Callao, 2011b)

3.7 Calculating Present Value of Total Transportation Cost

The total transportation cost is calculated as the sum of the road user cost and road agency cost. The total road user cost comprises of (Odoki & Kerali, 2000)

- Motorised transport (MT) vehicle operating cost
- MT travel time cost
- Non-motorised transport (NMT) time and operating cost
- Accident Cost

Out of these components, motorised transport (MT) vehicle operating cost and travel time cost only are taken into consideration due to the limitation of availability of accident data and non-motorised traffic data. The motorised transport vehicle operation cost and travel time cost depend largely on road roughness and the geometric characteristics of the road. The road roughness is usually expressed in terms of International Roughness Index (IRI).

As measurement of IRI is difficult for all roads, the IRI of the roads is estimated using a mobile application named “Roadroid” which is one of the widely used application for estimation and tacking of road condition (Gamage et al., 2016),(Johnston, 2013). Travel time Cost is calculated based on the passenger time cost (Rs/ passenger-hr), cargo holding time cost (Rs/veh-hr) number of passengers, number of vehicles and total travel time.

The road agency cost for maintenance and the upgrading of road is calculated based on the district rates and work norms prepared by DoR and DoLI. The rate analysis performed to calculate the cost is presented in APPENDIX-1

Now the Total Transport Cost is the sum of road user cost (u_{ij})and Road agency cost(a_{ij}). Similarly the present value of road agency cost, present value of road user cost and present value of Total Transportation cost is calculated for different traffic volume from 30 AADT to 1000 AADT for all alternatives as shown below

Table 3-4 Present Value of Agency Costs

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-MM	a11	a12	a13				
ETH-IM	a21	a22	a23				
GRA-MM							
GRA-IM							
DST-MM							
DST-IM							
AC-MM							
AC-IM							

Table 3-5 Present Value of Road User Cost

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-MM	u11	u12	u13				
ETH-IM	u21	u22	u23				
GRA-MM							
GRA-IM							
DST-MM							
DST-IM							
AC-MM							
AC-IM							

Table 3-6 Present Value of Total Transportation Costs

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-MM	$a_{11}+u_{11}$	$a_{12}+u_{12}$	$a_{13}+u_{13}$				
ETH-IM	$a_{21}+u_{21}$	$a_{22}+u_{22}$	$a_{23}+u_{23}$				
GRA-MM							
GRA-IM							
DST-MM							
DST-IM							
AC-MM					$t_{ij}=u_{ij}+ a_{ij}$		
AC-IM							

From the above table the alternative with the lowest Present Value of total transportation cost will be the best alternative for the given traffic volume

3.8 Compare Road User Costs and Total Transportation Cost of different alternatives

The result in Table 3.4 (Present Value of Road User Costs) is used to compare the effect of maintenance on Road User Cost at different traffic level for different alternatives of road. Similarly, the result in Table 3.5 (Present Value of Total Transportation cost) is used to compare the effect of maintenance on total society cost at different traffic levels for different alternatives of road.

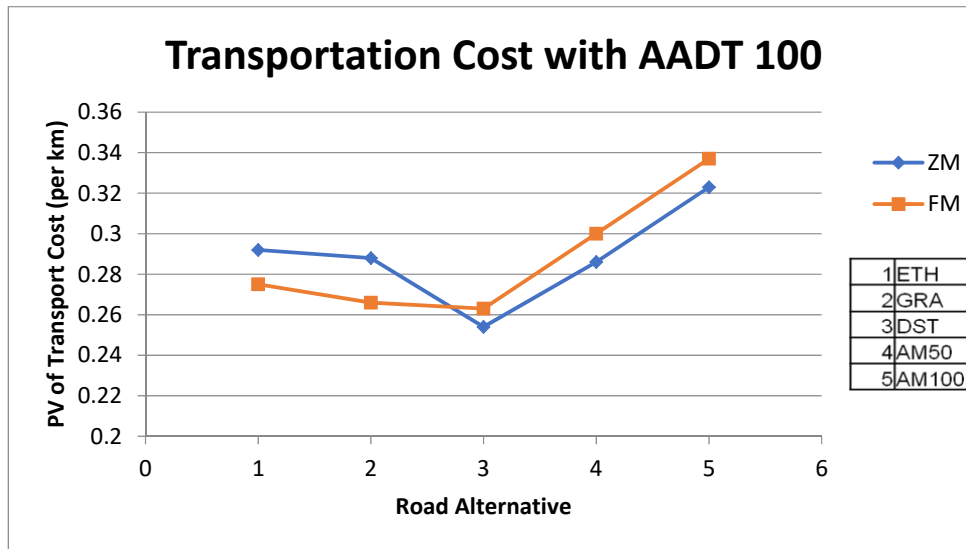


Figure 3-1 Transportation Cost with AADT 100

3.9 Calculate the Threshold Traffic Needed to Justify the Upgrading

The Net Present worth for an investment i.e. upgrading is computed for all project alternatives through the difference between Present value of base alternative and project alternative. The present condition of the road (say gravel road) was taken as base alternative and the intended upgrade is taken as project alternative. This computation is carried out for both conditions i.e. with Ideal maintenance and with Minimal maintenance. The alternative with positive Net Present Value is economically justified for given traffic volume.

Table 3-7 Net Present Value with Ideal Maintenance

Alternative Code	AADT					
	30	100	200	300	1000	2000
ETH-IM	0	0	0	0	0	0
GRA-IM	-ve	+ve	+ve	+ve	+ve	+ve
DST-IM	-ve	-ve	+ve	+ve	+ve	+ve
AC-IM	-ve	-ve	-ve	+ve	+ve	+ve
Base Alternative: Earthen Road with Ideal Maintenance						

Table 3-8 Net Present Value with Minimal Maintenance

Alternative Code	AADT					
	30	100	200	300	1000	2000
ETH-MM	0	0	0	0	0	0
GRA-MM	-ve	+ve	+ve	+ve	+ve	+ve
DST-MM	-ve	+ve	+ve	+ve	+ve	+ve
AC-MM	-ve	-ve	+ve	+ve	+ve	+ve

Base Alternative: Earthen Road with Minimal Maintenance

The net present value at different AADT as presented in above sample table for different project alternatives was plotted for Net Present Value (NPV) Vs Average Annual Daily Traffic (AADT) graph. The AADT corresponding to NPV=0 represents the threshold for Traffic needed to justify the upgrading from base alternative to the project alternative.

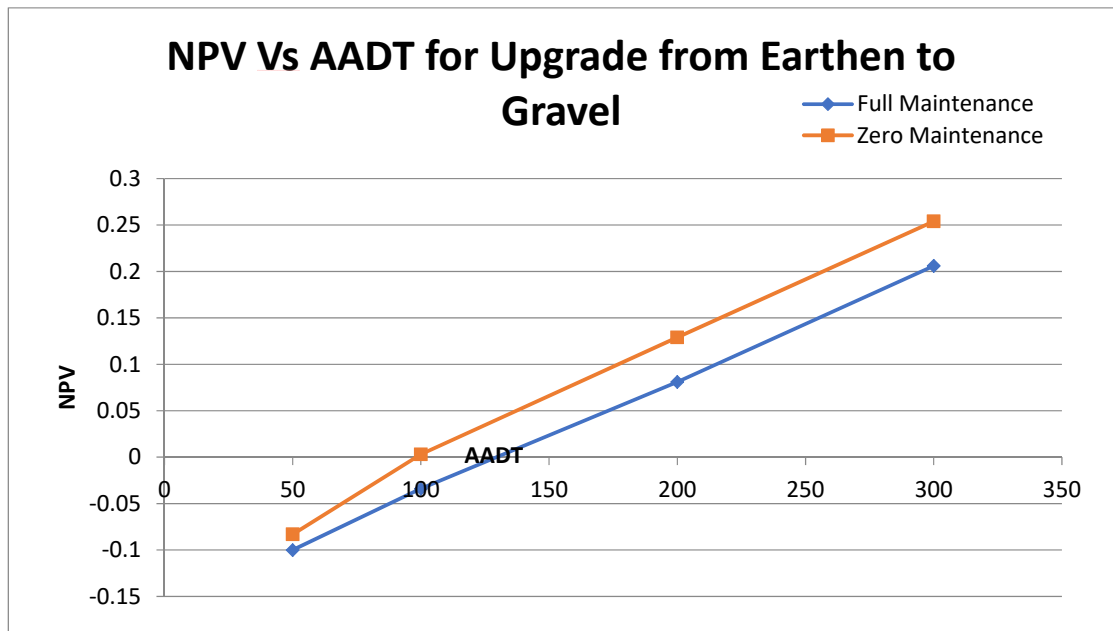


Figure 3-2 NPV Vs AADT for Upgrade from Earthen to Gravel

Considering the above sample graph of NPV Vs AADT for Upgrade from Earthen to Gravel the upgrade from Earthen to Gravel is justified for AADT 200 and 300 as NPV is positive but investment for AADT 50 is not justified as NPV is negative

From the AADT corresponding to NPV= 0 for Ideal maintenance is 130 and for Minimal maintenance is 100. So, threshold for Upgrade from Earthen road to Gravel road is 130 AADT for Ideal maintenance and 100 for Minimal maintenance. The graph shows that the Ideal maintenance increases the threshold for upgrading of road.

3.10 Presentation of data in graphs and tables

The results of above analysis is presented in graphs and tables as below

- a. Road deterioration graph for different road alternatives and traffic volume over the evaluation period
- b. Table and graph of Present Value of Road Agency Cost Vs Project Alternatives (in terms of initial investment)
- c. Table and graph of Present Value of Road User Cost Vs Project Alternatives (in terms of initial investment)
- d. Table and graph of Present Value of Total Transport Cost Vs Project Alternatives (in terms of initial investment)
- e. Table for Net Present Value for different project alternatives and different traffic volume with and without maintenance policy
- f. Graphs of NPV Vs AADT for different alternatives with and without maintenance policy

The thesis report includes results and discussions as per the analysis of data with reference to the relevant literatures. Suitable recommendation and concluding remarks are prepared for the future works and possible field application.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Deterioration of Road

Armadi-Banau Road of Parbat was taken into evaluation for the initial evaluation. The deterioration behaviour of various road surfaces is different. The road roughness of the existing road was measured using Roadroid. The calculation of IRI using Roadroid is shown in APPENDIX 2. The measurement of road roughness is a useful tool for tracking the deterioration of roads. The Figure 4-1 shows the deterioration of road with different road surface and Average daily traffic.

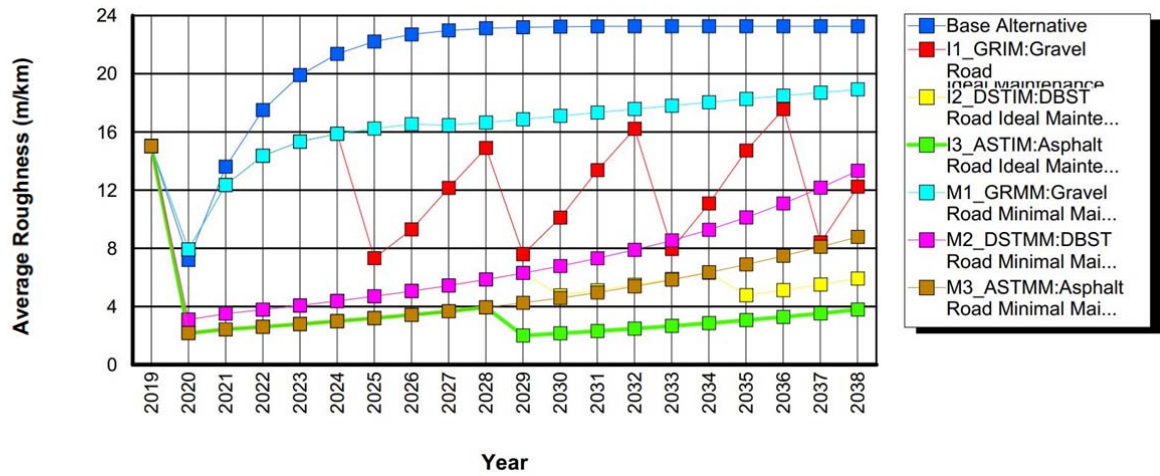


Figure 4-1 Roughness progression for AADT of 100

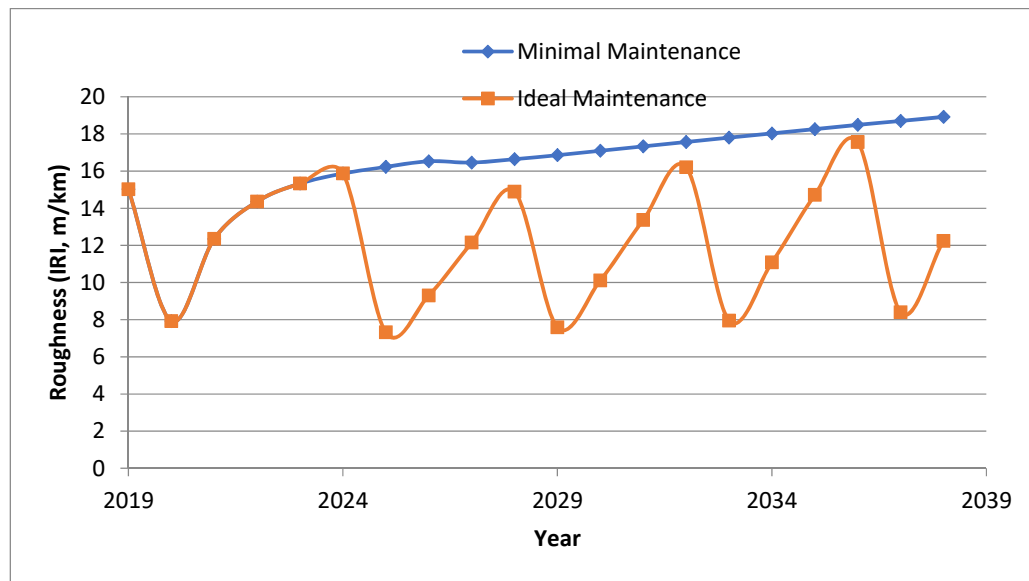


Figure 4-2 Roughness Progression for Gravel Road with AADT 100

Figure 4-2 shows the Roughness Progression for Gravel Road with AADT 100 for both Minimal maintenance and Ideal maintenance alternative. The graph shows that the Ideal Maintenance reduces average roughness of the road by 25 % in comparison with Minimal Maintenance.

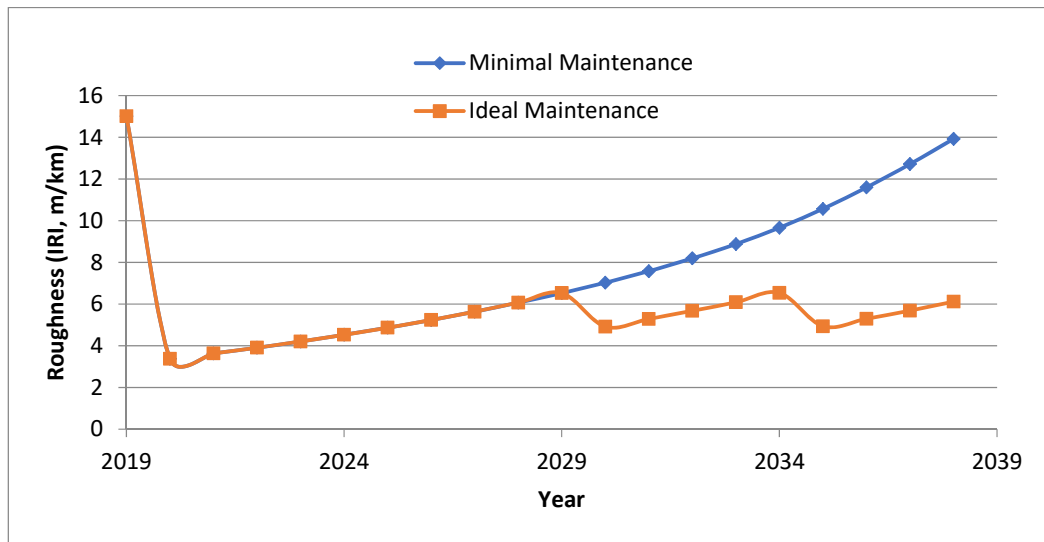


Figure 4-3 Roughness Progression for DBST Road with AADT 100

Figure 4-3 shows the Roughness Progression for DBST Road with AADT 100 for both Minimal maintenance and Ideal maintenance alternative. The graph shows that the Ideal Maintenance reduces average roughness of the road by 26 % in comparison with Minimal Maintenance.

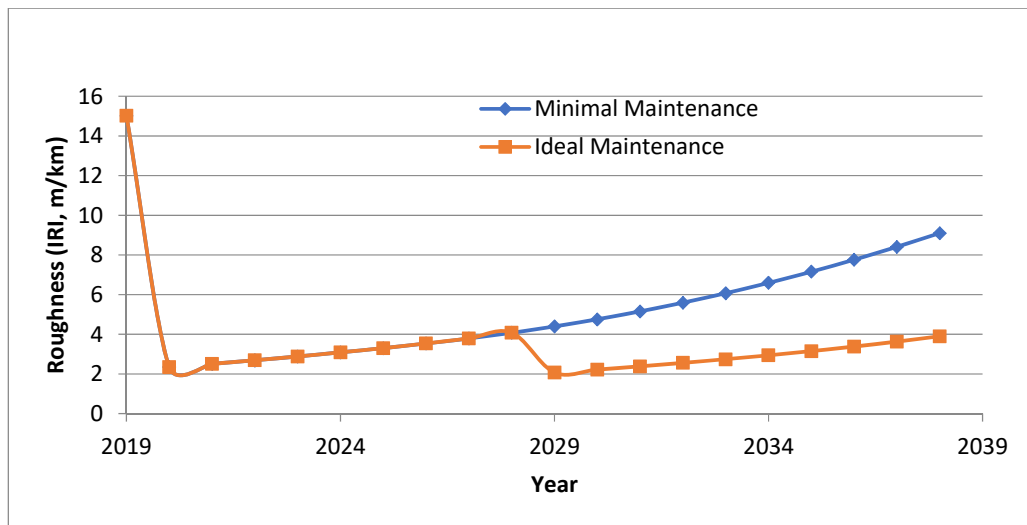


Figure 4-4 Roughness Progression for Asphalt Road with AADT 100

Figure 4-4 shows the Roughness Progression for Asphalt Road with AADT 100 for both Minimal maintenance and Ideal maintenance alternative. The graph shows that the Ideal Maintenance reduces average roughness of the road by 33% in comparison with Minimal Maintenance.

4.2 Comparison of Road Agency Cost

Table 4-1 shows the present value of road agency cost for different project alternatives and traffic scenarios. The road agency costs include the initial investment in upgrading the present value of future maintenance works. The cost streams computed by HDM-4 is summarized in APPENDIX 5

Table 4-1 Present Value of Road Agency Cost

Alternative Code	AADT							
	83	30	100	200	300	500	800	1000
ETH-MM	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
ETH-IM	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
GRA-MM	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427
GRA-IM	0.724	0.641	0.728	0.830	0.940	1.043	1.087	1.115
DST-MM	1.339	1.339	1.339	1.339	1.339	1.339	1.339	1.339
DST-IM	1.594	1.553	1.594	1.685	1.702	1.818	1.951	2.010
AC-MM	1.873	1.873	1.873	1.873	1.873	1.873	1.873	1.873
AC-IM	2.032	2.017	2.032	2.093	2.122	2.130	2.165	2.166

From the above table we observe that, the Ideal maintenance of low volume (30 AADT) increases the present value of road agency cost by 50% for gravel roads, 16% for DBST roads and 8% for Asphalt roads.

Similarly, the Ideal maintenance of medium volume (100 to 300 AADT) increases the present value of road agency cost by 95% for gravel roads, 24% for DBST roads and 11% for Asphalt roads.

Likewise, the Ideal maintenance of high volume (500 to 1000 AADT) increases the present value of road agency cost by 153% for gravel roads, 44% for DBST roads and 15% for Asphalt roads.

The road agency cost for minimal maintenance scenario is same irrespective of the traffic volume. It is because the investment from road agency cost in minimal maintenance is initial investment during the construction and the cost for routine maintenance which are constant irrespective to the traffic volume.

The road agency cost for ideal maintenance goes on increasing with increase in traffic volume. It is because the investment from the road agency cost for ideal maintenance includes the initial investment during the construction and the cost for periodic maintenance to maintain certain service level. As the traffic volume increases, the road deterioration increases. With the increase in road deterioration, the frequency of periodic maintenance activities increases to ensure the desired service level. The increase in frequency of maintenance activities increases the road agency cost.

4.3 Comparison of Road User Cost

Table 2 shows the present value of road user cost for different project alternatives and traffic scenarios. The road user costs include the vehicle operating cost and the travel time cost.

Table 4-2 Present Value of Road User Cost

Alternative Code	AADT							
	83	30	100	200	300	500	800	1000
ETH-MM	5.20	1.55	5.49	11.30	17.20	29.17	47.47	59.92
ETH-IM	5.09	1.55	5.49	11.30	17.20	29.17	47.47	59.92
GRA-MM	4.40	1.23	4.66	10.16	15.94	27.80	46.04	58.53
GRA-IM	3.86	1.13	4.08	8.65	13.41	24.15	40.85	52.63
DST-MM	3.22	1.00	3.40	6.94	10.61	18.20	30.11	38.30
DST-IM	3.11	0.98	3.27	6.57	9.91	16.61	26.87	33.73
AC-MM	3.09	0.97	3.26	6.57	9.96	17.01	28.65	37.35
AC-IM	3.01	0.95	3.17	6.37	9.58	16.18	26.64	33.22

From the above table we observe that, the Ideal maintenance of low volume roads (30 AADT) decreases the present value of road user cost by 8% for gravel roads, 2% for DBST roads and 2% for Asphalt roads.

Similarly, the Ideal maintenance of medium volume roads (100 to 300 AADT) decreases the present value of road user cost by 14% for gravel roads, 5% for DBST roads and 3% for Asphalt roads.

Likewise, the Ideal maintenance of high volume roads (500 to 1000 AADT) decreases the present value of road user cost by 11% for gravel roads, 10% for DBST roads and 7% for Asphalt roads.

The decrease in road user cost for ideal maintenance scenario in comparison with minimal maintenance scenario is due to low road roughness in ideal maintenance which decreases the vehicle operating cost. *Figure 4-1* shows that the roughness of the road for a given traffic and surface condition is higher for minimal maintenance than for the ideal maintenance. Similarly, Table 4-1 shows that the road user cost of the road for a given traffic and surface condition is higher for minimal maintenance scenario than for the ideal maintenance scenario. This shows that the ideal maintenance decreases the roughness of the road that in turn decreases the road user cost.

4.4 Total Transport Cost

Table 4-3 shows the present value of road user cost for different project alternatives and traffic scenarios. The road user costs include the vehicle operating cost and the travel time cost.

Table 4-3 Present Value of Total Transport Cost

Alternative Code	AADT							
	83	30	100	200	300	500	800	1000
ETH-MM	5.20	1.56	5.49	11.30	17.21	29.17	47.47	59.93
ETH-IM	5.10	1.56	5.49	11.30	17.21	29.17	47.47	59.93
GRA-MM	4.83	1.66	5.09	10.59	16.37	28.22	46.47	58.96
GRA-IM	4.58	1.77	4.81	9.48	14.35	25.19	41.94	53.75
DST-MM	4.56	2.34	4.73	8.28	11.95	19.54	31.45	39.63
DST-IM	4.70	2.53	4.87	8.25	11.61	18.43	28.82	35.74
AC-MM	4.97	2.84	5.13	8.45	11.83	18.88	30.52	39.23
AC-IM	5.04	2.96	5.20	8.46	11.71	18.31	28.81	35.39

From the above table we observe that, the Ideal maintenance of low volume roads (30 AADT) increases the present value of total transportation cost by 7% for gravel roads, 8% for DBST roads and 4% for Asphalt roads.

Similarly, the Ideal maintenance of medium volume roads (200 to 300 AADT) decreases the present value of total transportation cost by 9% for gravel roads, 1% for DBST roads and 1% for Asphalt roads.

Likewise, the Ideal maintenance of high volume roads (500 to 1000 AADT) decreases the present value of transportation cost by 9% for gravel roads, 8% for DBST roads and 5% for Asphalt roads.

Total Transportation Cost is the sum of Road Agency Cost and Road User Cost. Table 4-4 and Table 4-5 show the percentage share of road agency cost and road user cost on Total Transportation cost for Ideal Maintenance scenario respectively.

Table 4-4 Contribution of Road Agency Cost on Total Transportation Cost for Ideal Maintenance

Alternative Code	AADT							Average
	30	100	200	300	500	800	1000	
ETH-IM	0.19%	0.05%	0.03%	0.02%	0.01%	0.01%	0.01%	0.05%
GRA-IM	36.17%	15.13%	8.76%	6.55%	4.14%	2.59%	2.07%	11.40%
DBST-IM	61.29%	32.76%	20.42%	14.66%	9.86%	6.77%	5.62%	23.16%
AC-IM	68.05%	39.08%	24.73%	18.13%	11.63%	7.52%	6.12%	26.95%
Average	41.43%	21.76%	13.48%	9.84%	6.41%	4.22%	3.46%	15.39%

Table 4-5 Contribution of Road User Cost on Total Transportation Cost for Ideal Maintenance

Alternative Code	AADT							Average
	30	100	200	300	500	800	1000	
ETH-IM	99.81%	99.95%	99.97%	99.98%	99.99%	99.99%	99.99%	99.95%
GRA-IM	63.83%	84.87%	91.24%	93.45%	95.86%	97.41%	97.93%	88.60%
DBST-IM	38.71%	67.24%	79.58%	85.34%	90.14%	93.23%	94.38%	76.84%
AC-IM	31.95%	60.92%	75.27%	81.87%	88.37%	92.48%	93.88%	73.05%
Average	58.57%	78.24%	86.52%	90.16%	93.59%	95.78%	96.54%	84.61%

Table 4-6 and Table 4-7 show the percentage share of road agency cost and road user cost on Total Transportation cost for Minimal Maintenance scenario respectively.

Table 4-6 Contribution of Road Agency Cost on Total Transportation Cost for Minimal Maintenance

Alternative Code	AADT							Average
	30	100	200	300	500	800	1000	
ETH-MM	0.19%	0.05%	0.03%	0.02%	0.01%	0.01%	0.01%	0.05%
GRA-MM	25.71%	8.39%	4.03%	2.61%	1.51%	0.92%	0.72%	6.59%
DBST-MM	57.17%	28.28%	16.17%	11.21%	6.85%	4.26%	3.38%	19.58%
AC-MM	65.88%	36.51%	22.18%	15.83%	9.92%	6.14%	4.77%	24.87%
Average	37.24%	18.31%	10.60%	7.42%	4.57%	2.83%	2.22%	12.77%

Table 4-7 Contribution of Road User Cost on Total Transportation Cost for Minimal Maintenance

Alternative Code	AADT							Average
	30	100	200	300	500	800	1000	
ETH-MM	99.81%	99.95%	99.97%	99.98%	99.99%	99.99%	99.99%	99.95%
GRA-MM	74.29%	91.61%	95.97%	97.39%	98.49%	99.08%	99.28%	93.41%
DBST-MM	42.83%	71.72%	83.83%	88.79%	93.15%	95.74%	96.62%	80.42%
AC-MM	34.12%	63.49%	77.82%	84.17%	90.08%	93.86%	95.23%	75.13%
Average	62.76%	81.69%	89.40%	92.58%	95.43%	97.17%	97.78%	87.23%

From Table 4-4, Table 4-5, Table 4-6, Table 4-7, we can see that there is a significant contribution of road user cost in total transportation cost. The contribution of road user cost goes on increasing with increase in traffic volume. The contribution of road agency cost goes on increasing as the pavement surface improves i.e. from earthen to gravel, gravel to DBST and so on. The contribution of road user cost is more for minimal maintenance scenario i.e. 87.23% than ideal maintenance scenario i.e. 84.61%. The average value for contribution of road user cost in total transportation cost is about 86%.

Although the contribution of user cost is much more than the road agency cost, much discussion is focused on road user cost rather than road agency cost while considering a road investment project. It is mainly because of the reason that the road agency cost is the direct cost most of which is invested over short period of time but the road user cost is the indirect cost which is incurred over a long period of time. So, during the economic analysis of road project due importance must be given to the road user cost.

In comparing the share of road agency cost on total transportation among different roads, the share of road agency cost for gravel road is 7% , for DBST is 20% and for Asphalt is 25%. The share of road agency cost in total transportation increases with upgrading of road. On the other way the share of road user cost decreases with upgrading of road. But the road agencies are reluctant on upgrading the road as the share of road agency on total transportation increases with upgrading of road.

4.4.1 Effect of Upgrading Activities on Transportation Cost

The road agency cost, road user cost and total transportation for a traffic for given traffic condition (take 300 AADT for instance) from the data from Table 4-1, Table 4-2 and Table 4-3 are plotted in Figure 4-5.

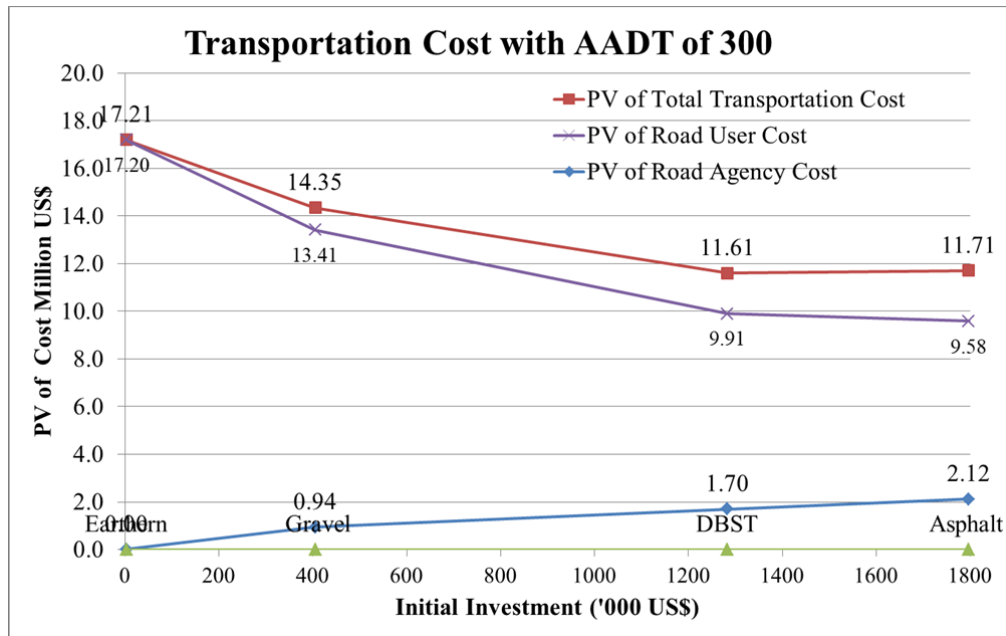


Figure 4-5 Comparison of Transportation Cost of Different Alternatives

From Figure 4-5, we can see that on upgrading the road the road agency cost increases, but corresponding road user cost decreases. If the decrease in road user cost is greater than the increase in road agency cost, then the total transportation cost for the society is decreases which make the investment economically justified. In Figure 4-5, the road agency cost increases on upgrading the road from gravel to DBST but the road user cost decreases and the total transportation cost decreases. So, upgrading this road from gravel to DBST can be economically justified.

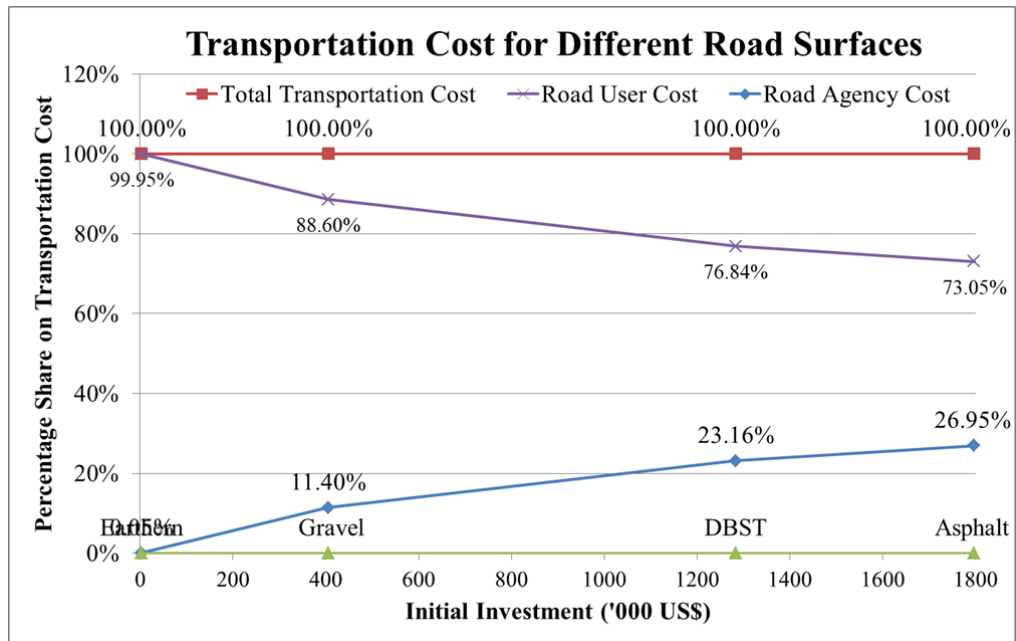


Figure 4-6 Share of Transportation Cost for different road surfaces

Figure 4-6 shows share of various transportation cost for different road surfaces. The share of road agency cost goes on increasing and the share of road user cost goes on decreasing on upgrading road surface. The reason for the increase in share of road user cost is the higher construction cost and maintenance cost of higher standard roads.

Considering the road with AADT 300 as shown in Figure 4-5, upgrading the road from gravel standards to DBST standards will cost road agency 0.76 thousand US\$. On other hand this upgrading will decrease the road user cost by 3.5 thousand US\$. This ultimately decreases the total transportation cost 2.74 thousand US\$. In other words, if road agency spends 0.76 thousand US\$ on upgrading this road from gravel standards to DBST standards, it will save 3.5 thousand US\$ for the road users and 2.74 thousand US\$ for the society as a whole.

4.4.2 Effect of Maintenance Activities on Total Transportation Cost

The Table 4-1 shows that the maintenance activities increases the road agency cost. But Table 4-2 shows that the maintenance activities decreases the road user cost. Table 4-3 which is the result of summation of both tables shows that the maintenance activities decreases the total transportation cost above 100 AADT for gravel road and above 300 AADT for black topped roads.

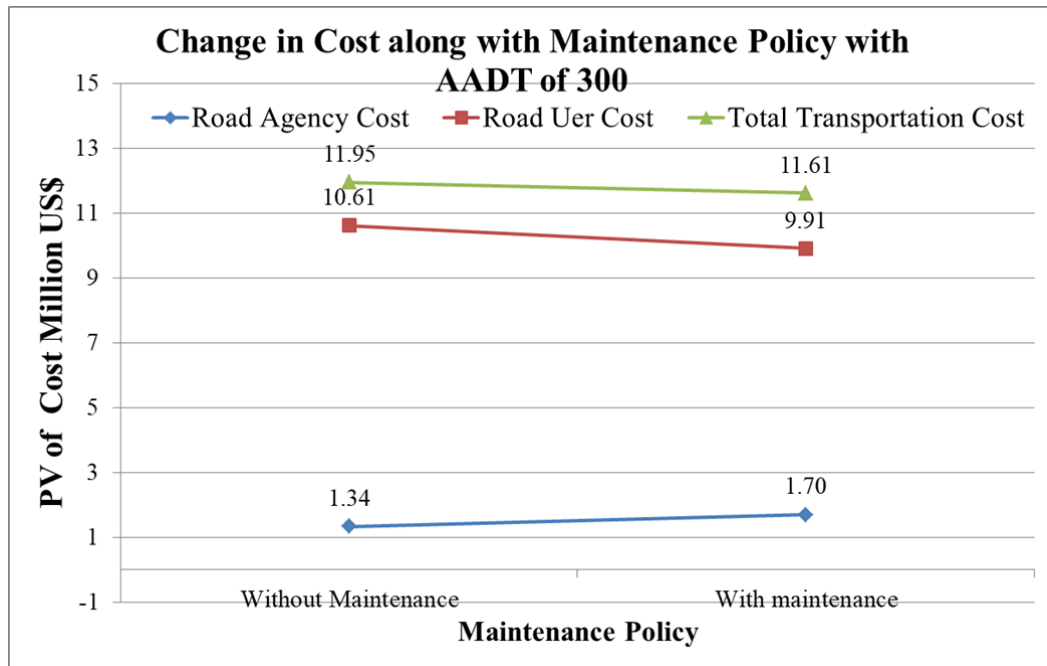


Figure 4-7 Change in Cost along with the Maintenance Policy with AADT of 300 for DBST road

Figure 4-7 presents the comparison of change in various components of transportation cost with the change in maintenance policy. We see that the maintenance activities increases the road agency cost but it decreases the road user cost. As the road user cost contribute more than road agency cost in total transportation, the increase in road agency cost is compensated by decrease in road user cost hence decreasing the total transportation cost. So, while evaluating a maintenance investment the decrease in road user cost must also be considered along with the increase in road agency cost to calculate total transportation cost.

Considering the road with AADT 300 as shown in Figure 4-7, carrying out the maintenance activities will cost road agency additional 0.36 thousand US\$. On other hand these maintenance activities will decrease the road user cost by 0.70 thousand US\$. This ultimately decreases the total transportation cost 0.34 thousand US\$. In other words, if road agency spends 0.36 thousand US\$ on maintenance of this road, it will save 0.70 thousand US\$ for the road users and 0.34 thousand US\$ for the society as a whole.

The transportation system mainly consists of the two types of cost one being the cost of the infrastructure and the other being the operational cost. The cost of infrastructure is mainly bared by the government through the construction and maintenance

expenditure and the operational cost is mainly bared by the road user in the form of fuel cost, depreciation cost of vehicle, travel time cost and so on. As illustrated in *Figure 4-5* and *Figure 4-7*, the benefit to the road user due to the investment in road upgrading and maintenance is more than the cost incurred to the road agency for the upgrading and maintenance which means the result of these activities is beneficial to society as the total transportation cost of the society decreases. The present practice of road infrastructure investment focuses on to optimization of road agency cost by minimizing their cost. But the focus must be made on optimizing the total cost to the society which is the sum of infrastructure cost for road agency and operational cost for road users.

4.4.3 Comparison of Total Transportation Cost

Based on the Table 4-3 we can plot the graphs for the total transportation cost for different pavement alternative with given traffic volume. Figure 1 shows the total transportation cost of different road alternatives with ADT 83 ie the present traffic condition of the road under evaluation.

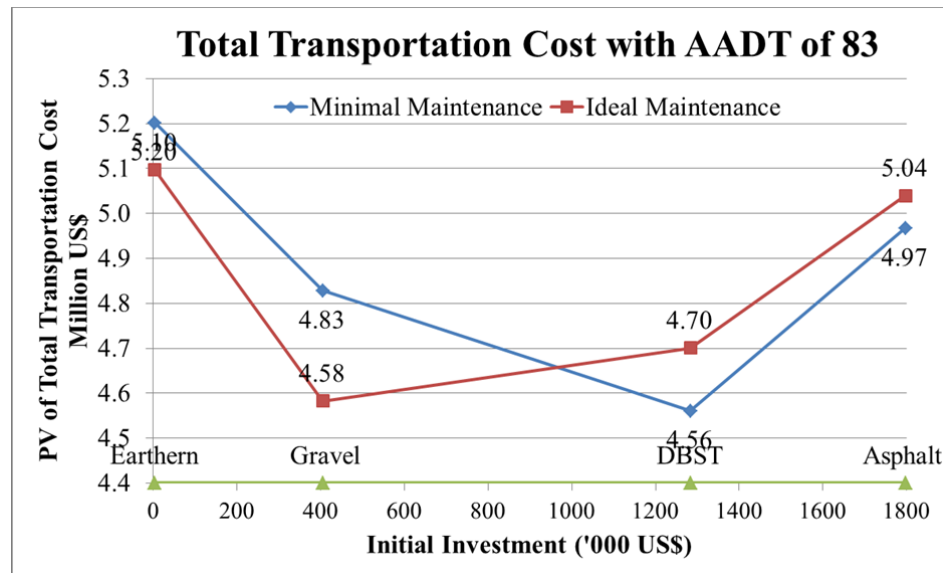


Figure 4-8 Total Transportation Cost with AADT of 83

Based on the above graph the DBST surface with Minimal maintenance is the best option with lowest total transport cost and Gravel surface with Ideal maintenance is the second best alternative.

Similarly, Figure 4-9 presents the transportation cost of different road alternatives with ADT 30. Based on the above graph the Gravel surface with Minimal

maintenance is the best option with lowest total transport cost and Gravel surface with Ideal maintenance is the second best alternative apart from the earthen road.

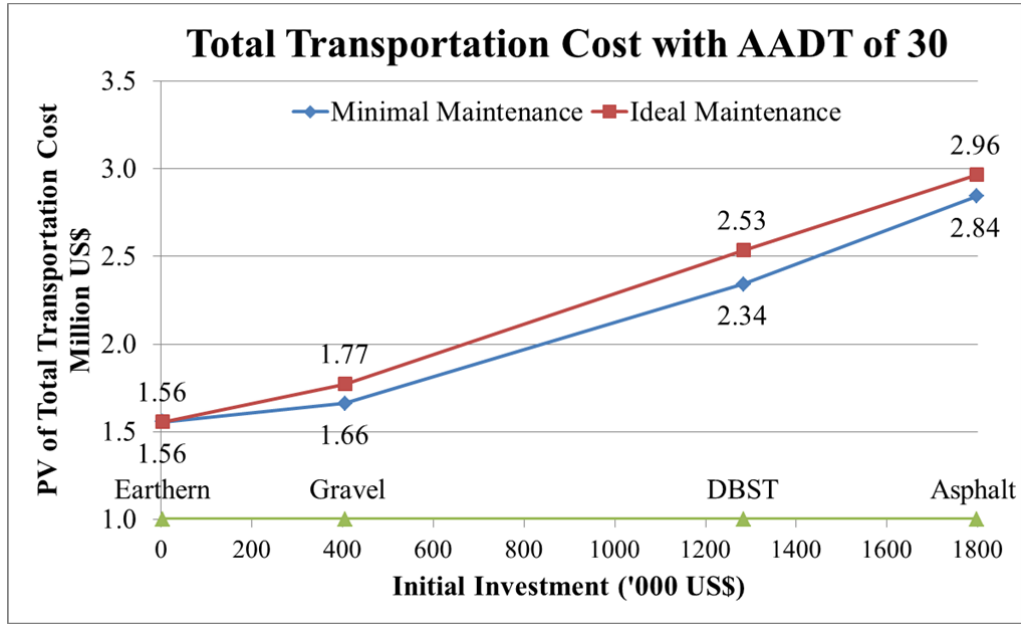


Figure 4-9 Total Transportation Cost with AADT of 30

Likewise, Figure 4-10 presents the transportation cost of different road alternatives with ADT 100. Based on the above graph the DBST surface with Minimal maintenance is the best option with lowest total transport cost and Gravel surface with Ideal maintenance is the second best alternative.

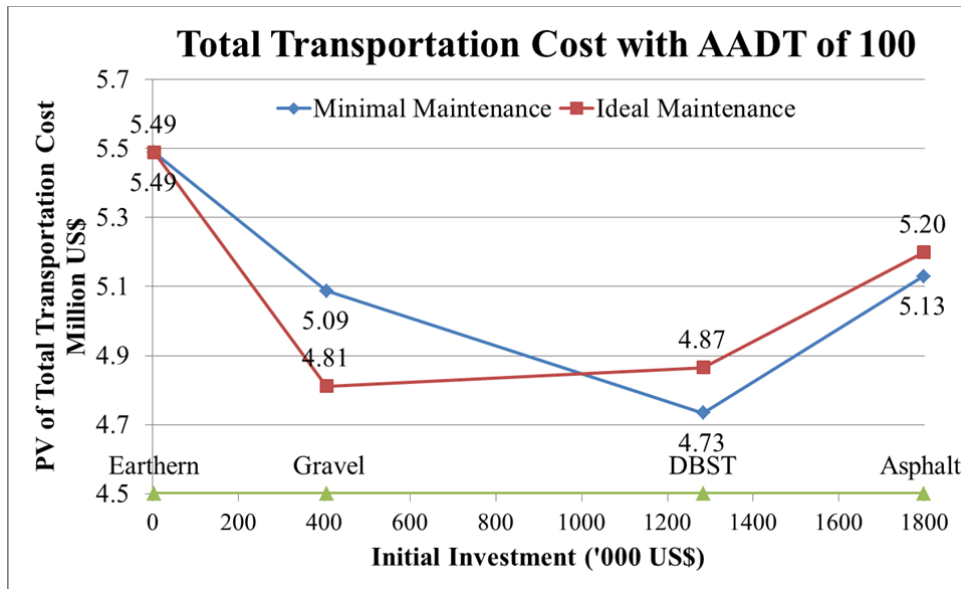


Figure 4-10 Total Transportation Cost with AADT of 100

Likewise, Figure 4-11 presents the transportation cost of different road alternatives with ADT 300. Based on the above graph the DBST surface with Ideal maintenance is the best option with lowest total transport cost and Asphalt surface with Ideal maintenance is the second best alternative.

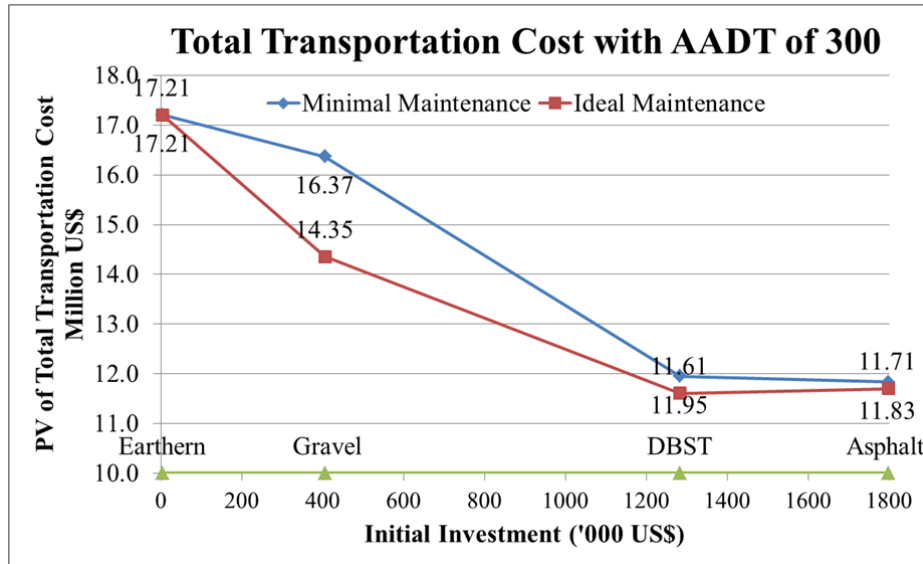


Figure 4-11 Total Transportation Cost with AADT of 300

Similarly, Figure 4-12 presents the transportation cost of different road alternatives with ADT 800. Based on the above graph the Asphalt surface with Ideal maintenance is the best option with lowest total transport cost and DBST surface with Ideal maintenance is the second best alternative.

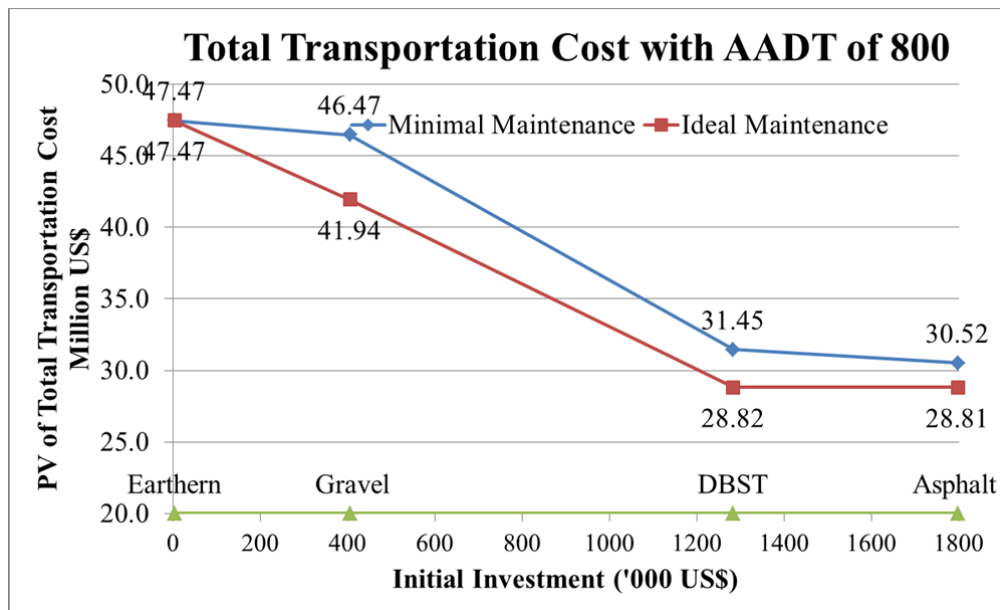


Figure 4-12 Total Transportation Cost with AADT of 800

Based on the Table 4-3, the road surface with lowest total transportation cost is the most suitable alternative for given traffic. The best road surface alternative for given traffic volume based on the total transportation cost is summarized in Table 4-8.

Table 4-8 Alternative with lowest Transportation Cost

AADT	Scenario		
	Overall	Ideal Maintenance	Minimal Maintenance
83	DBST-MM	Gravel	DBST
30	Earthen-MM	Earthen	Earthen
100	DBST-MM	Gravel	DBST
200	DBST-IM	DBST	DBST
300	DBST-IM	DBST	Asphalt
500	Asphalt-IM	Asphalt	Asphalt
800	Asphalt-IM	Asphalt	Asphalt
1000	Asphalt-IM	Asphalt	Asphalt

The Table 4-8 shows that the DBST surface with minimal maintenance scenario will be the best alternative for given traffic scenario i.e 83 AADT. But we have the provision of ideal maintenance, then the gravel surface will be the best alternative as it has the least total transportation cost.

Considering the traffic of 300 AADT, the DBST road would be the best alternative if we can ensure the ideal maintenance scenario but we need to upgrade it to an Asphalt standard if only minimal maintenance is ensured for this road.

4.4.4 Computation of Generalized Transportation Cost

The total transportation cost in *Table 4-3* is the transportation cost for the whole length of 12.8 km of the road and the corresponding traffic. This cost is divided with the length of the road and the corresponding traffic volume to get the generalized traffic cost as listed in *Table 4-9* and *Table 4-10*. The generalized transportation costs which are expressed as cost per km per AADT and can be used to compare the transportation cost among different scenario.

Table 4-9 Generalized Transportation Cost for Ideal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-IM	4.05	4.29	4.41	4.48	4.56	4.64	4.68
GRA-IM	4.61	3.76	3.70	3.74	3.94	4.10	4.20
DST-IM	6.60	3.80	3.22	3.02	2.88	2.81	2.79
AC-IM	7.72	4.06	3.31	3.05	2.86	2.81	2.76

(In thousand US\$/km/AADT)

Table 4-10 Generalized Transportation Cost for Minimal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-MM	4.05	4.29	4.41	4.48	4.56	4.64	4.68
GRA-MM	4.33	3.98	4.13	4.26	4.41	4.54	4.61
DST-MM	6.10	3.70	3.24	3.11	3.05	3.07	3.10
AC-MM	7.40	4.01	3.30	3.08	2.95	2.98	3.06

(In thousand US\$/km/AADT)

The generalized transportation cost for all project alternatives is plotted to observe the trend in change in generalized transportation cost along with the change in traffic volume.

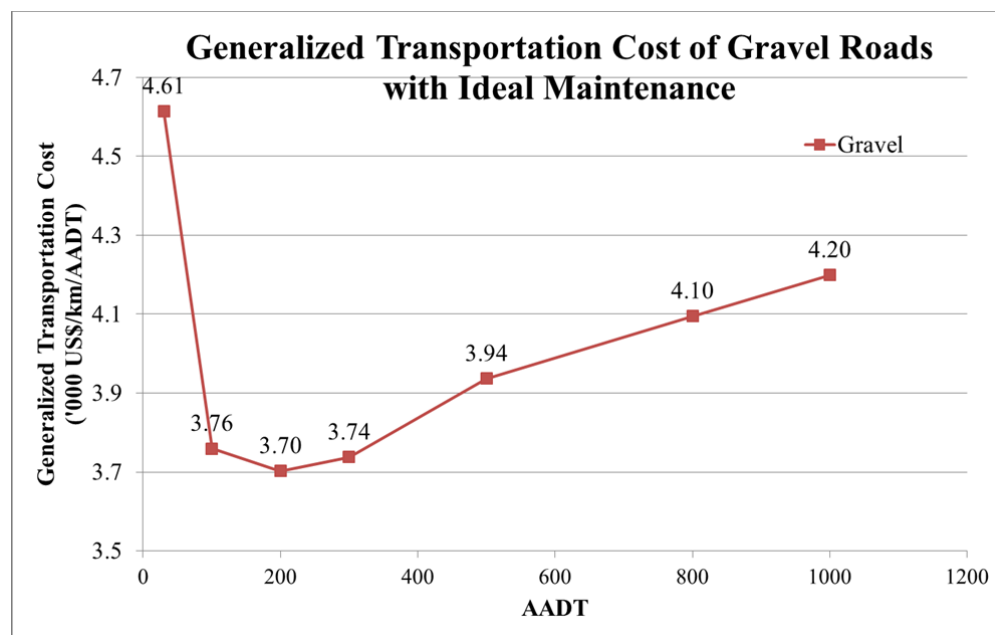


Figure 4-13 Generalized Transportation Cost of Gravel Roads with Ideal Maintenance

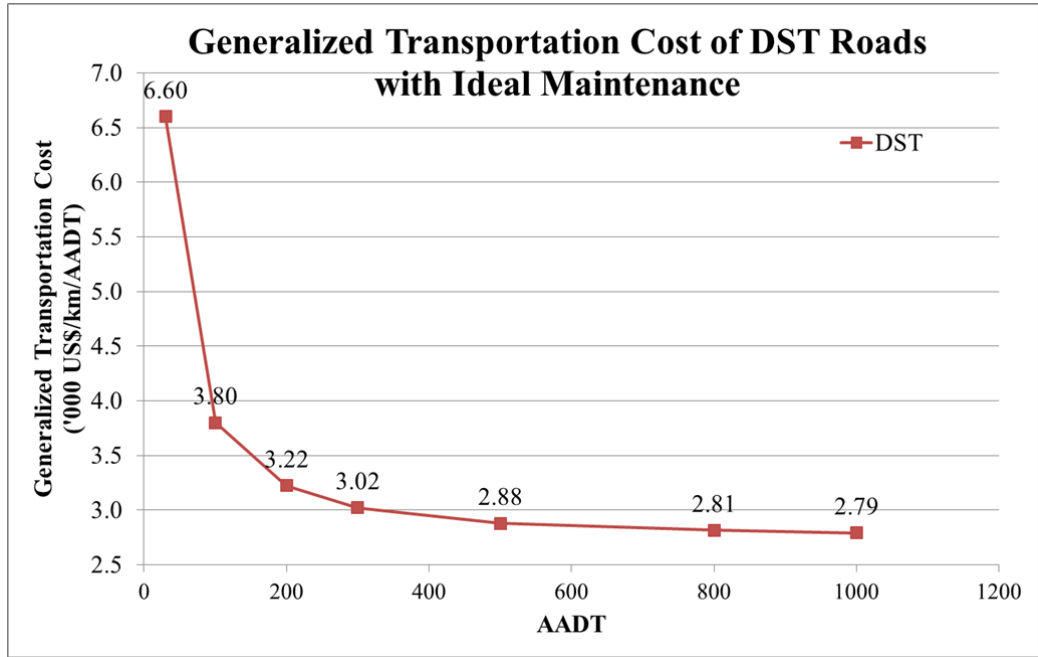


Figure 4-14 Generalized Transportation Cost of DST Roads with Ideal Maintenance

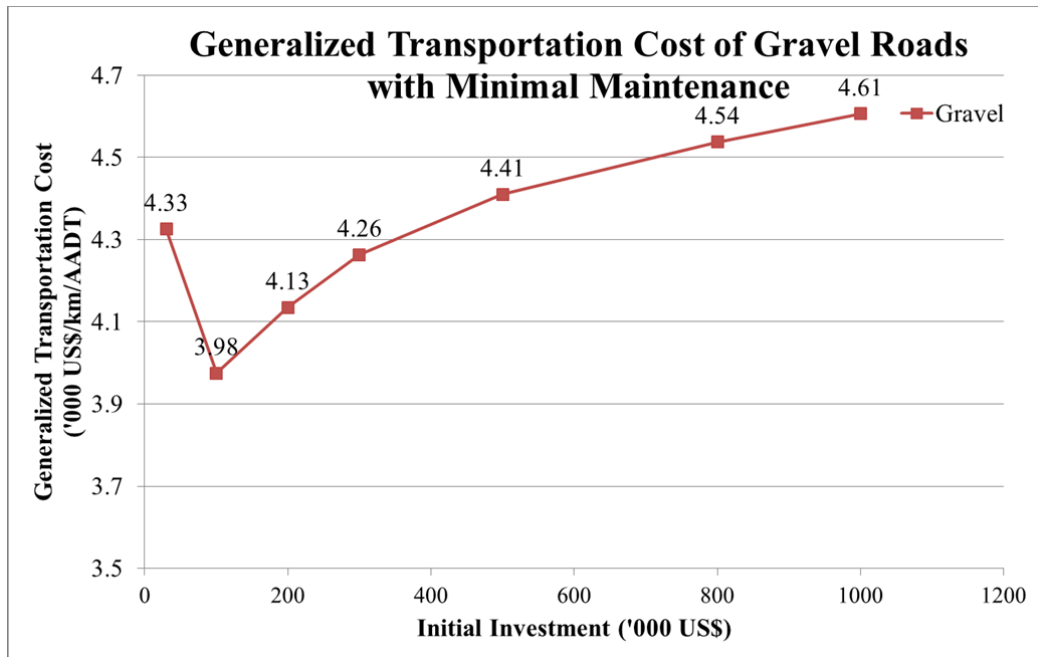


Figure 4-15 Generalized Transportation Cost of Gravel Roads with Minimal Maintenance

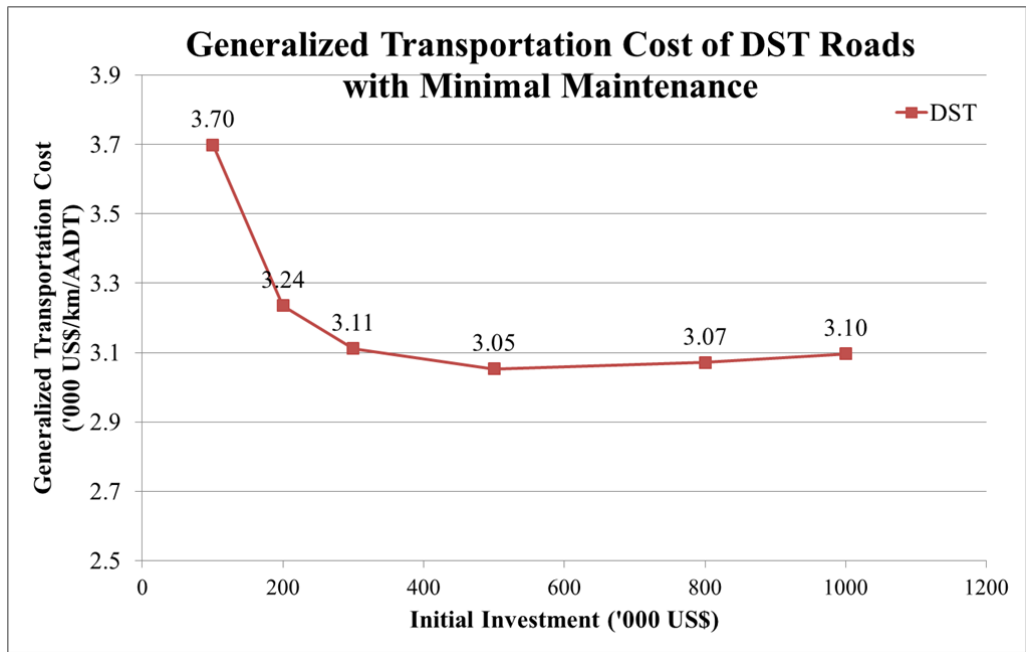


Figure 4-16 Generalized Transportation Cost of DST Roads with Minimal Maintenance

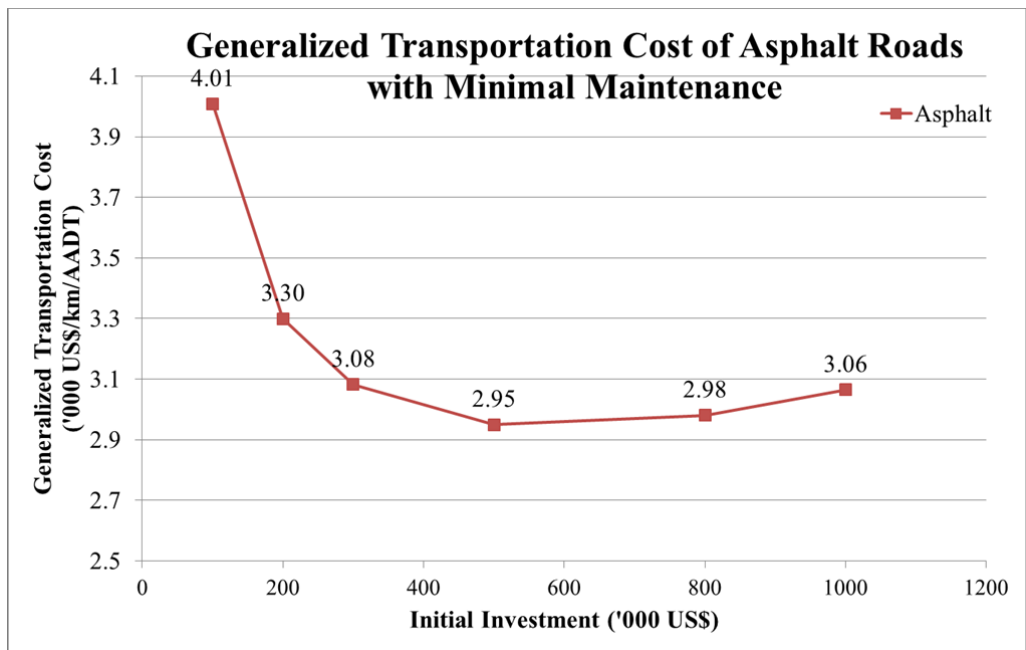


Figure 4-17 Generalized Transportation Cost of Asphalt Roads with Minimal Maintenance

From above tables and figures we can see that the generalized transportation cost (cost per km per AADT) for an existing road goes on decreasing as the traffic volume increases but starts to increase after certain traffic volume. As the traffic volume increases, the cost of infrastructure is shared by larger number of vehicle so the cost

per vehicle decreases. But after certain traffic volume the increase in road user cost due to increase in maintenance cost and vehicle operating cost as a result of high traffic volume becomes dominant, hence the generalized transportation cost increases. After that, the road needs to be upgraded to lower the maintenance cost and operational cost.

According to *Figure 4-13*, the gravel road with ideal maintenance needs to be upgraded after 200 AADT because after that point, the generalized transportation cost goes on increasing. As the generalized transportation cost goes on decreasing up to 1000 AADT for DST road and Asphalt road for ideal maintenance, these roads need not be upgraded up to 1000 AADT if proper maintenance is ensured. Similarly according to *Figure 4-14*, the gravel road with minimal maintenance needs to be upgraded after 100 AADT because after that point, the generalized transportation cost goes on increasing. Likewise *Figure 4-15* and *Figure 4-16* suggests that the DST road and Asphalt road need to be upgraded after 500 AADT because after that point, the generalized transportation cost goes on increasing.

Here, we can see that ensuring the proper maintenance can delay the necessity of upgrading a road using a huge investment i.e. a DBST road need to upgraded beyond 500 AADT if proper maintenance is not ensured but same road can still be economically beneficial to operate 1000 AADT traffic if proper maintenance is ensured as illustrated in above analysis.

4.5 Threshold for Upgrading the Road Surface

The net present value of the project alternatives is calculated considering the earthen road as base alternative as presented in Table 4-11 for Minimal Maintenance scenario and *Table 4-12* for Ideal Maintenance scenario.

Table 4-11 Net Present Value for Minimal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRA-MM	-0.11	0.40	0.71	0.84	0.95	1.00	0.97
DBST-MM	-0.79	0.75	3.02	5.26	9.63	16.02	20.29
AC-MM	-1.29	0.36	2.85	5.37	10.29	16.95	20.70

Table 4-12 Net Present Value for Ideal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
ETH-IM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRA-IM	-0.22	0.68	1.82	2.85	3.98	5.53	6.18
DBST-IM	-0.98	0.62	3.05	5.60	10.74	18.65	24.19
AC-IM	-1.41	0.29	2.84	5.50	10.86	18.66	24.54

The project alternative with positive net present Value is considered to be economically justifiable. From the above table it shows that it is not economically justifiable to upgrade the earthen road to gravel or black top for ADT of 30 or below but it is economically justifiable to upgrade to gravel or black top for ADT 100 or above. Figure 4-18 and Figure 4-19 presents the graph of the Net present Value ass of Table 4-11 and *Table 4-12*.

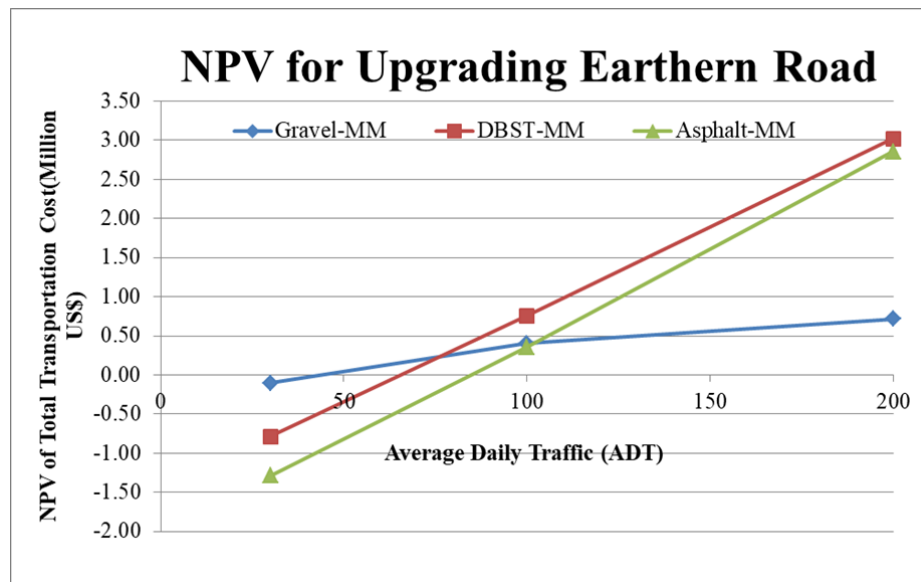


Figure 4-18 NPV for Upgrading Earthen Road for Minimal Maintenance

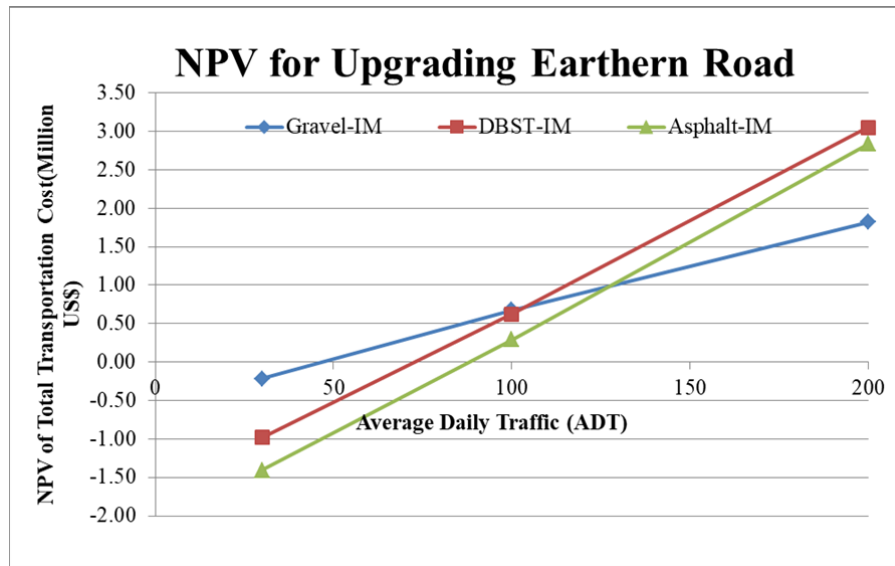


Figure 4-19 NPV for Upgrading Earthen Road for Ideal Maintenance

Figure 4-18 and Figure 4-19 shows that the traffic threshold that economically justifies the upgrading is as below:

Table 4-13 Minimum Traffic Threshold to Justify the Upgrading of Earthen Road

Project Alternative	Ideal Maintenance	Minimal Maintenance
Upgrading to Gravel	47	45
Upgrading to DBST	73	66
Upgrading to Asphalt	88	85

From *Table 4-13* we can observe that the threshold AADT for upgrading the road is higher for ideal maintenance scenario in comparison to minimal maintenance.

Now, the net present value of the project alternatives is calculated considering the Gravel road as base alternative as presented in *Table 4-14* for Ideal Maintenance scenario and *Table 4-15* for Minimal Maintenance scenario.

Table 4-14 Net Present Value for Minimal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
GRA-MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DBST-MM	-0.68	0.35	2.30	4.42	8.68	15.02	19.32
AC-MM	-1.18	-0.04	2.14	4.54	9.35	15.95	19.73

Table 4-15 Net Present Value for Ideal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
GRA-IM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DBST-IM	-0.76	-0.05	1.23	2.75	6.76	13.12	18.01
AC-IM	-1.19	-0.39	1.02	2.65	6.88	13.13	18.36

From the above table it shows that it is not economically justifiable to upgrade the gravel road to DBST for ADT of 30 or below but it is economically justifiable to upgrade to gravel or DBST for ADT 100 or above for Minimal Maintenance scenario. Similarly, it is not economically justifiable to upgrade the gravel road to DBST for ADT of 100 or below but it is economically justifiable to upgrade to gravel or DBST for ADT 200 or above for Ideal Maintenance scenario Figure 4-20 and Figure 4-21 presents the graph of the Net present Value as of Table 4-14 and Table 4-15.

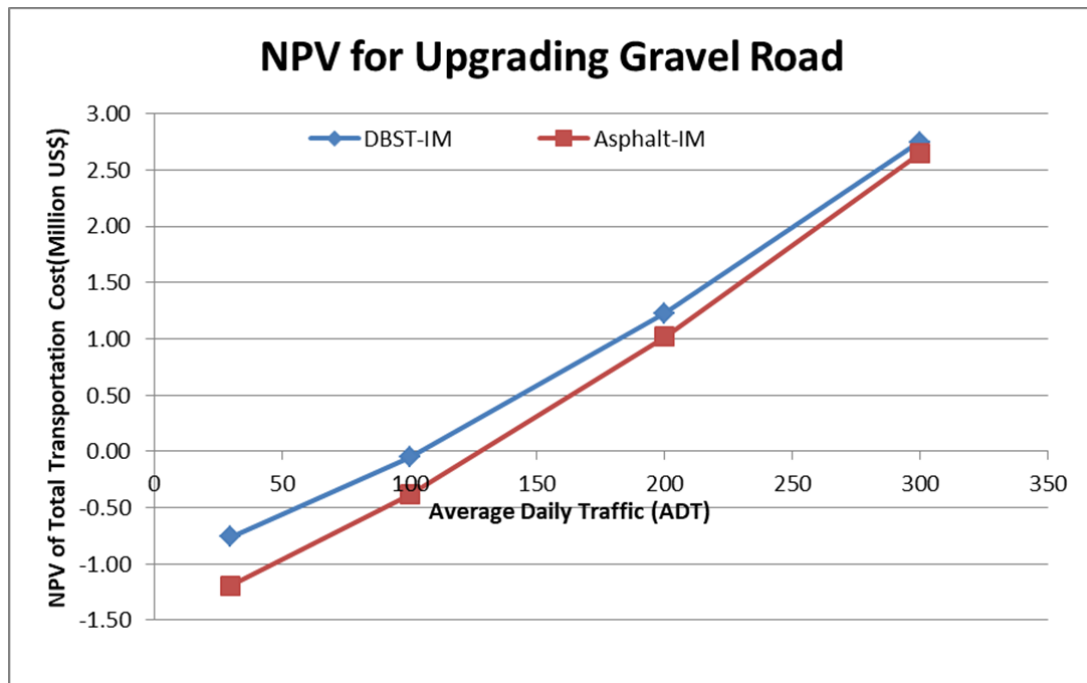


Figure 4-20 NPV for Upgrading Gravel Road for Minimal Maintenance

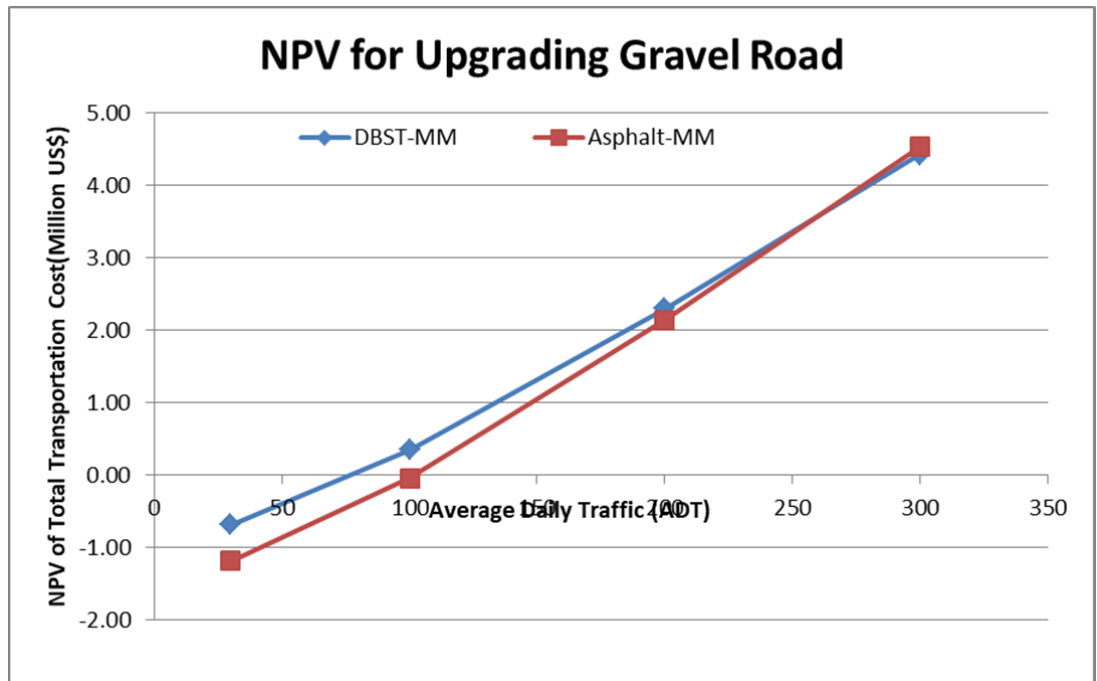


Figure 4-21 NPV for Upgrading Gravel Road for Full Maintenance

Figure 4-20 and Figure 4-21 shows that the traffic threshold that economically justifies the upgrading is as below:

Table 4-16 Minimum Traffic Threshold to Justify the Upgrading of Gravel Road

Project Alternative	Ideal Maintenance	Minimal Maintenance
Upgrading to DBST	104	76
Upgrading to Asphalt	128	102

From *Table 4-16* we can observe that the threshold AADT for upgrading the road is higher for ideal maintenance scenario in comparison to minimal maintenance.

Again, the net present value of the project alternatives is calculated considering the DBST road as base alternative as presented in *Table 4-17* for Minimal Maintenance scenario and *Table 4 16* for Ideal Maintenance scenario.

Table 4-17 Net Present Value for Minimal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
DBST-MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AC50-MM	-0.50	-0.40	-0.16	0.11	0.66	0.93	0.41

Table 4-18 Net Present Value for Ideal Maintenance Scenario

Alternative Code	AADT						
	30	100	200	300	500	800	1000
DBST-IM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AC50-IM	-0.43	-0.33	-0.21	-0.10	0.12	0.01	0.35

From the above table it shows that it is not economically justifiable to upgrade the DBST road to Asphalt for ADT of 200 or below but it is economically justifiable to upgrade to Asphalt for ADT 300 or above for Minimal Maintenance scenario. Similarly, it is not economically justifiable to upgrade the DBST road to Asphalt for ADT of 300 or below but it is economically justifiable to upgrade to Asphalt for ADT 500 or above for Ideal Maintenance scenario Figure 4-22 and Figure 4-23 presents the graph of the Net present Value as of Table 4-17 and Table 4-18.

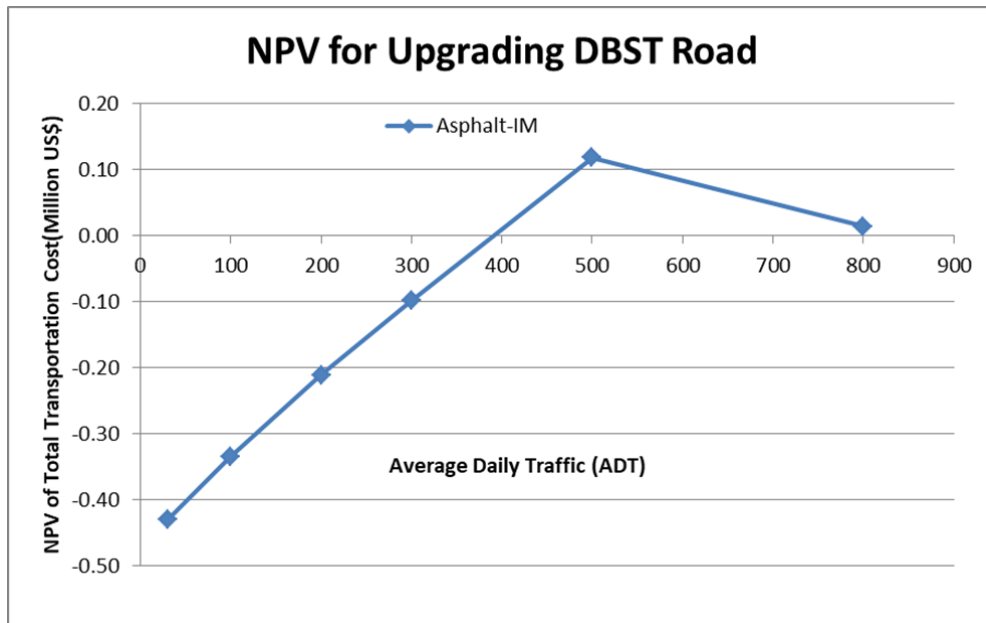


Figure 4-22 NPV for Upgrading DBST Road for Minimal Maintenance

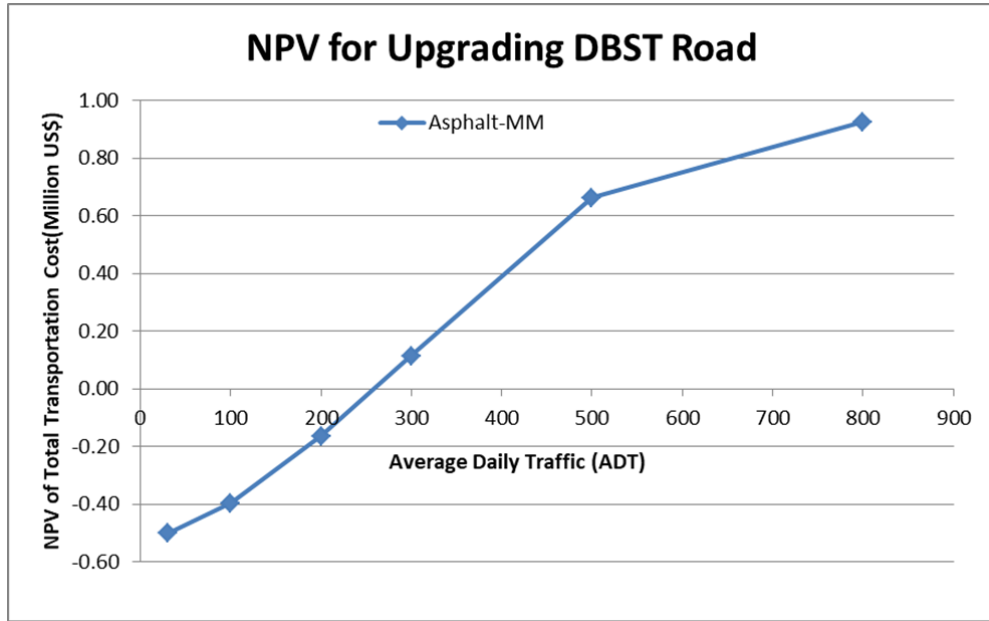


Figure 4-23 NPV for Upgrading DBST Road for Ideal Maintenance

Figure 10 and Figure 11 shows that the traffic threshold that economically justifies the upgrading is as below:

Table 4-19 Minimum Traffic Threshold to Justify the Upgrading of DBST Road

Project Alternative	Ideal Maintenance	Minimal Maintenance
Upgrading to Asphalt	391	259

From *Table 4-19* we can observe that the threshold AADT for upgrading the road is higher for ideal maintenance scenario in comparison to minimal maintenance.

4.6 Sensitivity Analysis of the Threshold AADT for Upgrading

Due to uncertainty in correctly determining inputs of model, the exact result of a project is always unknown. Sensitivity analysis helps determine the extent to which model results are affected by changes in inputs. As a result of sensitivity analysis we get the range of possible results rather than a single number.

The road agency cost, vehicle operation cost and travel time cost are the major inputs for the analysis. The road agency cost includes the construction cost and maintenance cost. Vehicle operation cost includes cost of vehicle, fuel cost and labour cost. Travel time cost includes the opportunity cost during the travel. So, sensitivity analysis is performed to analyse the effect of change in these factors to the result i.e. threshold for upgrading.

Table 4-20 Sensitivity Analysis for Road Agency Cost

Upgrading		Maintenance Policy	Base Case AADT	Road Agency Cost							
From	To			-20%		-10%		+10%		+20%	
			AADT	% Change	AADT	% Change	AADT	% Change	AADT	% Change	
Earthen	Gravel	Minimal	45	33	-26%	39	-13%	51	13%	56	26%
	DST		66	54	-18%	60	-9%	72	9%	78	18%
	Asphalt		85	69	-19%	77	-9%	93	9%	101	19%
	Gravel	Ideal	47	37	-22%	42	-11%	52	11%	58	22%
	DST		73	59	-19%	66	-9%	80	9%	87	19%
	Asphalt		88	71	-19%	80	-9%	96	9%	105	19%
Gravel	DST	Minimal	76	64	-16%	70	-8%	82	8%	88	16%
	Asphalt		102	85	-17%	94	-8%	109	7%	115	13%
	DST	Ideal	104	88	-16%	97	-7%	111	6%	118	13%
	Asphalt		128	109	-15%	118	-7%	137	7%	146	14%
DST	Asphalt	Minimal	259	221	-15%	240	-7%	278	7%	297	15%
	Asphalt	Ideal	391	314	-20%	355	-9%	423	8%	453	16%
Average					-18%		-9%		9%		18%

The Table 4-20 shows that 10 % decrease in road agency cost decreases the threshold AADT by 9% so, the change in road agency cost have significant impact on threshold for upgrading roads. The elasticity of road agency to threshold AADT is nearly 1.

Table 4-21 Sensitivity Analysis for Vehicle Operating Cost

Upgrading		Maintenance Policy	Base Case AADT	Vehicle Operating Cost							
From	To			-20%		-10%		+10%		+20%	
			AADT	% Change	AADT	% Change	AADT	% Change	AADT	% Change	
Earthen	Gravel	Minimal	45	56	26%	50	12%	40	-10%	36	-19%
	DST		66	78	19%	71	9%	61	-7%	57	-14%
	Asphalt		85	101	20%	92	9%	78	-7%	73	-14%
	Gravel	Ideal	47	58	23%	52	10%	43	-8%	40	-16%
	DST		73	87	20%	79	9%	67	-8%	63	-14%
	Asphalt		88	106	20%	96	9%	81	-8%	76	-14%
Gravel	DST	Minimal	76	89	17%	82	8%	71	-7%	67	-12%
	Asphalt		102	116	14%	108	6%	95	-6%	89	-13%
	DST	Ideal	104	119	14%	111	6%	98	-6%	92	-12%
	Asphalt		128	148	16%	137	7%	120	-6%	113	-11%
DST	Asphalt	Minimal	259	303	17%	279	8%	243	-6%	229	-12%
	Asphalt	Ideal	391	483	24%	433	11%	355	-9%	323	-17%
Average					19%		9%		-7%		-14%

The Table 4-21 shows that 10% decrease in vehicle operating cost increases the traffic threshold by 9% so the change in vehicle operating cost have significant impact on threshold for upgrading roads. The elasticity of vehicle operating cost to threshold AADT is nearly -1

Table 4-22 Sensitivity Analysis for Travel Time Cost

Upgrading		Maintenance Policy	Base Case AADT	Travel Time Cost							
From	To			-20%		-10%		+10%		+20%	
			AADT	% Change	AADT	% Change	AADT	% Change	AADT	% Change	
Earthen	Gravel	Minimal	45	47	5%	46	2%	44	-2%	43	-4%
	DST		66	67	3%	67	1%	65	-1%	64	-2%
	Asphalt		85	87	3%	86	1%	84	-1%	83	-2%
	Gravel	Ideal	47	49	4%	48	2%	46	-2%	45	-3%
	DST		73	75	3%	74	1%	72	-1%	71	-2%
	Asphalt		88	90	2%	89	1%	87	-1%	86	-2%
Gravel	DST	Minimal	76	78	2%	77	1%	75	-1%	75	-2%
	Asphalt		102	103	1%	103	1%	101	-1%	100	-1%
	DST	Ideal	104	105	1%	105	1%	104	-1%	103	-1%
	Asphalt		128	129	1%	128	1%	127	-1%	126	-1%
DST	Asphalt	Minimal	259	262	1%	260	0%	258	0%	256	-1%
	Asphalt	Ideal	391	400	2%	395	1%	386	-1%	382	-2%
Average					2%		1%		-1%		-2%

The Table 4-22 shows that 10% decrease in travel time cost results in just 1% increase in threshold AADT value so the change in travel time cost have nominal impact on threshold for upgrading roads. The elasticity of travel time cost to threshold AADT is less than -1

4.7 Comparing the result with the Existing Practice of Upgrading of Low Volume Roads

A number of low volume roads are being upgraded from unsealed roads to black top roads. Department of Local Infrastructure (DoLI), Province Government and Municipalities are the responsible for upgrading of Low volume roads. The result of this research has been compared with a number of road projects to study if these projects are economically justifiable based on this research.

Table 4-23 Existing Practice of Upgrading of Low Volume Roads compared with Threshold AADT

S. N.	Name of Road	Existing Road	Upgraded Road	Existing AADT	Threshold AADT
1	Chainpur - Barhabise Road, Sakhuwashabha	Earthen	Gravel	13	47
2	Parasan - Tribhuvanbasti - Laxmipur -Belauri Road, Kanchanpur	Earthen	Gravel	107	47
3	Putalikhet- Panchamul- Aaruchaur Rural Road, Syangya	Earthen	Gravel	66	47
4	Devpura-Ghorghas-Phulgama-Tulsiyahi Road, Dhanusha	Earthen	DBST	190	73
5	Sandhikharka-Balkot-Tamghas Road, Argakhachi	Earthen	DBST	102	73
6	RRM(Chaulika chowk)-Mahendranagar-Hirminiya-Holiya Road, Banke	Earthen	DBST	103	73
7	Puspalal Marg, Bardiya	Earthen	DBST	69	73
8	Kalakate-Gadhawa Road, Dang	Earthen	DBST	113	73
9	Kristi - Nirmalpokhari - Bharatpokhari Road, Kaski	Earthen	DBST	120	73
10	Krishna Marga (Sabung Deurali - Keladighat Road), Tanahun	Earthen	DBST	104	73
11	Mudheshanishchare – Dadagaun-Chanuwa Road, Dhankuta	Earthen	Asphalt	35	88
12	Samdin - Chokmangu - Nawamidada – Faktep, Panchthar	Earthen	Asphalt	29	88

S. N.	Name of Road	Existing Road	Upgraded Road	Existing AADT	Threshold AADT
13	Amaldagi - Samayagadh -Bansbari - Solmari Road, Jhapa	Earthen	Asphalt	98	88
14	Kharsangwari-Jalthal-Mangalware-Baundoka-Adhikari Chowk Road, Jhapa	Earthen	Asphalt	99	88
15	Mijhing - Dhuleodar - Namja – Sirp Road, Rolpa	Earthen	Asphalt	28	88
16	Mandredhunga-Khadgabhanjyang-Gorshyang-Dangsing-kaphalpani Road, Nuwakot	Gravel	DBST	121	104
17	Atmaram Path, Parsa	Gravel	DBST	188	104
18	Gaighat-Fattepur Road , Udayapur	Gravel	DBST	126	104
19	Shivalawa-Labani-Ma.Ra.Ma Road, Kapilbastu	Gravel	DBST	106	104
20	Inaruwa - Satterjhoda - Chhitaha - Purbakushaha - Biratnagar Road, Sunsari	Gravel	Asphalt	242	128

The Table 4-23 is presented in Figure 4-24 to compare existing AADT of the roads under study with the threshold AADT suggested by the research.

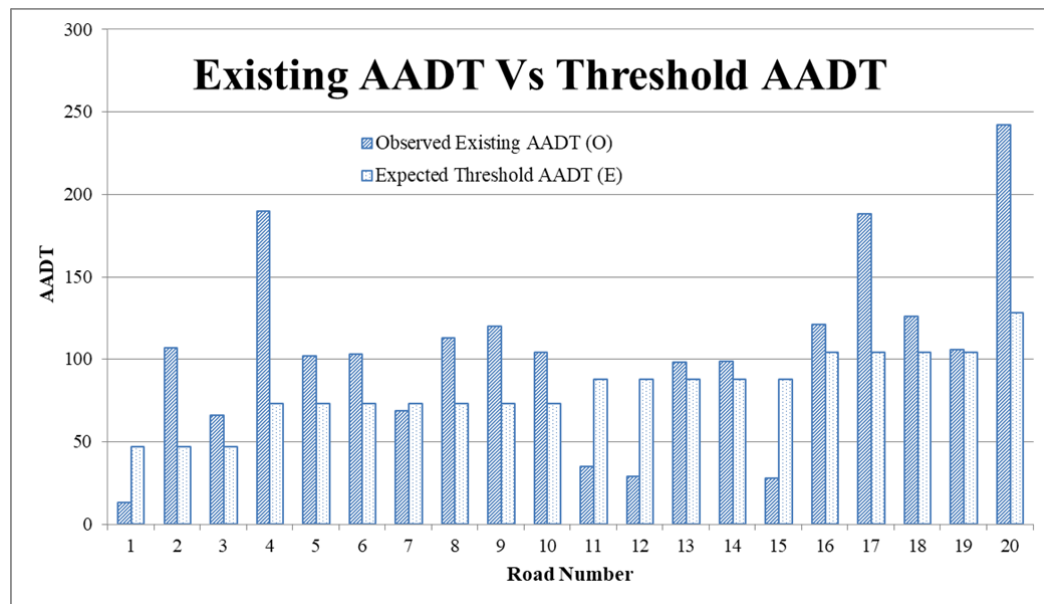


Figure 4-24 Comparison between existing AADT and threshold AADT

Out of 20 roads, 15 roads being upgraded have the traffic volume more than the threshold suggested by the research but 5 roads have the traffic volume less than the traffic threshold suggested by the research to upgrade. The upgrading of these roads seems to be the sub-optimal investment. It may be due to lack of evidence-based analysis for investment. Other reason is that perhaps the road user prefer black top road over the unsealed roads so the unsealed roads with low volume are black topped based on influence rather than traffic need.

4.8 Checking Goodness of Fit between Expected and Observed AADT

Chi-squared test is carried out to evaluate if the observed value of AADT at which the upgrading is carried out comply with the theoretical AADT derived in the research. The calculation for Chi-squared Test is attached in APPENDIX 6

Here

Calculated $X^2=677.55$

Number of sample $n=20$

Degree of Freedom= $n-1=20-1=19$

Taking $\alpha=5\%$, tabulated X^2 for 19 d.f. is 30.144

Since, calculated value of X^2 is greater than the tabulated value of X^2 , the calculated X^2 falls in rejection region which suggests that the observed value of AADT at which the upgrading of low volume road are being carried out and the theoretical AADT derived in the research are statistically indifferent. The major reason for this is that some roads are upgraded too early i.e. at much lower AADT than threshold AADT while other are upgraded too late i.e. at much higher AADT than the threshold AADT.

4.9 Validation of Results

A number of researches have been done to determine the threshold for upgrading the unsealed to sealed roads. The result of this result is compared with result of past work to validate the results. As no research were found that calculated the threshold traffic volume for upgrading the roads for all scenarios as in this research. The threshold calculated for different scenarios were compared with the corresponding value from this research.

Table 4-24 Validation of Results

Upgrading		Maintenance Policy	Threshold AADT			
			Calculated	(Department of Roads, 2007)	(Devkota, 2013)	(Neupane, 2015)
From	To					
Earthen	Gravel	Minimal	45	42	-	-
	DST		66	-	133	-
	Asphalt		85	-	133	-
	Gravel	Ideal	47	42	-	-
	DST		73	-	133	-
	Asphalt		88	-	133	-
Gravel	DST	Minimal	76	102	-	200
	Asphalt		102	102	-	-
	DST	Ideal	104	102	-	200
	Asphalt		128	102	-	-
DST	Asphalt	Minimal	259	-	-	-
	Asphalt	Ideal	391	-	-	-

As no research were found that calculated the threshold traffic volume for upgrading the roads for all scenarios as in this research. The threshold calculated for different scenarios were compared with the corresponding value from this research. On comparing the calculated value with previous research on computing the threshold AADT, we find that the result of this research and (Department of Roads, 2007) is similar due to similar approach of calculation use of same tool for analysis i.e. HDM-4. Meanwhile there is some difference between the result from research by (Devkota, 2013) as RED was used for analysis rather than HDM-4. There is also the difference in result from the research by (Neupane, 2015) due to difference in maintenance policy assumed during the analysis.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

The main objective of this research was to determine the effect of road maintenance on threshold for upgrading of low volume roads. The conclusions drawn as a result of the analysis to achieve the objective are:

1. The traffic needed to validate investment increases if proper maintenance is ensured both before and after upgrade. In other words, ensuring a proper maintenance will increase the threshold of traffic volume for upgrading a road surface i.e ensuring the proper maintenance can delay the necessity of upgrading a road using a huge investment.
2. The proper maintenance (ideal maintenance) will increase the road agency cost but decreases the roughness of the road that in turn decreases the road vehicle operating cost which ultimately decreases the road user cost. The analysis shows that proper maintenance in gravel road is always economically justified. Similarly for bituminous roads, proper maintenance is justified for traffic volume higher than 300 AADT.
3. The most suitable pavement for Armadi-Banau road which is the study area of the road is Gravel road for ideal maintenance scenario and DBST for minimal maintenance scenario.
4. The contribution of road user cost in total transportation cost is about 86%. As the road user cost contribute more than road agency cost in total transportation, the increase in road agency cost due to a road maintenance investment is usually compensated by decrease in road user cost hence decreasing the total transportation cost. The contribution of road user cost in total transportation cost decreases with upgrading of road.
5. The threshold for upgrading the low volume roads is as listed below

Upgrading		Threshold AADT	
From	To	Minimal Maintenance	Ideal Maintenance
Earthen	Gravel	45	47
	DST	66	73
	Asphalt	85	88
Gravel	DST	76	104
	Asphalt	102	128
DST	Asphalt	259	391

6. The threshold for upgrading a road is highly sensitive to change in road agency cost and vehicle operating cost whereas less sensitive to change in travel time cost.
7. The observed value of AADT at which the upgrading of low volume road are being carried out and the theoretical AADT derived in the research are statistically indifferent.

5.2 Recommendations

The recommendations based on the above analysis and conclusions are as below:

1. The proper maintenance is always recommended for all gravel roads and for the roads with traffic volume above 300 AADT.
2. As contribution of road user cost on total transportation cost is more than road agency cost, while evaluating a road maintenance investment the decrease in road user cost must also be considered along with the increase in road agency cost to calculate total transportation cost for economic analysis.
3. During the analysis of deciding any upgrading or maintenance investment, the focus must be made on optimizing the total cost to the society which is the sum of infrastructure cost for road agency and operational cost for road users rather than optimization of road agency cost alone.
4. The selection of roads for upgrading must be done only after ranking the roads based on economic analysis.
5. The calibration of the model hugely affects the result obtained from HDM-4. The reliable data for calibration of HDM-4 is not available, so road agencies must initiate to prepare the data for calibration of HDM-4 so that they can be used for future research and analysis.

REFERENCES

- Adler, H. A. (1971). *ECONOMIC APPRAISAL OF TRANSPORT PROJECTS: A MANUAL WITH CASE STUDIES*. <https://trid.trb.org/view/91282>
- Archondo-Callao, R. (2011a). Maintenance Impact on Economic Evaluation of Upgrading Unsealed Roads. *Transportation Research Record: Journal of the Transportation Research Board*, 2203(1), 151–159. <https://doi.org/10.3141/2203-19>
- Archondo-Callao, R. (2011b). Maintenance Impact on Economic Evaluation of Upgrading Unsealed Roads. *Transportation Research Record: Journal of the Transportation Research Board*, 2203(1), 151–159. <https://doi.org/10.3141/2203-19>
- Bennett, C. R., & Paterson, W. D. O. (2000). *Volume five A Guide to Calibration and Adaptation*. 6.
- Bhandari, S. B., Shahi, P. B., & Shrestha, R. N. (2016). *RANKING RURAL ROAD PROJECTS: WEIGHTING DIFFERENT EVALUATION CRITERIA WITH A FOCUS ON THE CASE OF NEPAL*. 23.
- Burningham, S., & Stankevich, N. (2005). Why Road Maintenance is Important and How to Get It Done. *World Bank*, 10.
- Department of Roads, G. of N. (2007). *Sector Wide Road Programme (SWRP) & Priority Investment Plan (PIP) Study*. Department of Roads.
- Devkota, S. (2013). Economic Analysis of Low Volume Road—A Case Study of Kalanki Ghyampedol Badvangyang Road. *Department of Civil Engineering*.

- DoLIDAR, G. of N. (2016). *Statistics of Local Road Network (SLRN)*. DoLIDAR.
- Eddington, R. (2006). *The Eddington Transport Study. Main Report: Transport's Role in Sustaining the UK's Productivity and Competitiveness*.
- Gamage, D., Pasindu, H. R., & Bandara, S. (2016). Pavement Roughness Evaluation Method for Low Volume Roads. *Proceedings of the Eighth International Conference on Maintenance and Rehabilitation of Pavements*, 976–985. <https://doi.org/10.3850/978-981-11-0449-7-199-cd>
- GoN, N. (2014). An Approach to the Graduation from the Least Developed Country by 2022. *National Planning Commission*.
- Harral, C., & Faiz, A. (1988). *Road deterioration in developing countries: Causes and remedies* (No. 13370; pp. 1–76). The World Bank. <http://documents.worldbank.org/curated/en/722851468162562433/Road-deterioration-in-developing-countries-causes-and-remedies>
- IRC, I. (2009). *Manual on Economic Evaluation of Highway Projects in India*. Indian Roads Congress.
- Johnston, M. (2013). *USING CELL-PHONES TO MONITOR ROAD ROUGHNESS*. 10.
- Kerali, H. G. R. (2000). Volume 1: Overview of HDM-4. *The World Road Association (PIARC)*, 53.
- MRCU, D. (1995). *Road pavement Management*. Department of Roads.
- Neupane, S. R. (2015). Deriving Threshold Traffic Levels for Feeder Road Upgraing Using HDM-4. *Department of Civil Engineering, Institute of Engineering*.

- Odoki, J. B., & Kerali, H. G. R. (2000). *Volume four Analytical Framework and Model Descriptions*. 8.
- P.K., A., Khan, A. B., & Choudhary, S. (2017). A Rational Strategy for Resource Allocation for Rural Road Maintenance. *Transportation Research Procedia*, 25, 2195–2207. <https://doi.org/10.1016/j.trpro.2017.05.422>
- RCIP, R. C. I. P. (2017). *DPR -Armadi—Banau Road, Parbat.pdf*. Department of Local Infrastructure.
- Thube, D. T. (2013). Highway Development and Management Model (HDM-4): Calibration and adoption for low-volume roads in local conditions. *International Journal of Pavement Engineering*, 14(1), 50–59. <https://doi.org/10.1080/10298436.2011.606320>
- Veeraragavan, A., & Reddy, K. B. R. (2003). Application of Highway Development and Management Tool for Low-Volume Roads. *Transportation Research Record: Journal of the Transportation Research Board*, 1819(1), 24–29. <https://doi.org/10.3141/1819a-05>

APPENDIX 1 :BASIC DATA

Unit Cost of Upgrading

US\$ to NPR

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	Unit Rate								
	Subgrade m2	Subbase m3	Base m3	Prime Coat	Tack Coat	Pavement	Total	Economic US\$	Financial US\$
Earthen to Gravel	23.3	2646.74					3,572,643.50	31,616.31	35,726.44
Earthen to DBST	23.3	2646.74	3343.98			606.495	11,329,287.50	100,259.18	113,292.88
Earthen to Asphalt	23.3	2646.74	3343.98	123.68	100.54	17932.13	15,864,451.90	140,393.38	158,644.52

	Unit	Rate		
		NPR	US\$ Economic	US\$ Financial
Routine for Gravel Hill	km/yr	79707.60	705.38	797.08
Routine for Gravel Plain	km/yr	79707.60	705.38	797.08
Routine for Blacktop Hill	km/yr	79707.60	705.38	797.08
Routine for Blacktop Plain	km/yr	79707.60	705.38	797.08
Crack Sealing	m2	11.34	0.10	0.11
Patching	m2	361.71	3.20	3.62
Edge Repair	m2	361.71	3.20	3.62
Fog Seal	m2	78.06	0.69	0.78
Drainage	km		0.00	0.00
Slurry Seal	m2	549.37	4.86	5.49
Rejuvenation	m2		0.00	0.00
Thin Overlay	m2		0.00	0.00
Mill and Replace	m2		0.00	0.00
Surface Dressing Single	m2	404.33	3.58	4.04
Surface Dressing Double	m2	808.66	7.16	8.09
Cape Seal	m2		0.00	0.00
Asphalt Overlay	m2	896.6065	7.93	8.97
Pavement Reconstruction	m2		0.00	0.00
Spot Regravaling	m2		0.00	0.00
Grading	km	23574.64	208.63	235.75
Regraving	m3	3343.98	29.59	33.44
Full Depth Repair	m2		0.00	0.00

Parameter	Value					Unit	Reference
	1	2	3	Avg(NPR)	Avg(US\$)		
New Vehicle	3,708,333	4,000,000	3,190,000	3,632,778	32,148.48		NADA
Replacement Tyre	48,000	57,000	62,000	55,667	492.63		NADA
Fuel	95			95	0.84		NOC
Lubricating Oil	1,000			1,000	8.85		NADA
Maintenace Labour	81			81	0.72		District Rate
Crew Charge	125			125	1.11		District Rate
Annual Overhead	72,656			72,656	642.97		DoTM calculation of Vehicle Fare for 2071
Annual Interest	10			10			
Passenger Working Time	83			83	0.73		Project Documents
Passenger Non-Working Time	21			21	0.19		Project Documents
Cargo	21			21	0.19		Project Documents

Car

Parameter	Value					Unit	Reference
	1	2	3	Avg(NPR)	Avg(US\$)		
New Vehicle	2,796,000	2,089,000	4,725,000	3,203,333	28,348.08		NADA
Replacement Tyre	3,500			3,500	30.97		NADA
Fuel	107			107	0.95		NOC
Lubricating Oil	1,000			1,000	8.85		NADA
Maintenace Labour	81			81	0.72		District Rate
Crew Charge	-			-	-		District Rate
Annual Overhead	32,033			32,033	283.48		DoTM calculation of Vehicle Fare for 2071
Annual Interest	10			10			
Passenger Working Time	180			180	1.59		Project Documents
Passenger Non-Working Time	45			45	0.40		Project Documents
Cargo	45			45	0.40		Project Documents

Truck

Parameter	Value					Unit	Reference
	1	2	3	Avg(NPR)	Avg(US\$)		
New Vehicle	2,475,000	3,105,000	3,410,000	2,996,667	26,519.17		NADA
Replacement Tyre	48,000	57,000	62,000	55,667	492.63		NADA
Fuel	95			95	0.84		NOC
Lubricating Oil	1,000			1,000	8.85		NADA
Maintenace Labour	81			81	0.72		District Rate
Crew Charge	125			125	1.11		District Rate
Annual Overhead	29,967			29,967	265.19		DoTM calculation of Vehicle Fare for 2071
Annual Interest	10			10			
Passenger Working Time	83			83	0.73		Project Documents
Passenger Non-Working Time	21			21	0.19		Project Documents
Cargo	21			21	0.19		Project Documents

Mini-Bus

Parameter	Value					Unit	Reference
	1	2	3	Avg(NPR)	Avg(US\$)		
New Vehicle	3,320,000			3,320,000	29,380.53		NADA
Replacement Tyre	5,273			5,273	46.66		NADA
Fuel	95			95	0.84		NOC
Lubricating Oil	1,000			1,000	8.85		NADA
Maintenace Labour	81			81	0.72		District Rate
Crew Charge	125			125	1.11		District Rate

Bicycle

Parameter	Value				Unit	Reference
	1	2	3	Avg(NPR)		
New Vehicle	35,000			35,000	309.73	NADA
Replacement Tyre	2,400			2,400	21.24	NADA
Fuel	-			-	-	NOC
Lubricating Oil	-			-	-	NADA
Maintenace Labour	-			-	-	District Rate
Crew Charge	-			-	-	District Rate
Annual Overhead	350			350	3.10	Road_User_Costs_Workin g_Paper DoR
Annual Interest	10			10		Market Survey
Passenger Working Time	83			83	0.73	Project Documents
Passenger Non-Working Time	21			21	0.19	Project Documents
Cargo	21			21	0.19	Project Documents

Description of works:		Routine (regular maintenance) of black top road in plain area (cross slope upto 10 percent)													Unit : km		
Spec. cl. No: 2901		Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.01.01	Skilled	md	0.05	1025.00	51.25	Fuel		8.00%	of L.C.	16.10	Tools		9.00%	of L.C.	18.11		
	Unskilled	md	0.20	750.00	150.00	Traning/ Insurance/ first Aid		3.00%	of L.C.	6.04	Maintenance of Tools		3.00%	of L.C.	6.04		
Sub total of A =					201.25	Sub total of B =					22.14	Sub total of C =					24.15
Sub total of A +B + C =					247.54	Contractor's overhead expenses 15% =					37.13	Unit Rate =					284.67
79707.60																	

Description of works:		Routine (regular maintenance) of Gravelled road in plain area (cross slope upto 10 percent)													Unit : km		
Spec. cl. No: 2901		Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.01.01	Skilled	md	0.05	1025.00	51.25	Fuel		8.00%	of L.C.	16.10	Tools		9.00%	of L.C.	18.11		
	Unskilled	md	0.20	750.00	150.00	Traning/ Insurance/ first Aid		3.00%	of L.C.	6.04	Maintenance of Tools		3.00%	of L.C.	6.04		
Sub total of A =					201.25	Sub total of B =					22.14	Sub total of C =					24.15
Sub total of A +B + C =					247.54	Contractor's overhead expenses 15% =					37.13	Unit Rate =					284.67
79707.60																	

Description of works:		Routine (regular maintenance) of Gravelled road in Rolling, Mountainous, steep area (cross slope > 10 percent)													Unit : km		
Spec. cl. No: 2901		Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.01.01	Skilled	md	0.05	1025.00	51.25	Fuel		8.00%	of L.C.	34.10	Tools		9.00%	of L.C.	38.36		
	Unskilled	md	0.50	750.00	375.00	Traning/ Insurance/ first Aid		3.00%	of L.C.	12.79	Maintenance of Tools		3.00%	of L.C.	12.79		
Sub total of A =					426.25	Sub total of B =					46.89	Sub total of C =					51.15
Sub total of A +B + C =					524.29	Contractor's overhead expenses 15% =					78.64	Unit Rate =					602.93

Description of works:		Restoration of rain cuts in embankment slopes including watering and compaction etc. all complete lead 10 m.													Unit : 1 m3		
Spec. cl. No: 2902		Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.01	Skilled	md	0.10	1025.00	102.50						Tools		3.00%	of L.C.	19.95		
	Unskilled	md	0.75	750.00	562.50												
Sub total of A =					665.00	Sub total of B =					0.00	Sub total of C =					19.95
Sub total of A +B + C =					684.95	Contractor's overhead expenses 15% =					102.74	Unit Rate =					787.69

Description of works:		Providing required material and repair the pot holes including removal of loose material, trimming of sides, cleaning of surface, applying tack coat , 20 mm thick pre-mix carpet and seal coat with bitumen emulsion as per Technical Specification and direction of the Engineer.													Unit : 200 m ²		
Spec. cl. No:	2903																
Norms No.	Labour (A)					Material (B)					Equipment (C)						
	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.10 ii	Skilled	md	2.00	1025.00	2050.00	Emulsion	Tonne	0.70	72030.00	50421.00	Concrete mixer/Mixing plant	hr	6.00	765.29	4591.74		
	Unskilled	md	18.00	750.00	13500.00	Crushed Stone Aggregate Nominal Size 13.2 mm to 5.6 mm	Cum	5.40	2190.91	11830.91	Air Compressor	hr	6.00	1458.72	8752.32		
						Crushed sand passing 2.36 mm	Cum	1.20	1940.82	2328.98	Emulsion pressur distributor	hr	0.00	4313.08	0.00		
											Smooth Wheeled Roller	Hour	6.00	1581.11	9486.66		
Sub total of A =					15550.00	Sub total of B =					64580.89	Sub total of C =					22830.72
Sub total of A +B + C =					102961.61	Contractor's overhead expenses 15% =					15444.24	Unit Rate =					118405.85
Rate per sqm																592.03	

Description of works:		Providing required material and repair the pot holes with Open graded Premix Surfacing 20 mm thickness including removal of failed material, trimming and finishing the surface using appropriate pavement cutter, applying tack coat on the sides and on the base of excavation, backfilling with hot bituminous material and													Unit : 600 m ²		
Spec. cl. No:	2903																
Norms No.	Labour (A)					Material (B)					Equipment (C)						
	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.11 A	Skilled	md	1.00	1025.00	1025.00	Crushed Stone Aggregate Nominal Size 13.2 mm	Cum	12.96	2190.91	28394.19	Air Compressor	hr	6.00	1458.72	8752.32		
	Unskilled	md	6.00	750.00	4500.00	Crushed Stone Aggregate Nominal Size 5 mm	Cum	6.48	1945.91	12609.49	Hot Mix plant	hr	1.00	13793	13793.00		
						Bitumen	Tonne	1.08	72030.00	77792.40	Tipper/ tractor	hr	6.00	1072.31	6433.86		
						Bitumen or Emulsion (for prime and Tack Coat)	Tonne	0.36	72030.00	25930.80	Smooth Wheeled Roller	Hour	6.00	1581.11	9486.66		
Sub total of A =					5525.00	Sub total of B =					144726.88	Sub total of C =					38465.84
Sub total of A +B + C =					188717.72	Contractor's overhead expenses 15% =					28307.66	Unit Rate =					217025.38
Rate per sqm																361.71	

Description of works:		Providing and Filling of Cracks using slow- curing bitumen emulsion and applying crusher dust in case cracks are wider than 3 mm as per Technical Specifications and instruction of the Engineer.													Unit : 1000 m		
Spec. cl. No:	2903																
Norms No.	Labour (A)					Material (B)					Equipment (C)						
	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.12	Skilled	md	1.00	1025.00	1025.00	Slow Curing Bitumen Emulsion	Kg	80.00	72.03	5762.40					0.00		
	Unskilled	md	4.00	750.00	3000.00	Stone Crusher dust	Cum	0.05	1500.00	75.00					0.00		
Sub total of A =					4025.00	Sub total of B =					5837.40	Sub total of C =					0.00
Sub total of A +B + C =					9862.40	Contractor's overhead expenses 15% =					1479.36	Unit Rate =					11341.76
Rate per m																11.34	

Description of works:		Providing and laying slurry seal (1.5 mm thickness) consisting of a mixture of fine aggregates, Portland Cement filler, Bituminous Emulsion and water on a road surface, mixing of slurry seal in a suitable mobile plant, lying and compacting to provide even riding surface.												Unit : 1200 Sqm.			
Spec. cl. No:	2903	Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.14 III	Skilled	md	1.00	1025.00	1025.00	Emulsion (@16%)	Tonne	6.40	72030.00	460992.00	Mechanical Broom	hr	6.00	1977.43	11864.58		
	Unskilled	md	6.00	750.00	4500.00	Fine Aggregates 2.36 mm and below (@82%)	Cum	22.00	1940.82	42698.04	Air Compressor	hr	6.00	1458.72	8752.32		
						Filler (@2%)	Tonne	0.80		0.00	Mobile Slurry Seal Equipment	hr	6.00	2628.84	15773.04		
						Cost of Water	KL	6.00	325.29	1951.74	Loader	hr	6.00	2877.25	17263.50		
											Tipper	hr	6.00	1406.08	8436.48		
Sub total of A =					5525.00	Sub total of B =					505641.78	Sub total of C =					62089.92
Sub total of A + B + C =					573256.70	Contractor's overhead expenses 15% =					85988.51	Unit Rate =					659245.21
Rate per sqm																549.37	

Description of works:		Providing and applying low viscosity bitumen emulsion for sealing cracks less than 3 mm wide or incipient fretting or disintegration in an existing bituminous surfacing. (Fog Sealing)												Unit : 5000 Sqm.			
Spec. cl. No:	2903	Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.15	Skilled	md	1.00	1025.00	1025.00	Emulsion (@16%)	Tonne	4.00	72030.00	288120.00	Mechanical Broom	hr	6.00	1977.43	11864.58		
	Unskilled	md	5.00	750.00	3750.00						Air Compressor	hr	6.00	1458.72	8752.32		
											Bitumen Emulsion Pressure Distributer	hr	6.00	4313.08	25878.48		
Sub total of A =					4775.00	Sub total of B =					288120.00	Sub total of C =					46495.38
Sub total of A + B + C =					339390.38	Contractor's overhead expenses 15% =					50908.56	Unit Rate =					390298.94
Rate per sqm																78.06	

Description of works:		Surface Dressing for maintenance works. Providing and laying surfacing dressing as wearing course in single coat using gravel of specified size for maintenance / repair works as per Technical specification												Unit : 500 m ²			
Spec. cl. No:	2903	Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
29.11 A	Skilled	md	11.00	1025.00	11275.00						Tools and Plants	0.50%		382.63	382.63		
	Unskilled	md	87.00	750.00	65250.00	Crushed Stone Aggregate Nominal Size 19 mm	Cum	7.50	1945.91	14594.32	Bitumen Boiler	hr	1.00	925.91	925.91		
						Bitumen	Tonne	0.60	72030.00	43218.00							
						Bitumen or Emulsion (for prime and Tack Coat)	Tonne	0.36	72030.00	25930.80	Vibretor Roller	Hour	6.00	2370.02	14220.12		
Sub total of A =					76525.00	Sub total of B =					83743.12	Sub total of C =					15528.66
Sub total of A + B + C =					175796.78	Contractor's overhead expenses 15% =					26369.52	Unit Rate =					202166.30
Rate per sqm																404.33	

Description of works:		Providing and laying Crusher Run Macadam on a prepared surface, spreading and mixing, watering and compacting to form a layer of base course as per Drawing and technical Specifications.												Unit : 360 Cum			
Spec. cl. No:	1204	Labour (A)					Material (B)					Equipment (C)					
Norms No.	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount	Type	Unit	Qty.	Rate	Amount		
12.07	Skilled	md	3.00	1025.00	3075.00	Aggregates (45 to 22.5 mm)	Cum	24.12	2080.91	50191.54	Motor Grader	hr	6.00	3523.64	21141.84		
	Unskilled	md	14.00	750.00	10500.00	Aggregates (22.4 to 5.6 mm)	Cum	237.60	2190.91	520560.21	Vibratory roller	hr	6.00	2370.02	14220.12		
						Aggregates (Below 5.6 mm)	Cum	213.48	1945.91	415412.86					0.00		
						Cost of water	KL	36.00	325.29	11710.44					0.00		
Sub total of A =					13575.00	Sub total of B =					997875.05	Sub total of C =					35361.96
Sub total of A + B + C =					1046812.01	Contractor's overhead expenses 15% =					157021.80	Unit Rate =					1203833.81
Unit Rate per m3																3343.98	

APPENDIX 2 :CALIBRATION DATA

Road Sections - Basic

Study Name: **Calibrated_Nepal Low Volume Roads**

Run Date: **31-07-2020**

ID	Name	Speed Flow Type	Traffic Flow Pattern	Road Class	Climate Zone	Surface Class	Pavement Type	Length (Km)	Width (m)	Shoulder width (m)	Lanes	MT AADT	NMT AADT	AAADT Year
0 R01	0_Armadi - Banau Road	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	83	0	2017
1 R01T30	1_Armadi-Banau Road 3	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	30	0	2019
2 R01T100	2_Armadi-Banau Road 1	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	100	0	2019
3 R01T200	3_Armadi-Banau Road 2	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	200	0	2019
4 R01T300	4_Armadi-Banau Road 3	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	300	0	2019
5 R01T500	5_Armadi-Banau Road 5	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	500	0	2019
6 R01T800	6_Armadi-Banau Road 8	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	800	0	2019
7 R01T1000	7_Armadi-Banau Road 1	Single Lane Road	Free-Flow	Tertiary or Local	Humid/SubTropica	Unsealed	Gravel	12.80	3.75	0.75	1	1,000	0	2019

Vehicle Fleet - Basic

Study Name: **Calibrated_Nepal Low Volume Roads**

Run Date: **31-07-2020**

Motorised Vehicle Types:

Name	Base Type	PCSE	No. of Wheels	No. of Axles	Tyre Type	Tyre Base Recap:	Tyre Retrac Cost (%)	Annua Km	Annua Work Hours	Avg Life	Private Use (%)	Pass- enger:	Work Relate Trips (%)	ESALF	Oper Weight (t)	Life Model
Nep Bus	Heavy Bus	1.60	10	3	Bias ply	1.30	15.00	77,000	1,750	12	0	40	75.00	0.80	10.00	Constant
Nep Heavy Truck	Heavy Truck	1.60	10	3	Bias ply	1.30	15.00	60,000	2,050	12	0	0	0.00	2.28	15.70	Constant
Nep Minibus	Mini Bus	1.20	4	2	Radial ply	1.30	15.00	30,000	750	8	0	10	75.00	0.01	1.50	Constant
Nep Car	Medium Car	1.00	4	2	Radial ply	1.30	15.00	20,000	550	15	100	2	75.00	0.00	1.20	Constant
Nep Pickup	Light Goods	1.00	4	2	Bias ply	1.30	15.00	30,000	1,300	8	0	0	0.00	0.01	1.50	Constant
Nep Tractors	Medium Truck	1.40	6	2	Bias ply	1.30	15.00	40,000	1,200	12	0	0	0.00	1.25	7.50	Constant
Nep Motorcycle	Motorcycle	0.50	2	2	Bias ply	1.30	15.00	10,000	400	10	100	1	75.00	0.00	0.20	Optimal

Vehicle Fleet - Economic

Study Name: **Calibrated_Nepal Low Volume Roads**

Run Date: **31-07-2020**

Currency: **To be completed**

Motorised Vehicle Types:

Name	Base Type	New Vehicle	Replac Tyre	Fuel (per litre)	Lubr. Oi (per litre)	Maint Labour (per hr)	Crew Wages (per hr)	Annua Overhea	Annua Interes (%)	Passenge Work Tim (per hr)	Passenge Non-Worl (per hr)	Cargc Holding (per hr)
Nep Bus	Heavy Bus	32,148	493	0.84	8.85	0.72	1.11	643	10.00	0.73	0.19	0.19
Nep Heavy Truck	Heavy Truck	26,512	493	0.84	8.85	0.72	1.11	265	10.00	0.73	0.19	0.19
Nep Minibus	Mini Bus	29,381	47	0.84	8.85	0.72	1.11	588	10.00	0.73	0.19	0.19
Nep Car	Medium Car	28,348	31	0.95	8.85	0.72	1.11	283	10.00	1.59	0.40	0.40
Nep Pickup	Light Goods	23,687	493	0.84	8.85	0.72	1.11	237	10.00	0.73	0.19	0.19
Nep Tractors	Medium Truck	26,519	493	0.84	8.85	0.72	1.11	265	10.00	0.73	0.19	0.19
Nep Motorcycle	Motorcycle	2,170	26	0.95	8.85	0.72	1.11	22	10.00	0.96	0.24	0.24

Study Name: **Calibrated_Nepal Low Volume Roads**
 Run Date: **31-07-2020**

Tyre Consumption

Energy Usage

Name	Base Type	Tyre Consumption				Energy Usage					
		Whee Diamete (m)	Constan Terr (dm ³)	Weai Coefficien (dm ³ /J-m)	Congestio Effects Facto	Wearabl Rubber Volume (dm ³)	Energy Used in Productio (GJ)	% Parts Made in Country	% Vehicl Made in Country	Tyre Weight (kg)	Unlader Vehick Weight (tonnes)
Nep Bus	Heavy Bus	1.05	0.0309	0.0024	0.10	8.00	1,000.00	10.00	10.00	11.20	8.000
Nep Car	Medium Car	0.60	0.0262	0.0020	0.10	1.40	100.00	10.00	10.00	3.50	1.000
Nep Heavy Truck	Heavy Truck	1.05	0.0353	0.0028	0.10	8.00	1,000.00	10.00	10.00	12.40	9.000
Nep Minibus	Mini Bus	0.70	0.0240	0.0019	0.10	1.60	300.00	10.00	10.00	4.00	1.100
Nep Motorcycle	Motorcycle	0.55	0.0064	0.0005	0.10	0.35	20.00	10.00	20.00	2.00	0.100
Nep Pickup	Light Goods	0.70	0.0240	0.0019	0.10	1.60	160.00	10.00	10.00	4.00	0.900
Nep Tractors	Medium Truck	1.05	0.0259	0.0020	0.10	6.00	600.00	10.00	10.00	12.40	4.500

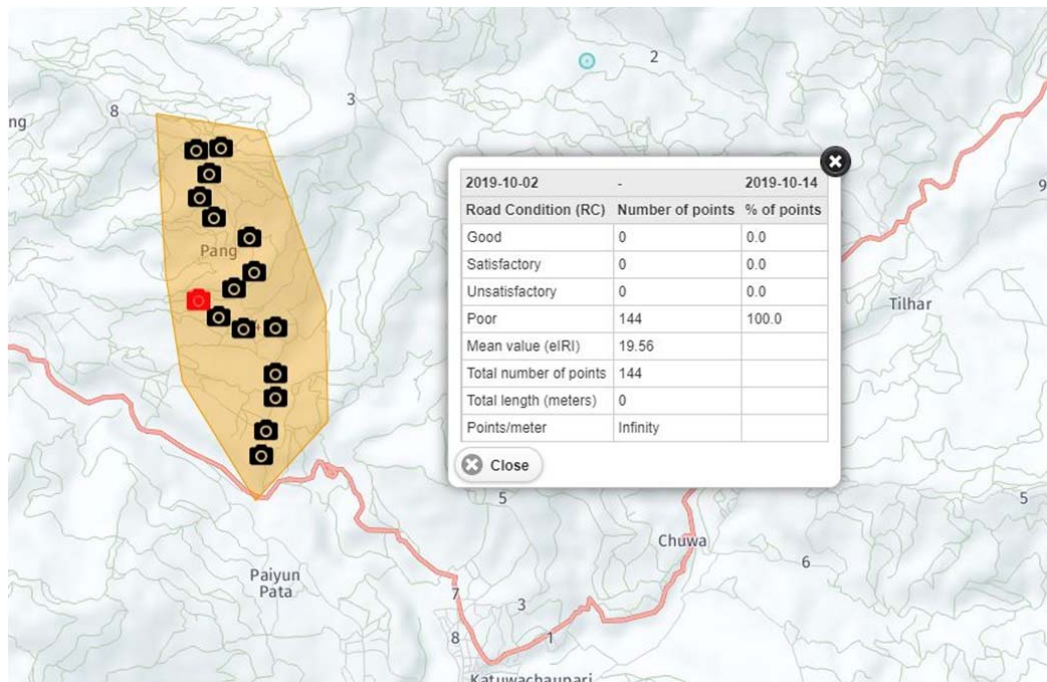
APPENDIX 3 :CALCULATION OF ROUGHNESS USING ROADROID

DateTime	Latitude	Longitude	Distance (m)	Speed (km/h)	Altitude (m)	Grade (%)	eIRI	cIRI	RoadId
10/3/2019 13:41	28.2605	83.65228	50	20.96	1141.71	0	24.8	9.55	...banau 001
10/3/2019 13:41	28.26044	83.6517	100	20.78	1143.17	2.9	19.16	8.69	...banau 001
10/3/2019 13:41	28.26068	83.65072	150	20.78	1143.17	0	19.16	8.69	...banau 001
10/3/2019 13:41	28.26068	83.65072	200	21.35	1148.5	10.67	15.99	3.37	...banau 001
10/3/2019 13:41	28.26082	83.64982	250	21.35	1148.5	0	15.99	3.37	...banau 001
10/3/2019 13:41	28.26085	83.64962	300	21.44	1159.67	22.33	15.04	5.41	...banau 001
10/3/2019 13:42	28.26084	83.64934	350	22.68	1166.38	13.42	13.35	6.87	...banau 001
10/3/2019 13:42	28.26059	83.64885	400	23.16	1165	-2.75	19.99	6.14	...banau 001
10/3/2019 13:42	28.26037	83.64845	450	20.7	1163	-4	14.6	2.66	...banau 001
10/3/2019 13:42	28.26017	83.64795	500	20.92	1163.5	1	12.04	3.09	...banau 001
10/3/2019 13:42	28.26094	83.64476	550	20.92	1163.5	0	12.04	3.09	...banau 001
10/3/2019 13:42	28.26103	83.64438	600	20.92	1163.5	0	12.04	3.09	...banau 001
10/3/2019 13:42	28.26104	83.64433	650	20.92	1163.5	0	12.04	3.09	...banau 001
10/3/2019 13:42	28.26104	83.64433	700	20.92	1163.5	0	12.04	3.09	...banau 001
10/3/2019 13:42	28.26104	83.64432	750	20.92	1163.5	0	12.04	3.09	...banau 001
10/3/2019 13:42	28.26104	83.64432	800	20.92	1163.5	0	12.04	3.09	...banau 001
10/3/2019 13:42	28.26104	83.64432	850	23.96	1177.8	28.6	12.47	4.09	...banau 001
10/3/2019 13:44	28.26111	83.64411	900	24.84	1180	4.4	17.79	10.3	...banau 001
10/3/2019 13:44	28.26419	83.644	950	24.84	1180	0	17.79	10.3	...banau 001
10/3/2019 13:44	28.26447	83.644	1000	24.84	1180	0	17.79	10.3	...banau 001
10/3/2019 13:44	28.26449	83.644	1050	24.84	1180	0	17.79	10.3	...banau 001
10/3/2019 13:44	28.2645	83.644	1100	24.84	1180	0	17.79	10.3	...banau 001
10/3/2019 13:44	28.2645	83.644	1150	24.84	1180	0	17.79	10.3	...banau 001
10/3/2019 13:44	28.2645	83.644	1200	24.84	1180	0	17.79	10.3	...banau 001

DateTime	Latitude	Longitude	Distance (m)	Speed (km/h)	Altitude (m)	Grade (%)	eIRI	cIRI	RoadId
10/3/2019 13:44	28.2645	83.644	1250	21.22	1257	154	21.41	8.64	...banau 001
10/3/2019 13:53	28.26453	83.64404	1300	20.63	1333.5	153	24.09	4.44	...banau 001
10/3/2019 13:53	28.2672	83.64704	1350	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26746	83.64733	1400	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26748	83.64736	1450	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26749	83.64736	1500	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26749	83.64736	1550	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26749	83.64736	1600	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26749	83.64736	1650	20.63	1333.5	0	24.09	4.44	...banau 001
10/3/2019 13:53	28.26749	83.64736	1700	21.28	1395	123	19.03	4.12	...banau 001
10/3/2019 14:04	28.26752	83.6474	1750	22.31	1459.2	128.4	21.81	4.7	...banau 001
10/3/2019 14:04	28.27142	83.64891	1800	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27161	83.64897	1850	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	1900	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	1950	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	2000	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	2050	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	2100	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	2150	22.31	1459.2	0	21.81	4.7	...banau 001
10/3/2019 14:04	28.27162	83.64897	2200	21	1488	57.6	18.63	9.21	...banau 001
10/3/2019 14:07	28.27164	83.64894	2250	21.06	1513.5	51	21.85	4.17	...banau 001
10/3/2019 14:07	28.27272	83.64715	2300	21.06	1513.5	0	21.85	4.17	...banau 001
10/3/2019 14:07	28.2729	83.64685	2350	21.06	1513.5	0	21.85	4.17	...banau 001
10/3/2019 14:07	28.27294	83.64679	2400	21.06	1513.5	0	21.85	4.17	...banau 001
10/3/2019 14:07	28.27295	83.64677	2450	21.06	1513.5	0	21.85	4.17	...banau 001
10/3/2019 14:07	28.27295	83.64677	2500	24.34	1547.67	68.33	28.42	7.9	...banau 001

DateTime	Latitude	Longitude	Distance (m)	Speed (km/h)	Altitude (m)	Grade (%)	eIRI	cIRI	RoadId
10/3/2019 14:11	28.27287	83.64633	2550	24.26	1558.25	21.17	32.1	16.96	...banau 001
10/3/2019 14:11	28.27254	83.64605	2600	20.98	1561.89	7.28	21.38	15.59	...banau 001
10/3/2019 14:12	28.27213	83.64581	2650	21.1	1562	0.22	15.57	10.19	...banau 001
10/3/2019 14:12	28.27216	83.64555	2700	20.63	1570	16	17.35	5.84	...banau 001
10/3/2019 14:12	28.2831	83.63926	2750	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	2800	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	2850	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	2900	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	2950	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3000	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3050	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3100	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3150	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3200	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3250	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3300	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3350	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3400	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3450	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3500	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3550	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3600	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3650	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3700	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3750	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3800	20.63	1570	0	17.35	5.84	...banau 001

DateTime	Latitude	Longitude	Distance (m)	Speed (km/h)	Altitude (m)	Grade (%)	eIRI	cIRI	RoadId
10/3/2019 14:12	28.28331	83.63915	3850	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3900	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	3950	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	4000	20.63	1570	0	17.35	5.84	...banau 001
10/3/2019 14:12	28.28331	83.63915	4050	20.11	1754.5	369	21.41	1.44	...banau 001
10/3/2019 14:28	28.28325	83.63923	4100	21.64	1933.25	357.5	27.02	8.01	...banau 001
10/3/2019 14:28	28.28356	83.63933	4150	21.64	1933.25	0	27.02	8.01	...banau 001
Average				21.48	1418.20	19.07	19.01	6.01	



Calculation of International Roughness Index using Roadroid

APPENDIX 4: GRAPHS OF AVERAGE ROUGHNESS PROGRESSION OF ROAD

Average Roughness by Section (Graph)

Study Name: **Calibrated_Nepal Low Volume Roads**

Run Date: **31-07-2020**

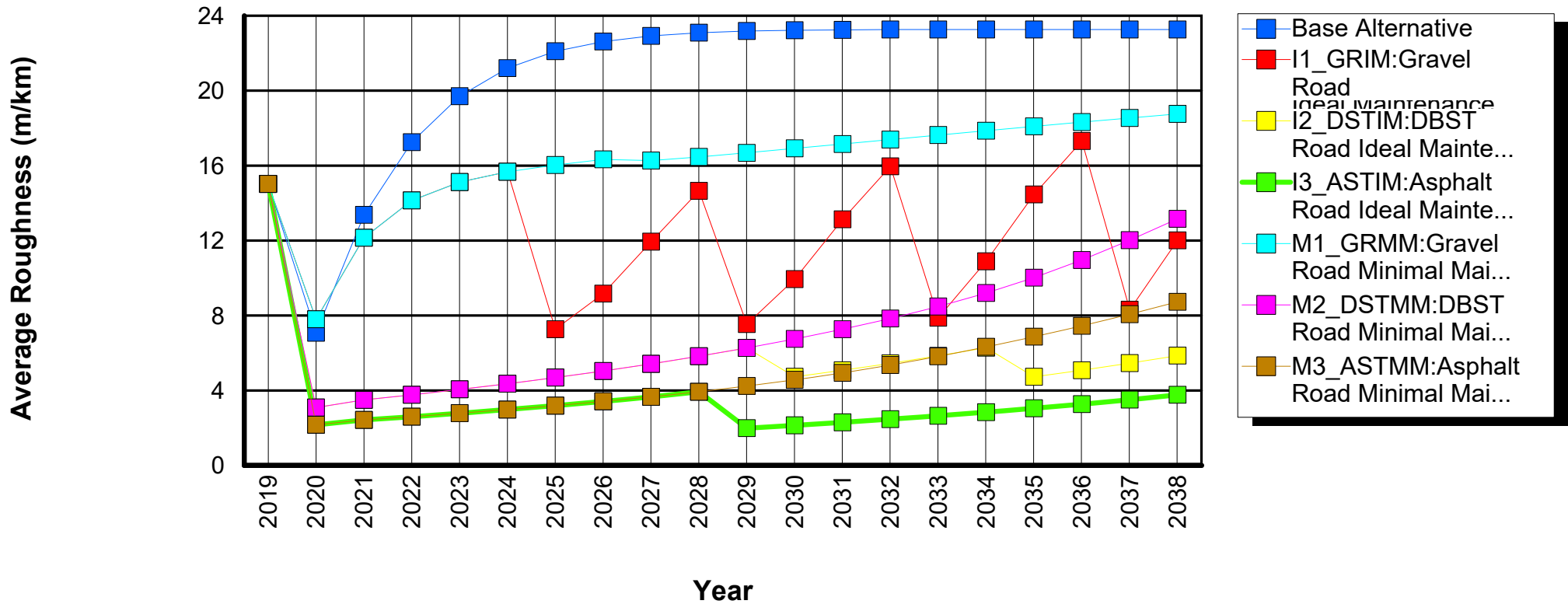
Section Details:

ID: **0_R01**
 Description: **0_Armadi - Banau Road**

Road Class: Tertiary or Local

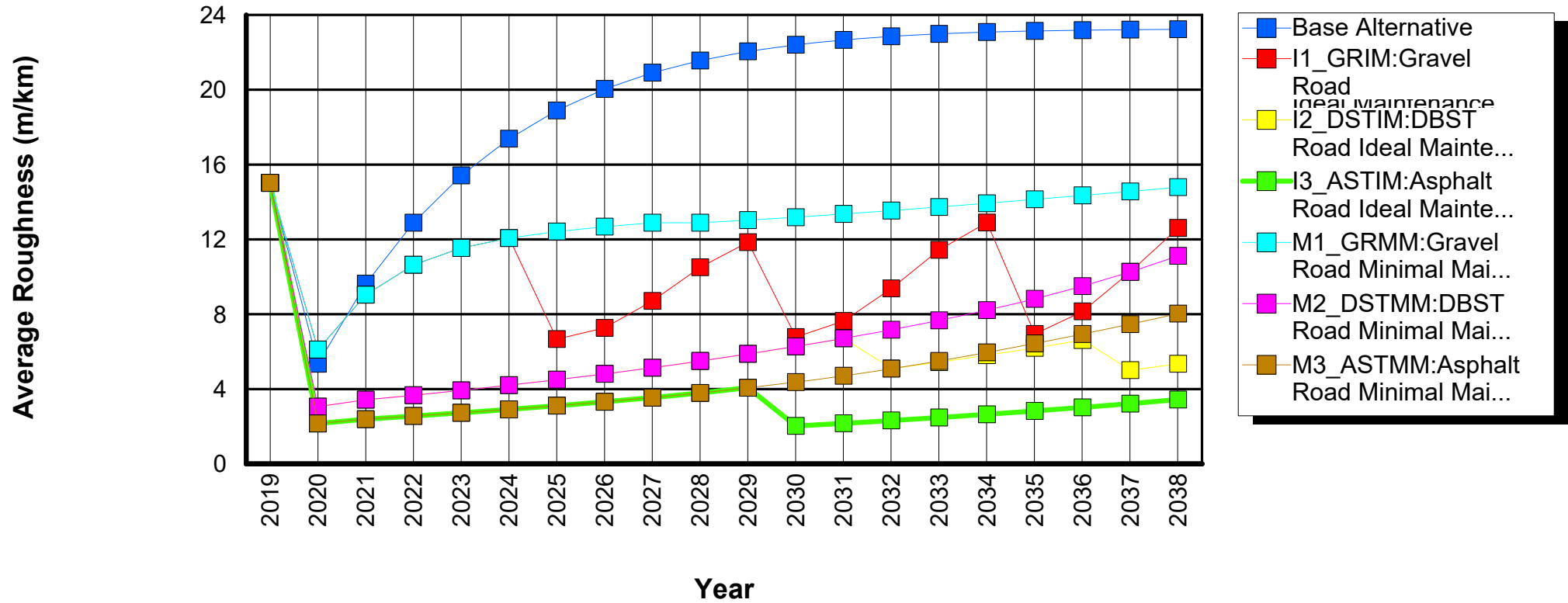
Length: 12.80km
 Width: 3.75m

Rise + Fall: 38.75m/km
 Curvature: 3.00deg/km



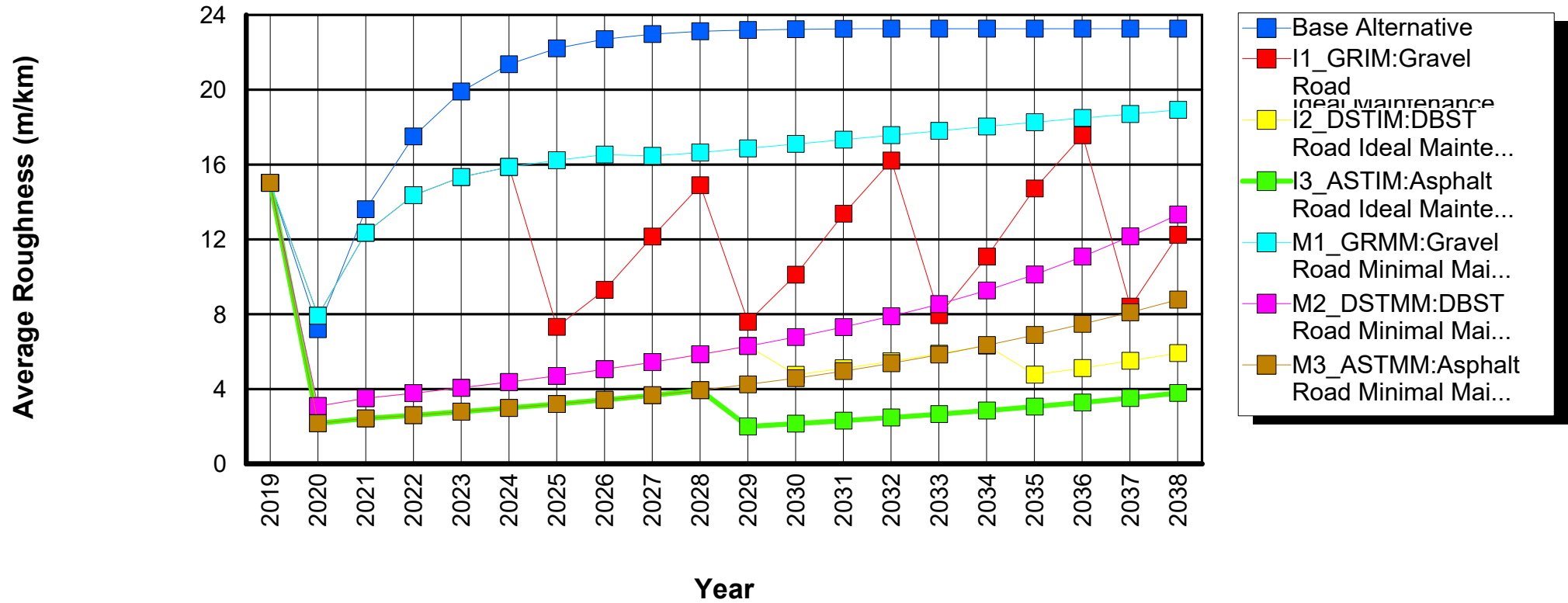
Section Details:

ID: 1_R01T30 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 1_Armadi-Banau Road 30 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



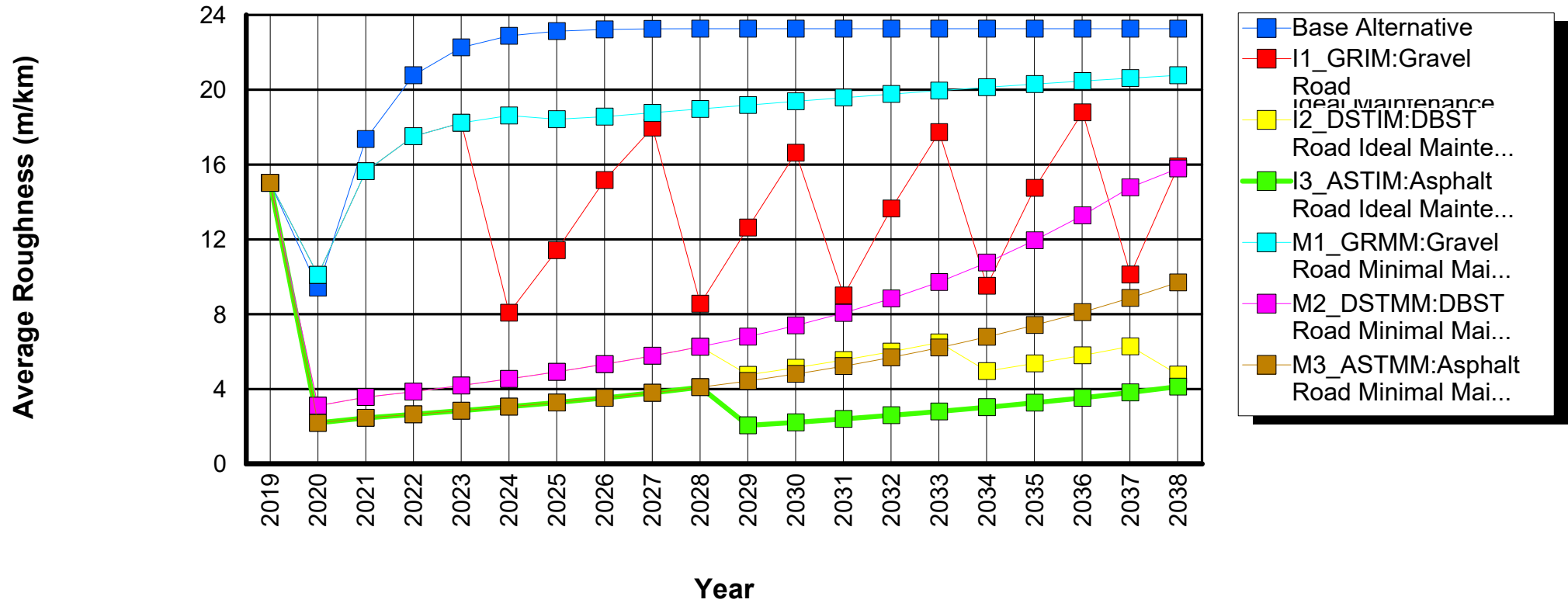
Section Details:

ID: 2_R01T100 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 2_Armadi-Banau Road 100 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



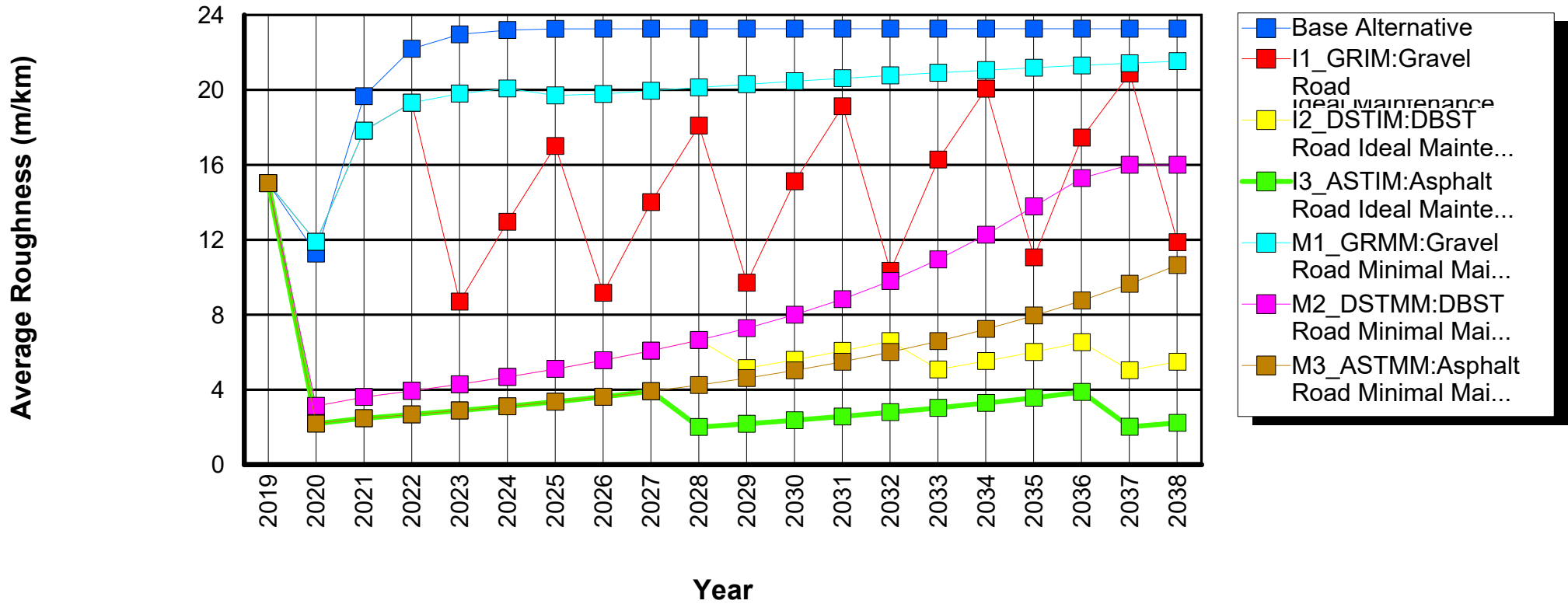
Section Details:

ID: 3_R01T200 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 3_Armadi-Banau Road 200 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



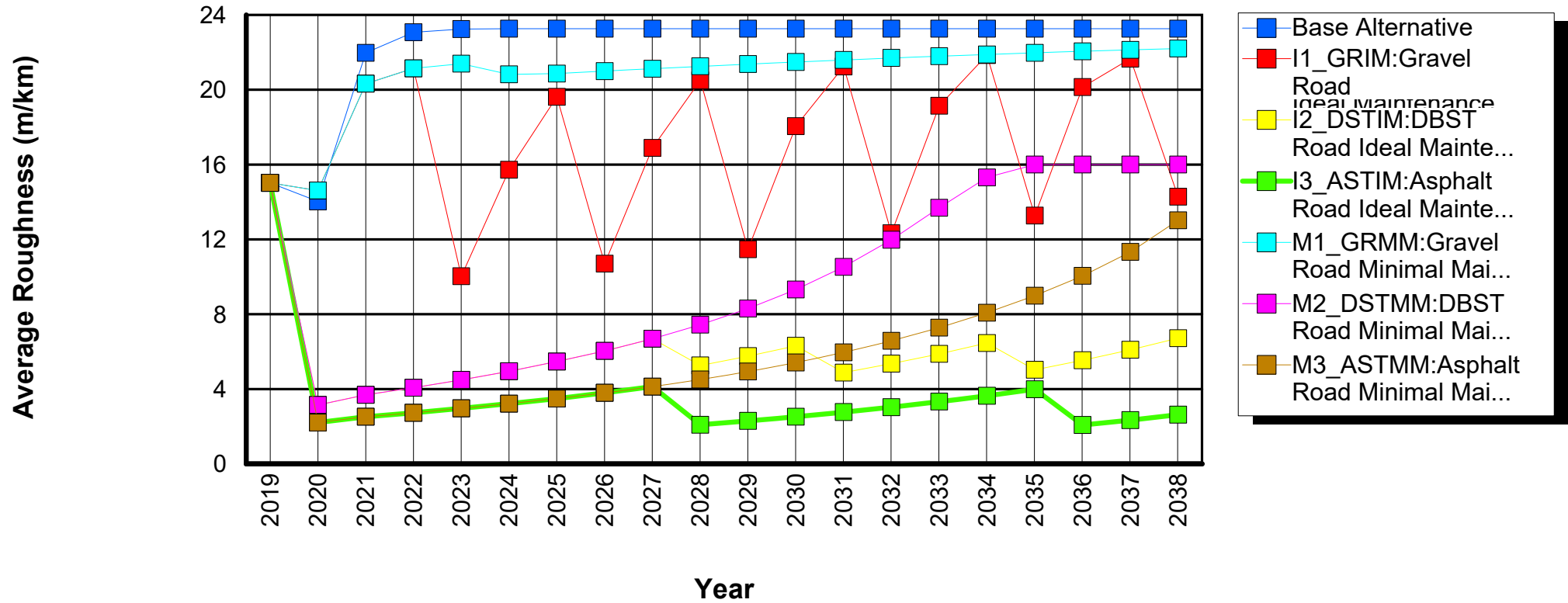
Section Details:

ID: 4_R01T300 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 4_Armadi-Banau Road 300 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



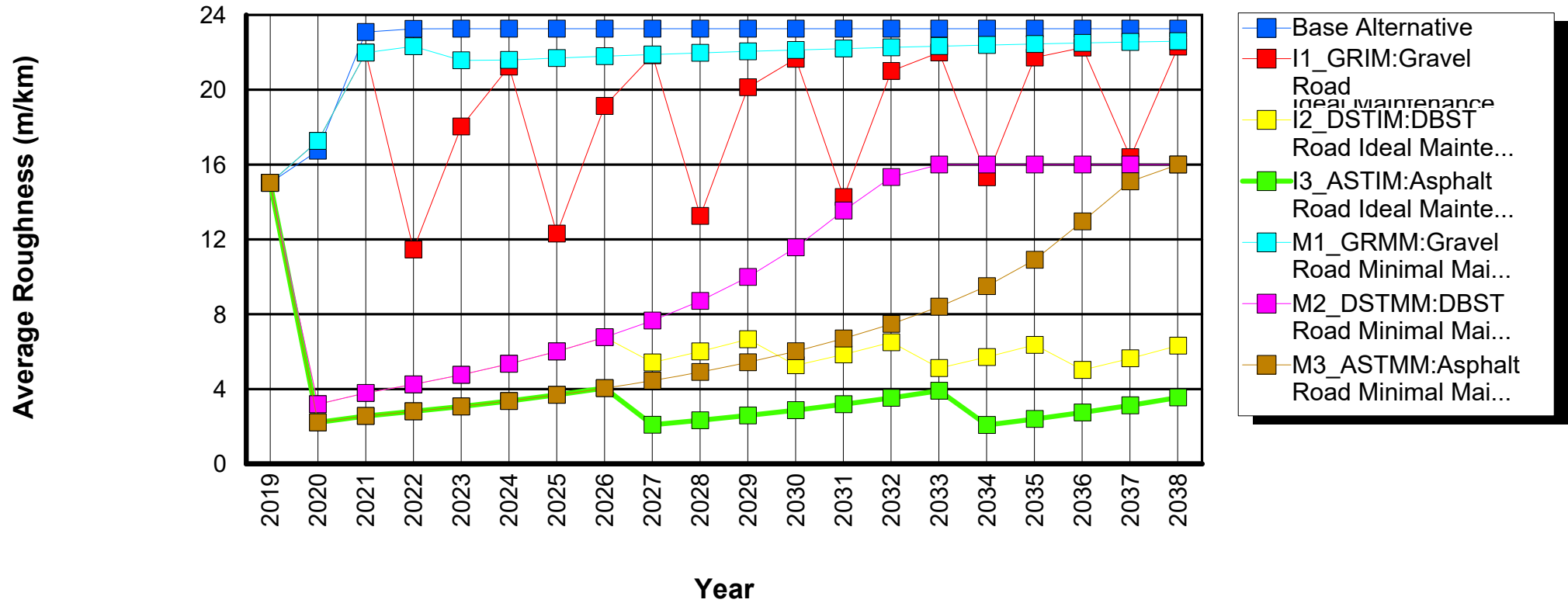
Section Details:

ID: 5_R01T500 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 5_Armadi-Banau Road 500 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



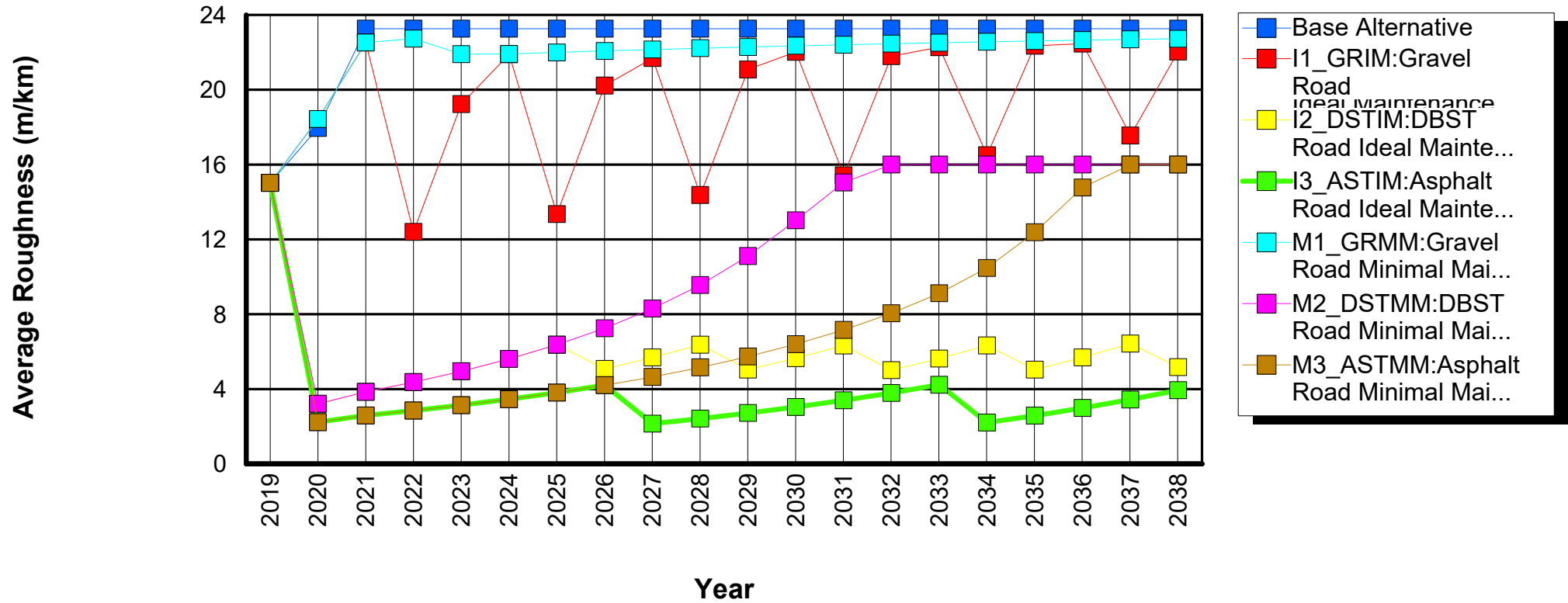
Section Details:

ID: 6_R01T800 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 6_Armadi-Banau Road 800 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



Section Details:

ID: 7_R01T1000 Road Class: Tertiary or Local Rise + Fall: 38.75m/km
 Description: 7_Armadi-Banau Road 1000 AADT Length: 12.80km Curvature: 3.00deg/km
 Width: 3.75m



APPENDIX 5: ROAD AGENCY AND USER COST STREAM

Road Agency and User Cost Streams (Discounted)

Study Name: **Calibrated_Nepal Low Volume Roads**
 Run Date: **31-07-2020**
 Currency: **US Dollar (millions)**
 Discount Rate: **10.00 %**

Section: 0_Armadi - Banau Road

Alternative: Base Alternative

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	0.242	0.032	0.000	0.000	0.273	0.000	0.276
2020	0.000	0.000	0.000	0.000	0.183	0.023	0.000	0.000	0.206	0.000	0.206
2021	0.000	0.000	0.000	0.000	0.217	0.027	0.000	0.000	0.244	0.000	0.244
2022	0.000	0.000	0.000	0.000	0.240	0.032	0.000	0.000	0.272	0.000	0.272
2023	0.000	0.000	0.000	0.000	0.256	0.035	0.000	0.000	0.291	0.000	0.291
2024	0.000	0.000	0.000	0.000	0.261	0.037	0.000	0.000	0.298	0.000	0.298
2025	0.000	0.000	0.000	0.000	0.261	0.037	0.000	0.000	0.298	0.000	0.298
2026	0.000	0.000	0.000	0.000	0.257	0.037	0.000	0.000	0.295	0.000	0.295
2027	0.000	0.000	0.000	0.000	0.253	0.037	0.000	0.000	0.289	0.000	0.289
2028	0.000	0.000	0.000	0.000	0.247	0.036	0.000	0.000	0.283	0.000	0.283
2029	0.000	0.000	0.000	0.000	0.241	0.035	0.000	0.000	0.276	0.000	0.276
2030	0.000	0.000	0.000	0.000	0.235	0.034	0.000	0.000	0.269	0.000	0.269
2031	0.000	0.000	0.000	0.000	0.228	0.033	0.000	0.000	0.262	0.000	0.262
2032	0.000	0.000	0.000	0.000	0.222	0.032	0.000	0.000	0.255	0.000	0.255
2033	0.000	0.000	0.000	0.000	0.216	0.032	0.000	0.000	0.248	0.000	0.248
2034	0.000	0.000	0.000	0.000	0.210	0.031	0.000	0.000	0.241	0.000	0.241
2035	0.000	0.000	0.000	0.000	0.205	0.030	0.000	0.000	0.235	0.000	0.235
2036	0.000	0.000	0.000	0.000	0.199	0.029	0.000	0.000	0.228	0.000	0.228

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

2037	0.000	0.000	0.000	0.000	0.194	0.028	0.000	0.000	0.222	0.000	0.222
2038	0.000	0.000	0.000	0.000	0.189	0.028	0.000	0.000	0.216	0.000	0.216
Total:	0.003	0.000	0.000	0.003	4.556	0.643	0.000	0.000	5.200	0.000	5.202

All costs are discounted at: 10.00 %

Section: 0_Armadi - Banau Road

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.242	0.032	0.000	0.000	0.273	0.000	0.678
2020	0.000	0.002	0.000	0.002	0.187	0.023	0.000	0.000	0.210	0.000	0.213
2021	0.000	0.002	0.000	0.002	0.209	0.025	0.000	0.000	0.234	0.000	0.236
2022	0.000	0.002	0.000	0.002	0.217	0.027	0.000	0.000	0.244	0.000	0.246
2023	0.000	0.002	0.000	0.002	0.217	0.028	0.000	0.000	0.245	0.000	0.247
2024	0.123	0.006	0.000	0.129	0.215	0.028	0.000	0.000	0.243	0.000	0.372
2025	0.000	0.002	0.000	0.002	0.161	0.020	0.000	0.000	0.181	0.000	0.182
2026	0.000	0.001	0.000	0.001	0.165	0.020	0.000	0.000	0.185	0.000	0.186
2027	0.000	0.001	0.000	0.001	0.174	0.021	0.000	0.000	0.195	0.000	0.196
2028	0.071	0.004	0.000	0.075	0.184	0.023	0.000	0.000	0.208	0.000	0.283
2029	0.000	0.001	0.000	0.001	0.145	0.018	0.000	0.000	0.163	0.000	0.164
2030	0.000	0.001	0.000	0.001	0.151	0.018	0.000	0.000	0.169	0.000	0.170
2031	0.000	0.001	0.000	0.001	0.162	0.020	0.000	0.000	0.182	0.000	0.183
2032	0.053	0.003	0.000	0.055	0.172	0.023	0.000	0.000	0.194	0.000	0.250
2033	0.000	0.001	0.000	0.001	0.131	0.016	0.000	0.000	0.147	0.000	0.148
2034	0.000	0.001	0.000	0.001	0.139	0.017	0.000	0.000	0.156	0.000	0.156
2035	0.000	0.001	0.000	0.001	0.151	0.019	0.000	0.000	0.170	0.000	0.171
2036	0.040	0.002	0.000	0.042	0.161	0.022	0.000	0.000	0.183	0.000	0.224
2037	0.000	0.000	0.000	0.000	0.119	0.015	0.000	0.000	0.133	0.000	0.134
2038	0.000	0.000	0.000	0.000	0.129	0.016	0.000	0.000	0.145	0.000	0.145
Total:	0.692	0.032	0.000	0.724	3.430	0.429	0.000	0.000	3.859	0.000	4.583

All costs are discounted at: 10.00 %

Section: 0_Armadi - Banau Road

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.242	0.032	0.000	0.000	0.273	0.000	1.557
2020	0.000	0.008	0.000	0.008	0.160	0.022	0.000	0.000	0.182	0.000	0.190
2021	0.000	0.007	0.000	0.007	0.157	0.021	0.000	0.000	0.179	0.000	0.186
2022	0.000	0.007	0.000	0.007	0.154	0.021	0.000	0.000	0.175	0.000	0.181
2023	0.000	0.006	0.000	0.006	0.151	0.020	0.000	0.000	0.171	0.000	0.177
2024	0.000	0.006	0.000	0.006	0.148	0.020	0.000	0.000	0.167	0.000	0.173
2025	0.000	0.005	0.000	0.005	0.145	0.019	0.000	0.000	0.164	0.000	0.169
2026	0.000	0.005	0.000	0.005	0.142	0.019	0.000	0.000	0.161	0.000	0.165
2027	0.000	0.004	0.000	0.004	0.139	0.018	0.000	0.000	0.158	0.000	0.162
2028	0.000	0.004	0.000	0.004	0.137	0.018	0.000	0.000	0.155	0.000	0.158
2029	0.145	0.003	0.000	0.148	0.135	0.017	0.000	0.000	0.152	0.000	0.300
2030	0.000	0.003	0.000	0.003	0.126	0.017	0.000	0.000	0.143	0.000	0.146
2031	0.000	0.003	0.000	0.003	0.124	0.016	0.000	0.000	0.140	0.000	0.143
2032	0.000	0.003	0.000	0.003	0.121	0.016	0.000	0.000	0.137	0.000	0.140
2033	0.000	0.002	0.000	0.002	0.119	0.016	0.000	0.000	0.135	0.000	0.137
2034	0.090	0.002	0.000	0.092	0.117	0.015	0.000	0.000	0.132	0.000	0.225
2035	0.000	0.002	0.000	0.002	0.110	0.015	0.000	0.000	0.125	0.000	0.127
2036	0.000	0.002	0.000	0.002	0.108	0.014	0.000	0.000	0.122	0.000	0.124
2037	0.000	0.002	0.000	0.002	0.106	0.014	0.000	0.000	0.120	0.000	0.121
2038	0.000	0.001	0.000	0.001	0.104	0.014	0.000	0.000	0.118	0.000	0.119
Total:	1.518	0.076	0.000	1.594	2.743	0.364	0.000	0.000	3.107	0.000	4.700

All costs are discounted at: 10.00 %

Section: 0_Armadi - Banau Road

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.242	0.032	0.000	0.000	0.273	0.000	2.070
2020	0.000	0.008	0.000	0.008	0.159	0.022	0.000	0.000	0.181	0.000	0.189
2021	0.000	0.007	0.000	0.007	0.155	0.022	0.000	0.000	0.176	0.000	0.184
2022	0.000	0.007	0.000	0.007	0.151	0.021	0.000	0.000	0.172	0.000	0.178
2023	0.000	0.006	0.000	0.006	0.147	0.020	0.000	0.000	0.167	0.000	0.173
2024	0.000	0.006	0.000	0.006	0.143	0.020	0.000	0.000	0.163	0.000	0.169
2025	0.000	0.005	0.000	0.005	0.140	0.019	0.000	0.000	0.159	0.000	0.164
2026	0.000	0.005	0.000	0.005	0.137	0.019	0.000	0.000	0.155	0.000	0.160
2027	0.000	0.004	0.000	0.004	0.134	0.018	0.000	0.000	0.152	0.000	0.156
2028	0.159	0.004	0.000	0.163	0.131	0.018	0.000	0.000	0.149	0.000	0.312
2029	0.000	0.003	0.000	0.003	0.124	0.017	0.000	0.000	0.141	0.000	0.145
2030	0.000	0.003	0.000	0.003	0.121	0.017	0.000	0.000	0.138	0.000	0.141
2031	0.000	0.003	0.000	0.003	0.117	0.016	0.000	0.000	0.134	0.000	0.137
2032	0.000	0.003	0.000	0.003	0.114	0.016	0.000	0.000	0.130	0.000	0.133
2033	0.000	0.002	0.000	0.002	0.111	0.016	0.000	0.000	0.127	0.000	0.129
2034	0.000	0.002	0.000	0.002	0.109	0.015	0.000	0.000	0.124	0.000	0.126
2035	0.000	0.002	0.000	0.002	0.106	0.015	0.000	0.000	0.121	0.000	0.123
2036	0.000	0.002	0.000	0.002	0.103	0.014	0.000	0.000	0.118	0.000	0.120
2037	0.000	0.002	0.000	0.002	0.101	0.014	0.000	0.000	0.115	0.000	0.117
2038	0.000	0.001	0.000	0.001	0.099	0.014	0.000	0.000	0.113	0.000	0.114
Total:	1.956	0.076	0.000	2.032	2.643	0.365	0.000	0.000	3.008	0.000	5.040

All costs are discounted at: 10.00 %

Section: 0_Armadi - Banau Road

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.242	0.032	0.000	0.000	0.273	0.000	0.678
2020	0.000	0.002	0.000	0.002	0.187	0.023	0.000	0.000	0.210	0.000	0.213
2021	0.000	0.002	0.000	0.002	0.209	0.025	0.000	0.000	0.234	0.000	0.236
2022	0.000	0.002	0.000	0.002	0.217	0.027	0.000	0.000	0.244	0.000	0.246
2023	0.000	0.002	0.000	0.002	0.217	0.028	0.000	0.000	0.245	0.000	0.247
2024	0.000	0.002	0.000	0.002	0.215	0.028	0.000	0.000	0.243	0.000	0.245
2025	0.000	0.002	0.000	0.002	0.212	0.028	0.000	0.000	0.239	0.000	0.241
2026	0.000	0.001	0.000	0.001	0.208	0.027	0.000	0.000	0.235	0.000	0.237
2027	0.000	0.001	0.000	0.001	0.202	0.026	0.000	0.000	0.228	0.000	0.230
2028	0.000	0.001	0.000	0.001	0.198	0.026	0.000	0.000	0.224	0.000	0.225
2029	0.000	0.001	0.000	0.001	0.194	0.026	0.000	0.000	0.219	0.000	0.220
2030	0.000	0.001	0.000	0.001	0.190	0.025	0.000	0.000	0.215	0.000	0.216
2031	0.000	0.001	0.000	0.001	0.187	0.025	0.000	0.000	0.212	0.000	0.213
2032	0.000	0.001	0.000	0.001	0.183	0.025	0.000	0.000	0.208	0.000	0.209
2033	0.000	0.001	0.000	0.001	0.180	0.024	0.000	0.000	0.204	0.000	0.205
2034	0.000	0.001	0.000	0.001	0.177	0.024	0.000	0.000	0.201	0.000	0.201
2035	0.000	0.001	0.000	0.001	0.174	0.023	0.000	0.000	0.197	0.000	0.198
2036	0.000	0.001	0.000	0.001	0.170	0.023	0.000	0.000	0.193	0.000	0.194
2037	0.000	0.000	0.000	0.000	0.167	0.023	0.000	0.000	0.190	0.000	0.190
2038	0.000	0.000	0.000	0.000	0.164	0.022	0.000	0.000	0.186	0.000	0.187
Total:	0.405	0.022	0.000	0.427	3.892	0.509	0.000	0.000	4.401	0.000	4.828

All costs are discounted at: 10.00 %

Section: 0_Armadi - Banau Road

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.242	0.032	0.000	0.000	0.273	0.000	1.557
2020	0.000	0.006	0.000	0.006	0.160	0.022	0.000	0.000	0.182	0.000	0.188
2021	0.000	0.005	0.000	0.005	0.157	0.021	0.000	0.000	0.179	0.000	0.184
2022	0.000	0.005	0.000	0.005	0.154	0.021	0.000	0.000	0.175	0.000	0.180
2023	0.000	0.005	0.000	0.005	0.151	0.020	0.000	0.000	0.171	0.000	0.175
2024	0.000	0.004	0.000	0.004	0.148	0.020	0.000	0.000	0.167	0.000	0.171
2025	0.000	0.004	0.000	0.004	0.145	0.019	0.000	0.000	0.164	0.000	0.168
2026	0.000	0.003	0.000	0.003	0.142	0.019	0.000	0.000	0.161	0.000	0.164
2027	0.000	0.003	0.000	0.003	0.139	0.018	0.000	0.000	0.158	0.000	0.161
2028	0.000	0.003	0.000	0.003	0.137	0.018	0.000	0.000	0.155	0.000	0.157
2029	0.000	0.003	0.000	0.003	0.135	0.017	0.000	0.000	0.152	0.000	0.154
2030	0.000	0.002	0.000	0.002	0.132	0.017	0.000	0.000	0.149	0.000	0.152
2031	0.000	0.002	0.000	0.002	0.130	0.016	0.000	0.000	0.147	0.000	0.149
2032	0.000	0.002	0.000	0.002	0.129	0.016	0.000	0.000	0.145	0.000	0.147
2033	0.000	0.002	0.000	0.002	0.127	0.016	0.000	0.000	0.143	0.000	0.144
2034	0.000	0.002	0.000	0.002	0.126	0.016	0.000	0.000	0.141	0.000	0.143
2035	0.000	0.001	0.000	0.001	0.125	0.015	0.000	0.000	0.140	0.000	0.141
2036	0.000	0.001	0.000	0.001	0.124	0.015	0.000	0.000	0.140	0.000	0.141
2037	0.000	0.001	0.000	0.001	0.125	0.016	0.000	0.000	0.140	0.000	0.142
2038	0.000	0.001	0.000	0.001	0.126	0.016	0.000	0.000	0.142	0.000	0.143
Total:	1.283	0.056	0.000	1.339	2.851	0.371	0.000	0.000	3.222	0.000	4.561

All costs are discounted at: 10.00 %

Section: 0_Armadi - Banau Road

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 0_R01

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.242	0.032	0.000	0.000	0.273	0.000	2.070
2020	0.000	0.008	0.000	0.008	0.159	0.022	0.000	0.000	0.181	0.000	0.189
2021	0.000	0.007	0.000	0.007	0.155	0.022	0.000	0.000	0.176	0.000	0.184
2022	0.000	0.007	0.000	0.007	0.151	0.021	0.000	0.000	0.172	0.000	0.178
2023	0.000	0.006	0.000	0.006	0.147	0.020	0.000	0.000	0.167	0.000	0.173
2024	0.000	0.006	0.000	0.006	0.143	0.020	0.000	0.000	0.163	0.000	0.169
2025	0.000	0.005	0.000	0.005	0.140	0.019	0.000	0.000	0.159	0.000	0.164
2026	0.000	0.005	0.000	0.005	0.137	0.019	0.000	0.000	0.155	0.000	0.160
2027	0.000	0.004	0.000	0.004	0.134	0.018	0.000	0.000	0.152	0.000	0.156
2028	0.000	0.004	0.000	0.004	0.131	0.018	0.000	0.000	0.149	0.000	0.153
2029	0.000	0.003	0.000	0.003	0.128	0.017	0.000	0.000	0.146	0.000	0.149
2030	0.000	0.003	0.000	0.003	0.126	0.017	0.000	0.000	0.143	0.000	0.146
2031	0.000	0.003	0.000	0.003	0.123	0.017	0.000	0.000	0.140	0.000	0.143
2032	0.000	0.003	0.000	0.003	0.121	0.016	0.000	0.000	0.137	0.000	0.140
2033	0.000	0.002	0.000	0.002	0.119	0.016	0.000	0.000	0.135	0.000	0.137
2034	0.000	0.002	0.000	0.002	0.118	0.015	0.000	0.000	0.133	0.000	0.135
2035	0.000	0.002	0.000	0.002	0.116	0.015	0.000	0.000	0.131	0.000	0.133
2036	0.000	0.002	0.000	0.002	0.114	0.015	0.000	0.000	0.129	0.000	0.131
2037	0.000	0.002	0.000	0.002	0.113	0.014	0.000	0.000	0.127	0.000	0.129
2038	0.000	0.001	0.000	0.001	0.112	0.014	0.000	0.000	0.126	0.000	0.127
Total:	1.797	0.075	0.000	1.873	2.727	0.367	0.000	0.000	3.093	0.000	4.966

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: Base Alternative

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	0.076	0.010	0.000	0.000	0.086	0.000	0.089
2020	0.000	0.000	0.000	0.000	0.055	0.007	0.000	0.000	0.062	0.000	0.062
2021	0.000	0.000	0.000	0.000	0.061	0.007	0.000	0.000	0.068	0.000	0.068
2022	0.000	0.000	0.000	0.000	0.066	0.008	0.000	0.000	0.074	0.000	0.074
2023	0.000	0.000	0.000	0.000	0.069	0.009	0.000	0.000	0.078	0.000	0.078
2024	0.000	0.000	0.000	0.000	0.072	0.010	0.000	0.000	0.082	0.000	0.082
2025	0.000	0.000	0.000	0.000	0.074	0.010	0.000	0.000	0.084	0.000	0.084
2026	0.000	0.000	0.000	0.000	0.075	0.010	0.000	0.000	0.086	0.000	0.086
2027	0.000	0.000	0.000	0.000	0.075	0.011	0.000	0.000	0.086	0.000	0.086
2028	0.000	0.000	0.000	0.000	0.074	0.011	0.000	0.000	0.085	0.000	0.085
2029	0.000	0.000	0.000	0.000	0.073	0.010	0.000	0.000	0.084	0.000	0.084
2030	0.000	0.000	0.000	0.000	0.072	0.010	0.000	0.000	0.083	0.000	0.083
2031	0.000	0.000	0.000	0.000	0.071	0.010	0.000	0.000	0.081	0.000	0.081
2032	0.000	0.000	0.000	0.000	0.069	0.010	0.000	0.000	0.079	0.000	0.079
2033	0.000	0.000	0.000	0.000	0.068	0.010	0.000	0.000	0.077	0.000	0.077
2034	0.000	0.000	0.000	0.000	0.066	0.010	0.000	0.000	0.075	0.000	0.075
2035	0.000	0.000	0.000	0.000	0.064	0.009	0.000	0.000	0.074	0.000	0.074
2036	0.000	0.000	0.000	0.000	0.063	0.009	0.000	0.000	0.072	0.000	0.072
2037	0.000	0.000	0.000	0.000	0.061	0.009	0.000	0.000	0.070	0.000	0.070
2038	0.000	0.000	0.000	0.000	0.059	0.009	0.000	0.000	0.068	0.000	0.068
Total:	0.003	0.000	0.000	0.003	1.364	0.188	0.000	0.000	1.553	0.000	1.555

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.076	0.010	0.000	0.000	0.086	0.000	0.491
2020	0.000	0.002	0.000	0.002	0.056	0.007	0.000	0.000	0.063	0.000	0.066
2021	0.000	0.002	0.000	0.002	0.060	0.007	0.000	0.000	0.067	0.000	0.069
2022	0.000	0.002	0.000	0.002	0.061	0.007	0.000	0.000	0.068	0.000	0.070
2023	0.000	0.002	0.000	0.002	0.061	0.007	0.000	0.000	0.068	0.000	0.070
2024	0.105	0.002	0.000	0.106	0.060	0.007	0.000	0.000	0.068	0.000	0.174
2025	0.000	0.002	0.000	0.002	0.050	0.006	0.000	0.000	0.056	0.000	0.058
2026	0.000	0.001	0.000	0.001	0.049	0.006	0.000	0.000	0.055	0.000	0.057
2027	0.000	0.001	0.000	0.001	0.050	0.006	0.000	0.000	0.056	0.000	0.057
2028	0.000	0.001	0.000	0.001	0.051	0.006	0.000	0.000	0.057	0.000	0.058
2029	0.067	0.001	0.000	0.068	0.052	0.006	0.000	0.000	0.058	0.000	0.126
2030	0.000	0.001	0.000	0.001	0.044	0.005	0.000	0.000	0.049	0.000	0.050
2031	0.000	0.001	0.000	0.001	0.043	0.005	0.000	0.000	0.049	0.000	0.050
2032	0.000	0.001	0.000	0.001	0.044	0.005	0.000	0.000	0.050	0.000	0.050
2033	0.000	0.001	0.000	0.001	0.046	0.005	0.000	0.000	0.051	0.000	0.052
2034	0.043	0.001	0.000	0.044	0.047	0.006	0.000	0.000	0.052	0.000	0.096
2035	0.000	0.001	0.000	0.001	0.038	0.005	0.000	0.000	0.043	0.000	0.043
2036	0.000	0.001	0.000	0.001	0.038	0.005	0.000	0.000	0.043	0.000	0.044
2037	0.000	0.000	0.000	0.000	0.040	0.005	0.000	0.000	0.044	0.000	0.045
2038	0.000	0.000	0.000	0.000	0.041	0.005	0.000	0.000	0.046	0.000	0.047
Total:	0.619	0.022	0.000	0.641	1.008	0.123	0.000	0.000	1.131	0.000	1.772

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.076	0.010	0.000	0.000	0.086	0.000	1.370
2020	0.000	0.008	0.000	0.008	0.051	0.007	0.000	0.000	0.057	0.000	0.066
2021	0.000	0.007	0.000	0.007	0.050	0.007	0.000	0.000	0.056	0.000	0.064
2022	0.000	0.007	0.000	0.007	0.048	0.007	0.000	0.000	0.055	0.000	0.062
2023	0.000	0.006	0.000	0.006	0.047	0.006	0.000	0.000	0.054	0.000	0.060
2024	0.000	0.006	0.000	0.006	0.046	0.006	0.000	0.000	0.053	0.000	0.058
2025	0.000	0.005	0.000	0.005	0.045	0.006	0.000	0.000	0.051	0.000	0.057
2026	0.000	0.005	0.000	0.005	0.045	0.006	0.000	0.000	0.050	0.000	0.055
2027	0.000	0.004	0.000	0.004	0.044	0.006	0.000	0.000	0.049	0.000	0.054
2028	0.000	0.004	0.000	0.004	0.043	0.006	0.000	0.000	0.048	0.000	0.052
2029	0.000	0.003	0.000	0.003	0.042	0.005	0.000	0.000	0.047	0.000	0.051
2030	0.000	0.003	0.000	0.003	0.041	0.005	0.000	0.000	0.047	0.000	0.050
2031	0.120	0.003	0.000	0.123	0.041	0.005	0.000	0.000	0.046	0.000	0.168
2032	0.000	0.003	0.000	0.003	0.038	0.005	0.000	0.000	0.043	0.000	0.046
2033	0.000	0.002	0.000	0.002	0.037	0.005	0.000	0.000	0.042	0.000	0.044
2034	0.000	0.002	0.000	0.002	0.037	0.005	0.000	0.000	0.041	0.000	0.043
2035	0.000	0.002	0.000	0.002	0.036	0.005	0.000	0.000	0.041	0.000	0.042
2036	0.074	0.002	0.000	0.076	0.035	0.004	0.000	0.000	0.040	0.000	0.116
2037	0.000	0.002	0.000	0.002	0.033	0.004	0.000	0.000	0.037	0.000	0.039
2038	0.000	0.001	0.000	0.001	0.032	0.004	0.000	0.000	0.037	0.000	0.038
Total:	1.477	0.076	0.000	1.553	0.867	0.114	0.000	0.000	0.982	0.000	2.534

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.076	0.010	0.000	0.000	0.086	0.000	1.883
2020	0.000	0.008	0.000	0.008	0.050	0.007	0.000	0.000	0.057	0.000	0.065
2021	0.000	0.007	0.000	0.007	0.049	0.007	0.000	0.000	0.056	0.000	0.063
2022	0.000	0.007	0.000	0.007	0.048	0.007	0.000	0.000	0.054	0.000	0.061
2023	0.000	0.006	0.000	0.006	0.046	0.006	0.000	0.000	0.053	0.000	0.059
2024	0.000	0.006	0.000	0.006	0.045	0.006	0.000	0.000	0.051	0.000	0.057
2025	0.000	0.005	0.000	0.005	0.044	0.006	0.000	0.000	0.050	0.000	0.055
2026	0.000	0.005	0.000	0.005	0.043	0.006	0.000	0.000	0.049	0.000	0.053
2027	0.000	0.004	0.000	0.004	0.042	0.006	0.000	0.000	0.048	0.000	0.052
2028	0.000	0.004	0.000	0.004	0.041	0.006	0.000	0.000	0.047	0.000	0.051
2029	0.145	0.003	0.000	0.148	0.040	0.005	0.000	0.000	0.046	0.000	0.194
2030	0.000	0.003	0.000	0.003	0.038	0.005	0.000	0.000	0.043	0.000	0.046
2031	0.000	0.003	0.000	0.003	0.037	0.005	0.000	0.000	0.042	0.000	0.045
2032	0.000	0.003	0.000	0.003	0.036	0.005	0.000	0.000	0.041	0.000	0.044
2033	0.000	0.002	0.000	0.002	0.035	0.005	0.000	0.000	0.040	0.000	0.042
2034	0.000	0.002	0.000	0.002	0.034	0.005	0.000	0.000	0.039	0.000	0.041
2035	0.000	0.002	0.000	0.002	0.033	0.005	0.000	0.000	0.038	0.000	0.040
2036	0.000	0.002	0.000	0.002	0.032	0.004	0.000	0.000	0.037	0.000	0.039
2037	0.000	0.002	0.000	0.002	0.032	0.004	0.000	0.000	0.036	0.000	0.038
2038	0.000	0.001	0.000	0.001	0.031	0.004	0.000	0.000	0.035	0.000	0.037
Total:	1.942	0.076	0.000	2.017	0.833	0.114	0.000	0.000	0.947	0.000	2.965

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.076	0.010	0.000	0.000	0.086	0.000	0.491
2020	0.000	0.002	0.000	0.002	0.056	0.007	0.000	0.000	0.063	0.000	0.066
2021	0.000	0.002	0.000	0.002	0.060	0.007	0.000	0.000	0.067	0.000	0.069
2022	0.000	0.002	0.000	0.002	0.061	0.007	0.000	0.000	0.068	0.000	0.070
2023	0.000	0.002	0.000	0.002	0.061	0.007	0.000	0.000	0.068	0.000	0.070
2024	0.000	0.002	0.000	0.002	0.060	0.007	0.000	0.000	0.068	0.000	0.069
2025	0.000	0.002	0.000	0.002	0.059	0.007	0.000	0.000	0.067	0.000	0.068
2026	0.000	0.001	0.000	0.001	0.058	0.007	0.000	0.000	0.065	0.000	0.067
2027	0.000	0.001	0.000	0.001	0.057	0.007	0.000	0.000	0.064	0.000	0.065
2028	0.000	0.001	0.000	0.001	0.056	0.007	0.000	0.000	0.062	0.000	0.063
2029	0.000	0.001	0.000	0.001	0.054	0.007	0.000	0.000	0.061	0.000	0.062
2030	0.000	0.001	0.000	0.001	0.053	0.006	0.000	0.000	0.060	0.000	0.061
2031	0.000	0.001	0.000	0.001	0.052	0.006	0.000	0.000	0.058	0.000	0.059
2032	0.000	0.001	0.000	0.001	0.051	0.006	0.000	0.000	0.057	0.000	0.058
2033	0.000	0.001	0.000	0.001	0.050	0.006	0.000	0.000	0.056	0.000	0.057
2034	0.000	0.001	0.000	0.001	0.049	0.006	0.000	0.000	0.055	0.000	0.055
2035	0.000	0.001	0.000	0.001	0.048	0.006	0.000	0.000	0.054	0.000	0.054
2036	0.000	0.001	0.000	0.001	0.047	0.006	0.000	0.000	0.053	0.000	0.053
2037	0.000	0.000	0.000	0.000	0.046	0.006	0.000	0.000	0.052	0.000	0.052
2038	0.000	0.000	0.000	0.000	0.045	0.006	0.000	0.000	0.051	0.000	0.051
Total:	0.405	0.022	0.000	0.427	1.099	0.135	0.000	0.000	1.234	0.000	1.661

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.076	0.010	0.000	0.000	0.086	0.000	1.370
2020	0.000	0.006	0.000	0.006	0.051	0.007	0.000	0.000	0.057	0.000	0.064
2021	0.000	0.005	0.000	0.005	0.050	0.007	0.000	0.000	0.056	0.000	0.062
2022	0.000	0.005	0.000	0.005	0.048	0.007	0.000	0.000	0.055	0.000	0.060
2023	0.000	0.005	0.000	0.005	0.047	0.006	0.000	0.000	0.054	0.000	0.058
2024	0.000	0.004	0.000	0.004	0.046	0.006	0.000	0.000	0.053	0.000	0.057
2025	0.000	0.004	0.000	0.004	0.045	0.006	0.000	0.000	0.051	0.000	0.055
2026	0.000	0.003	0.000	0.003	0.045	0.006	0.000	0.000	0.050	0.000	0.054
2027	0.000	0.003	0.000	0.003	0.044	0.006	0.000	0.000	0.049	0.000	0.052
2028	0.000	0.003	0.000	0.003	0.043	0.006	0.000	0.000	0.048	0.000	0.051
2029	0.000	0.003	0.000	0.003	0.042	0.005	0.000	0.000	0.047	0.000	0.050
2030	0.000	0.002	0.000	0.002	0.041	0.005	0.000	0.000	0.047	0.000	0.049
2031	0.000	0.002	0.000	0.002	0.041	0.005	0.000	0.000	0.046	0.000	0.048
2032	0.000	0.002	0.000	0.002	0.040	0.005	0.000	0.000	0.045	0.000	0.047
2033	0.000	0.002	0.000	0.002	0.039	0.005	0.000	0.000	0.044	0.000	0.046
2034	0.000	0.002	0.000	0.002	0.039	0.005	0.000	0.000	0.044	0.000	0.045
2035	0.000	0.001	0.000	0.001	0.038	0.005	0.000	0.000	0.043	0.000	0.044
2036	0.000	0.001	0.000	0.001	0.038	0.005	0.000	0.000	0.042	0.000	0.044
2037	0.000	0.001	0.000	0.001	0.037	0.005	0.000	0.000	0.042	0.000	0.043
2038	0.000	0.001	0.000	0.001	0.037	0.005	0.000	0.000	0.042	0.000	0.043
Total:	1.283	0.056	0.000	1.339	0.888	0.115	0.000	0.000	1.003	0.000	2.342

All costs are discounted at: 10.00 %

Section: 1_Armadi-Banau Road 30 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 1_R01T30

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.076	0.010	0.000	0.000	0.086	0.000	1.883
2020	0.000	0.008	0.000	0.008	0.050	0.007	0.000	0.000	0.057	0.000	0.065
2021	0.000	0.007	0.000	0.007	0.049	0.007	0.000	0.000	0.056	0.000	0.063
2022	0.000	0.007	0.000	0.007	0.048	0.007	0.000	0.000	0.054	0.000	0.061
2023	0.000	0.006	0.000	0.006	0.046	0.006	0.000	0.000	0.053	0.000	0.059
2024	0.000	0.006	0.000	0.006	0.045	0.006	0.000	0.000	0.051	0.000	0.057
2025	0.000	0.005	0.000	0.005	0.044	0.006	0.000	0.000	0.050	0.000	0.055
2026	0.000	0.005	0.000	0.005	0.043	0.006	0.000	0.000	0.049	0.000	0.053
2027	0.000	0.004	0.000	0.004	0.042	0.006	0.000	0.000	0.048	0.000	0.052
2028	0.000	0.004	0.000	0.004	0.041	0.006	0.000	0.000	0.047	0.000	0.051
2029	0.000	0.003	0.000	0.003	0.040	0.005	0.000	0.000	0.046	0.000	0.049
2030	0.000	0.003	0.000	0.003	0.039	0.005	0.000	0.000	0.045	0.000	0.048
2031	0.000	0.003	0.000	0.003	0.039	0.005	0.000	0.000	0.044	0.000	0.047
2032	0.000	0.003	0.000	0.003	0.038	0.005	0.000	0.000	0.043	0.000	0.046
2033	0.000	0.002	0.000	0.002	0.037	0.005	0.000	0.000	0.042	0.000	0.045
2034	0.000	0.002	0.000	0.002	0.037	0.005	0.000	0.000	0.041	0.000	0.044
2035	0.000	0.002	0.000	0.002	0.036	0.005	0.000	0.000	0.041	0.000	0.043
2036	0.000	0.002	0.000	0.002	0.036	0.005	0.000	0.000	0.040	0.000	0.042
2037	0.000	0.002	0.000	0.002	0.035	0.004	0.000	0.000	0.039	0.000	0.041
2038	0.000	0.001	0.000	0.001	0.035	0.004	0.000	0.000	0.039	0.000	0.040
Total:	1.797	0.075	0.000	1.873	0.856	0.114	0.000	0.000	0.970	0.000	2.843

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: Base Alternative

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	0.254	0.033	0.000	0.000	0.288	0.000	0.290
2020	0.000	0.000	0.000	0.000	0.194	0.024	0.000	0.000	0.218	0.000	0.218
2021	0.000	0.000	0.000	0.000	0.230	0.028	0.000	0.000	0.259	0.000	0.259
2022	0.000	0.000	0.000	0.000	0.255	0.034	0.000	0.000	0.289	0.000	0.289
2023	0.000	0.000	0.000	0.000	0.271	0.037	0.000	0.000	0.309	0.000	0.309
2024	0.000	0.000	0.000	0.000	0.276	0.039	0.000	0.000	0.315	0.000	0.315
2025	0.000	0.000	0.000	0.000	0.275	0.039	0.000	0.000	0.315	0.000	0.315
2026	0.000	0.000	0.000	0.000	0.272	0.039	0.000	0.000	0.311	0.000	0.311
2027	0.000	0.000	0.000	0.000	0.266	0.039	0.000	0.000	0.305	0.000	0.305
2028	0.000	0.000	0.000	0.000	0.260	0.038	0.000	0.000	0.298	0.000	0.298
2029	0.000	0.000	0.000	0.000	0.254	0.037	0.000	0.000	0.290	0.000	0.290
2030	0.000	0.000	0.000	0.000	0.247	0.036	0.000	0.000	0.283	0.000	0.283
2031	0.000	0.000	0.000	0.000	0.240	0.035	0.000	0.000	0.275	0.000	0.275
2032	0.000	0.000	0.000	0.000	0.234	0.034	0.000	0.000	0.268	0.000	0.268
2033	0.000	0.000	0.000	0.000	0.228	0.033	0.000	0.000	0.261	0.000	0.261
2034	0.000	0.000	0.000	0.000	0.221	0.032	0.000	0.000	0.254	0.000	0.254
2035	0.000	0.000	0.000	0.000	0.215	0.031	0.000	0.000	0.247	0.000	0.247
2036	0.000	0.000	0.000	0.000	0.210	0.031	0.000	0.000	0.240	0.000	0.240
2037	0.000	0.000	0.000	0.000	0.204	0.030	0.000	0.000	0.234	0.000	0.234
2038	0.000	0.000	0.000	0.000	0.198	0.029	0.000	0.000	0.228	0.000	0.228
Total:	0.003	0.000	0.000	0.003	4.806	0.679	0.000	0.000	5.485	0.000	5.488

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.254	0.033	0.000	0.000	0.288	0.000	0.692
2020	0.000	0.002	0.000	0.002	0.198	0.024	0.000	0.000	0.222	0.000	0.224
2021	0.000	0.002	0.000	0.002	0.221	0.027	0.000	0.000	0.248	0.000	0.250
2022	0.000	0.002	0.000	0.002	0.230	0.029	0.000	0.000	0.258	0.000	0.260
2023	0.000	0.002	0.000	0.002	0.230	0.030	0.000	0.000	0.260	0.000	0.262
2024	0.125	0.006	0.000	0.130	0.228	0.030	0.000	0.000	0.257	0.000	0.388
2025	0.000	0.002	0.000	0.002	0.170	0.021	0.000	0.000	0.191	0.000	0.192
2026	0.000	0.001	0.000	0.001	0.174	0.021	0.000	0.000	0.195	0.000	0.196
2027	0.000	0.001	0.000	0.001	0.184	0.022	0.000	0.000	0.207	0.000	0.208
2028	0.072	0.004	0.000	0.076	0.195	0.025	0.000	0.000	0.220	0.000	0.296
2029	0.000	0.001	0.000	0.001	0.153	0.019	0.000	0.000	0.172	0.000	0.173
2030	0.000	0.001	0.000	0.001	0.159	0.019	0.000	0.000	0.179	0.000	0.179
2031	0.000	0.001	0.000	0.001	0.172	0.021	0.000	0.000	0.193	0.000	0.194
2032	0.054	0.003	0.000	0.056	0.182	0.024	0.000	0.000	0.206	0.000	0.262
2033	0.000	0.001	0.000	0.001	0.138	0.017	0.000	0.000	0.155	0.000	0.156
2034	0.000	0.001	0.000	0.001	0.147	0.018	0.000	0.000	0.165	0.000	0.165
2035	0.000	0.001	0.000	0.001	0.160	0.021	0.000	0.000	0.181	0.000	0.181
2036	0.040	0.002	0.000	0.042	0.171	0.023	0.000	0.000	0.194	0.000	0.237
2037	0.000	0.000	0.000	0.000	0.125	0.015	0.000	0.000	0.141	0.000	0.141
2038	0.000	0.000	0.000	0.000	0.137	0.017	0.000	0.000	0.153	0.000	0.154
Total:	0.696	0.032	0.000	0.728	3.629	0.455	0.000	0.000	4.084	0.000	4.812

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.254	0.033	0.000	0.000	0.288	0.000	1.571
2020	0.000	0.008	0.000	0.008	0.169	0.023	0.000	0.000	0.192	0.000	0.200
2021	0.000	0.007	0.000	0.007	0.165	0.023	0.000	0.000	0.188	0.000	0.195
2022	0.000	0.007	0.000	0.007	0.162	0.022	0.000	0.000	0.184	0.000	0.191
2023	0.000	0.006	0.000	0.006	0.158	0.021	0.000	0.000	0.180	0.000	0.186
2024	0.000	0.006	0.000	0.006	0.155	0.021	0.000	0.000	0.176	0.000	0.182
2025	0.000	0.005	0.000	0.005	0.152	0.020	0.000	0.000	0.172	0.000	0.178
2026	0.000	0.005	0.000	0.005	0.149	0.020	0.000	0.000	0.169	0.000	0.174
2027	0.000	0.004	0.000	0.004	0.147	0.019	0.000	0.000	0.166	0.000	0.170
2028	0.000	0.004	0.000	0.004	0.144	0.019	0.000	0.000	0.163	0.000	0.167
2029	0.145	0.003	0.000	0.148	0.142	0.018	0.000	0.000	0.160	0.000	0.308
2030	0.000	0.003	0.000	0.003	0.133	0.018	0.000	0.000	0.150	0.000	0.154
2031	0.000	0.003	0.000	0.003	0.130	0.017	0.000	0.000	0.148	0.000	0.150
2032	0.000	0.003	0.000	0.003	0.128	0.017	0.000	0.000	0.145	0.000	0.147
2033	0.000	0.002	0.000	0.002	0.126	0.016	0.000	0.000	0.142	0.000	0.144
2034	0.090	0.002	0.000	0.092	0.124	0.016	0.000	0.000	0.139	0.000	0.232
2035	0.000	0.002	0.000	0.002	0.116	0.015	0.000	0.000	0.131	0.000	0.133
2036	0.000	0.002	0.000	0.002	0.114	0.015	0.000	0.000	0.129	0.000	0.130
2037	0.000	0.002	0.000	0.002	0.111	0.015	0.000	0.000	0.126	0.000	0.128
2038	0.000	0.001	0.000	0.001	0.110	0.014	0.000	0.000	0.124	0.000	0.125
Total:	1.518	0.076	0.000	1.594	2.888	0.383	0.000	0.000	3.271	0.000	4.865

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.254	0.033	0.000	0.000	0.288	0.000	2.085
2020	0.000	0.008	0.000	0.008	0.167	0.023	0.000	0.000	0.191	0.000	0.199
2021	0.000	0.007	0.000	0.007	0.163	0.023	0.000	0.000	0.186	0.000	0.193
2022	0.000	0.007	0.000	0.007	0.159	0.022	0.000	0.000	0.181	0.000	0.187
2023	0.000	0.006	0.000	0.006	0.154	0.021	0.000	0.000	0.176	0.000	0.182
2024	0.000	0.006	0.000	0.006	0.151	0.021	0.000	0.000	0.171	0.000	0.177
2025	0.000	0.005	0.000	0.005	0.147	0.020	0.000	0.000	0.167	0.000	0.172
2026	0.000	0.005	0.000	0.005	0.144	0.020	0.000	0.000	0.164	0.000	0.168
2027	0.000	0.004	0.000	0.004	0.141	0.019	0.000	0.000	0.160	0.000	0.164
2028	0.159	0.004	0.000	0.163	0.138	0.019	0.000	0.000	0.157	0.000	0.320
2029	0.000	0.003	0.000	0.003	0.130	0.018	0.000	0.000	0.149	0.000	0.152
2030	0.000	0.003	0.000	0.003	0.127	0.018	0.000	0.000	0.145	0.000	0.148
2031	0.000	0.003	0.000	0.003	0.124	0.017	0.000	0.000	0.141	0.000	0.144
2032	0.000	0.003	0.000	0.003	0.120	0.017	0.000	0.000	0.137	0.000	0.140
2033	0.000	0.002	0.000	0.002	0.117	0.016	0.000	0.000	0.134	0.000	0.136
2034	0.000	0.002	0.000	0.002	0.114	0.016	0.000	0.000	0.130	0.000	0.132
2035	0.000	0.002	0.000	0.002	0.111	0.016	0.000	0.000	0.127	0.000	0.129
2036	0.000	0.002	0.000	0.002	0.109	0.015	0.000	0.000	0.124	0.000	0.126
2037	0.000	0.002	0.000	0.002	0.107	0.015	0.000	0.000	0.121	0.000	0.123
2038	0.000	0.001	0.000	0.001	0.104	0.014	0.000	0.000	0.119	0.000	0.120
Total:	1.956	0.076	0.000	2.032	2.782	0.385	0.000	0.000	3.166	0.000	5.198

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.254	0.033	0.000	0.000	0.288	0.000	0.692
2020	0.000	0.002	0.000	0.002	0.198	0.024	0.000	0.000	0.222	0.000	0.224
2021	0.000	0.002	0.000	0.002	0.221	0.027	0.000	0.000	0.248	0.000	0.250
2022	0.000	0.002	0.000	0.002	0.230	0.029	0.000	0.000	0.258	0.000	0.260
2023	0.000	0.002	0.000	0.002	0.230	0.030	0.000	0.000	0.260	0.000	0.262
2024	0.000	0.002	0.000	0.002	0.228	0.030	0.000	0.000	0.257	0.000	0.259
2025	0.000	0.002	0.000	0.002	0.224	0.029	0.000	0.000	0.254	0.000	0.255
2026	0.000	0.001	0.000	0.001	0.220	0.029	0.000	0.000	0.249	0.000	0.251
2027	0.000	0.001	0.000	0.001	0.214	0.028	0.000	0.000	0.242	0.000	0.243
2028	0.000	0.001	0.000	0.001	0.209	0.028	0.000	0.000	0.237	0.000	0.238
2029	0.000	0.001	0.000	0.001	0.205	0.027	0.000	0.000	0.233	0.000	0.234
2030	0.000	0.001	0.000	0.001	0.202	0.027	0.000	0.000	0.228	0.000	0.229
2031	0.000	0.001	0.000	0.001	0.198	0.026	0.000	0.000	0.224	0.000	0.225
2032	0.000	0.001	0.000	0.001	0.194	0.026	0.000	0.000	0.220	0.000	0.221
2033	0.000	0.001	0.000	0.001	0.191	0.026	0.000	0.000	0.217	0.000	0.217
2034	0.000	0.001	0.000	0.001	0.187	0.025	0.000	0.000	0.213	0.000	0.213
2035	0.000	0.001	0.000	0.001	0.184	0.025	0.000	0.000	0.209	0.000	0.209
2036	0.000	0.001	0.000	0.001	0.180	0.025	0.000	0.000	0.205	0.000	0.205
2037	0.000	0.000	0.000	0.000	0.177	0.024	0.000	0.000	0.201	0.000	0.202
2038	0.000	0.000	0.000	0.000	0.173	0.024	0.000	0.000	0.197	0.000	0.198
Total:	0.405	0.022	0.000	0.427	4.120	0.541	0.000	0.000	4.661	0.000	5.088

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.254	0.033	0.000	0.000	0.288	0.000	1.571
2020	0.000	0.006	0.000	0.006	0.169	0.023	0.000	0.000	0.192	0.000	0.198
2021	0.000	0.005	0.000	0.005	0.165	0.023	0.000	0.000	0.188	0.000	0.193
2022	0.000	0.005	0.000	0.005	0.162	0.022	0.000	0.000	0.184	0.000	0.189
2023	0.000	0.005	0.000	0.005	0.158	0.021	0.000	0.000	0.180	0.000	0.184
2024	0.000	0.004	0.000	0.004	0.155	0.021	0.000	0.000	0.176	0.000	0.180
2025	0.000	0.004	0.000	0.004	0.152	0.020	0.000	0.000	0.172	0.000	0.176
2026	0.000	0.003	0.000	0.003	0.149	0.020	0.000	0.000	0.169	0.000	0.172
2027	0.000	0.003	0.000	0.003	0.147	0.019	0.000	0.000	0.166	0.000	0.169
2028	0.000	0.003	0.000	0.003	0.144	0.019	0.000	0.000	0.163	0.000	0.166
2029	0.000	0.003	0.000	0.003	0.142	0.018	0.000	0.000	0.160	0.000	0.162
2030	0.000	0.002	0.000	0.002	0.139	0.018	0.000	0.000	0.157	0.000	0.160
2031	0.000	0.002	0.000	0.002	0.137	0.017	0.000	0.000	0.155	0.000	0.157
2032	0.000	0.002	0.000	0.002	0.135	0.017	0.000	0.000	0.152	0.000	0.154
2033	0.000	0.002	0.000	0.002	0.134	0.017	0.000	0.000	0.150	0.000	0.152
2034	0.000	0.002	0.000	0.002	0.132	0.016	0.000	0.000	0.149	0.000	0.150
2035	0.000	0.001	0.000	0.001	0.132	0.016	0.000	0.000	0.148	0.000	0.149
2036	0.000	0.001	0.000	0.001	0.131	0.016	0.000	0.000	0.148	0.000	0.149
2037	0.000	0.001	0.000	0.001	0.132	0.017	0.000	0.000	0.149	0.000	0.150
2038	0.000	0.001	0.000	0.001	0.133	0.017	0.000	0.000	0.150	0.000	0.151
Total:	1.283	0.056	0.000	1.339	3.004	0.391	0.000	0.000	3.395	0.000	4.733

All costs are discounted at: 10.00 %

Section: 2_Armadi-Banau Road 100 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 2_R01T100

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.254	0.033	0.000	0.000	0.288	0.000	2.085
2020	0.000	0.008	0.000	0.008	0.167	0.023	0.000	0.000	0.191	0.000	0.199
2021	0.000	0.007	0.000	0.007	0.163	0.023	0.000	0.000	0.186	0.000	0.193
2022	0.000	0.007	0.000	0.007	0.159	0.022	0.000	0.000	0.181	0.000	0.187
2023	0.000	0.006	0.000	0.006	0.154	0.021	0.000	0.000	0.176	0.000	0.182
2024	0.000	0.006	0.000	0.006	0.151	0.021	0.000	0.000	0.171	0.000	0.177
2025	0.000	0.005	0.000	0.005	0.147	0.020	0.000	0.000	0.167	0.000	0.172
2026	0.000	0.005	0.000	0.005	0.144	0.020	0.000	0.000	0.164	0.000	0.168
2027	0.000	0.004	0.000	0.004	0.141	0.019	0.000	0.000	0.160	0.000	0.164
2028	0.000	0.004	0.000	0.004	0.138	0.019	0.000	0.000	0.157	0.000	0.160
2029	0.000	0.003	0.000	0.003	0.135	0.018	0.000	0.000	0.153	0.000	0.157
2030	0.000	0.003	0.000	0.003	0.132	0.018	0.000	0.000	0.150	0.000	0.153
2031	0.000	0.003	0.000	0.003	0.130	0.017	0.000	0.000	0.147	0.000	0.150
2032	0.000	0.003	0.000	0.003	0.128	0.017	0.000	0.000	0.145	0.000	0.147
2033	0.000	0.002	0.000	0.002	0.126	0.017	0.000	0.000	0.142	0.000	0.145
2034	0.000	0.002	0.000	0.002	0.124	0.016	0.000	0.000	0.140	0.000	0.142
2035	0.000	0.002	0.000	0.002	0.122	0.016	0.000	0.000	0.138	0.000	0.140
2036	0.000	0.002	0.000	0.002	0.120	0.015	0.000	0.000	0.136	0.000	0.138
2037	0.000	0.002	0.000	0.002	0.119	0.015	0.000	0.000	0.134	0.000	0.136
2038	0.000	0.001	0.000	0.001	0.118	0.015	0.000	0.000	0.132	0.000	0.134
Total:	1.797	0.075	0.000	1.873	2.871	0.386	0.000	0.000	3.257	0.000	5.129

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: Base Alternative

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	0.509	0.067	0.000	0.000	0.576	0.000	0.579
2020	0.000	0.000	0.000	0.000	0.414	0.050	0.000	0.000	0.464	0.000	0.464
2021	0.000	0.000	0.000	0.000	0.523	0.070	0.000	0.000	0.592	0.000	0.592
2022	0.000	0.000	0.000	0.000	0.574	0.081	0.000	0.000	0.654	0.000	0.654
2023	0.000	0.000	0.000	0.000	0.583	0.084	0.000	0.000	0.667	0.000	0.667
2024	0.000	0.000	0.000	0.000	0.578	0.084	0.000	0.000	0.662	0.000	0.662
2025	0.000	0.000	0.000	0.000	0.566	0.082	0.000	0.000	0.649	0.000	0.649
2026	0.000	0.000	0.000	0.000	0.552	0.081	0.000	0.000	0.633	0.000	0.633
2027	0.000	0.000	0.000	0.000	0.538	0.079	0.000	0.000	0.616	0.000	0.616
2028	0.000	0.000	0.000	0.000	0.523	0.077	0.000	0.000	0.600	0.000	0.600
2029	0.000	0.000	0.000	0.000	0.509	0.074	0.000	0.000	0.584	0.000	0.584
2030	0.000	0.000	0.000	0.000	0.496	0.073	0.000	0.000	0.568	0.000	0.568
2031	0.000	0.000	0.000	0.000	0.482	0.071	0.000	0.000	0.553	0.000	0.553
2032	0.000	0.000	0.000	0.000	0.469	0.069	0.000	0.000	0.538	0.000	0.538
2033	0.000	0.000	0.000	0.000	0.457	0.067	0.000	0.000	0.524	0.000	0.524
2034	0.000	0.000	0.000	0.000	0.444	0.065	0.000	0.000	0.510	0.000	0.510
2035	0.000	0.000	0.000	0.000	0.433	0.064	0.000	0.000	0.496	0.000	0.496
2036	0.000	0.000	0.000	0.000	0.421	0.062	0.000	0.000	0.483	0.000	0.483
2037	0.000	0.000	0.000	0.000	0.410	0.060	0.000	0.000	0.470	0.000	0.470
2038	0.000	0.000	0.000	0.000	0.399	0.059	0.000	0.000	0.458	0.000	0.458
Total:	0.003	0.000	0.000	0.003	9.880	1.416	0.000	0.000	11.296	0.000	11.299

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.509	0.067	0.000	0.000	0.576	0.000	0.981
2020	0.000	0.002	0.000	0.002	0.422	0.050	0.000	0.000	0.473	0.000	0.475
2021	0.000	0.002	0.000	0.002	0.492	0.064	0.000	0.000	0.556	0.000	0.558
2022	0.000	0.002	0.000	0.002	0.511	0.069	0.000	0.000	0.580	0.000	0.582
2023	0.133	0.007	0.000	0.140	0.511	0.069	0.000	0.000	0.581	0.000	0.721
2024	0.000	0.002	0.000	0.002	0.356	0.044	0.000	0.000	0.400	0.000	0.401
2025	0.000	0.002	0.000	0.002	0.381	0.046	0.000	0.000	0.427	0.000	0.429
2026	0.000	0.001	0.000	0.001	0.417	0.054	0.000	0.000	0.471	0.000	0.472
2027	0.099	0.005	0.000	0.103	0.445	0.061	0.000	0.000	0.506	0.000	0.609
2028	0.000	0.001	0.000	0.001	0.323	0.039	0.000	0.000	0.363	0.000	0.364
2029	0.000	0.001	0.000	0.001	0.355	0.044	0.000	0.000	0.399	0.000	0.400
2030	0.062	0.003	0.000	0.065	0.390	0.053	0.000	0.000	0.443	0.000	0.508
2031	0.000	0.001	0.000	0.001	0.301	0.037	0.000	0.000	0.338	0.000	0.339
2032	0.000	0.001	0.000	0.001	0.338	0.043	0.000	0.000	0.380	0.000	0.381
2033	0.051	0.003	0.000	0.054	0.374	0.052	0.000	0.000	0.426	0.000	0.480
2034	0.000	0.001	0.000	0.001	0.281	0.034	0.000	0.000	0.316	0.000	0.316
2035	0.000	0.001	0.000	0.001	0.322	0.042	0.000	0.000	0.363	0.000	0.364
2036	0.043	0.002	0.000	0.045	0.358	0.050	0.000	0.000	0.408	0.000	0.454
2037	0.000	0.000	0.000	0.000	0.264	0.032	0.000	0.000	0.296	0.000	0.296
2038	0.000	0.000	0.000	0.000	0.307	0.041	0.000	0.000	0.348	0.000	0.349
Total:	0.792	0.038	0.000	0.830	7.659	0.990	0.000	0.000	8.649	0.000	9.479

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.509	0.067	0.000	0.000	0.576	0.000	1.859
2020	0.000	0.008	0.000	0.008	0.337	0.047	0.000	0.000	0.384	0.000	0.392
2021	0.000	0.007	0.000	0.007	0.331	0.045	0.000	0.000	0.377	0.000	0.384
2022	0.000	0.007	0.000	0.007	0.324	0.044	0.000	0.000	0.369	0.000	0.375
2023	0.000	0.006	0.000	0.006	0.318	0.043	0.000	0.000	0.361	0.000	0.367
2024	0.000	0.006	0.000	0.006	0.312	0.042	0.000	0.000	0.354	0.000	0.359
2025	0.000	0.005	0.000	0.005	0.306	0.041	0.000	0.000	0.347	0.000	0.352
2026	0.000	0.005	0.000	0.005	0.301	0.040	0.000	0.000	0.341	0.000	0.345
2027	0.000	0.004	0.000	0.004	0.296	0.039	0.000	0.000	0.335	0.000	0.339
2028	0.159	0.004	0.000	0.163	0.291	0.038	0.000	0.000	0.329	0.000	0.492
2029	0.000	0.003	0.000	0.003	0.273	0.037	0.000	0.000	0.310	0.000	0.314
2030	0.000	0.003	0.000	0.003	0.268	0.036	0.000	0.000	0.304	0.000	0.307
2031	0.000	0.003	0.000	0.003	0.264	0.035	0.000	0.000	0.299	0.000	0.301
2032	0.000	0.003	0.000	0.003	0.259	0.034	0.000	0.000	0.293	0.000	0.296
2033	0.099	0.002	0.000	0.101	0.255	0.033	0.000	0.000	0.289	0.000	0.390
2034	0.000	0.002	0.000	0.002	0.239	0.032	0.000	0.000	0.272	0.000	0.274
2035	0.000	0.002	0.000	0.002	0.235	0.031	0.000	0.000	0.267	0.000	0.269
2036	0.000	0.002	0.000	0.002	0.231	0.031	0.000	0.000	0.262	0.000	0.264
2037	0.068	0.002	0.000	0.069	0.228	0.030	0.000	0.000	0.258	0.000	0.327
2038	0.000	0.001	0.000	0.001	0.214	0.029	0.000	0.000	0.243	0.000	0.244
Total:	1.609	0.076	0.000	1.685	5.793	0.773	0.000	0.000	6.566	0.000	8.251

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.509	0.067	0.000	0.000	0.576	0.000	2.373
2020	0.000	0.008	0.000	0.008	0.335	0.047	0.000	0.000	0.382	0.000	0.390
2021	0.000	0.007	0.000	0.007	0.326	0.046	0.000	0.000	0.372	0.000	0.379
2022	0.000	0.007	0.000	0.007	0.318	0.045	0.000	0.000	0.362	0.000	0.369
2023	0.000	0.006	0.000	0.006	0.310	0.043	0.000	0.000	0.353	0.000	0.359
2024	0.000	0.006	0.000	0.006	0.302	0.042	0.000	0.000	0.344	0.000	0.350
2025	0.000	0.005	0.000	0.005	0.295	0.041	0.000	0.000	0.336	0.000	0.341
2026	0.000	0.005	0.000	0.005	0.289	0.040	0.000	0.000	0.329	0.000	0.334
2027	0.000	0.004	0.000	0.004	0.283	0.039	0.000	0.000	0.322	0.000	0.326
2028	0.159	0.004	0.000	0.163	0.277	0.038	0.000	0.000	0.315	0.000	0.479
2029	0.000	0.003	0.000	0.003	0.262	0.037	0.000	0.000	0.299	0.000	0.302
2030	0.000	0.003	0.000	0.003	0.255	0.036	0.000	0.000	0.291	0.000	0.294
2031	0.000	0.003	0.000	0.003	0.248	0.035	0.000	0.000	0.283	0.000	0.286
2032	0.000	0.003	0.000	0.003	0.242	0.035	0.000	0.000	0.276	0.000	0.279
2033	0.000	0.002	0.000	0.002	0.235	0.034	0.000	0.000	0.269	0.000	0.272
2034	0.000	0.002	0.000	0.002	0.230	0.033	0.000	0.000	0.263	0.000	0.265
2035	0.000	0.002	0.000	0.002	0.225	0.032	0.000	0.000	0.257	0.000	0.259
2036	0.000	0.002	0.000	0.002	0.220	0.031	0.000	0.000	0.251	0.000	0.253
2037	0.000	0.002	0.000	0.002	0.216	0.031	0.000	0.000	0.246	0.000	0.248
2038	0.061	0.002	0.000	0.063	0.211	0.030	0.000	0.000	0.241	0.000	0.304
Total:	2.018	0.076	0.000	2.093	5.587	0.782	0.000	0.000	6.369	0.000	8.463

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.509	0.067	0.000	0.000	0.576	0.000	0.981
2020	0.000	0.002	0.000	0.002	0.422	0.050	0.000	0.000	0.473	0.000	0.475
2021	0.000	0.002	0.000	0.002	0.492	0.064	0.000	0.000	0.556	0.000	0.558
2022	0.000	0.002	0.000	0.002	0.511	0.069	0.000	0.000	0.580	0.000	0.582
2023	0.000	0.002	0.000	0.002	0.511	0.069	0.000	0.000	0.581	0.000	0.583
2024	0.000	0.002	0.000	0.002	0.505	0.069	0.000	0.000	0.573	0.000	0.575
2025	0.000	0.002	0.000	0.002	0.488	0.066	0.000	0.000	0.554	0.000	0.555
2026	0.000	0.001	0.000	0.001	0.477	0.065	0.000	0.000	0.542	0.000	0.543
2027	0.000	0.001	0.000	0.001	0.467	0.064	0.000	0.000	0.531	0.000	0.533
2028	0.000	0.001	0.000	0.001	0.458	0.063	0.000	0.000	0.521	0.000	0.522
2029	0.000	0.001	0.000	0.001	0.449	0.062	0.000	0.000	0.511	0.000	0.512
2030	0.000	0.001	0.000	0.001	0.440	0.061	0.000	0.000	0.501	0.000	0.502
2031	0.000	0.001	0.000	0.001	0.432	0.060	0.000	0.000	0.491	0.000	0.492
2032	0.000	0.001	0.000	0.001	0.423	0.059	0.000	0.000	0.482	0.000	0.483
2033	0.000	0.001	0.000	0.001	0.414	0.058	0.000	0.000	0.472	0.000	0.473
2034	0.000	0.001	0.000	0.001	0.405	0.057	0.000	0.000	0.462	0.000	0.463
2035	0.000	0.001	0.000	0.001	0.397	0.056	0.000	0.000	0.452	0.000	0.453
2036	0.000	0.001	0.000	0.001	0.388	0.055	0.000	0.000	0.443	0.000	0.443
2037	0.000	0.000	0.000	0.000	0.379	0.054	0.000	0.000	0.433	0.000	0.434
2038	0.000	0.000	0.000	0.000	0.371	0.053	0.000	0.000	0.424	0.000	0.424
Total:	0.405	0.022	0.000	0.427	8.940	1.218	0.000	0.000	10.159	0.000	10.586

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.509	0.067	0.000	0.000	0.576	0.000	1.859
2020	0.000	0.006	0.000	0.006	0.337	0.047	0.000	0.000	0.384	0.000	0.390
2021	0.000	0.005	0.000	0.005	0.331	0.045	0.000	0.000	0.377	0.000	0.382
2022	0.000	0.005	0.000	0.005	0.324	0.044	0.000	0.000	0.369	0.000	0.374
2023	0.000	0.005	0.000	0.005	0.318	0.043	0.000	0.000	0.361	0.000	0.366
2024	0.000	0.004	0.000	0.004	0.312	0.042	0.000	0.000	0.354	0.000	0.358
2025	0.000	0.004	0.000	0.004	0.306	0.041	0.000	0.000	0.347	0.000	0.351
2026	0.000	0.003	0.000	0.003	0.301	0.040	0.000	0.000	0.341	0.000	0.344
2027	0.000	0.003	0.000	0.003	0.296	0.039	0.000	0.000	0.335	0.000	0.338
2028	0.000	0.003	0.000	0.003	0.291	0.038	0.000	0.000	0.329	0.000	0.332
2029	0.000	0.003	0.000	0.003	0.287	0.037	0.000	0.000	0.324	0.000	0.326
2030	0.000	0.002	0.000	0.002	0.283	0.036	0.000	0.000	0.319	0.000	0.322
2031	0.000	0.002	0.000	0.002	0.280	0.035	0.000	0.000	0.315	0.000	0.317
2032	0.000	0.002	0.000	0.002	0.277	0.035	0.000	0.000	0.312	0.000	0.314
2033	0.000	0.002	0.000	0.002	0.276	0.034	0.000	0.000	0.310	0.000	0.312
2034	0.000	0.002	0.000	0.002	0.276	0.034	0.000	0.000	0.310	0.000	0.312
2035	0.000	0.001	0.000	0.001	0.278	0.035	0.000	0.000	0.313	0.000	0.314
2036	0.000	0.001	0.000	0.001	0.281	0.037	0.000	0.000	0.318	0.000	0.319
2037	0.000	0.001	0.000	0.001	0.286	0.039	0.000	0.000	0.325	0.000	0.326
2038	0.000	0.001	0.000	0.001	0.286	0.040	0.000	0.000	0.327	0.000	0.328
Total:	1.283	0.056	0.000	1.339	6.135	0.808	0.000	0.000	6.944	0.000	8.283

All costs are discounted at: 10.00 %

Section: 3_Armadi-Banau Road 200 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 3_R01T200

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.509	0.067	0.000	0.000	0.576	0.000	2.373
2020	0.000	0.008	0.000	0.008	0.335	0.047	0.000	0.000	0.382	0.000	0.390
2021	0.000	0.007	0.000	0.007	0.326	0.046	0.000	0.000	0.372	0.000	0.379
2022	0.000	0.007	0.000	0.007	0.318	0.045	0.000	0.000	0.362	0.000	0.369
2023	0.000	0.006	0.000	0.006	0.310	0.043	0.000	0.000	0.353	0.000	0.359
2024	0.000	0.006	0.000	0.006	0.302	0.042	0.000	0.000	0.344	0.000	0.350
2025	0.000	0.005	0.000	0.005	0.295	0.041	0.000	0.000	0.336	0.000	0.341
2026	0.000	0.005	0.000	0.005	0.289	0.040	0.000	0.000	0.329	0.000	0.334
2027	0.000	0.004	0.000	0.004	0.283	0.039	0.000	0.000	0.322	0.000	0.326
2028	0.000	0.004	0.000	0.004	0.277	0.038	0.000	0.000	0.315	0.000	0.319
2029	0.000	0.003	0.000	0.003	0.272	0.037	0.000	0.000	0.309	0.000	0.313
2030	0.000	0.003	0.000	0.003	0.267	0.036	0.000	0.000	0.303	0.000	0.306
2031	0.000	0.003	0.000	0.003	0.262	0.036	0.000	0.000	0.298	0.000	0.301
2032	0.000	0.003	0.000	0.003	0.258	0.035	0.000	0.000	0.293	0.000	0.295
2033	0.000	0.002	0.000	0.002	0.254	0.034	0.000	0.000	0.288	0.000	0.291
2034	0.000	0.002	0.000	0.002	0.251	0.033	0.000	0.000	0.284	0.000	0.286
2035	0.000	0.002	0.000	0.002	0.248	0.032	0.000	0.000	0.281	0.000	0.283
2036	0.000	0.002	0.000	0.002	0.246	0.032	0.000	0.000	0.277	0.000	0.279
2037	0.000	0.002	0.000	0.002	0.243	0.031	0.000	0.000	0.275	0.000	0.276
2038	0.000	0.001	0.000	0.001	0.242	0.031	0.000	0.000	0.273	0.000	0.274
Total:	1.797	0.075	0.000	1.873	5.787	0.786	0.000	0.000	6.574	0.000	8.446

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: Base Alternative

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	0.765	0.101	0.000	0.000	0.866	0.000	0.868
2020	0.000	0.000	0.000	0.000	0.658	0.079	0.000	0.000	0.737	0.000	0.737
2021	0.000	0.000	0.000	0.000	0.855	0.118	0.000	0.000	0.974	0.000	0.974
2022	0.000	0.000	0.000	0.000	0.899	0.129	0.000	0.000	1.028	0.000	1.028
2023	0.000	0.000	0.000	0.000	0.894	0.130	0.000	0.000	1.025	0.000	1.025
2024	0.000	0.000	0.000	0.000	0.876	0.128	0.000	0.000	1.004	0.000	1.004
2025	0.000	0.000	0.000	0.000	0.854	0.125	0.000	0.000	0.979	0.000	0.979
2026	0.000	0.000	0.000	0.000	0.831	0.122	0.000	0.000	0.953	0.000	0.953
2027	0.000	0.000	0.000	0.000	0.809	0.119	0.000	0.000	0.927	0.000	0.927
2028	0.000	0.000	0.000	0.000	0.787	0.116	0.000	0.000	0.903	0.000	0.903
2029	0.000	0.000	0.000	0.000	0.766	0.113	0.000	0.000	0.878	0.000	0.878
2030	0.000	0.000	0.000	0.000	0.745	0.110	0.000	0.000	0.855	0.000	0.855
2031	0.000	0.000	0.000	0.000	0.726	0.107	0.000	0.000	0.832	0.000	0.832
2032	0.000	0.000	0.000	0.000	0.706	0.104	0.000	0.000	0.810	0.000	0.810
2033	0.000	0.000	0.000	0.000	0.687	0.101	0.000	0.000	0.789	0.000	0.789
2034	0.000	0.000	0.000	0.000	0.669	0.099	0.000	0.000	0.768	0.000	0.768
2035	0.000	0.000	0.000	0.000	0.651	0.096	0.000	0.000	0.748	0.000	0.748
2036	0.000	0.000	0.000	0.000	0.634	0.094	0.000	0.000	0.728	0.000	0.728
2037	0.000	0.000	0.000	0.000	0.617	0.092	0.000	0.000	0.709	0.000	0.709
2038	0.000	0.000	0.000	0.000	0.601	0.089	0.000	0.000	0.690	0.000	0.690
Total:	0.003	0.000	0.000	0.003	15.031	2.171	0.000	0.000	17.202	0.000	17.204

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.765	0.101	0.000	0.000	0.866	0.000	1.270
2020	0.000	0.002	0.000	0.002	0.672	0.081	0.000	0.000	0.754	0.000	0.756
2021	0.000	0.002	0.000	0.002	0.799	0.108	0.000	0.000	0.907	0.000	0.909
2022	0.128	0.009	0.000	0.137	0.822	0.113	0.000	0.000	0.935	0.000	1.072
2023	0.000	0.002	0.000	0.002	0.559	0.068	0.000	0.000	0.627	0.000	0.629
2024	0.000	0.002	0.000	0.002	0.618	0.077	0.000	0.000	0.695	0.000	0.696
2025	0.103	0.005	0.000	0.108	0.682	0.093	0.000	0.000	0.774	0.000	0.882
2026	0.000	0.001	0.000	0.001	0.521	0.063	0.000	0.000	0.585	0.000	0.586
2027	0.000	0.001	0.000	0.001	0.588	0.075	0.000	0.000	0.663	0.000	0.664
2028	0.086	0.005	0.000	0.090	0.653	0.091	0.000	0.000	0.744	0.000	0.834
2029	0.000	0.001	0.000	0.001	0.487	0.059	0.000	0.000	0.547	0.000	0.548
2030	0.000	0.001	0.000	0.001	0.561	0.073	0.000	0.000	0.634	0.000	0.635
2031	0.072	0.004	0.000	0.076	0.623	0.088	0.000	0.000	0.712	0.000	0.788
2032	0.000	0.001	0.000	0.001	0.457	0.056	0.000	0.000	0.513	0.000	0.514
2033	0.000	0.001	0.000	0.001	0.535	0.072	0.000	0.000	0.608	0.000	0.609
2034	0.059	0.003	0.000	0.062	0.593	0.086	0.000	0.000	0.679	0.000	0.741
2035	0.000	0.001	0.000	0.001	0.431	0.053	0.000	0.000	0.484	0.000	0.485
2036	0.000	0.001	0.000	0.001	0.514	0.071	0.000	0.000	0.586	0.000	0.586
2037	0.044	0.003	0.000	0.047	0.560	0.082	0.000	0.000	0.643	0.000	0.689
2038	0.000	0.000	0.000	0.000	0.408	0.051	0.000	0.000	0.459	0.000	0.459
Total:	0.896	0.045	0.000	0.940	11.850	1.562	0.000	0.000	13.413	0.000	14.353

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.765	0.101	0.000	0.000	0.866	0.000	2.149
2020	0.000	0.008	0.000	0.008	0.506	0.070	0.000	0.000	0.577	0.000	0.585
2021	0.000	0.007	0.000	0.007	0.498	0.068	0.000	0.000	0.566	0.000	0.573
2022	0.000	0.007	0.000	0.007	0.488	0.067	0.000	0.000	0.554	0.000	0.561
2023	0.000	0.006	0.000	0.006	0.478	0.065	0.000	0.000	0.543	0.000	0.550
2024	0.000	0.006	0.000	0.006	0.470	0.063	0.000	0.000	0.533	0.000	0.539
2025	0.000	0.005	0.000	0.005	0.462	0.062	0.000	0.000	0.523	0.000	0.528
2026	0.000	0.005	0.000	0.005	0.454	0.060	0.000	0.000	0.514	0.000	0.519
2027	0.000	0.004	0.000	0.004	0.447	0.059	0.000	0.000	0.506	0.000	0.510
2028	0.159	0.004	0.000	0.163	0.441	0.057	0.000	0.000	0.498	0.000	0.662
2029	0.000	0.003	0.000	0.003	0.414	0.056	0.000	0.000	0.470	0.000	0.473
2030	0.000	0.003	0.000	0.003	0.407	0.054	0.000	0.000	0.462	0.000	0.465
2031	0.000	0.003	0.000	0.003	0.401	0.053	0.000	0.000	0.454	0.000	0.457
2032	0.109	0.003	0.000	0.112	0.395	0.052	0.000	0.000	0.447	0.000	0.558
2033	0.000	0.002	0.000	0.002	0.371	0.050	0.000	0.000	0.421	0.000	0.423
2034	0.000	0.002	0.000	0.002	0.365	0.049	0.000	0.000	0.414	0.000	0.416
2035	0.000	0.002	0.000	0.002	0.359	0.048	0.000	0.000	0.407	0.000	0.409
2036	0.074	0.002	0.000	0.076	0.354	0.047	0.000	0.000	0.401	0.000	0.477
2037	0.000	0.002	0.000	0.002	0.332	0.045	0.000	0.000	0.378	0.000	0.379
2038	0.000	0.001	0.000	0.001	0.327	0.044	0.000	0.000	0.371	0.000	0.373
Total:	1.626	0.076	0.000	1.702	8.735	1.170	0.000	0.000	9.905	0.000	11.607

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.765	0.101	0.000	0.000	0.866	0.000	2.663
2020	0.000	0.008	0.000	0.008	0.503	0.071	0.000	0.000	0.574	0.000	0.582
2021	0.000	0.007	0.000	0.007	0.490	0.069	0.000	0.000	0.559	0.000	0.567
2022	0.000	0.007	0.000	0.007	0.477	0.068	0.000	0.000	0.545	0.000	0.552
2023	0.000	0.006	0.000	0.006	0.465	0.066	0.000	0.000	0.531	0.000	0.537
2024	0.000	0.006	0.000	0.006	0.454	0.064	0.000	0.000	0.518	0.000	0.524
2025	0.000	0.005	0.000	0.005	0.444	0.063	0.000	0.000	0.507	0.000	0.512
2026	0.000	0.005	0.000	0.005	0.435	0.061	0.000	0.000	0.496	0.000	0.501
2027	0.175	0.004	0.000	0.180	0.426	0.060	0.000	0.000	0.486	0.000	0.666
2028	0.000	0.004	0.000	0.004	0.404	0.058	0.000	0.000	0.462	0.000	0.466
2029	0.000	0.003	0.000	0.003	0.394	0.057	0.000	0.000	0.451	0.000	0.454
2030	0.000	0.003	0.000	0.003	0.384	0.055	0.000	0.000	0.439	0.000	0.442
2031	0.000	0.003	0.000	0.003	0.374	0.054	0.000	0.000	0.428	0.000	0.431
2032	0.000	0.003	0.000	0.003	0.364	0.053	0.000	0.000	0.417	0.000	0.420
2033	0.000	0.002	0.000	0.002	0.356	0.052	0.000	0.000	0.407	0.000	0.410
2034	0.000	0.002	0.000	0.002	0.348	0.051	0.000	0.000	0.399	0.000	0.401
2035	0.000	0.002	0.000	0.002	0.341	0.050	0.000	0.000	0.391	0.000	0.393
2036	0.074	0.002	0.000	0.076	0.335	0.049	0.000	0.000	0.383	0.000	0.460
2037	0.000	0.002	0.000	0.002	0.318	0.047	0.000	0.000	0.365	0.000	0.367
2038	0.000	0.001	0.000	0.001	0.310	0.046	0.000	0.000	0.357	0.000	0.358
Total:	2.047	0.076	0.000	2.122	8.389	1.194	0.000	0.000	9.583	0.000	11.705

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	0.765	0.101	0.000	0.000	0.866	0.000	1.270
2020	0.000	0.002	0.000	0.002	0.672	0.081	0.000	0.000	0.754	0.000	0.756
2021	0.000	0.002	0.000	0.002	0.799	0.108	0.000	0.000	0.907	0.000	0.909
2022	0.000	0.002	0.000	0.002	0.822	0.113	0.000	0.000	0.935	0.000	0.937
2023	0.000	0.002	0.000	0.002	0.814	0.113	0.000	0.000	0.927	0.000	0.928
2024	0.000	0.002	0.000	0.002	0.799	0.111	0.000	0.000	0.911	0.000	0.912
2025	0.000	0.002	0.000	0.002	0.768	0.107	0.000	0.000	0.874	0.000	0.876
2026	0.000	0.001	0.000	0.001	0.749	0.104	0.000	0.000	0.854	0.000	0.855
2027	0.000	0.001	0.000	0.001	0.734	0.102	0.000	0.000	0.836	0.000	0.837
2028	0.000	0.001	0.000	0.001	0.718	0.101	0.000	0.000	0.818	0.000	0.820
2029	0.000	0.001	0.000	0.001	0.702	0.099	0.000	0.000	0.801	0.000	0.802
2030	0.000	0.001	0.000	0.001	0.687	0.097	0.000	0.000	0.784	0.000	0.785
2031	0.000	0.001	0.000	0.001	0.672	0.095	0.000	0.000	0.767	0.000	0.768
2032	0.000	0.001	0.000	0.001	0.657	0.093	0.000	0.000	0.750	0.000	0.751
2033	0.000	0.001	0.000	0.001	0.642	0.092	0.000	0.000	0.733	0.000	0.734
2034	0.000	0.001	0.000	0.001	0.627	0.090	0.000	0.000	0.717	0.000	0.718
2035	0.000	0.001	0.000	0.001	0.613	0.088	0.000	0.000	0.701	0.000	0.702
2036	0.000	0.001	0.000	0.001	0.599	0.086	0.000	0.000	0.685	0.000	0.686
2037	0.000	0.000	0.000	0.000	0.585	0.085	0.000	0.000	0.670	0.000	0.670
2038	0.000	0.000	0.000	0.000	0.572	0.083	0.000	0.000	0.655	0.000	0.655
Total:	0.405	0.022	0.000	0.427	13.995	1.948	0.000	0.000	15.944	0.000	16.371

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	0.765	0.101	0.000	0.000	0.866	0.000	2.149
2020	0.000	0.006	0.000	0.006	0.506	0.070	0.000	0.000	0.577	0.000	0.583
2021	0.000	0.005	0.000	0.005	0.498	0.068	0.000	0.000	0.566	0.000	0.571
2022	0.000	0.005	0.000	0.005	0.488	0.067	0.000	0.000	0.554	0.000	0.559
2023	0.000	0.005	0.000	0.005	0.478	0.065	0.000	0.000	0.543	0.000	0.548
2024	0.000	0.004	0.000	0.004	0.470	0.063	0.000	0.000	0.533	0.000	0.537
2025	0.000	0.004	0.000	0.004	0.462	0.062	0.000	0.000	0.523	0.000	0.527
2026	0.000	0.003	0.000	0.003	0.454	0.060	0.000	0.000	0.514	0.000	0.518
2027	0.000	0.003	0.000	0.003	0.447	0.059	0.000	0.000	0.506	0.000	0.509
2028	0.000	0.003	0.000	0.003	0.441	0.057	0.000	0.000	0.498	0.000	0.501
2029	0.000	0.003	0.000	0.003	0.436	0.056	0.000	0.000	0.492	0.000	0.494
2030	0.000	0.002	0.000	0.002	0.431	0.055	0.000	0.000	0.486	0.000	0.488
2031	0.000	0.002	0.000	0.002	0.428	0.054	0.000	0.000	0.482	0.000	0.484
2032	0.000	0.002	0.000	0.002	0.426	0.053	0.000	0.000	0.480	0.000	0.482
2033	0.000	0.002	0.000	0.002	0.428	0.054	0.000	0.000	0.482	0.000	0.484
2034	0.000	0.002	0.000	0.002	0.433	0.056	0.000	0.000	0.489	0.000	0.491
2035	0.000	0.001	0.000	0.001	0.441	0.059	0.000	0.000	0.500	0.000	0.501
2036	0.000	0.001	0.000	0.001	0.448	0.063	0.000	0.000	0.511	0.000	0.513
2037	0.000	0.001	0.000	0.001	0.446	0.064	0.000	0.000	0.509	0.000	0.511
2038	0.000	0.001	0.000	0.001	0.434	0.062	0.000	0.000	0.496	0.000	0.497
Total:	1.283	0.056	0.000	1.339	9.361	1.248	0.000	0.000	10.609	0.000	11.948

All costs are discounted at: 10.00 %

Section: 4_Armadi-Banau Road 300 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 4_R01T300

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	0.765	0.101	0.000	0.000	0.866	0.000	2.663
2020	0.000	0.008	0.000	0.008	0.503	0.071	0.000	0.000	0.574	0.000	0.582
2021	0.000	0.007	0.000	0.007	0.490	0.069	0.000	0.000	0.559	0.000	0.567
2022	0.000	0.007	0.000	0.007	0.477	0.068	0.000	0.000	0.545	0.000	0.552
2023	0.000	0.006	0.000	0.006	0.465	0.066	0.000	0.000	0.531	0.000	0.537
2024	0.000	0.006	0.000	0.006	0.454	0.064	0.000	0.000	0.518	0.000	0.524
2025	0.000	0.005	0.000	0.005	0.444	0.063	0.000	0.000	0.507	0.000	0.512
2026	0.000	0.005	0.000	0.005	0.435	0.061	0.000	0.000	0.496	0.000	0.501
2027	0.000	0.004	0.000	0.004	0.426	0.060	0.000	0.000	0.486	0.000	0.490
2028	0.000	0.004	0.000	0.004	0.418	0.058	0.000	0.000	0.477	0.000	0.480
2029	0.000	0.003	0.000	0.003	0.411	0.057	0.000	0.000	0.468	0.000	0.471
2030	0.000	0.003	0.000	0.003	0.404	0.056	0.000	0.000	0.459	0.000	0.462
2031	0.000	0.003	0.000	0.003	0.397	0.054	0.000	0.000	0.452	0.000	0.455
2032	0.000	0.003	0.000	0.003	0.392	0.053	0.000	0.000	0.445	0.000	0.448
2033	0.000	0.002	0.000	0.002	0.387	0.052	0.000	0.000	0.439	0.000	0.441
2034	0.000	0.002	0.000	0.002	0.383	0.051	0.000	0.000	0.434	0.000	0.436
2035	0.000	0.002	0.000	0.002	0.379	0.050	0.000	0.000	0.429	0.000	0.431
2036	0.000	0.002	0.000	0.002	0.376	0.050	0.000	0.000	0.426	0.000	0.428
2037	0.000	0.002	0.000	0.002	0.375	0.049	0.000	0.000	0.424	0.000	0.426
2038	0.000	0.001	0.000	0.001	0.375	0.050	0.000	0.000	0.425	0.000	0.427
Total:	1.797	0.075	0.000	1.873	8.758	1.203	0.000	0.000	9.961	0.000	11.833

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: Base Alternative

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	1.278	0.169	0.000	0.000	1.447	0.000	1.449
2020	0.000	0.000	0.000	0.000	1.205	0.152	0.000	0.000	1.358	0.000	1.358
2021	0.000	0.000	0.000	0.000	1.534	0.221	0.000	0.000	1.755	0.000	1.755
2022	0.000	0.000	0.000	0.000	1.541	0.226	0.000	0.000	1.767	0.000	1.767
2023	0.000	0.000	0.000	0.000	1.507	0.222	0.000	0.000	1.729	0.000	1.729
2024	0.000	0.000	0.000	0.000	1.468	0.216	0.000	0.000	1.684	0.000	1.684
2025	0.000	0.000	0.000	0.000	1.429	0.211	0.000	0.000	1.639	0.000	1.639
2026	0.000	0.000	0.000	0.000	1.391	0.205	0.000	0.000	1.596	0.000	1.596
2027	0.000	0.000	0.000	0.000	1.354	0.200	0.000	0.000	1.554	0.000	1.554
2028	0.000	0.000	0.000	0.000	1.318	0.195	0.000	0.000	1.513	0.000	1.513
2029	0.000	0.000	0.000	0.000	1.283	0.190	0.000	0.000	1.473	0.000	1.473
2030	0.000	0.000	0.000	0.000	1.249	0.186	0.000	0.000	1.435	0.000	1.435
2031	0.000	0.000	0.000	0.000	1.216	0.181	0.000	0.000	1.397	0.000	1.397
2032	0.000	0.000	0.000	0.000	1.184	0.177	0.000	0.000	1.361	0.000	1.361
2033	0.000	0.000	0.000	0.000	1.153	0.172	0.000	0.000	1.326	0.000	1.326
2034	0.000	0.000	0.000	0.000	1.123	0.168	0.000	0.000	1.291	0.000	1.291
2035	0.000	0.000	0.000	0.000	1.094	0.164	0.000	0.000	1.258	0.000	1.258
2036	0.000	0.000	0.000	0.000	1.066	0.160	0.000	0.000	1.226	0.000	1.226
2037	0.000	0.000	0.000	0.000	1.038	0.157	0.000	0.000	1.195	0.000	1.195
2038	0.000	0.000	0.000	0.000	1.011	0.153	0.000	0.000	1.165	0.000	1.165
Total:	0.003	0.000	0.000	0.003	25.443	3.726	0.000	0.000	29.169	0.000	29.171

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	1.278	0.169	0.000	0.000	1.447	0.000	1.851
2020	0.000	0.002	0.000	0.002	1.228	0.157	0.000	0.000	1.385	0.000	1.387
2021	0.000	0.002	0.000	0.002	1.461	0.205	0.000	0.000	1.666	0.000	1.668
2022	0.167	0.011	0.000	0.178	1.457	0.208	0.000	0.000	1.665	0.000	1.843
2023	0.000	0.002	0.000	0.002	0.968	0.118	0.000	0.000	1.086	0.000	1.088
2024	0.000	0.002	0.000	0.002	1.124	0.150	0.000	0.000	1.274	0.000	1.276
2025	0.136	0.007	0.000	0.143	1.249	0.179	0.000	0.000	1.428	0.000	1.571
2026	0.000	0.001	0.000	0.001	0.911	0.112	0.000	0.000	1.022	0.000	1.024
2027	0.000	0.001	0.000	0.001	1.076	0.148	0.000	0.000	1.224	0.000	1.225
2028	0.104	0.006	0.000	0.110	1.184	0.172	0.000	0.000	1.356	0.000	1.466
2029	0.000	0.001	0.000	0.001	0.860	0.107	0.000	0.000	0.967	0.000	0.968
2030	0.000	0.001	0.000	0.001	1.035	0.146	0.000	0.000	1.181	0.000	1.182
2031	0.078	0.005	0.000	0.083	1.116	0.165	0.000	0.000	1.281	0.000	1.364
2032	0.000	0.001	0.000	0.001	0.815	0.103	0.000	0.000	0.918	0.000	0.919
2033	0.000	0.001	0.000	0.001	0.992	0.143	0.000	0.000	1.135	0.000	1.135
2034	0.059	0.004	0.000	0.062	1.048	0.158	0.000	0.000	1.206	0.000	1.268
2035	0.000	0.001	0.000	0.001	0.776	0.101	0.000	0.000	0.877	0.000	0.877
2036	0.000	0.001	0.000	0.001	0.947	0.140	0.000	0.000	1.087	0.000	1.088
2037	0.044	0.003	0.000	0.047	0.963	0.146	0.000	0.000	1.109	0.000	1.156
2038	0.000	0.000	0.000	0.000	0.740	0.099	0.000	0.000	0.839	0.000	0.839
Total:	0.993	0.050	0.000	1.043	21.227	2.924	0.000	0.000	24.151	0.000	25.194

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	1.278	0.169	0.000	0.000	1.447	0.000	2.730
2020	0.000	0.008	0.000	0.008	0.845	0.118	0.000	0.000	0.964	0.000	0.972
2021	0.000	0.007	0.000	0.007	0.832	0.115	0.000	0.000	0.947	0.000	0.954
2022	0.000	0.007	0.000	0.007	0.816	0.112	0.000	0.000	0.929	0.000	0.936
2023	0.000	0.006	0.000	0.006	0.802	0.110	0.000	0.000	0.912	0.000	0.918
2024	0.000	0.006	0.000	0.006	0.789	0.107	0.000	0.000	0.896	0.000	0.902
2025	0.000	0.005	0.000	0.005	0.777	0.104	0.000	0.000	0.882	0.000	0.887
2026	0.000	0.005	0.000	0.005	0.767	0.102	0.000	0.000	0.869	0.000	0.874
2027	0.175	0.005	0.000	0.180	0.758	0.100	0.000	0.000	0.858	0.000	1.038
2028	0.000	0.004	0.000	0.004	0.713	0.097	0.000	0.000	0.810	0.000	0.814
2029	0.000	0.003	0.000	0.003	0.703	0.095	0.000	0.000	0.797	0.000	0.801
2030	0.132	0.003	0.000	0.135	0.693	0.092	0.000	0.000	0.786	0.000	0.921
2031	0.000	0.003	0.000	0.003	0.651	0.090	0.000	0.000	0.741	0.000	0.744
2032	0.000	0.003	0.000	0.003	0.641	0.088	0.000	0.000	0.729	0.000	0.732
2033	0.000	0.002	0.000	0.002	0.632	0.086	0.000	0.000	0.718	0.000	0.721
2034	0.090	0.002	0.000	0.092	0.624	0.084	0.000	0.000	0.708	0.000	0.801
2035	0.000	0.002	0.000	0.002	0.587	0.082	0.000	0.000	0.669	0.000	0.671
2036	0.000	0.002	0.000	0.002	0.579	0.080	0.000	0.000	0.659	0.000	0.661
2037	0.000	0.002	0.000	0.002	0.571	0.079	0.000	0.000	0.650	0.000	0.651
2038	0.061	0.002	0.000	0.063	0.565	0.077	0.000	0.000	0.642	0.000	0.705
Total:	1.742	0.076	0.000	1.818	14.626	1.987	0.000	0.000	16.613	0.000	18.431

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	1.278	0.169	0.000	0.000	1.447	0.000	3.244
2020	0.000	0.008	0.000	0.008	0.841	0.121	0.000	0.000	0.962	0.000	0.970
2021	0.000	0.007	0.000	0.007	0.820	0.118	0.000	0.000	0.938	0.000	0.945
2022	0.000	0.007	0.000	0.007	0.799	0.115	0.000	0.000	0.914	0.000	0.921
2023	0.000	0.006	0.000	0.006	0.779	0.112	0.000	0.000	0.892	0.000	0.898
2024	0.000	0.006	0.000	0.006	0.762	0.110	0.000	0.000	0.872	0.000	0.877
2025	0.000	0.005	0.000	0.005	0.746	0.107	0.000	0.000	0.854	0.000	0.859
2026	0.000	0.005	0.000	0.005	0.732	0.105	0.000	0.000	0.837	0.000	0.842
2027	0.175	0.004	0.000	0.180	0.719	0.103	0.000	0.000	0.822	0.000	1.001
2028	0.000	0.004	0.000	0.004	0.679	0.100	0.000	0.000	0.779	0.000	0.783
2029	0.000	0.003	0.000	0.003	0.662	0.098	0.000	0.000	0.760	0.000	0.763
2030	0.000	0.003	0.000	0.003	0.645	0.096	0.000	0.000	0.742	0.000	0.745
2031	0.000	0.003	0.000	0.003	0.630	0.094	0.000	0.000	0.724	0.000	0.727
2032	0.000	0.003	0.000	0.003	0.616	0.093	0.000	0.000	0.708	0.000	0.711
2033	0.000	0.002	0.000	0.002	0.604	0.091	0.000	0.000	0.695	0.000	0.697
2034	0.000	0.002	0.000	0.002	0.593	0.089	0.000	0.000	0.683	0.000	0.685
2035	0.082	0.002	0.000	0.084	0.584	0.088	0.000	0.000	0.672	0.000	0.756
2036	0.000	0.002	0.000	0.002	0.555	0.086	0.000	0.000	0.641	0.000	0.643
2037	0.000	0.002	0.000	0.002	0.542	0.085	0.000	0.000	0.627	0.000	0.629
2038	0.000	0.001	0.000	0.001	0.531	0.084	0.000	0.000	0.615	0.000	0.617
Total:	2.054	0.076	0.000	2.130	14.116	2.067	0.000	0.000	16.183	0.000	18.313

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	1.278	0.169	0.000	0.000	1.447	0.000	1.851
2020	0.000	0.002	0.000	0.002	1.228	0.157	0.000	0.000	1.385	0.000	1.387
2021	0.000	0.002	0.000	0.002	1.461	0.205	0.000	0.000	1.666	0.000	1.668
2022	0.000	0.002	0.000	0.002	1.457	0.208	0.000	0.000	1.665	0.000	1.667
2023	0.000	0.002	0.000	0.002	1.429	0.205	0.000	0.000	1.633	0.000	1.635
2024	0.000	0.002	0.000	0.002	1.367	0.194	0.000	0.000	1.561	0.000	1.563
2025	0.000	0.002	0.000	0.002	1.332	0.190	0.000	0.000	1.522	0.000	1.523
2026	0.000	0.001	0.000	0.001	1.302	0.186	0.000	0.000	1.488	0.000	1.489
2027	0.000	0.001	0.000	0.001	1.272	0.182	0.000	0.000	1.455	0.000	1.456
2028	0.000	0.001	0.000	0.001	1.243	0.179	0.000	0.000	1.422	0.000	1.423
2029	0.000	0.001	0.000	0.001	1.215	0.175	0.000	0.000	1.390	0.000	1.391
2030	0.000	0.001	0.000	0.001	1.187	0.172	0.000	0.000	1.359	0.000	1.359
2031	0.000	0.001	0.000	0.001	1.159	0.169	0.000	0.000	1.328	0.000	1.328
2032	0.000	0.001	0.000	0.001	1.132	0.165	0.000	0.000	1.297	0.000	1.298
2033	0.000	0.001	0.000	0.001	1.105	0.162	0.000	0.000	1.267	0.000	1.268
2034	0.000	0.001	0.000	0.001	1.080	0.159	0.000	0.000	1.238	0.000	1.239
2035	0.000	0.001	0.000	0.001	1.054	0.156	0.000	0.000	1.210	0.000	1.210
2036	0.000	0.001	0.000	0.001	1.029	0.152	0.000	0.000	1.182	0.000	1.182
2037	0.000	0.000	0.000	0.000	1.005	0.149	0.000	0.000	1.154	0.000	1.155
2038	0.000	0.000	0.000	0.000	0.981	0.146	0.000	0.000	1.128	0.000	1.128
Total:	0.405	0.022	0.000	0.427	24.315	3.481	0.000	0.000	27.796	0.000	28.224

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	1.278	0.169	0.000	0.000	1.447	0.000	2.730
2020	0.000	0.006	0.000	0.006	0.845	0.118	0.000	0.000	0.964	0.000	0.970
2021	0.000	0.005	0.000	0.005	0.832	0.115	0.000	0.000	0.947	0.000	0.952
2022	0.000	0.005	0.000	0.005	0.816	0.112	0.000	0.000	0.929	0.000	0.934
2023	0.000	0.005	0.000	0.005	0.802	0.110	0.000	0.000	0.912	0.000	0.916
2024	0.000	0.004	0.000	0.004	0.789	0.107	0.000	0.000	0.896	0.000	0.900
2025	0.000	0.004	0.000	0.004	0.777	0.104	0.000	0.000	0.882	0.000	0.886
2026	0.000	0.003	0.000	0.003	0.767	0.102	0.000	0.000	0.869	0.000	0.872
2027	0.000	0.003	0.000	0.003	0.758	0.100	0.000	0.000	0.858	0.000	0.861
2028	0.000	0.003	0.000	0.003	0.751	0.097	0.000	0.000	0.849	0.000	0.851
2029	0.000	0.003	0.000	0.003	0.746	0.096	0.000	0.000	0.842	0.000	0.844
2030	0.000	0.002	0.000	0.002	0.744	0.095	0.000	0.000	0.839	0.000	0.841
2031	0.000	0.002	0.000	0.002	0.748	0.095	0.000	0.000	0.843	0.000	0.845
2032	0.000	0.002	0.000	0.002	0.759	0.099	0.000	0.000	0.858	0.000	0.860
2033	0.000	0.002	0.000	0.002	0.778	0.105	0.000	0.000	0.883	0.000	0.885
2034	0.000	0.002	0.000	0.002	0.794	0.113	0.000	0.000	0.907	0.000	0.909
2035	0.000	0.001	0.000	0.001	0.789	0.114	0.000	0.000	0.904	0.000	0.905
2036	0.000	0.001	0.000	0.001	0.769	0.112	0.000	0.000	0.881	0.000	0.882
2037	0.000	0.001	0.000	0.001	0.749	0.109	0.000	0.000	0.858	0.000	0.859
2038	0.000	0.001	0.000	0.001	0.730	0.107	0.000	0.000	0.836	0.000	0.838
Total:	1.283	0.056	0.000	1.339	16.023	2.179	0.000	0.000	18.202	0.000	19.541

All costs are discounted at: 10.00 %

Section: 5_Armadi-Banau Road 500 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 5_R01T500

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	1.278	0.169	0.000	0.000	1.447	0.000	3.244
2020	0.000	0.008	0.000	0.008	0.841	0.121	0.000	0.000	0.962	0.000	0.970
2021	0.000	0.007	0.000	0.007	0.820	0.118	0.000	0.000	0.938	0.000	0.945
2022	0.000	0.007	0.000	0.007	0.799	0.115	0.000	0.000	0.914	0.000	0.921
2023	0.000	0.006	0.000	0.006	0.779	0.112	0.000	0.000	0.892	0.000	0.898
2024	0.000	0.006	0.000	0.006	0.762	0.110	0.000	0.000	0.872	0.000	0.877
2025	0.000	0.005	0.000	0.005	0.746	0.107	0.000	0.000	0.854	0.000	0.859
2026	0.000	0.005	0.000	0.005	0.732	0.105	0.000	0.000	0.837	0.000	0.842
2027	0.000	0.004	0.000	0.004	0.719	0.103	0.000	0.000	0.822	0.000	0.826
2028	0.000	0.004	0.000	0.004	0.706	0.101	0.000	0.000	0.807	0.000	0.811
2029	0.000	0.003	0.000	0.003	0.695	0.099	0.000	0.000	0.794	0.000	0.797
2030	0.000	0.003	0.000	0.003	0.685	0.097	0.000	0.000	0.782	0.000	0.785
2031	0.000	0.003	0.000	0.003	0.676	0.095	0.000	0.000	0.771	0.000	0.774
2032	0.000	0.003	0.000	0.003	0.669	0.093	0.000	0.000	0.762	0.000	0.765
2033	0.000	0.002	0.000	0.002	0.664	0.092	0.000	0.000	0.756	0.000	0.758
2034	0.000	0.002	0.000	0.002	0.660	0.091	0.000	0.000	0.750	0.000	0.753
2035	0.000	0.002	0.000	0.002	0.658	0.090	0.000	0.000	0.748	0.000	0.750
2036	0.000	0.002	0.000	0.002	0.660	0.091	0.000	0.000	0.751	0.000	0.752
2037	0.000	0.002	0.000	0.002	0.668	0.093	0.000	0.000	0.761	0.000	0.763
2038	0.000	0.001	0.000	0.001	0.687	0.099	0.000	0.000	0.786	0.000	0.788
Total:	1.797	0.075	0.000	1.873	14.904	2.101	0.000	0.000	17.005	0.000	18.877

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: Base Alternative

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	2.051	0.274	0.000	0.000	2.325	0.000	2.328
2020	0.000	0.000	0.000	0.000	2.113	0.286	0.000	0.000	2.399	0.000	2.399
2021	0.000	0.000	0.000	0.000	2.545	0.376	0.000	0.000	2.921	0.000	2.921
2022	0.000	0.000	0.000	0.000	2.490	0.369	0.000	0.000	2.860	0.000	2.860
2023	0.000	0.000	0.000	0.000	2.425	0.360	0.000	0.000	2.786	0.000	2.786
2024	0.000	0.000	0.000	0.000	2.361	0.351	0.000	0.000	2.713	0.000	2.713
2025	0.000	0.000	0.000	0.000	2.299	0.343	0.000	0.000	2.642	0.000	2.642
2026	0.000	0.000	0.000	0.000	2.239	0.335	0.000	0.000	2.574	0.000	2.574
2027	0.000	0.000	0.000	0.000	2.181	0.326	0.000	0.000	2.507	0.000	2.507
2028	0.000	0.000	0.000	0.000	2.124	0.319	0.000	0.000	2.443	0.000	2.443
2029	0.000	0.000	0.000	0.000	2.069	0.311	0.000	0.000	2.380	0.000	2.380
2030	0.000	0.000	0.000	0.000	2.016	0.304	0.000	0.000	2.320	0.000	2.320
2031	0.000	0.000	0.000	0.000	1.964	0.297	0.000	0.000	2.261	0.000	2.261
2032	0.000	0.000	0.000	0.000	1.914	0.290	0.000	0.000	2.204	0.000	2.204
2033	0.000	0.000	0.000	0.000	1.865	0.284	0.000	0.000	2.149	0.000	2.149
2034	0.000	0.000	0.000	0.000	1.818	0.278	0.000	0.000	2.096	0.000	2.096
2035	0.000	0.000	0.000	0.000	1.773	0.272	0.000	0.000	2.044	0.000	2.044
2036	0.000	0.000	0.000	0.000	1.729	0.266	0.000	0.000	1.995	0.000	1.995
2037	0.000	0.000	0.000	0.000	1.686	0.261	0.000	0.000	1.947	0.000	1.947
2038	0.000	0.000	0.000	0.000	1.645	0.256	0.000	0.000	1.901	0.000	1.901
Total:	0.003	0.000	0.000	0.003	41.308	6.158	0.000	0.000	47.466	0.000	47.469

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	2.051	0.274	0.000	0.000	2.325	0.000	2.730
2020	0.000	0.002	0.000	0.002	2.156	0.294	0.000	0.000	2.450	0.000	2.453
2021	0.161	0.012	0.000	0.174	2.466	0.359	0.000	0.000	2.825	0.000	2.998
2022	0.000	0.002	0.000	0.002	1.669	0.207	0.000	0.000	1.876	0.000	1.878
2023	0.000	0.002	0.000	0.002	2.008	0.282	0.000	0.000	2.291	0.000	2.292
2024	0.152	0.009	0.000	0.161	2.165	0.321	0.000	0.000	2.486	0.000	2.648
2025	0.000	0.002	0.000	0.002	1.582	0.200	0.000	0.000	1.782	0.000	1.784
2026	0.000	0.001	0.000	0.001	1.924	0.277	0.000	0.000	2.202	0.000	2.203
2027	0.114	0.007	0.000	0.121	2.034	0.306	0.000	0.000	2.340	0.000	2.462
2028	0.000	0.001	0.000	0.001	1.506	0.195	0.000	0.000	1.701	0.000	1.702
2029	0.000	0.001	0.000	0.001	1.839	0.271	0.000	0.000	2.109	0.000	2.110
2030	0.086	0.005	0.000	0.091	1.870	0.283	0.000	0.000	2.153	0.000	2.244
2031	0.000	0.001	0.000	0.001	1.435	0.192	0.000	0.000	1.628	0.000	1.629
2032	0.000	0.001	0.000	0.001	1.743	0.263	0.000	0.000	2.006	0.000	2.007
2033	0.065	0.004	0.000	0.068	1.747	0.268	0.000	0.000	2.015	0.000	2.084
2034	0.000	0.001	0.000	0.001	1.373	0.191	0.000	0.000	1.564	0.000	1.565
2035	0.000	0.001	0.000	0.001	1.648	0.254	0.000	0.000	1.902	0.000	1.903
2036	0.049	0.003	0.000	0.051	1.631	0.254	0.000	0.000	1.884	0.000	1.936
2037	0.000	0.000	0.000	0.000	1.318	0.190	0.000	0.000	1.509	0.000	1.509
2038	0.000	0.000	0.000	0.000	1.554	0.244	0.000	0.000	1.798	0.000	1.799
Total:	1.032	0.055	0.000	1.087	35.722	5.126	0.000	0.000	40.848	0.000	41.935

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	2.051	0.274	0.000	0.000	2.325	0.000	3.609
2020	0.000	0.008	0.000	0.008	1.356	0.192	0.000	0.000	1.548	0.000	1.556
2021	0.000	0.007	0.000	0.007	1.337	0.187	0.000	0.000	1.524	0.000	1.532
2022	0.000	0.007	0.000	0.007	1.315	0.183	0.000	0.000	1.498	0.000	1.505
2023	0.000	0.006	0.000	0.006	1.295	0.179	0.000	0.000	1.474	0.000	1.480
2024	0.000	0.006	0.000	0.006	1.278	0.175	0.000	0.000	1.453	0.000	1.459
2025	0.000	0.005	0.000	0.005	1.264	0.171	0.000	0.000	1.435	0.000	1.440
2026	0.193	0.005	0.000	0.198	1.253	0.167	0.000	0.000	1.421	0.000	1.619
2027	0.000	0.004	0.000	0.004	1.182	0.163	0.000	0.000	1.345	0.000	1.349
2028	0.000	0.004	0.000	0.004	1.167	0.159	0.000	0.000	1.327	0.000	1.331
2029	0.145	0.004	0.000	0.149	1.155	0.156	0.000	0.000	1.311	0.000	1.460
2030	0.000	0.003	0.000	0.003	1.087	0.152	0.000	0.000	1.239	0.000	1.242
2031	0.000	0.003	0.000	0.003	1.074	0.149	0.000	0.000	1.223	0.000	1.226
2032	0.109	0.003	0.000	0.112	1.062	0.146	0.000	0.000	1.209	0.000	1.320
2033	0.000	0.002	0.000	0.002	1.001	0.143	0.000	0.000	1.144	0.000	1.146
2034	0.000	0.002	0.000	0.002	0.989	0.140	0.000	0.000	1.130	0.000	1.132
2035	0.082	0.002	0.000	0.084	0.980	0.138	0.000	0.000	1.117	0.000	1.201
2036	0.000	0.002	0.000	0.002	0.925	0.135	0.000	0.000	1.059	0.000	1.061
2037	0.000	0.002	0.000	0.002	0.915	0.133	0.000	0.000	1.048	0.000	1.049
2038	0.061	0.002	0.000	0.063	0.907	0.131	0.000	0.000	1.038	0.000	1.101
Total:	1.873	0.077	0.000	1.951	23.595	3.273	0.000	0.000	26.868	0.000	28.818

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	2.051	0.274	0.000	0.000	2.325	0.000	4.122
2020	0.000	0.008	0.000	0.008	1.354	0.199	0.000	0.000	1.553	0.000	1.561
2021	0.000	0.007	0.000	0.007	1.320	0.195	0.000	0.000	1.515	0.000	1.523
2022	0.000	0.007	0.000	0.007	1.288	0.191	0.000	0.000	1.479	0.000	1.486
2023	0.000	0.006	0.000	0.006	1.259	0.187	0.000	0.000	1.446	0.000	1.452
2024	0.000	0.006	0.000	0.006	1.234	0.183	0.000	0.000	1.418	0.000	1.423
2025	0.000	0.005	0.000	0.005	1.212	0.180	0.000	0.000	1.392	0.000	1.397
2026	0.193	0.005	0.000	0.198	1.192	0.177	0.000	0.000	1.369	0.000	1.567
2027	0.000	0.004	0.000	0.004	1.130	0.173	0.000	0.000	1.303	0.000	1.307
2028	0.000	0.004	0.000	0.004	1.104	0.170	0.000	0.000	1.274	0.000	1.278
2029	0.000	0.003	0.000	0.003	1.079	0.168	0.000	0.000	1.247	0.000	1.250
2030	0.000	0.003	0.000	0.003	1.056	0.165	0.000	0.000	1.221	0.000	1.225
2031	0.000	0.003	0.000	0.003	1.038	0.163	0.000	0.000	1.201	0.000	1.204
2032	0.000	0.003	0.000	0.003	1.024	0.161	0.000	0.000	1.186	0.000	1.188
2033	0.099	0.003	0.000	0.102	1.013	0.160	0.000	0.000	1.173	0.000	1.275
2034	0.000	0.002	0.000	0.002	0.970	0.158	0.000	0.000	1.128	0.000	1.131
2035	0.000	0.002	0.000	0.002	0.957	0.157	0.000	0.000	1.114	0.000	1.116
2036	0.000	0.002	0.000	0.002	0.942	0.157	0.000	0.000	1.100	0.000	1.101
2037	0.000	0.002	0.000	0.002	0.939	0.158	0.000	0.000	1.096	0.000	1.098
2038	0.000	0.001	0.000	0.001	0.938	0.161	0.000	0.000	1.099	0.000	1.100
Total:	2.089	0.076	0.000	2.165	23.101	3.539	0.000	0.000	26.640	0.000	28.805

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	2.051	0.274	0.000	0.000	2.325	0.000	2.730
2020	0.000	0.002	0.000	0.002	2.156	0.294	0.000	0.000	2.450	0.000	2.453
2021	0.000	0.002	0.000	0.002	2.466	0.359	0.000	0.000	2.825	0.000	2.827
2022	0.000	0.002	0.000	0.002	2.425	0.355	0.000	0.000	2.780	0.000	2.782
2023	0.000	0.002	0.000	0.002	2.310	0.335	0.000	0.000	2.645	0.000	2.647
2024	0.000	0.002	0.000	0.002	2.250	0.327	0.000	0.000	2.577	0.000	2.579
2025	0.000	0.002	0.000	0.002	2.197	0.321	0.000	0.000	2.518	0.000	2.520
2026	0.000	0.001	0.000	0.001	2.146	0.314	0.000	0.000	2.460	0.000	2.462
2027	0.000	0.001	0.000	0.001	2.096	0.308	0.000	0.000	2.404	0.000	2.405
2028	0.000	0.001	0.000	0.001	2.046	0.302	0.000	0.000	2.348	0.000	2.349
2029	0.000	0.001	0.000	0.001	1.998	0.296	0.000	0.000	2.294	0.000	2.295
2030	0.000	0.001	0.000	0.001	1.951	0.290	0.000	0.000	2.241	0.000	2.242
2031	0.000	0.001	0.000	0.001	1.905	0.284	0.000	0.000	2.189	0.000	2.190
2032	0.000	0.001	0.000	0.001	1.860	0.279	0.000	0.000	2.139	0.000	2.140
2033	0.000	0.001	0.000	0.001	1.816	0.273	0.000	0.000	2.089	0.000	2.090
2034	0.000	0.001	0.000	0.001	1.773	0.268	0.000	0.000	2.041	0.000	2.042
2035	0.000	0.001	0.000	0.001	1.732	0.263	0.000	0.000	1.995	0.000	1.995
2036	0.000	0.001	0.000	0.001	1.691	0.258	0.000	0.000	1.949	0.000	1.950
2037	0.000	0.000	0.000	0.000	1.652	0.253	0.000	0.000	1.906	0.000	1.906
2038	0.000	0.000	0.000	0.000	1.614	0.249	0.000	0.000	1.863	0.000	1.864
Total:	0.405	0.022	0.000	0.427	40.137	5.903	0.000	0.000	46.040	0.000	46.467

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	2.051	0.274	0.000	0.000	2.325	0.000	3.609
2020	0.000	0.006	0.000	0.006	1.356	0.192	0.000	0.000	1.548	0.000	1.554
2021	0.000	0.005	0.000	0.005	1.337	0.187	0.000	0.000	1.524	0.000	1.530
2022	0.000	0.005	0.000	0.005	1.315	0.183	0.000	0.000	1.498	0.000	1.503
2023	0.000	0.005	0.000	0.005	1.295	0.179	0.000	0.000	1.474	0.000	1.479
2024	0.000	0.004	0.000	0.004	1.278	0.175	0.000	0.000	1.453	0.000	1.457
2025	0.000	0.004	0.000	0.004	1.264	0.171	0.000	0.000	1.435	0.000	1.439
2026	0.000	0.003	0.000	0.003	1.253	0.167	0.000	0.000	1.421	0.000	1.424
2027	0.000	0.003	0.000	0.003	1.246	0.164	0.000	0.000	1.410	0.000	1.413
2028	0.000	0.003	0.000	0.003	1.244	0.162	0.000	0.000	1.406	0.000	1.409
2029	0.000	0.003	0.000	0.003	1.251	0.162	0.000	0.000	1.413	0.000	1.416
2030	0.000	0.002	0.000	0.002	1.275	0.168	0.000	0.000	1.442	0.000	1.444
2031	0.000	0.002	0.000	0.002	1.317	0.181	0.000	0.000	1.498	0.000	1.501
2032	0.000	0.002	0.000	0.002	1.353	0.195	0.000	0.000	1.548	0.000	1.550
2033	0.000	0.002	0.000	0.002	1.345	0.198	0.000	0.000	1.543	0.000	1.545
2034	0.000	0.002	0.000	0.002	1.311	0.194	0.000	0.000	1.505	0.000	1.507
2035	0.000	0.001	0.000	0.001	1.278	0.190	0.000	0.000	1.468	0.000	1.470
2036	0.000	0.001	0.000	0.001	1.246	0.186	0.000	0.000	1.432	0.000	1.434
2037	0.000	0.001	0.000	0.001	1.215	0.182	0.000	0.000	1.398	0.000	1.399
2038	0.000	0.001	0.000	0.001	1.186	0.179	0.000	0.000	1.364	0.000	1.365
Total:	1.283	0.056	0.000	1.339	26.419	3.689	0.000	0.000	30.108	0.000	31.447

All costs are discounted at: 10.00 %

Section: 6_Armadi-Banau Road 800 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 6_R01T800

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	2.051	0.274	0.000	0.000	2.325	0.000	4.122
2020	0.000	0.008	0.000	0.008	1.354	0.199	0.000	0.000	1.553	0.000	1.561
2021	0.000	0.007	0.000	0.007	1.320	0.195	0.000	0.000	1.515	0.000	1.523
2022	0.000	0.007	0.000	0.007	1.288	0.191	0.000	0.000	1.479	0.000	1.486
2023	0.000	0.006	0.000	0.006	1.259	0.187	0.000	0.000	1.446	0.000	1.452
2024	0.000	0.006	0.000	0.006	1.234	0.183	0.000	0.000	1.418	0.000	1.423
2025	0.000	0.005	0.000	0.005	1.212	0.180	0.000	0.000	1.392	0.000	1.397
2026	0.000	0.005	0.000	0.005	1.192	0.177	0.000	0.000	1.369	0.000	1.374
2027	0.000	0.004	0.000	0.004	1.174	0.174	0.000	0.000	1.348	0.000	1.352
2028	0.000	0.004	0.000	0.004	1.158	0.171	0.000	0.000	1.329	0.000	1.333
2029	0.000	0.003	0.000	0.003	1.144	0.169	0.000	0.000	1.313	0.000	1.317
2030	0.000	0.003	0.000	0.003	1.134	0.166	0.000	0.000	1.300	0.000	1.303
2031	0.000	0.003	0.000	0.003	1.127	0.165	0.000	0.000	1.292	0.000	1.294
2032	0.000	0.003	0.000	0.003	1.124	0.163	0.000	0.000	1.288	0.000	1.290
2033	0.000	0.002	0.000	0.002	1.124	0.163	0.000	0.000	1.287	0.000	1.289
2034	0.000	0.002	0.000	0.002	1.137	0.164	0.000	0.000	1.301	0.000	1.303
2035	0.000	0.002	0.000	0.002	1.159	0.169	0.000	0.000	1.328	0.000	1.330
2036	0.000	0.002	0.000	0.002	1.207	0.182	0.000	0.000	1.390	0.000	1.391
2037	0.000	0.002	0.000	0.002	1.274	0.200	0.000	0.000	1.474	0.000	1.475
2038	0.000	0.001	0.000	0.001	1.294	0.209	0.000	0.000	1.502	0.000	1.504
Total:	1.797	0.075	0.000	1.873	24.967	3.682	0.000	0.000	28.649	0.000	30.521

All costs are discounted at: 10.00 %

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: Base Alternative

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.003	0.000	0.000	0.003	2.570	0.346	0.000	0.000	2.915	0.000	2.918
2020	0.000	0.000	0.000	0.000	2.776	0.384	0.000	0.000	3.160	0.000	3.160
2021	0.000	0.000	0.000	0.000	3.208	0.478	0.000	0.000	3.686	0.000	3.686
2022	0.000	0.000	0.000	0.000	3.124	0.466	0.000	0.000	3.590	0.000	3.590
2023	0.000	0.000	0.000	0.000	3.042	0.455	0.000	0.000	3.497	0.000	3.497
2024	0.000	0.000	0.000	0.000	2.963	0.444	0.000	0.000	3.407	0.000	3.407
2025	0.000	0.000	0.000	0.000	2.886	0.433	0.000	0.000	3.319	0.000	3.319
2026	0.000	0.000	0.000	0.000	2.811	0.423	0.000	0.000	3.234	0.000	3.234
2027	0.000	0.000	0.000	0.000	2.739	0.413	0.000	0.000	3.152	0.000	3.152
2028	0.000	0.000	0.000	0.000	2.668	0.404	0.000	0.000	3.073	0.000	3.073
2029	0.000	0.000	0.000	0.000	2.600	0.395	0.000	0.000	2.995	0.000	2.995
2030	0.000	0.000	0.000	0.000	2.535	0.386	0.000	0.000	2.921	0.000	2.921
2031	0.000	0.000	0.000	0.000	2.471	0.378	0.000	0.000	2.849	0.000	2.849
2032	0.000	0.000	0.000	0.000	2.409	0.370	0.000	0.000	2.779	0.000	2.779
2033	0.000	0.000	0.000	0.000	2.349	0.362	0.000	0.000	2.712	0.000	2.712
2034	0.000	0.000	0.000	0.000	2.292	0.355	0.000	0.000	2.647	0.000	2.647
2035	0.000	0.000	0.000	0.000	2.236	0.348	0.000	0.000	2.584	0.000	2.584
2036	0.000	0.000	0.000	0.000	2.183	0.341	0.000	0.000	2.524	0.000	2.524
2037	0.000	0.000	0.000	0.000	2.132	0.335	0.000	0.000	2.467	0.000	2.467
2038	0.000	0.000	0.000	0.000	2.083	0.329	0.000	0.000	2.412	0.000	2.412
Total:	0.003	0.000	0.000	0.003	52.078	7.846	0.000	0.000	59.924	0.000	59.927

All costs are discounted at: 10.00 %

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: I1_GRIM:Gravel Road Ideal Maintenance

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	2.570	0.346	0.000	0.000	2.915	0.000	3.320
2020	0.000	0.002	0.000	0.002	2.827	0.393	0.000	0.000	3.221	0.000	3.223
2021	0.189	0.013	0.000	0.202	3.141	0.463	0.000	0.000	3.604	0.000	3.806
2022	0.000	0.002	0.000	0.002	2.156	0.273	0.000	0.000	2.429	0.000	2.431
2023	0.000	0.002	0.000	0.002	2.624	0.379	0.000	0.000	3.003	0.000	3.004
2024	0.152	0.009	0.000	0.161	2.768	0.418	0.000	0.000	3.185	0.000	3.347
2025	0.000	0.002	0.000	0.002	2.052	0.267	0.000	0.000	2.318	0.000	2.320
2026	0.000	0.001	0.000	0.001	2.505	0.370	0.000	0.000	2.875	0.000	2.876
2027	0.114	0.007	0.000	0.121	2.544	0.386	0.000	0.000	2.930	0.000	3.051
2028	0.000	0.001	0.000	0.001	1.957	0.263	0.000	0.000	2.220	0.000	2.221
2029	0.000	0.001	0.000	0.001	2.374	0.359	0.000	0.000	2.733	0.000	2.734
2030	0.086	0.005	0.000	0.091	2.376	0.365	0.000	0.000	2.741	0.000	2.832
2031	0.000	0.001	0.000	0.001	1.873	0.261	0.000	0.000	2.134	0.000	2.135
2032	0.000	0.001	0.000	0.001	2.244	0.346	0.000	0.000	2.590	0.000	2.591
2033	0.065	0.004	0.000	0.068	2.218	0.346	0.000	0.000	2.563	0.000	2.632
2034	0.000	0.001	0.000	0.001	1.799	0.261	0.000	0.000	2.060	0.000	2.061
2035	0.000	0.001	0.000	0.001	2.115	0.333	0.000	0.000	2.448	0.000	2.449
2036	0.049	0.003	0.000	0.051	2.071	0.328	0.000	0.000	2.399	0.000	2.451
2037	0.000	0.000	0.000	0.000	1.740	0.261	0.000	0.000	2.001	0.000	2.001
2038	0.000	0.000	0.000	0.000	1.953	0.311	0.000	0.000	2.264	0.000	2.265
Total:	1.059	0.056	0.000	1.115	45.907	6.727	0.000	0.000	52.635	0.000	53.750

All costs are discounted at: 10.00 %

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

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: I2_DSTIM:DBST Road Ideal Maintenance

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	2.570	0.346	0.000	0.000	2.915	0.000	4.199
2020	0.000	0.008	0.000	0.008	1.699	0.243	0.000	0.000	1.941	0.000	1.949
2021	0.000	0.007	0.000	0.007	1.676	0.237	0.000	0.000	1.913	0.000	1.921
2022	0.000	0.007	0.000	0.007	1.651	0.232	0.000	0.000	1.883	0.000	1.890
2023	0.000	0.006	0.000	0.006	1.629	0.226	0.000	0.000	1.856	0.000	1.862
2024	0.000	0.006	0.000	0.006	1.612	0.221	0.000	0.000	1.833	0.000	1.839
2025	0.212	0.006	0.000	0.218	1.598	0.217	0.000	0.000	1.815	0.000	2.033
2026	0.000	0.005	0.000	0.005	1.510	0.212	0.000	0.000	1.721	0.000	1.726
2027	0.000	0.004	0.000	0.004	1.492	0.207	0.000	0.000	1.699	0.000	1.703
2028	0.159	0.004	0.000	0.164	1.477	0.203	0.000	0.000	1.680	0.000	1.844
2029	0.000	0.003	0.000	0.003	1.393	0.198	0.000	0.000	1.592	0.000	1.595
2030	0.000	0.003	0.000	0.003	1.378	0.195	0.000	0.000	1.572	0.000	1.576
2031	0.120	0.003	0.000	0.123	1.365	0.191	0.000	0.000	1.556	0.000	1.679
2032	0.000	0.003	0.000	0.003	1.288	0.187	0.000	0.000	1.475	0.000	1.478
2033	0.000	0.002	0.000	0.002	1.275	0.184	0.000	0.000	1.459	0.000	1.461
2034	0.090	0.002	0.000	0.092	1.265	0.181	0.000	0.000	1.446	0.000	1.538
2035	0.000	0.002	0.000	0.002	1.196	0.177	0.000	0.000	1.373	0.000	1.375
2036	0.000	0.002	0.000	0.002	1.186	0.175	0.000	0.000	1.361	0.000	1.363
2037	0.068	0.002	0.000	0.070	1.178	0.173	0.000	0.000	1.351	0.000	1.421
2038	0.000	0.001	0.000	0.001	1.117	0.170	0.000	0.000	1.286	0.000	1.288
Total:	1.932	0.078	0.000	2.010	29.555	4.174	0.000	0.000	33.729	0.000	35.739

All costs are discounted at: 10.00 %

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: I3_ASTIM:Asphalt Road Ideal Maintenance

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	2.570	0.346	0.000	0.000	2.915	0.000	4.713
2020	0.000	0.008	0.000	0.008	1.700	0.254	0.000	0.000	1.955	0.000	1.963
2021	0.000	0.007	0.000	0.007	1.660	0.249	0.000	0.000	1.909	0.000	1.917
2022	0.000	0.007	0.000	0.007	1.621	0.245	0.000	0.000	1.866	0.000	1.873
2023	0.000	0.006	0.000	0.006	1.587	0.240	0.000	0.000	1.827	0.000	1.833
2024	0.000	0.006	0.000	0.006	1.559	0.236	0.000	0.000	1.795	0.000	1.801
2025	0.000	0.005	0.000	0.005	1.534	0.233	0.000	0.000	1.767	0.000	1.772
2026	0.193	0.006	0.000	0.198	1.512	0.229	0.000	0.000	1.741	0.000	1.940
2027	0.000	0.004	0.000	0.004	1.431	0.225	0.000	0.000	1.656	0.000	1.660
2028	0.000	0.004	0.000	0.004	1.402	0.222	0.000	0.000	1.625	0.000	1.628
2029	0.000	0.003	0.000	0.003	1.376	0.220	0.000	0.000	1.596	0.000	1.599
2030	0.000	0.003	0.000	0.003	1.351	0.218	0.000	0.000	1.569	0.000	1.572
2031	0.000	0.003	0.000	0.003	1.340	0.217	0.000	0.000	1.557	0.000	1.560
2032	0.000	0.003	0.000	0.003	1.331	0.216	0.000	0.000	1.547	0.000	1.550
2033	0.099	0.003	0.000	0.102	1.325	0.216	0.000	0.000	1.541	0.000	1.643
2034	0.000	0.002	0.000	0.002	1.273	0.217	0.000	0.000	1.489	0.000	1.492
2035	0.000	0.002	0.000	0.002	1.264	0.221	0.000	0.000	1.484	0.000	1.486
2036	0.000	0.002	0.000	0.002	1.272	0.227	0.000	0.000	1.499	0.000	1.501
2037	0.000	0.002	0.000	0.002	1.297	0.240	0.000	0.000	1.537	0.000	1.539
2038	0.061	0.002	0.000	0.063	1.340	0.262	0.000	0.000	1.602	0.000	1.666
Total:	2.150	0.077	0.000	2.228	29.745	4.734	0.000	0.000	34.479	0.000	36.706

All costs are discounted at: 10.00 %

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: M1_GRMM:Gravel Road Minimal Maintenance

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	0.405	0.000	0.000	0.405	2.570	0.346	0.000	0.000	2.915	0.000	3.320
2020	0.000	0.002	0.000	0.002	2.827	0.393	0.000	0.000	3.221	0.000	3.223
2021	0.000	0.002	0.000	0.002	3.141	0.463	0.000	0.000	3.604	0.000	3.606
2022	0.000	0.002	0.000	0.002	3.077	0.456	0.000	0.000	3.533	0.000	3.535
2023	0.000	0.002	0.000	0.002	2.925	0.429	0.000	0.000	3.354	0.000	3.356
2024	0.000	0.002	0.000	0.002	2.850	0.419	0.000	0.000	3.269	0.000	3.271
2025	0.000	0.002	0.000	0.002	2.782	0.411	0.000	0.000	3.193	0.000	3.195
2026	0.000	0.001	0.000	0.001	2.717	0.403	0.000	0.000	3.120	0.000	3.121
2027	0.000	0.001	0.000	0.001	2.653	0.395	0.000	0.000	3.048	0.000	3.049
2028	0.000	0.001	0.000	0.001	2.590	0.387	0.000	0.000	2.977	0.000	2.978
2029	0.000	0.001	0.000	0.001	2.529	0.379	0.000	0.000	2.908	0.000	2.909
2030	0.000	0.001	0.000	0.001	2.469	0.372	0.000	0.000	2.841	0.000	2.842
2031	0.000	0.001	0.000	0.001	2.411	0.365	0.000	0.000	2.776	0.000	2.777
2032	0.000	0.001	0.000	0.001	2.355	0.358	0.000	0.000	2.713	0.000	2.714
2033	0.000	0.001	0.000	0.001	2.300	0.352	0.000	0.000	2.651	0.000	2.652
2034	0.000	0.001	0.000	0.001	2.247	0.345	0.000	0.000	2.592	0.000	2.592
2035	0.000	0.001	0.000	0.001	2.195	0.339	0.000	0.000	2.534	0.000	2.535
2036	0.000	0.001	0.000	0.001	2.145	0.333	0.000	0.000	2.479	0.000	2.479
2037	0.000	0.000	0.000	0.000	2.097	0.328	0.000	0.000	2.425	0.000	2.426
2038	0.000	0.000	0.000	0.000	2.051	0.323	0.000	0.000	2.374	0.000	2.374
Total:	0.405	0.022	0.000	0.427	50.932	7.597	0.000	0.000	58.529	0.000	58.956

All costs are discounted at: 10.00 %

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: M2_DSTMM:DBST Road Minimal Maintenance

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.283	0.000	0.000	1.283	2.570	0.346	0.000	0.000	2.915	0.000	4.199
2020	0.000	0.006	0.000	0.006	1.699	0.243	0.000	0.000	1.941	0.000	1.947
2021	0.000	0.005	0.000	0.005	1.676	0.237	0.000	0.000	1.913	0.000	1.919
2022	0.000	0.005	0.000	0.005	1.651	0.232	0.000	0.000	1.883	0.000	1.888
2023	0.000	0.005	0.000	0.005	1.629	0.226	0.000	0.000	1.856	0.000	1.860
2024	0.000	0.004	0.000	0.004	1.612	0.221	0.000	0.000	1.833	0.000	1.837
2025	0.000	0.004	0.000	0.004	1.598	0.217	0.000	0.000	1.815	0.000	1.819
2026	0.000	0.003	0.000	0.003	1.589	0.213	0.000	0.000	1.802	0.000	1.806
2027	0.000	0.003	0.000	0.003	1.587	0.210	0.000	0.000	1.797	0.000	1.800
2028	0.000	0.003	0.000	0.003	1.594	0.209	0.000	0.000	1.804	0.000	1.806
2029	0.000	0.003	0.000	0.003	1.621	0.214	0.000	0.000	1.836	0.000	1.838
2030	0.000	0.002	0.000	0.002	1.673	0.229	0.000	0.000	1.903	0.000	1.905
2031	0.000	0.002	0.000	0.002	1.731	0.251	0.000	0.000	1.982	0.000	1.984
2032	0.000	0.002	0.000	0.002	1.737	0.258	0.000	0.000	1.996	0.000	1.998
2033	0.000	0.002	0.000	0.002	1.694	0.253	0.000	0.000	1.947	0.000	1.949
2034	0.000	0.002	0.000	0.002	1.652	0.248	0.000	0.000	1.900	0.000	1.902
2035	0.000	0.001	0.000	0.001	1.612	0.244	0.000	0.000	1.855	0.000	1.857
2036	0.000	0.001	0.000	0.001	1.573	0.239	0.000	0.000	1.812	0.000	1.814
2037	0.000	0.001	0.000	0.001	1.537	0.235	0.000	0.000	1.772	0.000	1.773
2038	0.000	0.001	0.000	0.001	1.503	0.231	0.000	0.000	1.734	0.000	1.735
Total:	1.283	0.056	0.000	1.339	33.539	4.756	0.000	0.000	38.295	0.000	39.634

All costs are discounted at: 10.00 %

Section: 7_Armadi-Banau Road 1000 AADT

Alternative: M3_ASTMM:Asphalt Road Minimal Maintenance

Sect ID: 7_R01T1000

Road Class: Tertiary or Local

Length: 12.80 km

Width: 3.75 m

Rise+Fall: 38.75 m/km

Curvature: 3.00 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	1.797	0.000	0.000	1.797	2.570	0.346	0.000	0.000	2.915	0.000	4.713
2020	0.000	0.008	0.000	0.008	1.700	0.254	0.000	0.000	1.955	0.000	1.963
2021	0.000	0.007	0.000	0.007	1.660	0.249	0.000	0.000	1.909	0.000	1.917
2022	0.000	0.007	0.000	0.007	1.621	0.245	0.000	0.000	1.866	0.000	1.873
2023	0.000	0.006	0.000	0.006	1.587	0.240	0.000	0.000	1.827	0.000	1.833
2024	0.000	0.006	0.000	0.006	1.559	0.236	0.000	0.000	1.795	0.000	1.801
2025	0.000	0.005	0.000	0.005	1.534	0.233	0.000	0.000	1.767	0.000	1.772
2026	0.000	0.005	0.000	0.005	1.512	0.229	0.000	0.000	1.741	0.000	1.746
2027	0.000	0.004	0.000	0.004	1.493	0.226	0.000	0.000	1.719	0.000	1.723
2028	0.000	0.004	0.000	0.004	1.478	0.224	0.000	0.000	1.702	0.000	1.706
2029	0.000	0.003	0.000	0.003	1.468	0.222	0.000	0.000	1.689	0.000	1.693
2030	0.000	0.003	0.000	0.003	1.459	0.220	0.000	0.000	1.679	0.000	1.683
2031	0.000	0.003	0.000	0.003	1.463	0.219	0.000	0.000	1.682	0.000	1.685
2032	0.000	0.003	0.000	0.003	1.470	0.220	0.000	0.000	1.690	0.000	1.692
2033	0.000	0.002	0.000	0.002	1.484	0.222	0.000	0.000	1.707	0.000	1.709
2034	0.000	0.002	0.000	0.002	1.515	0.229	0.000	0.000	1.745	0.000	1.747
2035	0.000	0.002	0.000	0.002	1.587	0.248	0.000	0.000	1.835	0.000	1.837
2036	0.000	0.002	0.000	0.002	1.698	0.278	0.000	0.000	1.976	0.000	1.978
2037	0.000	0.002	0.000	0.002	1.754	0.301	0.000	0.000	2.055	0.000	2.057
2038	0.000	0.001	0.000	0.001	1.779	0.319	0.000	0.000	2.099	0.000	2.100
Total:	1.797	0.075	0.000	1.873	32.392	4.961	0.000	0.000	37.353	0.000	39.225

All costs are discounted at: 10.00 %

APPENDIX 6 : CHECKING GOODNESS OF FIT

Road No.	Observed Existing AADT (O)	Expected Threshold AADT (E)	$(O - E)^2$	$\frac{(O - E)^2}{E}$
1	13	47	1156	24.60
2	107	47	3600	76.60
3	66	47	361	7.68
4	190	73	13689	187.52
5	102	73	841	11.52
6	103	73	900	12.33
7	69	73	16	0.22
8	113	73	1600	21.92
9	120	73	2209	30.26
10	104	73	961	13.16
11	35	88	2809	31.92
12	29	88	3481	39.56
13	98	88	100	1.14
14	99	88	121	1.38
15	28	88	3600	40.91
16	121	104	289	2.78
17	188	104	7056	67.85
18	126	104	484	4.65
19	106	104	4	0.04
20	242	128	12996	101.53
			$\sum \frac{(O - E)^2}{E}$	677.55

Here,

Calculated $\chi^2 = 677.55$

Number of sample $n=20$

Degree of Freedom= $n-1=20-1=19$

Taking $\alpha=5\%$, tabulated χ^2 for 19 d.f is 30.144