ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

ASSESSMENT OF COST BENEFIT ANALYSIS BETWEEN ROADWAY AND CABLEWAY TRANSPORT MODES (A CASE STUDY FROM KOLADIT JUNCTION TO GISHEN MARIAM CHURCH)

A Thesis in Road And Transport

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A Thesis

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CERTIFICATION

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ABSTRACT

Ropeways are potential means of transport that are adaptable to the existing terrain, and an alternative transport solution for difficult topographical landscapes, manmade obstacles, for instance Rivers, lagoons and estuaries. Ropeway decrease environmental impact caused by road construction and energy efficient than most transport systems and can be used in urban transport system to overcome the city traffic by installing intermediate towers.

Before 19th centuries, in Ethiopia, China, Japan, Brazil, Newzland and India used traditional cable car transport. Now a days, modern cable care were emerging specially in Latin America, people were using cable car to connect unsuitable terrain type with human or man-made berries and provide new perspective for viewing scenery as recreational activities. The maximum capacity of the existing cable cars is 4000 person per hr with maximum speed of 43.2km and the basic component of the Arial cable car is cabin, a driver, returned terminal, towers and ropes.

The objective of this research is to explore an alternative means of transportation mode for the road segments from Koladit junction to Gishen Mariam church. This section of the road is found in a very difficult terrain with combination of steep gradient and winding sharp curves to tackle escarpments and mountainous terrain. The problem of transportation will not be solved only by constructing road up to the church from Koladit junction, but also by introduction of other means of transportation that is suitable for its terrain type.

After collecting primary and secondary data from site during field visit, qualitative and quantities, methods adopted to analysis the data. The site visit were made on one of the peak season from between March 17, 2021 up to March 21, 2021 while the Meskel celebration was on March 19. Generally, 55.49% and 64.67% of the pilgrims and peoples living around the route have an interest to use cable car respectively. This helps to estimate the number of people that will use the cable car after implementations and intern the number of users is used for fix the average fair price. The estimated traffic used for economic evaluation of both cable car and roadway are stated in the table below.

Table 0-1:- Estimated traffic for cable car

Descriptions	**L/Rover**	**S/Bus**	**L/Bus**	**Total**

Total AADT @2021 estimated by Beza Consulting	164	3	5	172
Percentage composition	95%	2%	3%	1
Total estimated traffic by local administration 20,000	19,070	349	581	20,000
Total Estimated traffic	61,023	3,349	16,278	80,651

Source:- Estimations

Table 0-2:- Estimated traffic for road user

Descriptions	Car	L/Rover	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	Truck & Trail	Total
Total AADT @2021	0	164	3	5	68	7	8	1	256
Percentage composition	0	64.06	1.17	1.95	26.5	2.73	3.125	0.39	100

Source:- Estimations and adopted from the BCE data base

Economic analysis has carried out using HDM-4 model (version 1.1). The model, which based on life cycle costing, used for assessing the costs and benefits of implementation technologies. Within this framework, two mutually exclusive project alternatives i.e. i) Construction of able car and ii) construction of road, have been considered for assessing the economic viability against the do nothing scenarios. Based on the traffic and engineering assessment, a comparison made between the construction of cable car and implementation of upgrading the existing road to asphalt Concrete road.

Summary results of the economic analysis presented in Table 0-3 below.

Table 0-3: Economic Analysis: Summary Results (Do-minimum versus With the Project Alternatives)

Scenarios	Construction of cable car	Construction of road way
Base Case		
IRR @ 10.23%	33.1%	26.8
NPV (In Million Birr)	18,851	220
Benefit Cost Ratio(B/C)	4.412	4.294
Cost Increased by 20 %		
IRR @ 10.23%	31.7	24.4
NPV (In Million Birr)	18,625	207
Benefit Cost Ratio(B/C)	4.367	3.599

Scenarios	Construction of cable car	Construction of road way
Benefits decreased by 20%		
IRR @ 10.23%	26.7%	23.5
NPV (In Million Birr)	13,716	163
Benefit Cost Ratio(B/C)	3.165	3.435
Cost Increased by 20% & Benefits decreased by 20%		
IRR @ 10.23%	26.0%	21.1
NPV (In Million Birr)	13500	150
Benefit Cost Ratio(B/C)	3.13	2.879

Source:- Out put from HDM4

The economic analysis, as well as overall engineering and traffic assessment show that both proposed technologies are economically worthwhile based on direct traffic benefits. However, the economic parameters of cable car is higher than the construction of road. In addition, users benefit for cable car: user cost savings including travel time is more viable than for the implementation of road. The EIRR of the project investment for cable car is 33.1%, which is higher than the EIRR of road construction. Even under the most pessimistic scenario of 20% increase capital cost and 20% decrease in project benefits, it yields an EIRR of 26.0% still higher value from the road construction (i.e., considering the cut-off rate applicable in Ethiopia is 10.23%). In addition, the fair price for transportation of cable car was estimated at an averagely price of 46.25birr per trip. For fair price analysis yearly pilgrim's growth rate and inflation rate was used.

This assessment revels that the installation of cable car on rugged terrain with man mad and natural barriers, with seasonal traffic, with limited right-of-way and with beautiful landscape areas, is more viable than construction of roadways. Hence, this research presents the cost benefit analysis between cable car and road way construction in the case of Koladit Junction to Gishen Mariam Church which is located in northern part of Ethiopia around 482 km from Addis Ababa.

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ABBREVIATION

BCK: Beza Engineering Kenya Limited

BCR: Benefit Cost Ratio

BDG: Bicable Detachable Gondolas

CO : Carbon Oxide

EIRR:-Economic internal rate of Retun

ERA: Ethiopian Road Authority

ETB: Ethiopian Birr

GDP: Growth Domestic Product

MT: Motorized Traffic

NF: Night Factor

NPV:- Net Present Value

NMT:- Non Motorized Traffic

NOx: Nitrogen Oxides and

NT: Normal Traffic

N: Nitrogen

P: phosphorus

PM: Particular Matter

SCF: Seasonal conversion Factor

TDG: Tricable Detachable Gondolas

VOC: Vehicle Operating Cost

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNWTO: United Nations World Tourism Organization

VOC: Vehicle Operating Cost

CHAPTER 1 INTRODUCTION

1.1 Background

Ministry of transport of Ethiopia prepared a Ten-year Development Plan (2013-2022), to ensure and modernizing logistics transformation by significantly improving modem transportation modes, traffic safety and management. In this plan, the government have included the introduction of a new technology, cable car, in Ethiopia. A Cable car is an eco-friendly type of transportation mode used for mass transit where rail cars (Cabins) are dragged by a continuously moving cable running at a constant speed. Individual cars stop and start by releasing and gripping this cable as required. Cable cars are different from funiculars, where the cars permanently attached to the cable and cable railways, which are similar to funiculars, but where the rail vehicles are attached and detached manually.

Ropeways are extremely adaptable to difficult terrain and represent an optimal transport solution for challenging topographical landscapes such as hilly terrains.[47] However, even on flat land, ropeways have the capacity to overcome many other types of natural and manmade obstacles, for instance rivers, lagoons and estuaries, harp ours, railways and motorways. In some areas, the cable car systems have emerged as an optimal way to connect informal settlements that were established over the past decades along steep slopes and hilly terrains and public transport supply is largely underdeveloped. The major potential of aerial ropeway systems is seen in the significant increase in accessibility between these settlements and other locations within the urban fabric, supporting social inclusion and access to work and education opportunities.[48]

The cable car is becoming more popular transport system struggle to keep up with booming construction and growing populations in the developing world. In Latin America, Cable cars are particularly common, where almost every city has expressed an interest in a cable car network. In 2004, Medellín introduced its cable car network to serve underprivileged hilltop neighborhoods, giving each line a letter and color – deliberately echoing the city's existing metro system.[49]

The reason that have really taken off in Latin America is the ease of construction over steep terrain. In many mountainous cities, where informal developments tend to be built on hilltops, bus-based public transit is often unreliable or unavailable to people living in those difficult terrain. In contrast, cable cars can slide effortlessly over these areas.

The construction of a cable car in Lagos, Nigeria, is nearly complete and the World Banks has approved a $175 million financing loan to construct one in Kampala, Uganda. [49]

Even though Ethiopia has multi-lateral problem regarding traffic jam and cost overrun on construction technologies, still introducing cable care technologies are under feasibility study.

One of the studies, which are taken currently by US based company name Doppelmayr to build a 5 to 7km length cable car on the outskirts of Addis Ababa. The solar powered cars can accommodate up to 35 people. They can perform the work of 200 buses in one hour. The company proposes building the car from Jemmo- Vatican, Klinto – Hayat, Legeatfao- Hayat and Bole Bulbula to Bole.

The study has demonstrated that roads construction produces significant adverse effects on environment and human health due to the discharge in atmosphere of pollutants released during the execution of the various construction processes (earthmovings, trucks transit on unpaved roads, crushing, and material production) and the operation of diesel-powered equipment. In additions, road construction at rugged terrain with dead end locations, will be very expensive than other means of transportation.

Installation of cable cars in Ethiopia, especially in places like Gishen Mariam Church can boost tourism which is located around mountainous terrain and with a beautiful land scape instead of constructing roads and disturb the landscape.

The road segment from Koladit junction up to Gishen Mariam church road has an existing road with 14km gravel with very difficult terrain. The start of segment 482km far from Addis Ababa and the elevation difference between the start of the road segments and the end of the road is around 1009 above mean sea level. Hence, geometrically departures will be introduced that will be very sensitive for safety and dangerous for environmental condition of the area. hence, this thesis mainly focuses on finding an alternative mode of transport along the section were manmade or nature barriers exist in general and compare cable care with that of roadway along Koladit junction up to Gishen Mariam in particular. Therefore, significance of this research is providing an alternative mode of transport for the segments that have difficult terrain other than upgrading the existing road to pavement standard. This will help policy makers and transport planes to consider cable car as an alternative transportation mechanism for the segments that have difficult terrain, dead end places, and isolated settlement and so on.

1.2 Problem Statements

Gishen Mariam church is one of the old traditional churches that have high seasonal tourise traffic. The pilgrimage is made four times a year resulting high human traffic congestion along difficult terrain

. The church is found one of the highest mountains in Ethiopia call Amba Geshen Mountain. The church is accessed with 14km gravel road that has combination of steep gradient and sharp curves in escapement terrain that is diverted from Dessi Kutaber asphalt road. The profile shows that the elevation difference between the start of the road upto the end of the road is around 1009m above mean sea level and existing road has a width if 7 meter and most of the travelers were coming for religious celebration.

Currently, because of high traffic and unsafe condition of the 14km road, the government of Ethiopia has a plan to construct the road to asphalt standard with an investment cost of Birr 94 million per kilometer which amounts to about Birr 1.3 billion. Hence, based on some country's experience around the world with similar terrain and tourist attraction, an alternative mode of transport with less land acquisition and less travel time. In addition, landscape should be protected and not sacrificed in favor of increasing access. Instead, there should be a way of preserving the landscape as well as create access to historical and religious places.

Four times in a year, the area will experience a tremendous traffic for religious celebration. According to the woreda administration, because of difficult terrain with narrow width, traffic accidents were occurred on every celebrations, hence in order to overcome accidents, only changing the existing road from unsealed pavement type with paved standard but either widening the road with or find another mechanism to overcome the difficult terrain.

As shown in the figure 1.1 and 1.2, the existing road width 7m and at some place it will narrow to 5m and pass only one bus at a time and widening the road to standard is almost impossible at those locations. The figure illustrates the transversal direction of the landscape makes the construction work very difficult and makes the construction work expensive.

Figure 1-1 location of existing road

Figure 1-2 location of existing road

Hence, with the problem of environments and safety by construction of asphalt road will not ensure mobility of the peoples and pilgrims. Hence, an alternative mode of transport shall be assessed for the road segments from Koladit junction to Gishen Mariam church.

The significance of this research is instead of upgrading the existing road that have terrain constraints with seasonal traffic, other means of transport shall be considered.

1.3 Objective of the study

1.3.1 General Objective

The main objective of this study is to explore an alternative means of transportation mode other than construction of a road on difficult terrain or along barriers (man kind or natural). The existing road to Gishen Mariam Church, from Koladit to Gishen Mariam section, has taken as a case study to find /explore an alternative means of transportation mechanism and to draw a conclusion for better means of transportation on unsuitable terrain.

1.3.2 Specific Objectives

Specifically, the research tries to address the following objectives:

i. To assess the traffic demand along the project road from Koladit Junction to Gishen Mariam and its potential source of traffic;

ii. To assess the advantages and disadvantages of the construction of both the cable car and the road way;
iii. To conduct comparative Cost and benefit analysis between cable car and roadway
iv. Recommend the most viable mode for consideration by pertinent policy makers.

1.4 Research question

This proposal tries to address the following research questions:

- What types of transportation modes are currently common in the project area?
- What are the challenges of transport problems around this tourist attraction area?
- What kind of alternative shall we consider to alleviate transportation problems in Ethiopia?
- What are the problems that faced during upgrade of the existing roads specially mountains and escarpment section?
- Is cableway transport mode is feasible than roadway transport mode for this specific route from Koladit to Gishen Mariam?

1.5 Significance of Research

The results of the study will be of great benefit to the following:

- Can provide additional transport dimensions within the country and complementary solution that could help many isolated hillside residents access jobs and opportunities in the country.
- The result of the study will help the decision makers to have possible number of options on transportation system for comprehensive alternative planning process.
- Helps to provide information regarding cable car current practice in the world as well as in Ethiopia.
- In addition, tourism industries will have an alternative means of transportation for connecting tourism attraction areas.

1.6 Application and Limitation of the Study

The result of this study can be applied a cable way transportation mode to replace or to consider as an alternative with that of roadway transportation system around tourist attraction places, religious areas and places with difficult terrain type to construct roads.

The research will mainly focus on feasibility study to compare cableway with that of roadway construction on Koladit Junction to Gishen Mariam Church route which is located in northern part of Ethiopia around 482 km from Addis Ababa.

The cableway transportation mode is new to Ethiopian transportation mode. Hence, construction cost will be estimated in per Km adapting from some other countries that has already designed cableway transportation system and has similar characteristics with our location. In additions, feasibility study/cost benefit analysis made by HDM-4 however, software is manly designed for road constructions. Hence, for the study purposes it has been adjusted all inputs to suite for cable car construction.

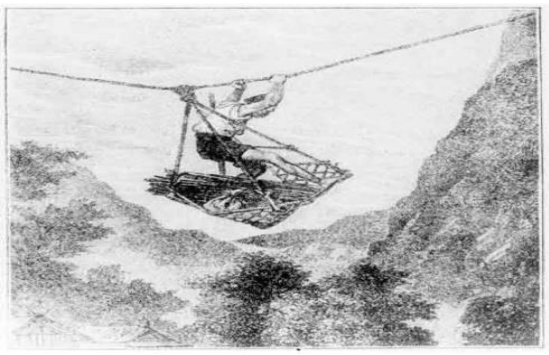
CHAPTER 2 LITERATURE REVIEW

2.1 History of cable car in the world

Before19th centuries, traditional means of transport which is ropeway were used like wood or woven from animal skin or plant fibers to pass rivers and gorges as show in the figure below.[17] Such early ropeways have been found in Ethiopia, China, Japan, Brazil, New Zealand, and Indian. In mid-19th, ropeway appeared as a modern transport mechanism and starts differentiated between passenger and cargo transportation. The first urban cableway was built in Lyon, France in 1862, where the three-car trains carried up to 324 people.[42]

From 1907, the experience acquired with the intensive use of similar systems for goods began to be applied to the construction of modern aerial cableways for passengers. In 1908, the first ropeway for passenger transportation in Central Europe, "Kohlernbahn" was built in Bozen, Italy, by Leinter. [42]

Since 2004 Colombian Medellin, "Metro cable" car was opened for traffic and then urban cable cars have grown in popularity around the world. Recent cable car projects mainly considered to serving those poor hillside neighborhoods, many of which were poorly connected to the rest of the city and underserved by conventional transport services. Connecting hilly areas to urban centers by aerial cable cars can bring considerable travel timesaving and other socio-economic benefits due to direct linkages and the absence of constraints from road traffic. This can be seen from recent projects in Medellín, Rio de Janeiro, Caracas, Guayaquil, Santo Domingo, La Paz, Yeosu, South Korea, Taiwan, Hong Kong, Cape Town and London. Sometimes especially places that have geographical barriers such as hills and rivers, Cable cars make other modes infeasible. [19]



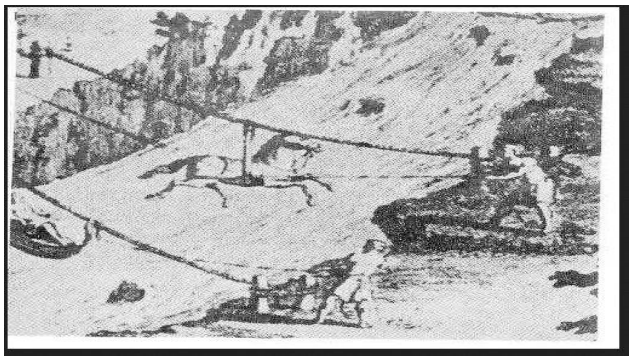


Figure 2-1 Traditional means of roadway in ancient times

Some of the world country's experience that has used an alternative means of transportation modes that could overcame difficult terrain type with high seasonal traffic are illustrated in the following sub section.

2.1.1 Venezuela's Mérida Cable Car

Venezuela's Mérida Cable Car is one of the second longer cable car with 12.5km long and was constructed before 40years and closed in 2008. After modernizing and fixing mechanical installation, a recent model of cable car was launched in October 2016 again. This cable car connects the city of Merida and the Espejo peak and create access along the rugged terrain. [43]

This cable car gives access to the most beautiful Venezuelan mountain, unique landscape in the world, and facilitate the movement of tourists.

Figure 2-2:-Venezuela's Mérida Cable Car

2.1.2 South Africa's, Table mountain Arial cable way

The Table Mountain Aerial Cableway is a cable car transportation system offering visitors a five-minute ride to the top of Table Mountain in Cape Town, South Africa. It is one of Cape Town's most popular tourist attractions with approximately one million people a year using the Cableway.[15]

At the top of Table mountain with an elevation of 1,067meters offers over view of Cape Town, Table Bay and Robben island north, and the Atlantic seaboard to the west and south


Figure 2-3 Cape Town, South Africa Cable Car

2.1.3 Switzerland, Stanserhorn Cable Car

The Stanserhorn is a mountain in Switzerland, located in the canton of Nidwalden near to the border with Obwalden, with the peak at 1,898 meters above sea level. It is a popular tourist destination, which can be reached from the adjacent town of Stans by a cable car, or via walking routes from Stans.


Figure 2-4 Stanserhorn, Switzerland

As shown in the above sub sections, Venezuela, south Africa and Switzerland installed cable car to connect isolated place and as the same time they have used the cable car as means of tourist attraction.

2.2 History of cable car in Ethiopia

It is difficult to get literatures regarding the history of cable car/rope way transportation system in relation to its past application in Ethiopia. In limited literatures, states that for centuries, pilgrims/tourist used leather rope to climb 15m cliff to reach to Debredamo monastery. Debre Damo monastery is situated on an isolated mountain in northern part of Tigray and only accessed by leather rope. Debre Damo was built, in the sixteenth century AD, with curved wood panels, painted ceilings

and walls dedicated to the legend of Saint (Abune) Aregawi.[21]. Hence, Ethiopian has a traditional cable car experience for centuries.

As shown in the figure below, this is the oldest cable way/ropeway transportation system used since 16th century and still peoples are using it to get to the monastery.

Figure 2-5 History of Rope way transportation system

Source: focusedcollection.com

Figure 2-6 Debre - damo monastery church

Source: africanarguments.org and focusedcollection.com

According to Solomon Yimer stated on eitho news, SWIG Railway Company presented the idea of building a commercial cableway to the Ethiopian Minister of Transport two years ago. According to the company, cable car construction has competitive advantages over railway and road construction method. Indeed, it significantly reduces the land use for roads and infrastructure and helps to access communities which are found on difficult terrain type. The company intends to finance the development of its project through public-private partnerships in which the public can invest. [22]

Currently, because of the expansion of cities, increasing in number of population, establishment of recreational areas on mountainous section, complication in ROW issues in towns might need cable car in the future.

2.3 Cable car purpose and use

Cable car transport is carried out using aerial cable cars, surface lifts, and funiculars (Doppelmayr 1997). With ski lifts and funiculars (or funicular railways), passengers are carried above ground level; with aerial cable cars, passengers are carried in the air.

Furthermore, cable way can provide the following services.

i. Transportation alternatives and traffic jam alleviation. Cable way systems can overcome landscape barriers and directly connect tourist attractions and major transportation hubs. They can also be used to create new transportation routes, effectively replacing and sharing the burden of existing roads, while expanding the capacity of transportation services.
ii. Connection services between recreational hotspots. Cable cars can systematically connect hotspots and recreational resources, thus saving time and travel costs between hotspots, increasing journey flexibility, and diversifying recreational activities.
iii. Outdoor scenery and recreation. Introducing cable cars can provide a completely new perspective for viewing scenery and enjoying recreational activities, enabling tourists to appreciate unique natural views and scenery from the air.
iv. Environmentally-acceptable electric drive and the possibility of transporting passengers above the ground, which can provide additional transport dimensions within urban centers.
v. No exhaust emissions
vi. Cable car speed limited to 12 m/s or 43,2 km/h with max capacity of 4000 person/h
vii. The problem of right of way will decrease drastically since the cable car will be above the ground
viii. Cable car systems can be applied to transportation of goods in addition to passengers.

2.4 Capacity of cable car

According to operating principles, aerial cable cars are divided into aerial tramways and gondolas. Aerial tramways (jig-back ropeways, reversible aerial ropeways) transport passengers using one or two cabins that move back and forth on cables. Their maximum speed is 12 m/s or 43.2 km/h.[44] With only two cabins, they can overcome greater inclines than gondolas, the span between the towers can be extraordinarily long (more than 1 km) so they can overcome major gaps and heights, and they are suitable for distances up to 3 km. The cabins stop completely at stations, so passengers have enough time to enter or exit. As only two cabins are available, they have small capacities (200 persons per

cabin, max. 2,000 persons/h), and the average waiting time of passengers at the station is longer; the times of entry and exit (stay times) also are longer than gondolas. Gondolas are uni-directional aerial cable cars with circulating vehicles (cabins). They consist of several cabins that can carry up to 30 persons each and have greater capacities than aerial cars, up to 4,000 persons/h. The speed is slower than aerial cars, with a maximum of 7 m/s for bi-cable gondolas and a maximum of 6 m/s for monocable gondolas.[44] Dwell times are shorter than aerial cars, as the cabins are smaller. Passengers do not need to wait for the vehicles at the station, as the vehicles constantly come and go. The spans between the towers are smaller than aerial tramways because there is more than one vehicle on the rope at a time and the lengths of gaps and precipices over which cabins can travel are smaller than for the aerial tramways. When at a station, cabins do not stand still but move slowly through the station, which can make it difficult for persons with disabilities and older adults to enter. Time of entry into the cabin is limited depending on the speed and length of the platform. Gondolas are the more suitable for public passenger transport, which requires maximum capacity. Aerial tramways are faster; the speed of a gondola—21–25 km/h—is less than the average speeds of buses in urban centers. The speeds of cable cars are low but, in the case of gondolas, the vehicles come constantly into stations and passengers do not need to wait.

2.5 Technology, Characteristics and Implementation

ART is a relatively new transit mode that is yet to be fully understood and documented in the research and professional communities. Therefore, it is important first to understand the characteristics and features of this technology, in order to later define its role and possible application areas. The main manufacturer of urban ART systems Doppelmayr/Garaventa Group, Leitner Technologies, and Poma Group. The basic components of any ART system include carriers (cabins), a drive and a return terminal, towers (to support ropes between terminals and stations), and ropes (which may be haulage or track ropes).

At the present time, ART technologies that have been used as mass transit modes in urban areas include five technologies:

- Aerial Tramways,
- Dual-Haul Aerial Tramways
- Monocable Detachable Gondolas (MDG),
- Bicable Detachable Gondolas (BDG) and
- Tricable Detachable Gondolas (TDG).

An aerial tramway consists of two passenger cabins that are suspended on a track rope and pulled by a haulage rope. These cabins typically, but not necessarily, reciprocate between terminals and pass each other midway on the cable span. In detachable gondola systems (i.e. MDG, BDG and TDG), the stations include an area where each gondola is detached from the ropeway; decelerated to a speed slow enough for boarding and disembarking; and then accelerated, allowing for the reattachment of the gondola's grip to the haulage rope. Safety systems include electronic monitors and mechanisms that automatically bring a gondola to a halt if the detachment or attachment of grips fails. The three types of detachable gondolas operate similarly; however, the BDG and TDG systems have one and two track ropes, respectively, and have improved stability and higher maximum speeds.

2.6 Mode of Transport Selection Criteria

Different transportation mode are exists around the world, and road transport has dominant position. Some of the criteria are used to select the mode of transport during pre-feasibility stage. Transport planners shall consider the following criteria's to select the suitable mode of transport for specific location. Some of the criteria's are stated below.

- Social
- economic activities of the area
- Cost (construction cost and running cost)
- Time (construction time and traveling time)
- Flexibility
- Environment: Terrain type
- Safety
- The number of traffic (passenger and goods)
- Other

2.6.1 Social (Demography, school and health center)

Number of People in transport project areas with their age limits must be considered to select the type of transportation mode, including the number of schools and health center must be identified.

2.6.2 Economy

Economic benefit to the area must be clearly identified to or selected the mode of transport. GDP contribution components like the amount of agriculture, industries like manufacturing and construction and service like tourist attraction place must be considered to select the type of mode of transport.

2.6.3 Environment

Ecosystems (forestry coverage, types of plant species, carbon emission, soil erosion, etc.) have to be identified to select mode of transport. Including the type of terrain along the project corridor must be identified before constructing the transportation mode or infrastructure.

2.7 Mode of Transport

Transportation or Transport is the movement of people, goods and animals from one location (origin) to another location (destination); could be horizontal, vertical or both. Transpiration must be safe, convenient comfortable convenient, cost effective and sustainability.

Hence, in order to create access and mobility, transportation modes are used all over the world. Some of the common transportation modes are road, railway, water, cable, and space. Transport modes are designed to carry either passengers or freight, but most modes can carry a combination of both. Different modes have varying processes and information requirements. This partly branches from different infrastructures, different capabilities for handling larger or smaller amounts of cargo, but also from different international, national and even local regimes for a specific mode.

2.8 Method to Select Mode of Transport

Cost benefit or Feasibility study will be taken to select the transportation mode using different models based on the type of traffic exited in the area. The following subsection illustrate the models

2.8.1 Traditional Method

Data are collected from Pertinent government offices at different levels, nationally and regionally; Farmers in project areas; and Development and research offices, nationally and regionally.

2.8.2 Red Model

RED Model is developed to improve the decision-making process for the development and maintenance of low-volume rural roads.

2.8.3 HDM-4 Vehicle Operating Costs Module

The approach in conducting economic feasibility studies of existing roads and the sources of benefits are generally, Vehicle operating cost savings, Time savings, Congestion costs savings, Accident costs savings, Environmental benefits, Social (health, education, etc) Savings Etc.

2.9 Method for Determining sample size

There are several approaches to determine the sample size such as

Census for small population:- this method use the entire population as sample and helps to eliminate sampling error. This method is expensive and provide data on all the individuals but and makes it impossible to use for larger population. This method would be very effective when the number of population is small less than 200.

Using a sample size of a similar study:- this method recommends to use same sample size as those of studies similar to the one we planned. This method has risk of repeating the errors that were made in determine the sample size for another study.

Using Published Tables:- this method relay on published tables which provide the sample size for the given set of criteria. These sample sizes reflect the number of obtained responses, and not necessarily the number of surveys mailed or interviews planned (this number is often increased to compensate for nonresponse).

- Using formulas to calculate a sample size:- different kinds formulas were applied to determine the sample size.

$n0 = (Z2pq)/e2)$……(1)

- Simplified formula for proportion:- Yamane provides a simplified formula to calculate sample sizes with the following formula. The formula stated in equation 2 below is Slovin's formula were n=size of the sample, N=Number of populations and e=error tolerance level

$n = N/(1 + N(e2))$……(2)

2.10 Impact of road construction on the environment

2.10.1 Effects on wildlife

2.10.1.1 Distraction of habitat

Roads can act as barriers or filters to animal movement and lead to habitat fragmentation. Many species will not cross the open space created by a road due to the threat of predation and roads also cause increased animal mortality from traffic. This barrier effect can prevent species from migrating and

recolonizing areas where the species has gone locally extinct as well as restricting access to seasonally available or widely scattered resources. [29]

The presence of roads also decreases the amount of habitat accessible to species. This is to say that it decreases the amount of usable habitat available to organisms without crossing a road. That being said, whether a habitat on the other side of the road becomes inaccessible to an organism or not varies between species. Roads are a permeable barrier to some organisms and impermeable to others. [32]

2.10.1.2 Effect on Birds

The traffic load near large cities may show dramatic cyclical changes induced by weekend tourism, and this could induce cyclical changes in the activity patterns of birds. Road implantation may also lead birds to avoid certain sites, as they are seen as being less habitable (because of increases in noise and chemical pollution). Certain bird populations may then become confined into smaller habitable sites, leading to an increase in possibility of extinction caused by illness or habitat perturbation. [30]

2.10.1.3 Facilitation of poaching of flora and fauna

Roads that run through forests that house edible animals may encourage or facilitate poaching. Especially in poor areas, the construction of roads has promoted not only poaching for personal consumption but also for sale (for consumption or as a pet) to third parties. Similarly, the construction of roads in forested areas has also promoted illegal logging as it becomes easier for illegal loggers to transport the wood.[31]

2.10.1.4 Roads as Barriers

Roads can impede animal movements by direct mortality or avoidance behavior. The barrier effect varies between species, road types, and adjacent habitat quality; however, traffic volume and speed strongly influence the effect. Some authors have suggested that divided highways with 90 m of cleared areas, as barriers are as effective as bodies of water twice as wide in obstructing dispersal of small forest mammals.[50]

The barrier effect for some species is less related to traffic than to habitat changes (road-forest edges and gap creation caused by roads). Small road clearances (less than 5 m) can impede movement of certain small mammals. Barriers to the movement of wildlife can lead to fragmentation of populations. Isolation caused by physical barriers to movement, such as roads, may reduce gene flow, thus causing genetic effects that in the extreme could result in local extirpation.

2.10.2 Effect on the quality of air

The air quality will be affected since the beginning of the road constructions by dust, noise and emission of gases from heavy equipment. Perhaps, Nitrogen Oxides (NOx), fine Particulate Matter (PM2.5), Volatile Organic Compounds (VOCs), Carbon Monoxide (CO), and Sulphur Dioxide (SO2) are the most common air pollutants emitted by vehicles. Then after the road complete and open to traffic, emissions include particulate emissions from diesel engines, NOx, volatile organic compounds, carbon monoxide and various other hazardous air pollutants including benzene. [33] Carbon dioxide is non-toxic to humans but is a major greenhouse gas and motor vehicle emissions are an important contributor to the growth of CO2 concentrations in the atmosphere and therefore to global warming. [35]

Noise pollution is a factor of environmental degradation that is often overlooked and typically seen as not having a significant effect, though traffic noise can contribute to numerous disturbances for wildlife. An increasing number of studies have been done on the effects of noise on wildlife. Both the sounds made by motors and the wind over moving vehicle structures, and the ultrasonic vibrations transmitted through the air and ground from vehicle passage can overlap with the frequency ranges and amplitudes used by animals for communication.[27]

2.10.3 Impact on water bodies

The surface water runoff and the groundwater close to a construction site become polluted with various materials used in the construction work. As described for air pollution above, the following construction contaminants can pollute the water: VOCs, paints, glues, diesel, oils, other toxic chemicals, and cement. The immediate effect is creating turbidity in the runoff water and affected surface and groundwater (since some of the runoff water may infiltrate in the subsurface reaching the groundwater.

De-icing chemicals and sand can run off into roadsides, contaminate groundwater and pollute surface waters. Road salts (primarily chlorides of sodium, calcium or magnesium) can be toxic to sensitive plants and animals. Sand can alter stream bed environments, causing stress for the plants and animals that live there. Several studies have found a definite difference in physical properties of waters between catchments or hydric systems immediately adjacent to roads compared with those in environments further away from the studied roads. De-icing chemicals, salt, chlorides and the nutrients brought by particulate pollution such as nitrogen (N) and phosphorus (P) can trigger trophic cascades in adjacent waterways.[36]

In fact, both ground waters below your home and surface runoff close to your home may constitute a source of pollution emanating from the construction sites. Domestic animals and pets may drink contaminated water and soil may become contaminated too. Additionally, once the groundwater below your home becomes contaminated, it may affect you in the following ways: through direct consumption if you use water from a property well, and indirectly by affecting the quality of your indoor air (vapor intrusion of the volatile contaminants from water). Overall, water pollution from construction sites is underestimated and has potential to generate severe environmental problems.

2.10.4 Impact on soil

Soil at and around a construction site may become contaminated due to air transport followed by deposition of construction contaminants (listed at air pollution) as well as water runoff of construction contaminants (as listed for water pollution). Soil may constitute a sink for pollutants and some of those may accumulate in soil and persist over longer periods of time (e.g., PAHs).

Landslides, Physical disturbance can disrupt ecological systems, and roads promote such disturbances. For example, roads in mountainous areas can create landslides due to unstable soil and steep slopes. Paved road surfaces can increase water discharge rates in watersheds, thus increasing the potential for landslides and flash floods in streams and rivers.

2.10.5 Local Climate Effects

Roads interact with climate at a wide range of scales. At local scales, highly developed areas (urban centers) have been shown to experience an increase in temperature in a process called the urban-heat-island effect. Urban heating can also result in increased rainfall. [22]

Roads change the albedo (fraction of light reflected by a surface) and other surface characteristics, but other structures, such as buildings, parking lots, and sidewalks, also contribute to heat-island effects.

Local climate might also be affected simply by the presence of roads and associated development. The loss of pervious surfaces and vegetation and their replacement with impervious surfaces that hold heat and do not respire result in localized temperature increases. Temperature increases can result in increased volatilization of organic contaminants from vehicular emissions.[38]

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

This research on cost benefit analysis between cable car and roadway is the aim to identify alternative means of transport mechanism for transportation corridors that have natural or man-made barriers in general and from Koladit junction up to Gishen Mariam Church in particular. Quantitative and qualitative methodologies has been utilized in researches in order to get a quantitative understanding of the interest of the people to use cable car or not and to identify the personal feelings and experience of respondents in the research process. This will enable the researcher to grasp perceived changes from the participants own view. The study will also employ quantities research methods for analysis of the road cost and benefits and number of road users based on secondary sources.

This chapter discusses the methodology used in order to achieve the objectives of the study and deals with the clear-over view about the study area, method of data collections and how the data was selected and organized. It also contains detailed discussion on assumptions made that helps to draw a conclusion.

3.2 Description of the study area

Finding alternative means of transportation was done on the road segments from Koladit junction to Gishen Mariam church that have very difficult gravel road with a combination of steep gradient and winding geometrical characteristics. The start of the project road is 482km away from Addis Ababa along Dessi kutaber asphalt road and then continue up to Gishen Mariam Church with 14km long. Gishen Mariam church located at easting of 539211.3503 and northing of 1273299.3829. The project road has a seasonal traffic and peoples are used 4 wheel drive and public transport. However, the dominant means of transport are non-motorized means of transport. The location of the existing road and the proposed alternative route for cable car construction are shown in the figure 3.1 below.

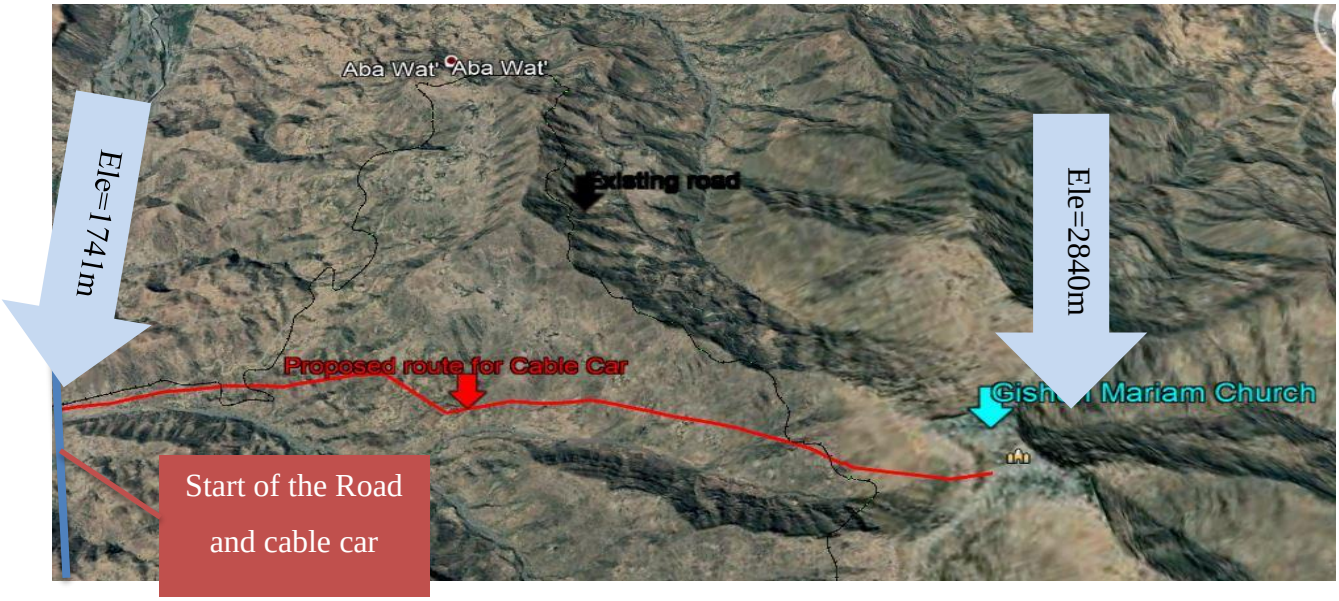


Figure 3-1:- The existing road and proposed route for cable car.

The proposed route for cable car, to overcome the difficult geometric characteristics, will be 6.52km of total length starting from Koladit to Gishen Mariam church in a different route from the existing road alignment.

As shown in the plan profile in Appendix 5, the Gishen Mariam church located 2,840m above mean sea level and the elevation difference from the start of the project road, which is Koladit junction up to Gishen Mariam church, is 1009m. In additions, the terrain classification shows dominantly mountainous and escarpment section.

3.2.1 Travel Time/Journey Time

During the site visit, journey time recorded along the existing road from Koladit Junction to Gishen Mariam Church and the recorded data are found in the table 3-1 below.

Table 3-1:- Journey time Recorded

Timing Segment	Distance, Km	Average Journey Time, min	Average Speed, Kph
Koladit Junction-Gishen Mariam Church	14km	42	20

Sourece:- Findings from site

As the table 3-1 above shows, the average speed along the project road is only 20km per hour and journey time is 0.7 hours. Traffic condition of the area

The project road is intended to connect one of the oldest church in Orthodox religion and the terrain type is very difficult. Hence, because of the difficulty of the terrain, the dominant mode of transport is 4WD and public transports as shown in the figure below. In additions, most of the peoples were using non-motorized mode of transport since public transport will be available during celebration days, which means four times a year.

Figure 3 2 :- Traffic composition of the area. Research Method

3.2.2 Geographic localization of the proposed route

Global Positioning System (GPS) were used to localization of the proposed line (from Gishen junction to Gishen) other than the existing gravel road. This route was selected based on topography of the area, the terrain classification of the road location and the characteristics of the traffic along the route. The proposed route starts at the junction name Koladit junction with the coordinate of X=536543.831 ,Y=1267590.407 and ends at the get of Gishen Mariam Church with the coordinate of X=539211.350 , Y=1273299.382 .

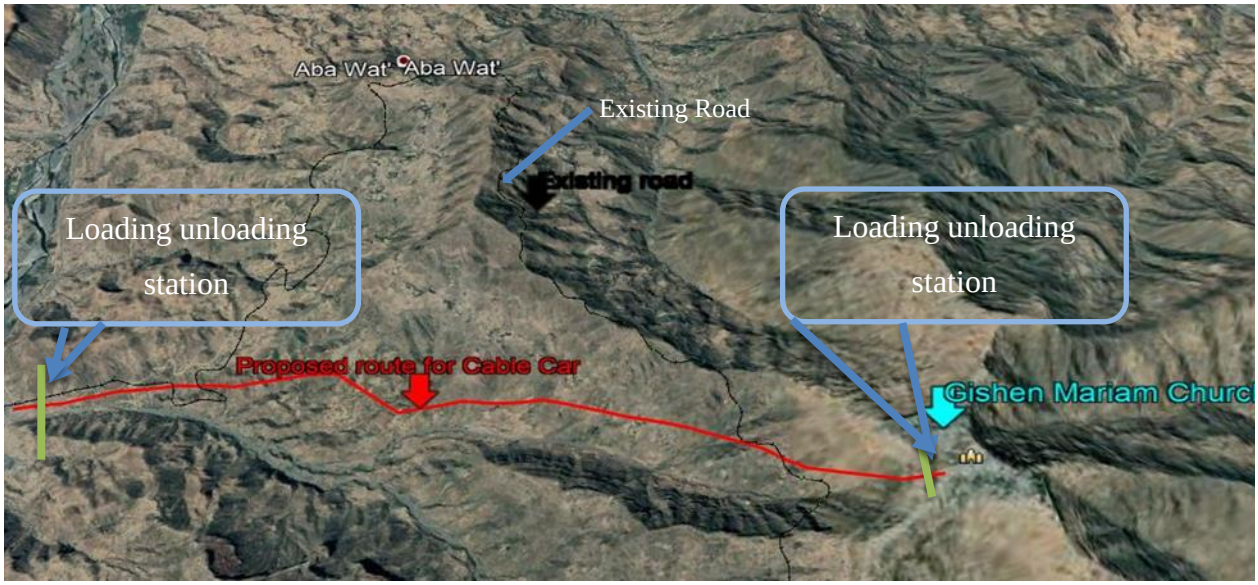


Figure 3-1:-Location of the area

3.3 Data source

The study involves both primary and secondary sources of data. The primary data was collected using qualitative approach with selecting random peoples and pilgrims for filling questioner. Four hundred twenty nine questioner were collected both from peoples living around the road corridors and from pilgrims. The major points of stated in the questioner is age, proximity, trip expectations, means of transport use to came to Gishen Mariam and their interest to use cable car after implementation. In addition, personal observation was also used as a source of primary data collection. This technique is believed to enable to collect more qualitative data as it helps to grasp information that cannot be obtained through interviews. Events observed include nature of road users, the area of parking lots, the location of market place and entrance of the church.

Collection of secondary data is another major source for the study. It involves books, research journals and articles, internet sources, different reports including different road project reports, woreda administration minutes of meetings, policies and manuals were gathered, reviewed and analyzed.

3.3.1 Data collection instruments

3.3.1.1 Questioner

In order to explore, experiences, interest and opinions of pilgrims as well as people living around the project road for using cable car or not is used by questioners. Out of the 427 individuals interviewed,

214 were pilgrims and 213 were peoples living around the area. This tool is used because it permits the researcher to explore the full facts and realities from those who have personally experienced it.

3.3.1.2 Key Informant on questioner

Questioners prepared and distributed randomly at four locations by four students recruited by the researchers during the site visit. On the questioners like age, education background, type of means of transportation used and their willingness to use cable car or not is included. As much as possible, the recruiters tries to distribute the questioners to represent all age group and picked from different mode of transport users. A structured questioner attached in Appendix 4.

3.3.1.3 Researcher's Observation

Field visit was made from March 17, 2021 up to March 21, 2021 to collect data, questioners and to appreciate the existing road condition as well as to identify the route for cable car installation. The traffic count was made on one of the peak season of the area among four peak seasons in a year. The field visit were planned considering "Meskel" celebration held on March 19 every year at Gishen Mariam church and peoples gathered to celebrate from all part of Ethiopia. A considerable amount of peoples were come for celebration, but according to the peoples living around, "Meskel" celebration was the only celebration that have minimum amount of people involved for celebration among four major celebrations.

During the field investigation, the following works were undertaken:-

- The existing roads were tracked
- Alternative routes were selected
- Questioners were distributed and collected,
- Interviews were taken,
- Meeting was held with local administrative and
- Traffic counts were taken

The field visits were done on one of the peak period among the four celebrations and the following points were observed:-

- The condition of the existing road is a very difficult and deteriorated road around 14km length with 7.0m width. Most of the road section passes through mountainous and escarpment.
- The landscape of the area were disturbed because of the road construction.

- Most of the peoples were came for religious purpose, hence there is no normal traffic, the existing traffic were seasonal traffic and the road is dead end.
- The project road has a difficult of parking area around the church. In addition, to expand the parking area it is very difficult because the project road has found at the ridge top.
- Shortage on public transportation was observed,
- According to the people living around Gishen Church, for October 1 celebration, getting out from church will take around one full day. As shown in the figure 3.5 and 3.6 the gates of the church from parking area is so narrow only one people can pass at a time.
- The existing road is under construction with total construction of 1,317,000,000 birr
- Based on the information from woreda peoples, the number pilgrims were decreased when compared to last year Meskel celebration. It might be due to COVID 19 and political situation of the area.

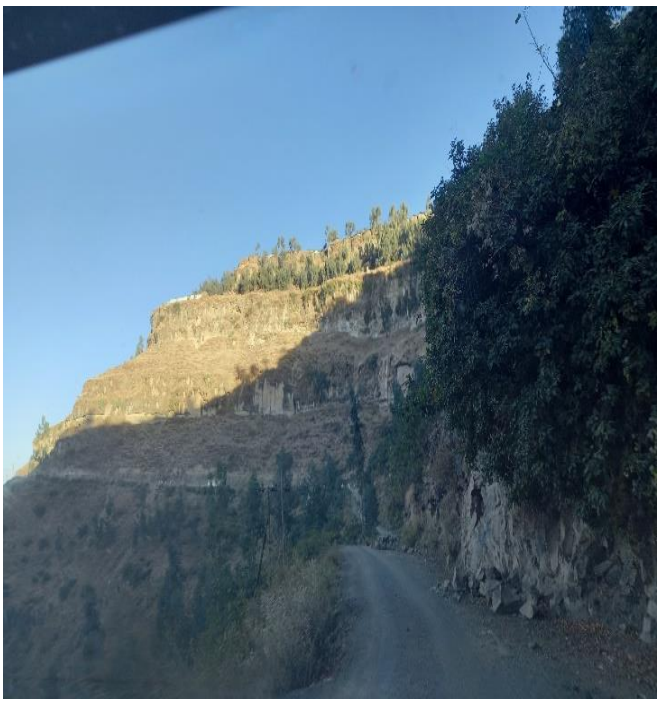


Figure 3-2 :- The condtion of the existing road

Figure 3-3:- the escarpment section of the road

Figure 3-4:- at the entrance of the Gishen Mariam and the location of parking areas.

Figure 3-5:- the entrance of Gishen Mariam

3.3.2 Method of Data Analysis

The qualitative information collected through questioners to assess the social aspects were categorized, checked and verified to identify regularities and patterns of different issues and problems. The interest of the people /pilgrims were fixed and make other questions as variables so that to identify the expectation of the respondent. Quantitative data obtained through different record and documents organized using appropriate format. Using qualitive and quantive data, economic evaluation is analyzed using conventional method. The study findings were presented in the form of narration, cases and tables. Pictures and maps are also provided to supplement the outcome of the study.

3.3.2.1 Determination of sample size

Among different method of determining sample size, Yamane formula/equation were selected to determine the sample size of the populations. Since our population is finite and sample size can be estimated using simplified equation illustrated on equation number 3. This formula used to calculate the sample sizes with 95% confidence level and with .5 precision.

$$n = N/(1 + N(e^2) \quad \text{..... (3)}$$

n= sample size, N= Population size and e= level of Precision.

$$n=20000/ (1+20000(0.05)^2$$

$$n=392 \quad \text{..... (3)}$$

For our research purpose, based on the woreda people administration, number of pilgrims for Meskel celebration is around 20,000 pilgrims. Hence, the sample size for questioner would be estimated 392 based on Yamane formula.

3.3.2.2 Questioners

Questioners were designed to determine the interest of the community including pilgrims coming for religious celebration regarding the use of cable car to avoid the difficulty of the road from Gishen junction to Gishen Mariam. The data used in the study is obtained from the replies given by the people living around the road and people coming for Meskel celebration on March 19. Hence, simplified formulas called Yemane's equation applied to estimate the total number of people interviewed from both the nearby area and people coming for religious celebration.

A total number of 427 people were interviewed for research that is more than estimated by Yemane's formula in section 3.4 and we have interviewed commuters and peoples living around the project road respectively during celebration with four encoders. Once the data was compiled in a excel file, it could be analyzed using ranking method. This sample size is considered sufficient to perform a ranking method. To ensure the validity and reliability of this research, only complete data on the variables necessary for this study will be used for the sample.

The results from this interview are discussed in detail in chapter 4. Asked how they can feel if cable car present/is brought: many people replied that it could be a better way of public transport (safe, no congestion and quick) but some of the people says they fear of flying/using aerial paths and some people were prefer to use difficult road for getting more blessing. In addition, some people may fear that it might be more expensive than usual buses and taxis.

3.3.2.3 Variables

For the specifics of this case, the response variable is the willingness of the people coming to Gishen Mariam for religious purpose as well as people living around the area to use a cable car, a score of the community would use it and the score of the community would not use it. In our survey, respondents living around the project road and pilgrims coming from different location were asked around 11 and 14 questions respectively. Among the questions, interest of the peoples to use a cable car, age, educations, occupation and proximity are involved.

Hence, the interest of the people to use a cable car would be linked with different variables like with age, education occupation, mode of transport, proximity, frequency road condition and trip expectation and so on and give different score to anticipate the social risk of the proposed alternative or means of transport.

The score or rank were given based on the importance of the factors or influential component to choose cable are or not. For example, age is one of the main factor that will influence the choose of transportation mode. Hence, the score shall be larger or according to my classification, it is very high influential. In addition, mode of transport, proximity and road condition also considered as very high influential factors. The following table shows the weightage given for each variables with its influential factors but the results will be discussed in the next chapter.

Table 3-2:-Influential factors for variables.

Influential factors

Description	Very High	High	Moderate	Low	Very Low
Rank/score	5	4	3	2	1

Table 3-3:-Score for all variables.

Number	**Variables**	**Score based on influential factors**
1	Age	5
2	Religion	2
3	Education	2
4	Occupation	2
5	Mode of Transport	5
6	Proximity	5
7	Purpose	3
8	Frequency	3
9	Road Condition	5
10	Trip Expectation	2
11	Interested in Coming Back	4

Each categories have its own subcategories and stated in the table below.

Table 3-4:- Sub categories for each variables

Number	Category	Score/Weight	Sub categories	Score
1	Age	5	0-18	1
			19-30	2
			31-42	4
			42-62	5
			63-70	5
			71-Above	5
2	Religion	2	Orthodox	2
			Muslim	2
			Catholic	2
			Protestant	2

			other	2
3	Education	2	Illiteracy	2
			Up to first grade(0-8)	2
			Up to second grade(9-12)	2
			Diploma and above	2
4	Occupation	2	Employee	2
			Merchant	2
			house wife	2
			other	2
5	Mode of Transport	5	Private car	2
			Public transport	5
			foot	5
6	Proximity	5	Around the project road	5
			outside the project road	5
7	Purpose	3	celebration for religious	3
			tourism	3
			family visit	3
			other	3
8	Frequency	3	first time	3
			second time	3
			third time and above	3
9	Road Condition	5	Excelent	1
			Very Good	2
			Good	3
			Bad	5
			Very Bad	5
			worest	5
10	Trip Expectation	2	car accident and problems	5
			tiredness	5
			nothing	2

11	Interested In Coming Back	4	returning back	4
			not returning back	3

3.4 Design principles of both Cable car and Roadway

3.4.1 Introduction

The project road is located in the Northern part of the country, and lies in Amhara Regional State of the Federal Democratic Republic of Ethiopia, particularly in South Wello Administrative Zone, and is entirely located in Ambassel Wereda, The project road starts at around 60km from Desse town on Desse-Kutaber-Wegel Tena road. The road passes through small villages and one Kebele. The total project length is estimated to be around 14km, plus 1.8km spur road and a total of 1.56 access roads to parking areas. In addition, the project includes four parking lots, which are going to part of the overall project. The proposed road construction is shown in the figure below with its design type

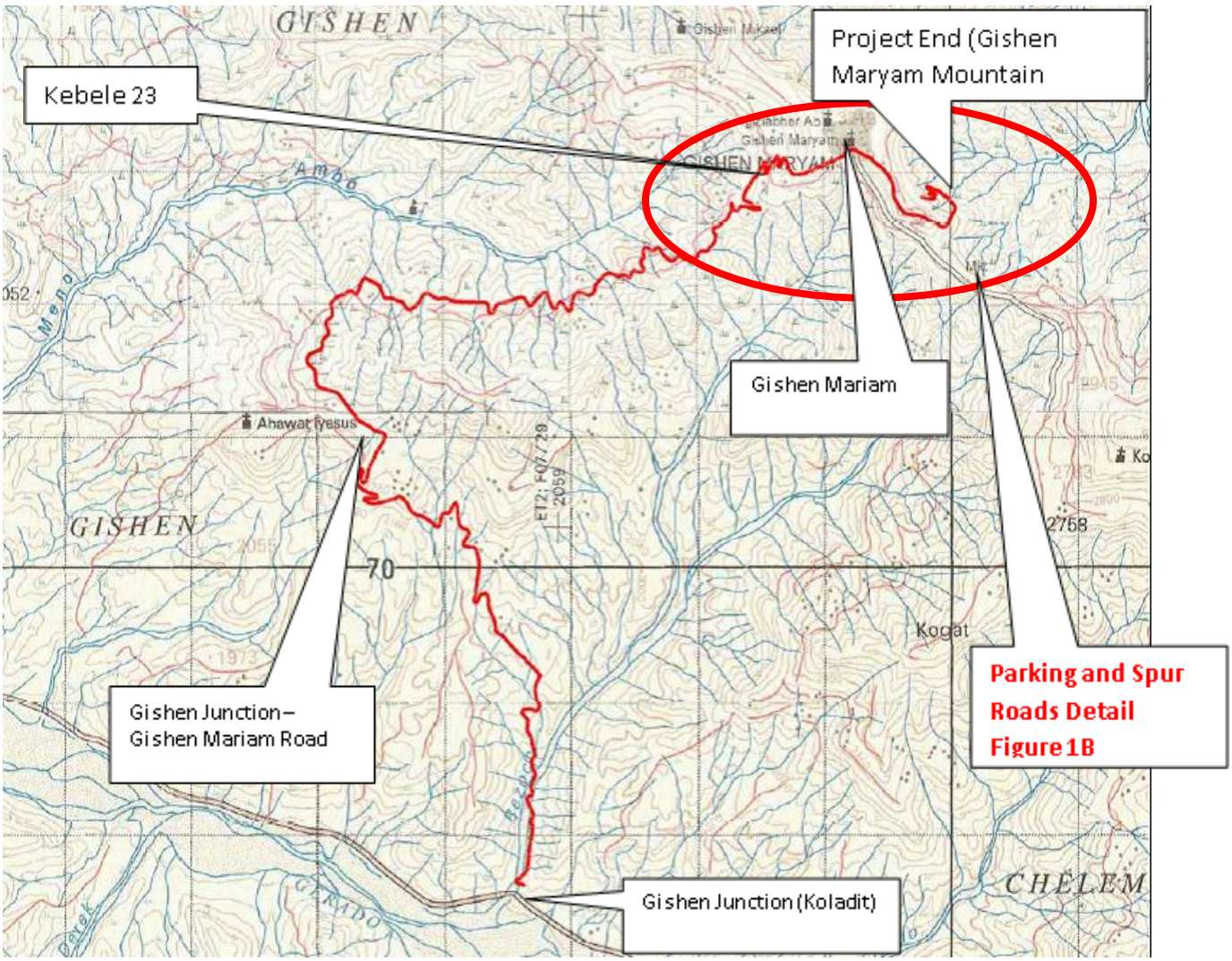


Figure 3-6:- Existing Road way

The total length of the proposed route for cable car is 6km as shown in the figure 3-7 below together with the existing road construction.

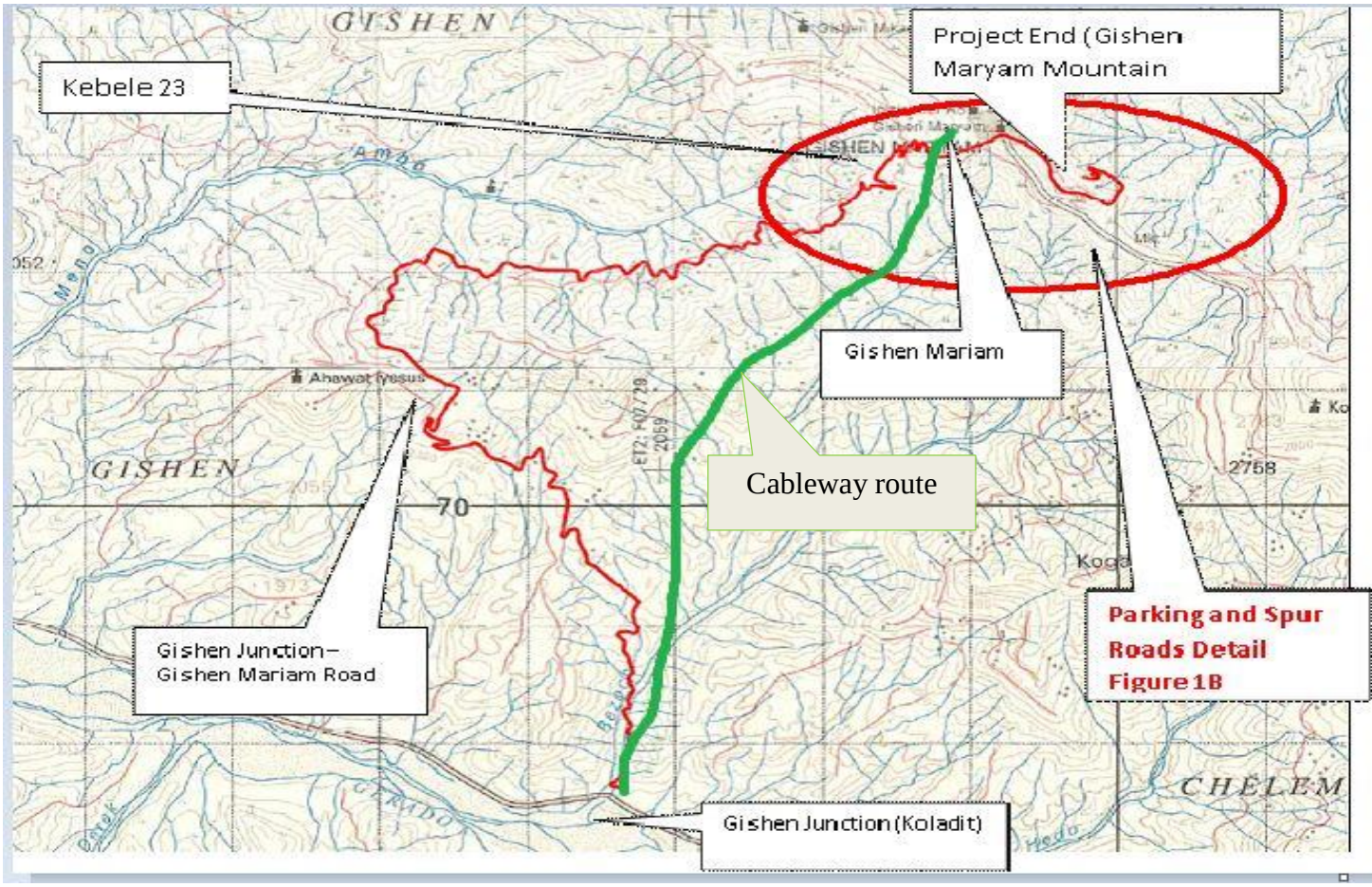


Figure 3-7:- Existing Road way

3.4.2 Proposed design

3.4.2.1 Road construction

According to the traffic study done by Beza consulting engineer's plc, DC 5 design standard was proposed for the road from Koladit junction to Gishen Mariam church. Hence, in the table 3-5 parameters estimated for DC 5 based on 2013 ERA Geometric design manual.

Table 3-5:- Parameters on design

No.	Description	Limiting values for design
1	Design Class	DC 5
2	Design Vehicle	DV 4
3	Road Functional Classification	Link
4	Present Road Condition	5m wide gravel road from Gishen Mariam Junction(Koladit) to Gishen Mariam Mountain

5	Type of Surfacing	AC for Carriageway and DBST for Shoulder
6	Proposed Carriageway width/cross fall	3.5m/2.5%
7	Shoulder surfacing/width/cross fall	DBST/1.5-0.5/4%
8	Proposed length	14km

3.4.2.2 Aerial cable car

Proposed Aerial cable road construction to connect two points from Koladit junctions to Gishen Mariam church is stated in the table 3-6 below.

Table 3-6:- Parameters on design

No	System Characteristics	Dual Haul Aerial Tramway
1	Aerial Cable car	Dual Haul Aerial Tramway
2	Cable Configuration	Cabins are suspended from two fixed cables and are pulled by another cable
3	Maximum Number of Passenger cabins	2 cabins
4	Maximum Number of station	Can have multiple stations
5	Maximum Distance between Towers	less than 1000m
6	Cabin capacity	High capacity(more than 100Pass/cabin)
7	Maximum Transport capacity	2800 Pass/hr.
8	Speed	Up to 29km/hr.

3.4.3 Estimated Cost

Both construction and maintenance costs are estimated for both cable car and roadway implementations. The method used to estimate the costs are illustrated in the following sections.

3.4.3.1 Estimation of construction cost of roadway

As stated in the table 3-5 above Link road with DC 5 design standard proposed to construct for project road. The cost estimates include earthwork and structural works. Civil work of the infrastructure, installation of cables for the car to hang and loading unloading stations. Hence, the bill of quantities for construction or installation of cable car attached in Appendix 3. Design of the roads were done by Beza consulting Engineers plc three years back and the researcher revised the design as well as total cost by the current market price and found 1,316,700,136.62 birr. Detail cost breakdown is attached in the Appendix 2.

3.4.3.2 Estimation of construction of Ariel cable car

As stated in the table 3-5 above dual aerial cable car proposed to construct for project road. Since it is a new technology for our country, the estimation of construction cost is a bit complex. However, a number of assumption made and illustrated as follows:-

- The design and Construction of intermediate supports and loading and unloading sections considered as piers. Hence, the researcher assumed two station, at the start and end of the route for loading and unloading station and six intermediate supports based on the actual site and the specification of Ariel cable car.
- The implementation of cables for holding the cabins adopted from the cost used to compare cable car with that of skyway construction from Ministry of transport.

Detail cost estimations for cable car attached in Appendix 2 with this report.

3.4.3.3 Estimation of maintenance and operating cost for roadway

Maintenance cost used for the economic evaluations of the expenditure is adopted the current road maintenance cost used by on force/ERA.

3.4.3.4 Estimation of maintenance cost for cable car

The maintenance and operating cost calculated as follows for the implementations of cable car for 20 years. We have adapted the average maintenance and operating cost from four countries by extrapolating the maintenance cost estimated using the number of cabin designed for route from the case study done by World Bank, urban transport specialist in 2020. [52]

The procedures are

- Prepare/select four countries from the case studies and that have similar GDP with our country.
- Convert the price of the maintenance and operating cost(USD) in a year to per km
- The price of maintenance per km is in USD than changed with the rate of 45 on date august 22,2021
- Then extrapolate maintenance and operating cost per km for Ethiopia using number of cable car cabins.

The following figure shows that the maintenance of cable car in Colombia, Brazil, Equator, Bolivia and extrapolate for our case.

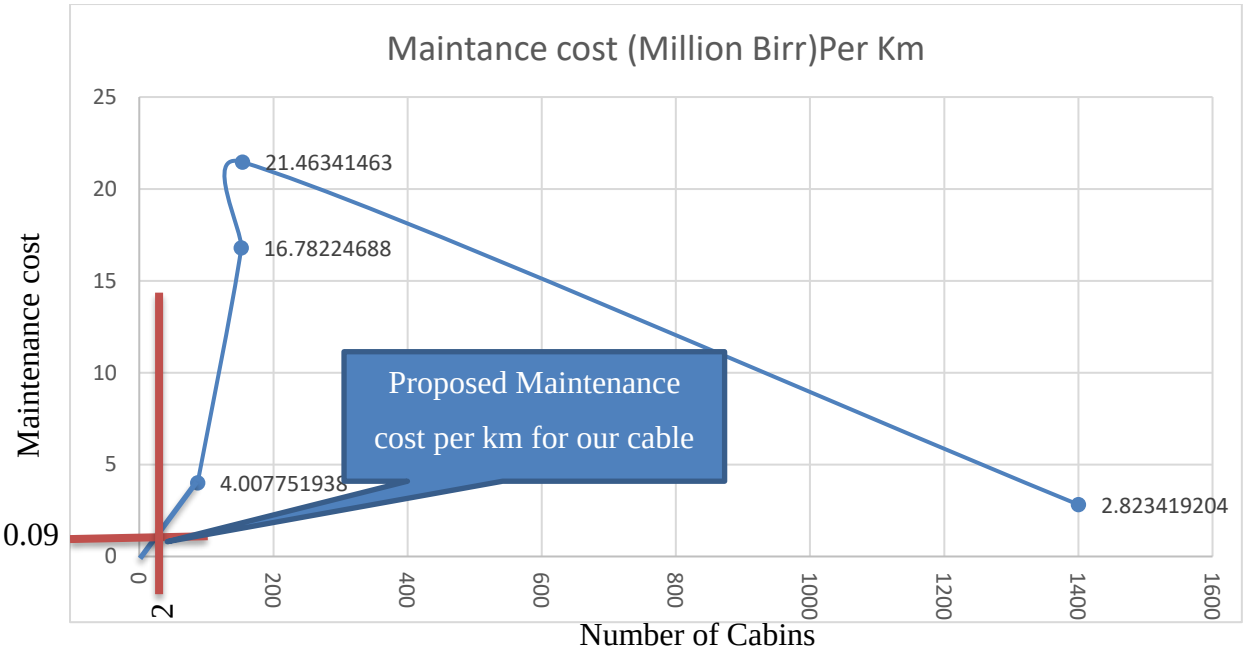


Figure 3-8:- Maintenance cost estimated

Table 3-7:- Maintenance and operating cost for four countries

	Open for Traffic	No of cars	Capacity (passenger/unit)	Speed (m/s)	Travel Time (min)	Capacity (passenger/hour/direction)	Length (km)	Maintance cost (Million USD)	Maintance cost (Million USD) Per Km in every year	Maintance cost (Million Birr) Per Km
Colombia, Manizales aerial cable car Colombia	2009	87	10	5	4.75	8500	2.58	0.235	0.091	4.01
Brazil	2011	152	10	5	17	2800	0.721	0.275	0.381	16.78
Equador	2020	154	10	5	20	40000	4.1	2	0.487	21.46
Bolivia	2014	1400	10	5	12.37	29000	30.5	1.957142857	0.064	2.82

Source:- urban transport specialist in 2020

Based on the above figure 3.8 and table 3.6 the maintenance and operating cost extracted for our cable car implementation and cost benefit analysis, the final output illustrated in the table 3.7 below.

Table 3-8:- Estimated Maintenance and operating cost for cable car

Description	Total Maintenance and operating cost	Maintenance and operating cost per km
Cable car from Koladit junction to Gishen Mariam Church.	617,285.93	92,132.23

Source:- Researcher Implementations.

3.4.3.5 Estimation of Tariff for Cable Car

Calculation of fair for the transportation of cable car shown in these subsections.

The procedures are

- Calculate total constriction cost and distribute for 20years.
- Estimate total maintenance cost for every year considering the overall inflation rate. As per statistics agency forecast, the inflation rate from 2022-2026 will be 8.04.[52]
- Sum up the capital cost and maintenance cost for each year
- Calculate the total number of traveler every year considering the growth rate of 2.6%. Growth rate estimated adopted from statistic agency.
- Then to get the fair price that can cover the expense, divide the summation of capital cost and maintenance cost by the number of Travers.

The following table will illustrate the procedure described above.

Table 3-9:- estimation of fair for the transposition of cable car

Year	Discounted Capital Cost	Maintenance cost	Total cost (Maintenance and Capital Cost)	Number of traveler	Fair price estimated
1.00	15564697.50	617285.93	16181983.43	288600.00	56.07
2.00	15564697.50	669137.95	16233835.45	296103.60	54.82
3.00	15564697.50	725345.54	16290043.04	303802.29	53.62
4.00	15564697.50	786274.56	16350972.06	311701.15	52.46
5.00	15564697.50	852321.62	16417019.12	319805.38	51.33
6.00	15564697.50	923916.64	16488614.14	328120.32	50.25
7.00	15564697.50	1001525.64	16566223.14	336651.45	49.21
8.00	15564697.50	1085653.79	16650351.29	345404.39	48.21
9.00	15564697.50	1176848.71	16741546.21	354384.90	47.24
10.00	15564697.50	1275704.00	16840401.50	363598.91	46.32
11.00	15564697.50	1382863.14	16947560.64	373052.48	45.43

Year	Discounted Capital Cost	Maintenance cost	Total cost (Maintenance and Capital Cost)	Number of traveler	Fair price estimated
12.00	15564697.50	1499023.64	17063721.14	382751.85	44.58
13.00	15564697.50	1624941.63	17189639.13	392703.40	43.77
14.00	15564697.50	1761436.73	17326134.23	402913.68	43.00
15.00	15564697.50	1909397.41	17474094.91	413389.44	42.27
16.00	15564697.50	2069786.79	17634484.29	424137.56	41.58
17.00	15564697.50	2243648.88	17808346.38	435165.14	40.92
18.00	15564697.50	2432115.39	17996812.89	446479.44	40.31
19.00	15564697.50	2636413.08	18201110.58	458087.90	39.73
20.00	15564697.50	2857871.78	18422569.28	469998.19	39.20
Average fair price adopted=					46.52

Source:- Researcher Implementations.

3.4.4 Estimation of Traffic Demand

3.4.4.1 Traffic for cable car

During the meeting with local peoples and the minutes of meeting signed by local administration and Beza Consulting Engineers Plc, a huge amount of seasonal traffic were encountered 4 times in a year and above 20,000 vehicles were recorded each day. The minuets of meeting with local peoples were attaché with this report in APPENDIX 01. Almost all peoples were coming for religious celebration since; Gishen Mariam is one of the oldest church in Orthodox thewahedo. In addition, the orthodox believes that going to Gishen Mariam considered as going to holy city of Cristian, which is Jerusalem and they thinks that Jesus cross were kept here. Moreover, the name of the Gishen Mariam church also called Dagme Eyerusalem in Amharic words, which means another Jerusalem in Ethiopia.

The procedure used for estimating traffic for Cable car is as follows

- Consider the traffic estimated by Beza Consulting engineer's plc to use it as reference for estimating percentage composition of each vehicles.
- Take in to consideration of percentage composition only for utility and public transportations.
- Multiply each vehicle composition by the total number of traffic estimated by the woreda administration.
- Then determine the number of peoples coming for celebration by the multiplying the loading capacity of each vehicles categories.

Table 3-10:- AADT for Gishen Mariam

Descriptions	**L/Rover**	**S/Bus**	**L/Bus**	**Total**
Total AADT @2021 estimated by Beza Consulting	164	3	5	172
Percentage composition	95%	2%	3%	1
Total estimated traffic by local administration 20,000	19,070	349	581	20,000
Total People traveled	76,279	4,186	20,349	100,814
55% of the total Pilgrims	41,954	2,302	11,192	55,448
25% of Pilgrims as shifted traffic	19,070	1,047	5,087	25,204
Total Estimated traffic	61,023	3,349	16,278	80,651

Source:- from Beza Consulting engineers PLC and Researcher estimation

For the research purpose, a number of assumptions were taken to model the financial statues of the alternative transportation mechanism.

- Pilgrims start coming to Gishen Mariam Church for religious celebration 4 days before the actual celebration day.
- Cable car technology were new to the country and their might be a huge amount of modal shift will be experienced after installation. Hence, 25% of uninterested pilgrims will divert from roadway to cableway construction after the cable car was installed.
- The percent of estimated pilgrims that are interested to use the cable car were adapted or estimated from questioner.
- Total estimated traffic were adopted from the meeting held by Beza consulting Engineers plc with local administrative on 2018.
- The rise and fall geometric design parameters that will be used in the HDM-4 are estimated the rise and fall of the cables that the cables is travelling
- The electric power will be used from Gishen substation, since 33kv lines exists
- Construction cost was adapted from Medellin cable car and modified to suit for our country and total cost of construction of cable car is estimated 65million per KM. This is a rough estimation and the cost of construction will be dependent on the condition terrain, climate conditions availability of spaces, structure engineering networks communication and so on. The detail estimated Bill of quantities are attached in Appendix 2.

CHAPTER 4 RESULTS AND DISSCUSSION

4.1 Social Assessment

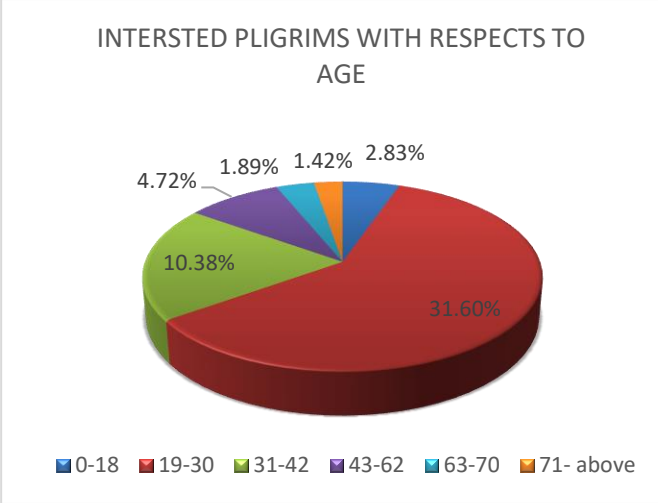
The descriptive statistic of the response variables shown in the following figures. The questioners were distributed among the people living around the area as well as pilgrims, it is important to evaluate if the type of affiliation is a significant variables to predict the probability of the willingness to take a possible aerial tramway. The questioner have 14 questions for pilgrims and 11 questions for the people living around the area. The questions tries to identify the age, religion occupation mode of transport used, proximity, purpose of travel, trip expectation and the interest to the people coming back and so on. Hence, the analysis was done by fixing the interest of using cable car with that of all variables like interest of the people-using cable car and with age, interest of using cable care with religion, the condition of the road and so on. The analysis for incorporating the willingness to take a possible cableway transportation mode will be illustrated in the following subsection.

4.1.1 Age related to interest of the people using cable car

Age group of respondents ranged from age of 18 up to 75 and we have categorized in two 5 sections. The searcher thinks that age is the main factor to choose the mode of transport hence; it has a score of 5 (very high).

As shown in the figure 4.1 among the pilgrims, 19-30 age groups are welling to use the cable care with total percentage of 31.6% and 13.21% were uninterested. Then age group of 31-42 were 10.38% is willing to use and 26.89% were not willing to use. In addition, in the figure 4.2 shows among the local peoples, age group, 31-42 and 19-30 age groups are welling to use the cable car with total percentage of 19.53% but 31-42 age groups, 10.7% were uninterested and with age group 19-30, 9.30% were uninterested. Then age group of 43-62, 7.44% is willing to use and 5.58% were not willing to use.

As the number shows 19-30 age group is more interested to use cable car, this is because this age group is very close to technologies and they are more willing to try new technologies than other age groups.



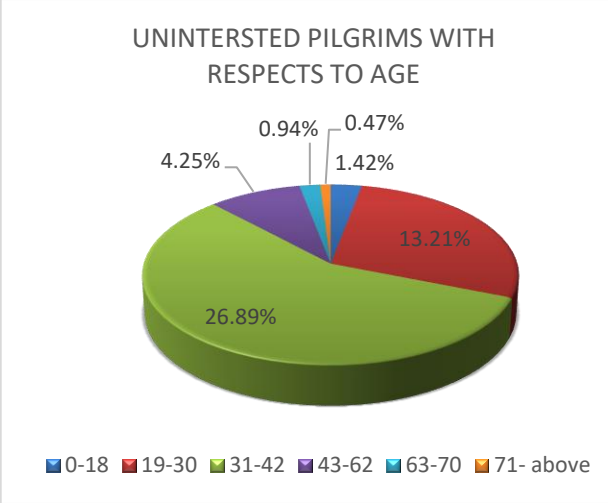
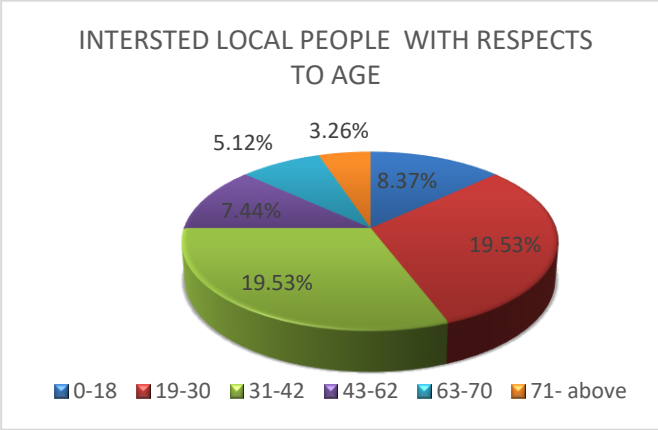


Figure 4-1 the interest of the pilgrims using cable car or not



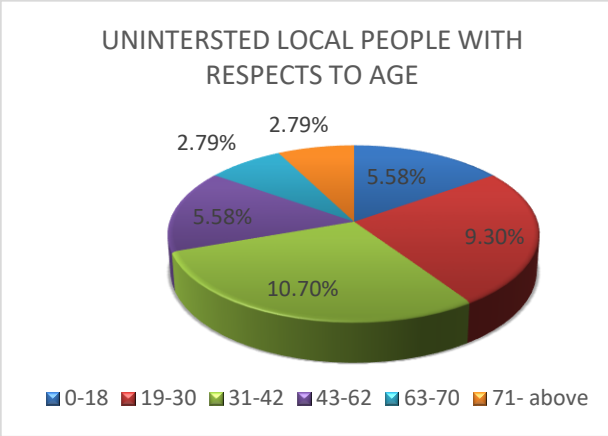
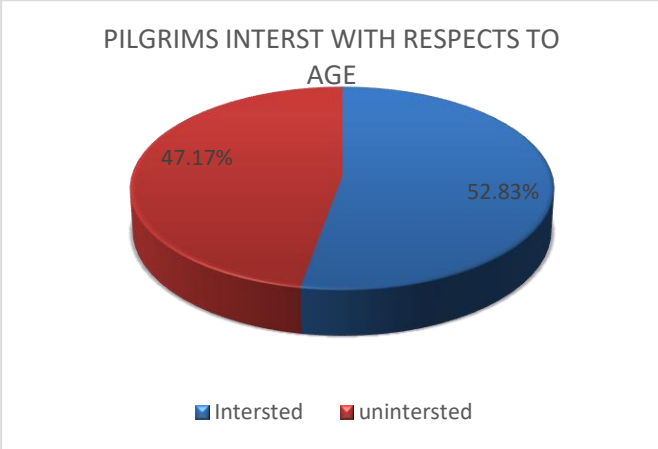


Figure 4-2 the interest of the local people using cable care or not



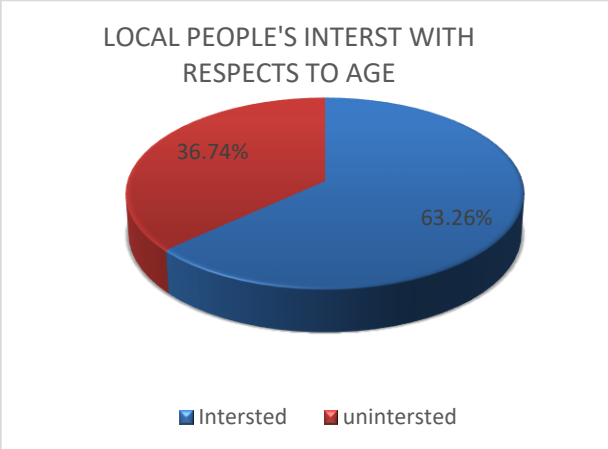


Figure 4-3 Total Percentage for using cable car or not**.**

As shown in the figure 4.3, all age groups were merged together and among the pilgrims, 52.83% were interested and 47.17% were not interested. Among the local people, 63.26 were interested and 36.74% were uninterested to use the cable car. This shows that if the cable are constructed and installed for the route from Koladit junction to Gishen Mariam Church as an alternative means of transportations modes in addition to the existing road.

4.1.2 Religion related to interest of the people using cable car

Religion is not a main factor for choosing cable car for traveling difficult terrain. Where the person is Orthodox or Muslim or other religion it does not affect the preference of choosing the cable car or not but it will help to understand the background of the road users. However, the religion variables used to identify the pilgrim's religion that was travel to Gishen Mariam Church and has the low score.

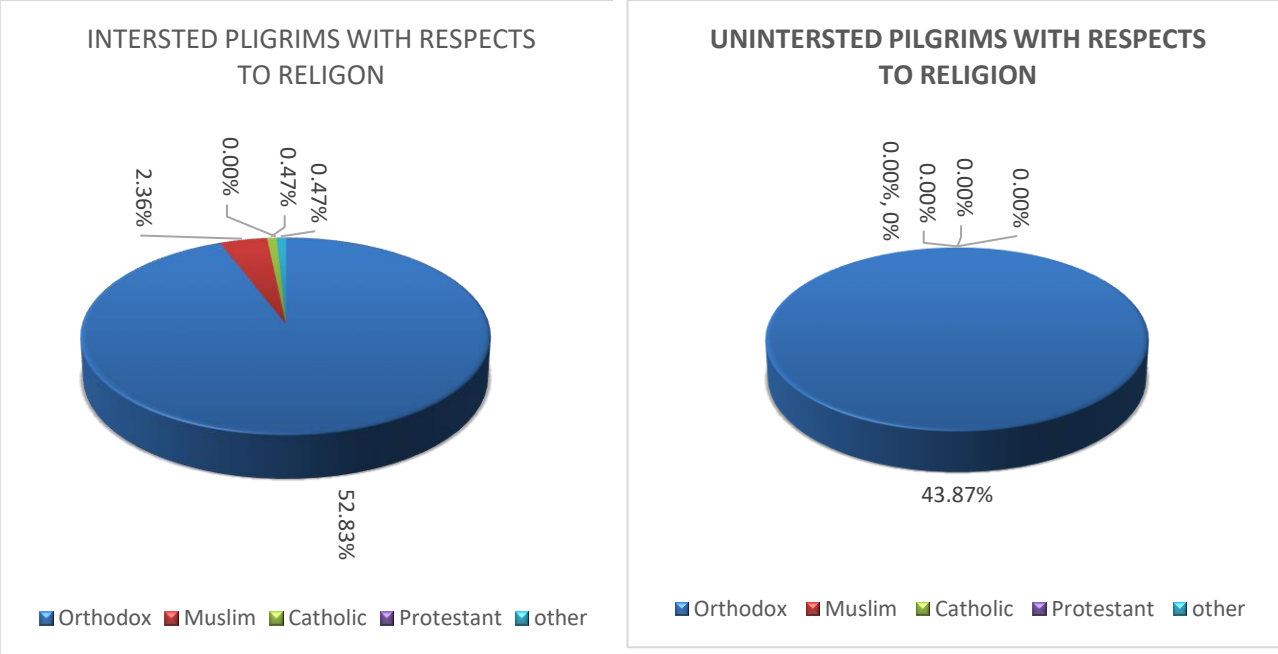


Figure 4-4 the interest of the travels with respects to their religion

As shown in the figure 4.4, majority of the pilgrim's religions were orthodox with the total travelers 52.83% were interested and 43.87% were not interested to use cable car.

Looking in to the collected questioner and filed observations, the researcher tires to explore the religious background of the people living around the route. Hence, among the interviewer, almost 96.7% were orthodox and 2.4% were Muslims. From the travelers, almost all Muslims were came for family visiting and most of the orthodox were came of Meskel celebrations.

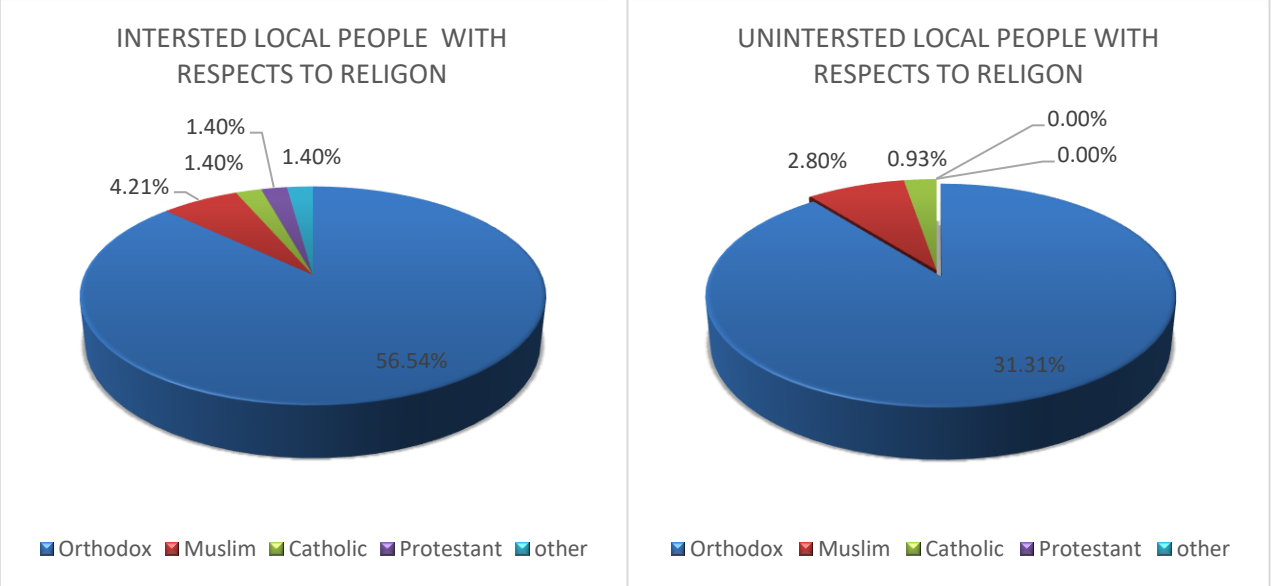


Figure 4-5 the interest of the local people with respects to their religion

As shown in the figure 4.5, among the local peoples, 56.54 orthodoxies were willing to use the cable car and 31.31% were not interested. Then Muslims local peoples with 4.2% and 2.8% were willing to use and were not willing to use the cable car respectively.

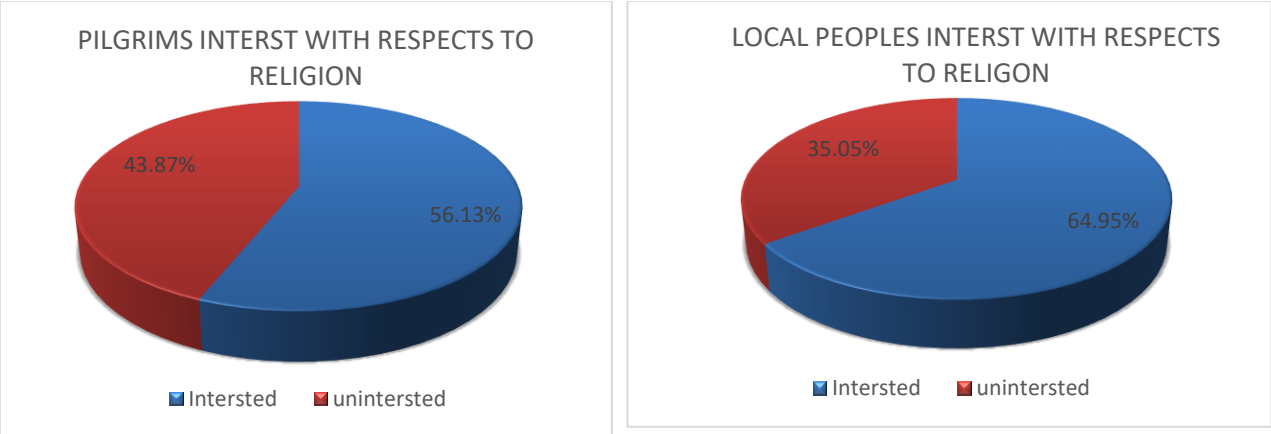
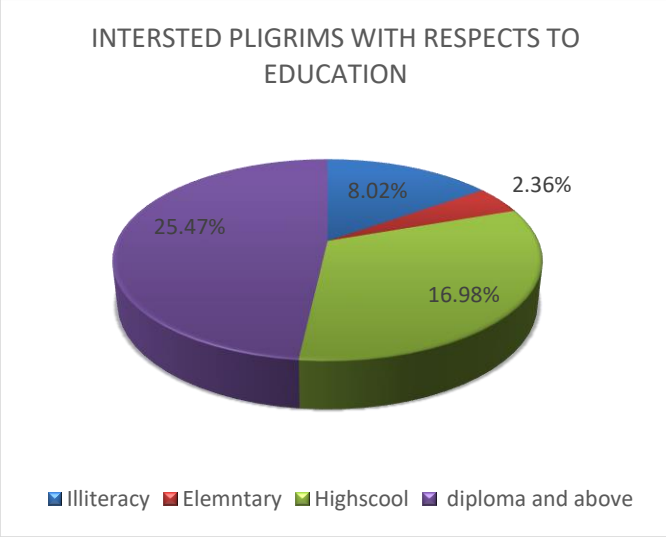


Figure 4-6 Total Percentage for using cable car or not with respects to religions.

Generally, 56.13% of pilgrims were willing to use the cable car and at the Contraries 43.87% were not willing to use the cable car. Among the local peoples, 64.95% were interested and 35.05% were not interested to use cable car.

4.1.3 Education Level related to interest of the people using cable car

Education level is not a main factor for choosing cable car to travel difficult terrain but it will provide the background of the travelers and also the people living around the route. As the result, Education level has low score.



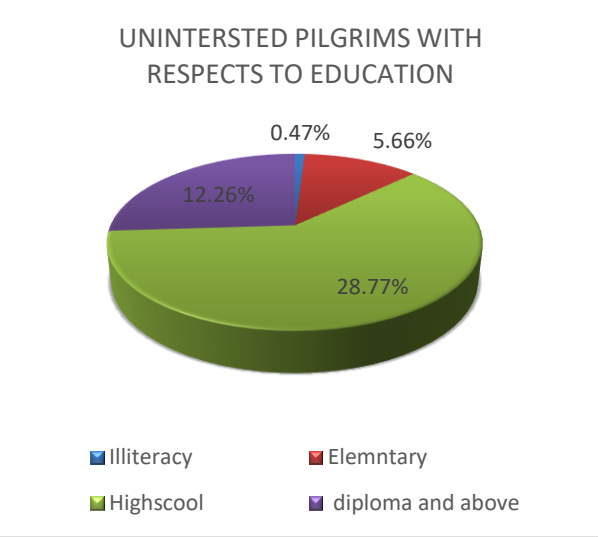
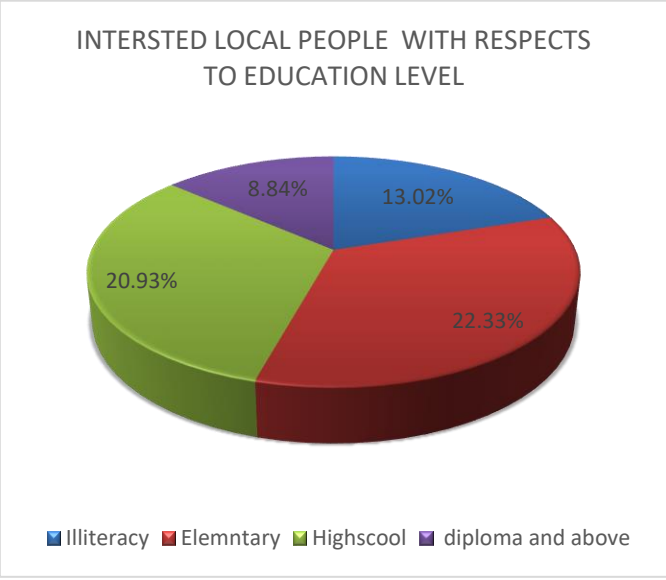


Figure 4-7 the interest of the travels with respects to their education status

As shown in the figure 4.7, Among the pilgrims that are interested to use cable car was with higher percentage with 25.47% of the pilgrims have Diploma and above, then 16.98%, which is interested to use, are high school students. The people with diploma and above education background has more interested to use a cable car since they are mainly near to technologies.



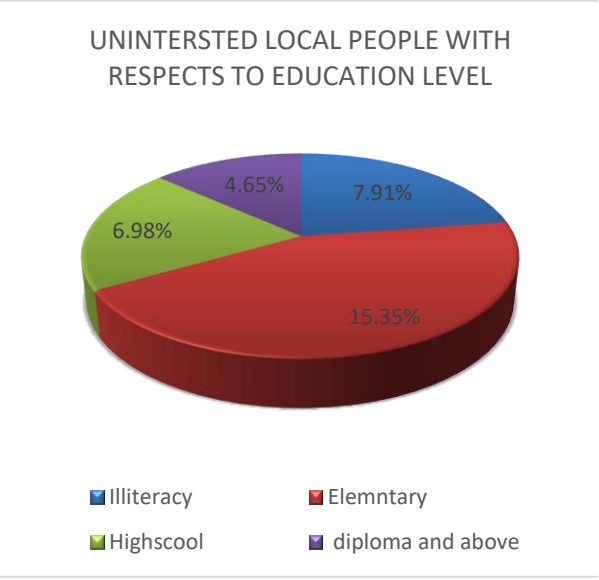
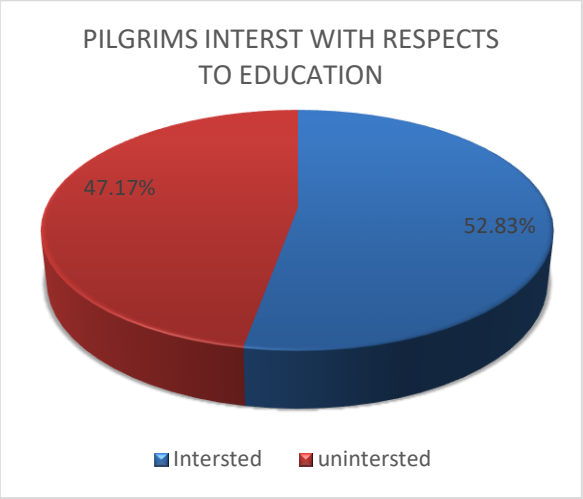


Figure 4-8 the interest of the local people with respects to their education status

As shown in the figure 4.8, among the local peoples that are interested to use a cable car is elementary students with 22.33%. Then secondly, high school students with 20.93% were interested.



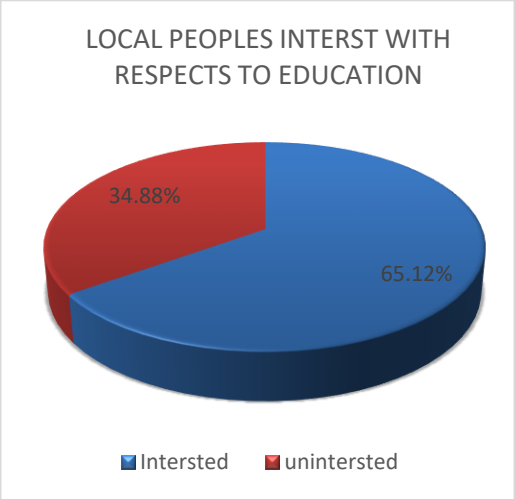
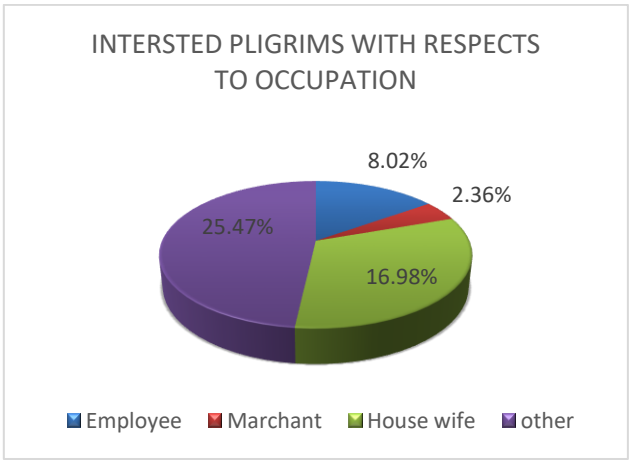


Figure 4-9 Total Percentage for using cable car or not with respects to their education status

As shown in the figure 4.9, generally, 52.83% pilgrims were interested and 47.17% were not interested to use cable car. In addition, among the local peoples, 65.12% were interested and 34.88% were not interested.

4.1.4 Occupation related to interest of the people using cable car

Occupation is not a main factor for choosing cable car to travel difficult terrain. Hence, we just used to identify the pilgrim's occupation that traveled to Gishen Maraim Church. As the result, occupation got the low score.



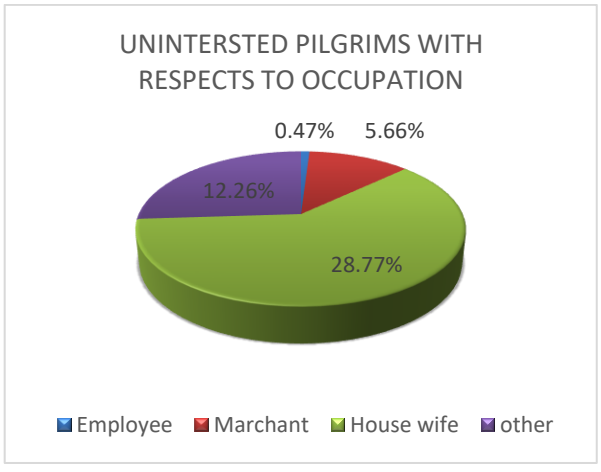
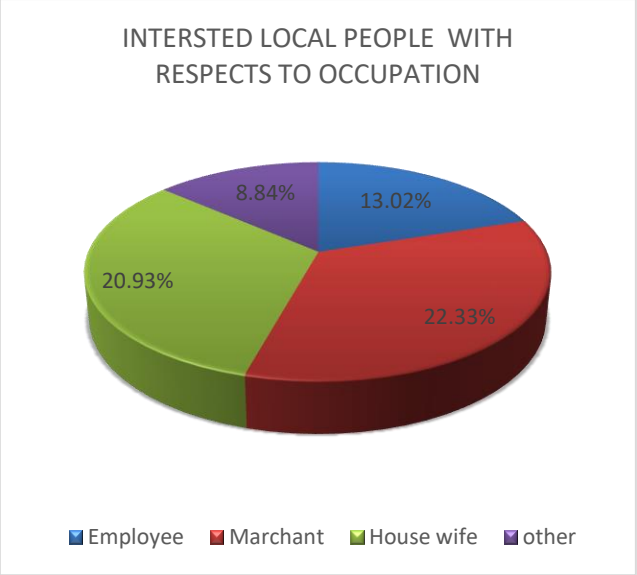


Figure 4-10 the interest of the travels with respects to their occupation status

In the figure 4.10, among the pilgrims, most of the travels that are willing to use cable car were others but the second abundant occupation were house wife.



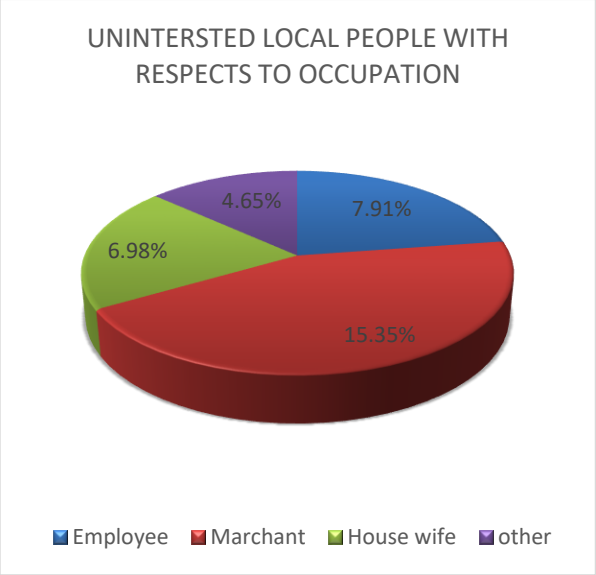


Figure 4-11 the interest of the local people with respects to their occupation status

Among the local peoples that are interested to use cable care were merchants with 22.33% and next house wife with 20.93%. as shown from the figure, local merchants were taking their items to the market every market day, the movement of peoples would have been better if they cable care were install.

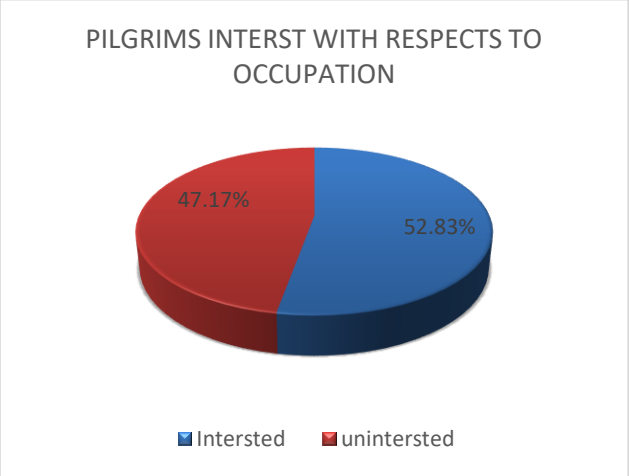
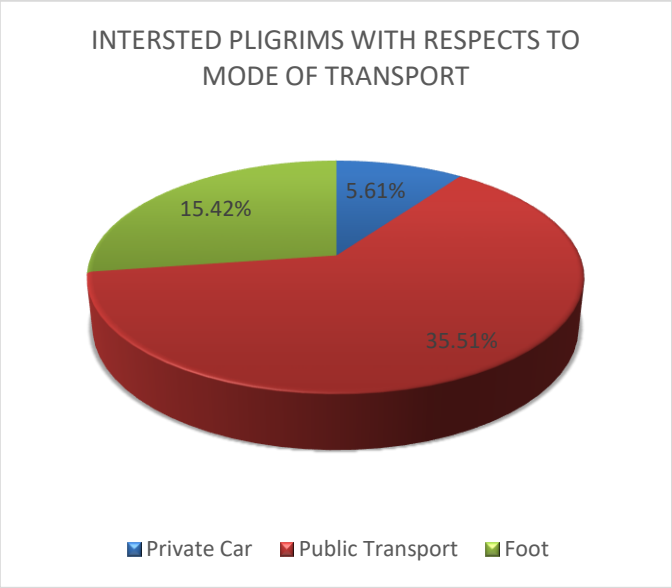


Figure 4-12 Total Percentage for using cable car or not with respects to their occupation status.

As shown in the figure 4.9, among the pilgrim's with their occupation, 52.83% were interested and 47.17% were not interested. Moreover, for local peoples 65.12% were interested and 34.88% were not interested.

4.1.5 Mode of transport related to interest of the people using cable car

The existing transportation mode is a main factor that will affect for choosing cable car to travel difficult terrain. These variables can be considered, as modal shift analysis and it will help to estimate the number of people that will shift to cable car transportation mode. Hence, mode of transport verse the interest of the pilgrims as well as local peoples interested of using cable car has a high influential factor with 5 score.



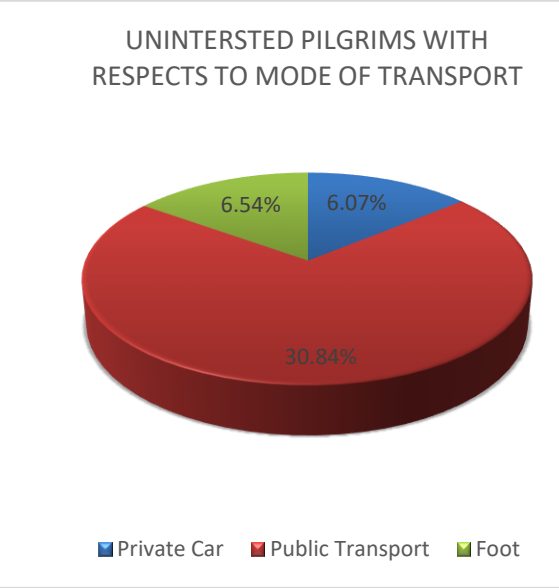
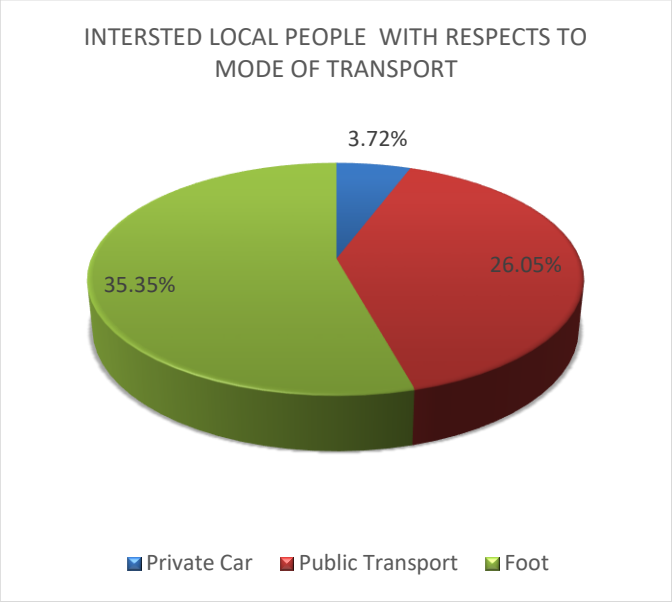


Figure 4-13 the interest of the travels with respects to their Mode of transport status

As shown in the figure 4.13 above, among the pilgrims that are interested to use cable car, 35.51% were used public transport and then 15.42% were came to Gishen Mariam with their foot. Among the pilgrims that are not willing to use cable car were 30.84% used public transport and 6.54% were used by foot.



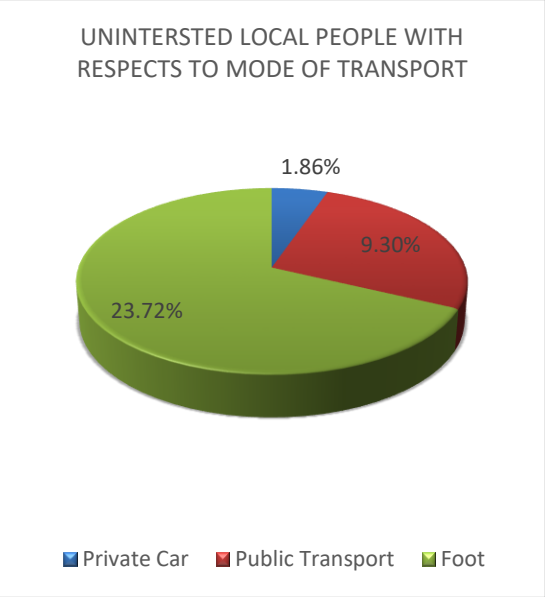
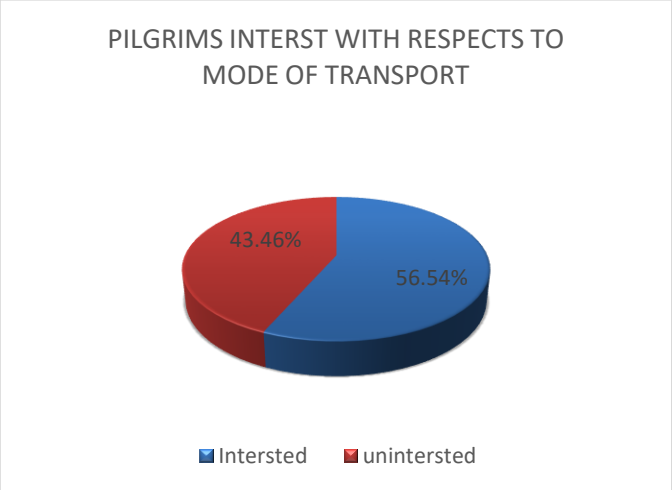


Figure 4-14 the interest of the local people with respects to their Mode of transport status

As shown in the figure 4.14 above, most of the local people that are interested to use cable car were came to Gishen Mariam with foot with 35.35% then 26.05% were came by public transport.



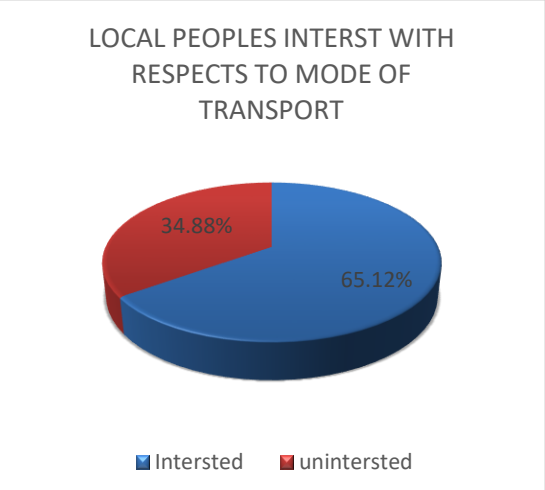
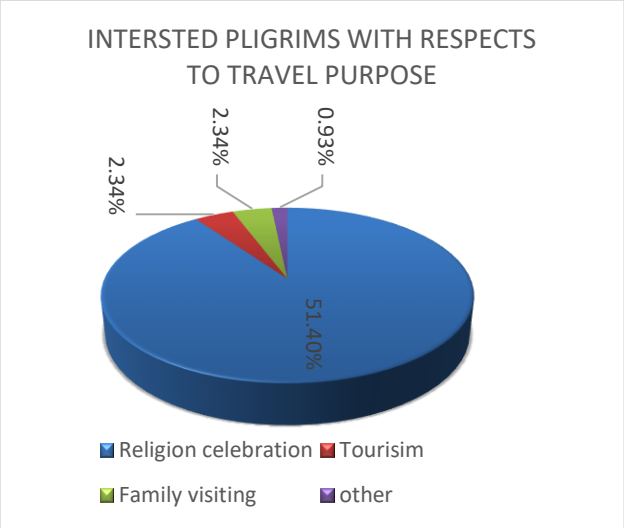


Figure 4-15 Total Percentage for using cable car or not with respects to their Mode of transport status

Generally, 56.54% of pilgrims were interested and 65.12% local peoples were interested. Moreover, 43.46% of pilgrims and 34.88% of local peoples were not interested to use cable car.

4.1.6 Purpose for travel with respect to the interest of the people using cable car

Purpose of travel has a moderate factor for choosing cable car for traveling difficult terrain. Hence, purpose for travel has given moderate score.



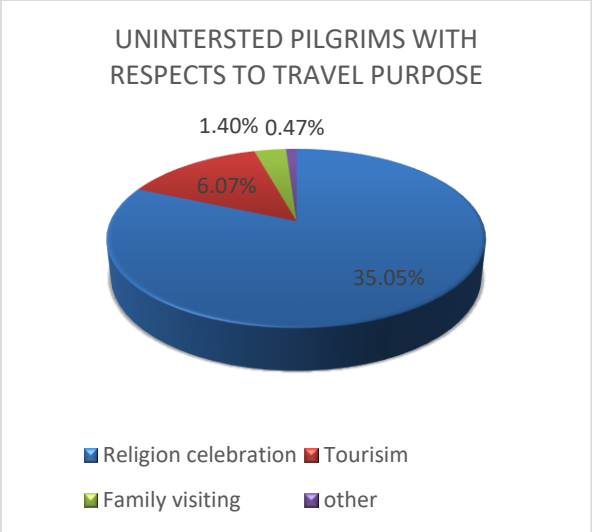


Figure 4-16 the interest of the travels with respects to their travel Purpose

As shown in the figure 4.16 most of the pilgrims that are interested to use cable car were came to Gishen Mariam for religious celebration with 51.04% and uninterested people that were came for religious celebration accounts 35.05%.

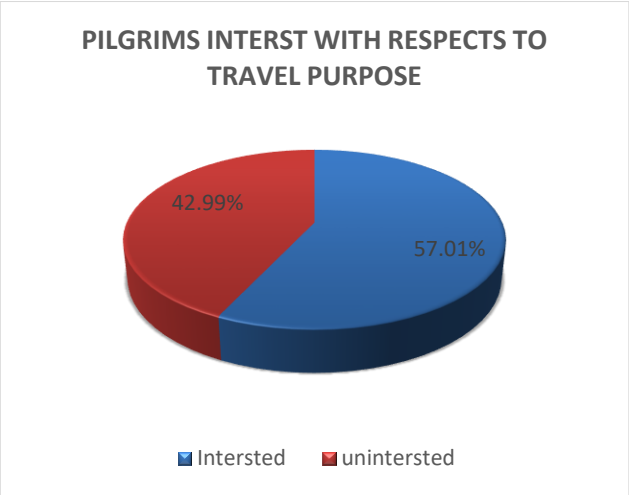
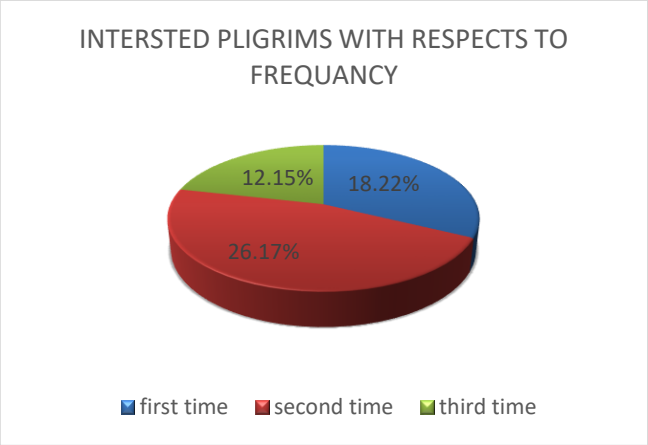


Figure 4-17 Total Percentage for using cable car or not with respects to their Mode of transport status

As shown in the figure 4.17, interested travelers were accounts 57.01% and uninterested pilgrims were accounts 42.99%.

4.1.7 Frequency for travel with respect to the interest of the people using cable car

Frequency has a main factor for choosing cable car for traveling difficult terrain. Hence, Frequency of traveling has given moderate score.



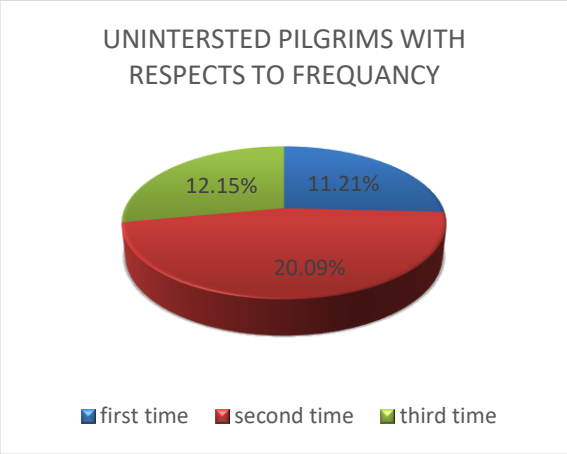


Figure 4-18 the interest of the travels with respects to their Mode of transport status

As shown in the figure 4.18, pilgrims that are interested to use cable car to travel to Gishen Mariam, were the one that are came with the second times with 26.17% and uninterested pilgrims came for the second times accounts 20.09%.

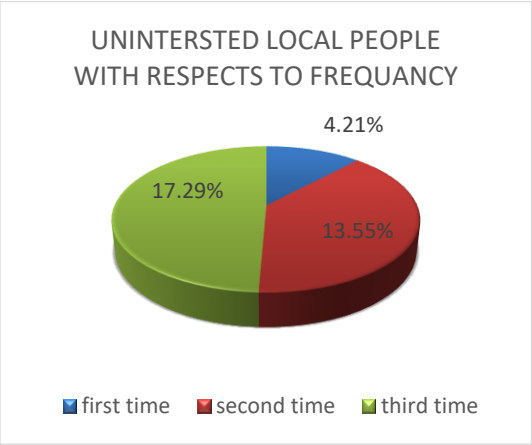
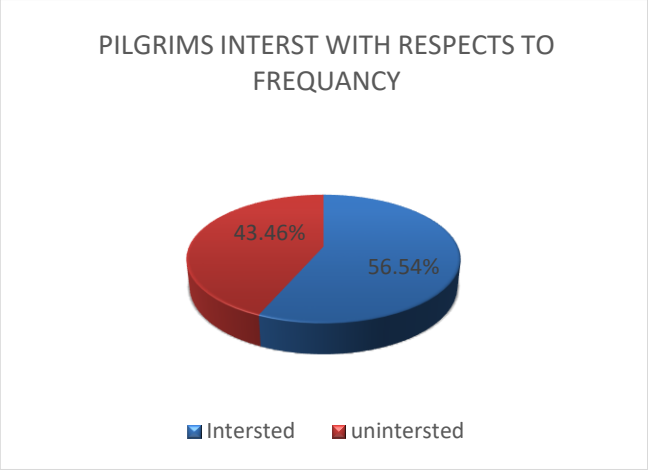


Figure 4-19 the interest of the local people with respects to their Mode of transport status

As shown in the figure 4.19, interested local people were the one that are travel to show for the second times with 33.18% and uninterested local peoples were accounts 13.55%.



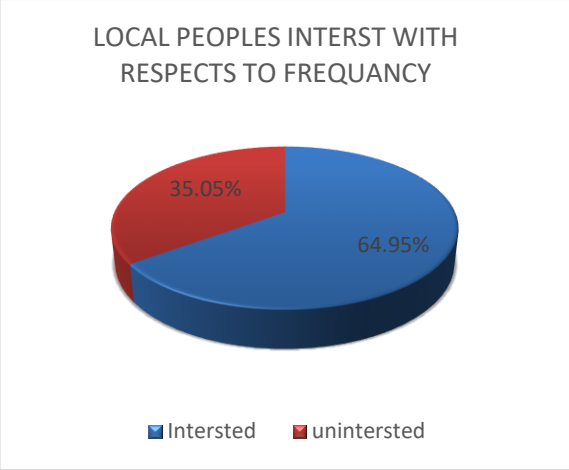


Figure 4-20 Total Percentage for using cable car or not with respects to their Mode of transport status

Generally, as shown in the figure 4.20, pilgrims and local peoples were accounts 56.54% and 64.95% respectively.

4.1.8 Proximity or origin and destination (OD) analysis

OD survey were taken in order to determine the trip pattern and characteristics along the proposed road. The proximity affects the preference of choosing the cable car or not. Hence, proximity has given high score.

Pilgrims																										
Destination	origin																									
	Harer	Hawassa	Hayke	Lalibela	Mersa	Mekelle	Raya	Bure	Bahirdar	Addis Ababa	Adama	Kutaber	combolcha	Weldya	Wechale	Delanta	Dessi	Debre Sina	Debrebrehan	Diredawa	Jinca	Gerager	Gonder	Gojam	Total
Gishen Mariam	3	4	5	3	1	1	7	1	13	44	2	5	10	27	6	1	57	1	6	1	1	1	6	8	214

Figure 4-21:- Origin Destination analysis

As shown in the figure 4.21, above most of the Pilgrims around 27%were came from Dessi which is 25km away from Gishen Mariam Church, then 21% were came from Addis Ababa which is 500km away from Gishen Mariam.

4.1.9 Trip Expectation

Since the road is very difficult and found on harsh terrain type, some people experience accidents, braking of cars, Tiredness and so on. However, on the contrary peoples were enjoying the trip, hence the analysis of trip expectations are stated below with table.

Table 4-1:- Trip expectations for Pilgrims

Trip Expectation for Pilgrims			
Number	**Descriptions**	**Number of Peoples Encountered**	**Percentage**
1	Difficulty Road	33	15.40%
2	Car Accident	18	8.40%
3	Difficulty Road plus rain	1	0.50%
4	Vehicle Broke Down	27	12.60%
5	vehicle strap	1	0.50%
6	Hunger	4	1.90%
7	Blessing	4	1.90%
8	walking by foot	28	13.10%
9	tiredness	62	29.00%
10	No Response	36	16.80%
Total=		**214**	

As shown in the table 4.1 most of the pilgrims were experiencing tiredness during traveling to Gishen Mariam church with an account of 29.0%. Then secondly, 15.4% were sensing that the road is very difficult and has a winding of curves. Among the pilgrims, 1.9% were feeling blessed with traveling with this difficult types of roads, even they were saying that they will not use cable car since they have a mindset that traveling along the difficult terrain will bring blessings.

Table 4-2:- trip experience for the people living around the area

Trip Expectation for Local Peoples			
Number	**Descriptions**	**Number of People Encountered**	**Percentage**
1	Car Accident	8	3.69%
2	Broke done of Vehicles	5	2.30%
3	Vehicle strapping	2	0.92%
4	Hunger	8	3.69%
5	Waling by foot	13	5.99%
6	Difficulty of the road	14	6.45%
7	Tiredness	129	59.45%
8	Sickness	1	0.46%

Trip Expectation for Local Peoples			
Number	**Descriptions**	**Number of People Encountered**	**Percentage**
9	Shortage transport	14	6.45%
10	Attacked by sneak	1	0.46%
11	No response	22	10.14%
Total=		217	

4.1.10 Results of interview/Questioner

As per sub section from 4.1.1 up to 4.1.9 shows that the interest of the pilgrims as well as the local people's interest using the cable car or not after the cable car were introduced. Hence, the total estimation when we combined all variables and illustrated in the table 4-3 below.

Table 4-3:- trip experience for the people living around the area

No.	Category	% of Interested Pilgrims	% of uninterested Pilgrims	% of interested Local People	% of uninterested Local People
1	Age	52.83%	47.17%	63.26%	36.74%
2	Religion	56.13%	43.87%	64.95%	35.05%
3	Education	56.54%	43.46%	65.12%	34.88%
4	Occupation	52.83%	47.17%	64.62%	35.38%
5	Mode of Transport	56.54%	43.46%	65.12%	34.88%
6	Purpose	57.01%	42.99%		
7	Frequency	56.54%	43.46%	64.95%	35.05%
Average		55.49%	44.51%	64.67%	35.33%

Therefore, pilgrims with age group of 19-30 of an orthodox Christian that have diploma and above education background, public transport users and came for religious celebrations from Desse and Addis Ababa were interested to use cable car with 55.49% and 64.67% of the local peoples willing to use cable car. This shows that the majority of the pilgrims and local peoples will use the cable car instead of using public transport.

4.2 ECONOMIC EVALUATION

4.2.1 Demand Analysis

Based on the estimation above on table 3.9, 100,000 pilgrims and above were traveled every celebration to Gishen Mariam church for religious celebration from all over Ethiopia. Hence, based on the social assessments, 55.5% were interested to travel with cable car. Hence, among the total pilgrims, around 40,840 pilgrims were willing to travel to Gishen Mariam church by cable car from Gishen Junction to Gishen Mariam Church. In addition, after the cableway constructed and open for users, some of the people expected to shift to cable car in addition to the 55.5% is diverted traffic. The researcher estimated 25% of the pilgrims as a diverted traffic from modal shift.

Table 4-4. Estimation of number of peoples coming for celebration

Descriptions	L/Rover	S/Bus	L/Bus	Total
Total AADT @2021 estimated by Beza Consulting Engineers Plc	164	3	5	172
Percentage composition/estimated by Beza Consulting Engineers Plc	95%	2%	3%	1
Total estimated traffic by local administration 20,000	19,070	349	581	20,000
Total People traveled	76,279	4,186	20,349	100,814
Total interested People to use cable car	41,954	2,302	11,192	55,448
Sifted traffic(25% of total traffic)	19,070	1,047	5,087	25,204
Total Estimated Traffic	61,023	3,349	16,278	80,651

Source:- Researcher estimation

4.3 Economic Analysis

The Economic Evaluation results of the project established based on comparisons between costs and benefits has been done for both cable car and road way constructions. The economic study of the proposed mode of transport has investigated depending on the specific nature of the implementation strategy type.

The required input data and information for each alternative technology such as cable car and roadway collected through field visits and desk studies are attached with this document in Appendex 6.

The analysis done by considering each alternative or technologies with against do nothing. The major considerations in the measurement of costs and benefits for the economic appraisal of this project are: the travelling that incurs costs to road users such as the time spent travelling; costs arising from direct costs of fuel, maintenance and depreciation for technologies.

The result of the economic analysis expressed by the following standard measures to evaluate the economic viability of the proposed technologies such as-

-Net Present Value (NPV) – the sum of the discounted stream of project costs and benefits during the project lifetime. The project is acceptable as long as NPV>0.

-Economic Internal Rate of Return (EIRR) - represents the discount rate at which the NPV of the project would be equal to zero. IRR above the cut-off point are economically viable.

- Benefit Cost Ratio

Currently, we use the minimum requirement of a project to be economically feasible is to have a positive NPV and an EIRR greater than the discount rate, 10.23%.

4.3.1 Economic Parameters

The financial investment and maintenance costs of the technologies estimated based on the current unit costs which are estimated for combination of different works. For the purpose of economic analysis, a conversion factor of 0.87 is used in the model to convert financial costs into Economic costs.[45] The conversion factor used is based on the Manual of National Economic Parameters and Conversion Factors for Ethiopia, which was prepared and issued by the Ministry of Finance.

In addition, the economical justified level of investment in road improvement is dependent on the discount rate to be applied in the economic analysis. This rate equals the opportunity cost of capital for the project. The appropriate discount rate is measured by the marginal rate of return on public sector investments. A discount rate of 10.23% is applied in the economic analysis of the project road.

4.3.2 Cost Benefit Analysis for Cable Car

The Cost- Benefit analysis of the cable car measures the capital cost in monetary terms on the one hand, and the benefits that accrue in the form of travel time and the vehicle operating cost savings on the other.

The major considerations in the measurement of costs and benefits for the economic appraisal of this cable car project are the travelling that incurs costs to cable car users such as the time spent travelling; costs arising from direct costs of electricity, maintenance and depreciation. The direct benefits were derived from the fare revenue projections based on estimated demand for the ART service, and the cost included capital(construction) cost as well as an annual ridership growth rate of 2%, construction time one year for MDG system and two year for TDG system [51]. The construction cost includes the civil work of the terminals and the piers that will hang the cables. The annual inflation and real discount rates of 10.23%. [45]. The primary evaluation criteria were the net present value, Benefit Cost Ration (B/C) and internal rate of return.

The analytical tool used in the evaluation of this project is the HDM model, which is very comprehensive and needs a wide range of inputs. The data input requirement of the model is discussed here in relation to the project study. The analysis is based on specific data requirements of the dynamic model that incorporate a series of mathematical sub models simulating the effects of different physical characteristics and conditions of the existing road, on the operating speeds of different types of vehicles and the resultant fuel and lubricant consumption, maintenance requirements, etc.

Table 4-5. The characteristic of Arial Cable car

No	System Characteristics	Dual Haul Aerial Tramway
1	Cable Configuration	Cabins are suspended from two fixed cables and are pulled by another cable
2	Maximum Number of Passenger cabins	2 cabins
3	Maximum Number of station	Can have multiple stations
4	Maximum Distance between Towers	less than 1000m
5	Cabin capacity	High capacity(more than 100Pass/cabin)
6	Maximum Transport capacity	2800 Pass/hr
7	Speed	Up to 29km/hr
8	Estimated Passengers total amount	Above 20,000 Pilgrims
9	The Total Length of the proposed route	6.7km
10	Time it take to travel from Gishen Junction to Gishen Mariam (min)	12.4137931
11	Total Trips within 1hr	5
12	Total Passengers with one Cabin within 1hr	483
13	Total Passengers with one Cabin within one day	5800

Source:-Estimation

4.3.2.1 Cable car Route

As shown in the figure 4-22 below, the route of the cable car is illustrated. The route is shorter than the existing road almost by half but the start and the end of the projects are similar.

Figure 4-22:- the location of proposed route for cable car

4.3.2.2 Improvement strategies

4.3.2.2.1 Construction cost

Providing cable car have been considered for the route from Koladit Junction upto Gishen Mariam Junction as a means of public transport and comparing against the base case, do minimum alternative. The proposed alternative of the project consider constructing cable car in a different route from the existing gravel road. Capital cost of the project estimated based on the assumption illustrated on chapter 3 above. Hence, the capital cost for constructing cable car illustrated below on table 4.5. The BOQ is attached in Appendix 2.

Table 4-6 : Total Financial and Economic Costs of the Project (In Million ETB)

Option	**Assumed Total Cost**	**Financial Cost Per Km**	**Economic Costs Per Km**
Cable car construction	435,811,530.99	74,803,471.74	65,046,497.16

Source: - Estimation

Since, cable car was not implanted yet in our country, for our research, purpose we have adapted the construction cost done for skyway construction to be implemented from Ayat to Tulu Dimtu road Corridors.

4.3.2.2.2 Maintenance cost

On section 3.4.3.4, developed maintenance cost taking in to consideration of maintenance work form different countries and illustrated in the table 4-6 below.

Table 4-7:- Maintenance Cost Estimated

Option	Financial Cost Per Km	Economic Costs Per
Cable car Maintenance cost	92,132.23	76,469.75

Source: - Estimation

4.3.2.3 Results

Based on the demand analysis and all assumptions made for the input in HDM 4, construction of cable car instead of roads is more viable and has more advantages regarding economic evaluation as shown in table 4-6 below.

Table 4-8: Results of economic analysis

Description	EIRR %	NPV in Million ETB	BC
Gishen Junction – Gishen Mariam	33.1	18851	4.412
Sensitivity Test			
Cost Increase by 20%	31.7	18625	4.367
Benefit Decrease by 20%	26.7	13716	3.165
Cost Increase by 20% and Benefit Decrease by 20%	26.0	13500	3.13

4.3.3 Economic Evaluation for Road Construction

Upgrading the road from Koladit Junction up to Gishen Mariam Junction to AC (Asphalt Concrete) improvement alternatives have been considered and comparing against the base case, do minimum alternative. The proposed improvements of the project consider upgrading of the existing poor gravel road to paved standard, Asphalt Concrete (AC). Capital cost of the project is estimated for the two construction options and the estimated per km project costs are presented below and BOQ attached in Appendix 2.

Table 4-9 : Total Financial and Economic Costs of the Project (In Million ETB)

Option	Total	Financial Cost Per Km	Economic Costs Per Km
Asphalt Road	1,316,700,000	108,157,500.00	94,050,000

Source: - From BCE Data Base

4.3.3.1 Road Maintenance Standard and Strategies

Maintenance costs comprise routine and periodic maintenance components. The routine maintenance cost to be incurred every year involves day-to-day repairs for maintenance of road, structures etc. Periodic maintenance is aimed at pavement resurfacing/renewal for improving riding quality and condition of pavement and its interval depends on the maintenance strategy that we are assuming.

The maintenance strategies and standards used in the economic evaluation will depend on the existing road condition and current maintenance practices. The following maintenance strategies are used or assumed in the economic analysis.

- Do minimum

The ‘do minimum’ maintenance strategy reflects the current minimum maintenance standard, which is used to keep the road at acceptable level of serviceability.

Existing Gravel Road

- Routine Maintenance every year;
- Grading, Scheduled every 180 days;

- ‘With Project’ Case

The ‘with project’ maintenance strategy is adopted following the implementation of the upgrading of the project road. The applicable maintenance strategy of the ‘with project’ case that are applicable for both upgrading options (Asphalt Concrete and Double surface Treatment) option are presented below.

AC Option

- Routine Maintenance every year;
- Crack Sealing, Responsive when Wide Structural Cracking ≥10%;
- Pothole patching, Responsive when Pothole ≥10 no./km; and

- Overlay, Responsive when Roughness ≥5.0 IRI

Unit cost of road maintenance operations is presented in the following table.

Table 4-10: Estimate of Maintenance Operation Unit Cost, Financial

Work Item	**Unit**	**Unit Cost, Birr**
Routine Maintenance	Km	20,000
Gravel		
Re-Gravelling	M^3	204
Spot-Gravelling	M^3	60
Grading	Km	7100
Paved		
Overlay	M^2	75
Resealing	M^2	68
Patching	M^2	78
Crack Sealing	M^2	73

Source: - ERA and different Feasibility Study Reports.

4.3.3.2 Works schedule

The following work schedule is considered in the analysis:

Table 4-11 : Project Implementation Schedule

Activity	**Period**
Completion of Concept Design and tender process.	End of 2021
Construction (1 years starting Beginning of 2022)	2022
Completion of the construction	End of 2022
Open for traffic	Beginning of 2023
Design Period (20 years)	2023-2042

The construction works duration is considered one years and the road will be opened to traffic starting year 2022.

4.3.3.3 Input to HDM-4 Models

The economic analysis of the project has been undertaken using the Highway Development and Management Model (HDM-4) Version 1.1.The inputs to the model have been derived from field investigations and available secondary data collected from different organizations and ERA. The following are the basic inputs data used for the HDM-4 Model.

4.3.3.4 Traffic Data

The traffic volume and its composition in terms of AADT by vehicle type and annual traffic growth rates are key inputs for economic analysis. The derivation of the base year AADT and traffic growth rates have been discussed earlier in Traffic Survey and Analysis section. Eight vehicle Categories, pedestrians and Pack animals were considered for this study. The following table shows the AADT and traffic growth rate used in the HDM-4 Model.

Table 4-12: Base Year (2021) AADT, 2021

Descriptions	Car	L/Rover	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	Truck & Trailer	Total
Total AADT @2021	0	164	3	5	68	7	8	1	256
Percentage composition	0	64.06	1.17	1.95	26.5	2.73	3.125	0.39	100

Source:- BCE's Estimations

Table 4-13: Traffic Growth Rates (%PA)

Period	Cars	4WD	S/ Bus	L/Bus	S/Truck/	M/Truck	L/Truck	T/T
2021 - 2029	9.9	9.9	10.5	10.5	10.6	10.6	10.6	10.6
2030 - 2040	8.6	8.6	9.2	9.2	9.8	9.8	9.8	9.8

Source:- BCE's Estimations

4.3.3.5 Vehicle Fleet and Operating Costs

The vehicle fleet data provide the characteristics of the vehicles, which include vehicle type, number of axels, passenger car space equivalent factor, and average annual utilization in km, the economic cost of the vehicle, trip characteristics, value of time for passengers and the cargo.

The major inputs required for HDM-4 to estimate the VOC are the prices of vehicles, fuel (petrol and diesel), lubricants, tires, repairs and maintenance, the proportion of depreciation related to vehicle use and other vehicle fleet characteristics. Accordingly, the main data for the VOC model used for the analysis are the prices of vehicles, tire costs, prices of fuel and lubricants, maintenance, labor and crew costs and vehicle utilization.

For this study, cost and price data have been collected from a variety of sources including consultant's current investigation and previous studies, using the conversion factors for the economic cost of

vehicles, Tire, fuel, lubricants, maintenance and crew costs are calculated. The speed of the vehicles on the existing road project is measured during the condition survey. Based on this the average running speed over the whole route is estimated and inserted into the model.

The types of fuel used by the vehicles are petrol and diesel. The fuel prices vary from place to place in Ethiopia as determined by the Ethiopian Petroleum Enterprise. For the purpose of this study, the average fuel price has been considered.

As HDM4 model require vehicle fleet characteristics comprising physical characteristics, utilization and unit costs; therefore, the following table presented this information taken from recent road project studies.

Table 4-14 vehicle fleet characteristics for road construction.

Vehicle Type	**Car**	**L/Rover**	**S/Bus**	**L/Bus**	**S/Truck**	**M/Truck**	**H/Truck**	**T/Truck**
Passenger	4	4	20	45	2	2	2	2
Utilization								
Annual Run (km)	20000	40000	50000	60000	50000	60000	65000	65000
Annual Hours	600	900	1800	2000	1600	1800	2100	2100
Average Service Life	10	12	15	15	12	15	20	20
Unit Costs (Economic)								
New Vehicle Price (Birr)	2,000,000	4,200,000	2,074,000	2,650,000	2,350,000	3,900,000	4,800,000	5,180,000
Tyre Price (Birr)	2,458	7,925	10,750	14,517	8,560	14,517	14,517	14,517
Fuel (per liter)	20.04	17.70	17.70	17.70	17.70	17.70	17.70	17.70
Lubricant oil (per liter)	76	76	76	76	76	76	76	76
Crew Wages (Birr/hr.)	37.93	47.73	46.59	45.45	37.78	39.77	48.30	48.30
Annual Overhead (Birr)	18000	50000	60000	80000	30000	30000	50000	60000

Vehicle Type	Car	L/Rover	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	T/Truck
Maintenance Labor(ETB/hr.)	67.71	67.71	74.54	74.54	67.71	81.38	84.64	81.38
Annual Interest Rate (%)	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23
Passenger Working time(per hour)	2.06	2.06	1.47	1.47	2.26	2.26	2.26	2.26
Passenger Non-working time (per hour)	0.72	0.72	0.52	0.52	0.79	0.79	0.79	0.79
Cargo Costs (per hour)					0.13	0.3	0.36	0.77

Source: Different Recent Feasibility Study Reports, ERA

4.3.3.6 Summary of Results

Based on the results of the economic evaluation, investment in the proposed upgrading of the road to asphalt is found to be economically viable using NPV Method. It is also analyzed under sensitivity analysis and the proposed road is still viable if both costs increase by 20% and benefits, decrease by 20% combined which is the worst case. The results of the economic analysis of the road project with the different standards presented below in Table 4-12.

Table 4-15: Results of Sensitivity Analysis

Scenarios	IRR @ 10.23% Discount Rate (%)	NPV (In Million Birr)	Benefit Cost Ratio(B/C)
Base Case			
AC	26.8%	220	4.294
Cost Increased by 20 %			
AC	24.1%	2078.82	3.599
Benefits decreased by 20%			
AC	23.5%	1632.23	3.435
Cost Increased by 20% & Benefits decreased by 20%			
AC	21.1%	1502.932	2.879

The results of the sensitivity analysis indicate that the project is economically viable even if both cost increases by 20% and benefits decrease by 20% taken together.

4.3.3.7 Summary of Results

As shown in the section, 4-14 the analysis were done for both cable car and roadway construction against do nothing with HDM-4 and the following tables show the results.

Table 4-16: Results of Economic Analysis

Scenarios	Construction of cable car	Construction of road way
Base Case		
IRR @ 10.23%	33.1%	26.8
NPV (In Million Birr)	18,851	220
Benefit Cost Ratio(B/C)	4.412	4.294
Cost Increased by 20 %		
IRR @ 10.23%	31.7	24.4
NPV (In Million Birr)	18,625	207
Benefit Cost Ratio(B/C)	4.367	3.599
Benefits decreased by 20%		
IRR @ 10.23%	26.7%	23.5
NPV (In Million Birr)	13,716	163
Benefit Cost Ratio(B/C)	3.165	3.435
Cost Increased by 20% & Benefits decreased by 20%		
IRR @ 10.23%	26.0%	21.1
NPV (In Million Birr)	13500	150
Benefit Cost Ratio(B/C)	3.13	2.879

The results of the sensitivity analysis indicate that the project is economically viable even if both cost increases by 20% and benefits decrease by 20% taken together. Hence, based on the results the cable car installation is more feasibility than construction of roads.

4.4 Right of way problems

One of the analysis for comparing the cost benefit analysis of the cable car against road way is by estimating the right of way limits. In the table, 4-16 show the area required to implement each theologies.

Table 4-17: Occupational Area

No	Descriptions	Total Occupational area M2	Score
1	Cable Car	33,500.00	1st
2	Road Way	700,000.00	2nd

Source:- Estimation

As shown in the table above construction of cable car as an advantage of consuming very less land acquisitions than road construction.

4.5 Travel Time/Journey Time

As shown in the table below the comparison between cable car and road way travel time from Koladit junction to Gishen Mariam Church.

Table 4-18:- Comparison of travel time between Cable car and roadway

Timing Segment	**Distance, Km**	**Average Journey Time, min**	**Average Speed, Kph**
Koladit Junction – Gishen Mariam Church Road Construction	14km	42min	20
Koladit Junction - Gishen Mariam Church cable car	6.7km	13min	29

Source:- Estimation

The existing gravel road is clearly uneconomic with respects to travel time. The construction or implementation of cable car will decrease the travel time of 25min. This means that the existing road costs an average car user over ¼ hours in journey time.

CHAPTER 5 CONCLUSIONS

Assessment was made on the cost benefit analysis to compare a cable car against the road way on Koladit Junction to Gishen Mariam Church in North Central Ethiopia. There is an existing road at the moment but it will create a negative impact on the environment around mountainous and tourist attraction areas if it is upgraded to Asphalt Road. Based on the economic evaluations of the cable car, it has an ideal solution for dead-end and tourist attraction areas making access to the people living in isolated location with rivers and difficult terrains. The ultimate goal of investment on road infrastructure is reducing poverty in the project area and the country by promoting economic growth through direct benefit to road users; through easing access to market centers for food, education, health services and other services, promoting trading, and productivity of produce and reducing transport costs. However, these benefits will be exaggerated when the project road is located at the suitable terrain type connecting different towns and villages. If the location of the project is isolated and dead-end, with seasonal traffic and difficult terrain mountainous, road construction will have negative impact on investment as well adverse impact on environments due to vehicle emissions.

The study has shown that roads construction produces significant adverse effects on environment and human health due to carbon emissions and pollutants released during the execution of the various construction processes (earthmovings, trucks transit on unpaved roads, crushing, and material production) and the operation of diesel-powered equipment and more of vehicle emissions during the life of the road project. Among the pollutants, the concentration of particular matter (PM) is an increasing concern for the negative effects on human health of workers, inhabitants and environment.

A questionnaire was developed and 429 number of pilgrims and local people were interviewed and the responses were analyzed. The analysis was made in respect of age, location of the area, religion, frequency of trips to Gishen MariamChurch as variables and making interest to use cable car fixed. Hence, 65% of the people are willing to use a cable car and the rest 35% were not willing to use because they believe walking to church along difficult terrains is a blessing; some of them responded that cable car would be expensive and so on. Hence, additional 25% was added and 75% of the people were assumed to use cable car after installations. The study findings showed that cable car has an economic advantage over roadway construction by conducting cost-benefit analysis using the HDM-4 Software for the selected route. The analysis was done road way construction compared against do nothing and cable car construction against do nothing, and the results show that both projects are feasible but cable car has more economic benefits than road way.

The construction or installation of cable cars has the following advantage when compared with the construction of road for the route from Koladit junction to Gishen Mariam Chruch.

- Cheaper than construction of roads on hill mountainous, section.
- Decrease Travel Time
- Has less or zero emission during its implantation stage
- Consumes less right of way
- Increase the number of tourists
- It is also helped the transport planner to get an alternative means of transport for the place that have manmade and natural barriers in additions

Moreover, based on the economic activates of our country and the experience of other countries like Brazil, Ecuador, Bolivia and Colombia, the researcher developed an average fair price to be paid by the cable car users. The income will incorporated in yearly maintenance activities. The fair price is developed by considering the inflation of our countries as well and the growth on populations for the life of the cable car.

Finally, the overall observation of the area and economic analysis of the cable car implies, despite the luck of experience and literatures, cable car provision will improve access to mobility and physical access to remote and isolated area with dead-end and seasonal traffic, with difficult terrain like Gishen Mariam. The project under study implies that the importance of installing cable car on the area that is difficult to access with roads but the place is a tourist attraction area with seasonal traffic is high.

CHAPTER 6 RECOMMENDATION

Even though the cable car is an ideal solution for tourism as well as for tackling the existing geographical barriers, recommendations has done to avoid risk of using cable car.

- As the Ropeway Towers, which shall be made up of steel, are to be erected over the ground, the base of the towers shall be of some danger to the Wild Life. Thus they should be closed with a mesh wire enclosure which shall be approximately 6 feet (2 m) high. This would prevent any animals from straying into these steel girder bases of the towers.
- The main stations of the Ropeway housing the pulleys with moving parts should be secured for bird hits by enclosing them with bird meshes.
- Further research needs on accident rates and safety of the cable car.
- Further reaserch shall be conducted for modal shifting models.
- Ethiopia is a country with valleys and rugged areas so the installation of cable car wherever absolutely needed is very advisable.
- Generally, cable cars are advantageous to climb steep hills at a fraction of the investment cost of a new tunnel or bridge. Cable cars are also faster to implement than building new roads, which calls decision-makers to consider since they demand results quickly.

CHAPTER 7 REFERENCES

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APPENDIX 01

APPENDIX 02

APPENDIX 03:-Output of HDM 4 Analysis for Both Road way and Cable car implementations

- Base case scenarios for cable car

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021

This report shows total economic benefits using the following:
Currency: Birr (millions).
Discount rate: 10%.
Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	8,029	0	0	115,727.52	4.47	0	0	0.00	107,702.75
Discounted	5,525	0	0	24,372	4	0	0	0	18,851

Economic Internal Rate of Return (EIRR) = 33.1% (No. of solutions = 1)

HDM-4 Version 1.1 Page 1 of 1

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Prese Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retun (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	5,524.678	24,376.066	0.000	18,851.388	3.412	33.1 (1)

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

HDM-4 Version 1.1 Page 1 of 1

- Increase 20% cost for cable car

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021

This report shows total economic benefits using the following:
Currency: Birr (millions).
Discount rate: 10%.
Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	8,029	0	0	115,482.18	3.69	0	0	0.00	107,436.82
Discounted	5,532	0	0	24,154	3	0	0	0	18,625

Economic Internal Rate of Return (EIRR) = 31.7% (No. of solutions = 1)

HDM-4 Version 1.1 Page 1 of 1

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

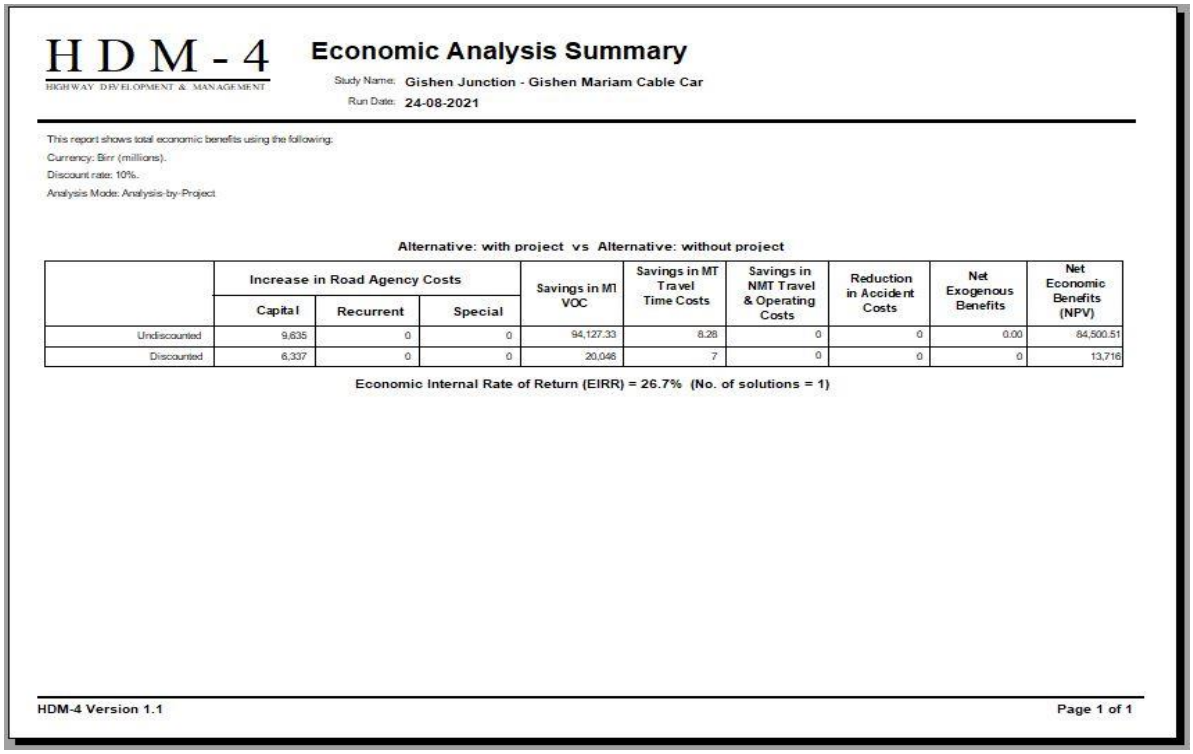
Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase in Agency Cost (C)	Decrease in User Cost (B)	Net Exogenous Benefit (E)	Net Present Value (NPV = B + E - C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return (IRR)
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	5,531.577	24,157.055	0.000	18,625.478	3.367	31.7 (1)

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

HDM-4 Version 1.1 Page 1 of 1

- Decrease 20% Benefit for cable car



HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021

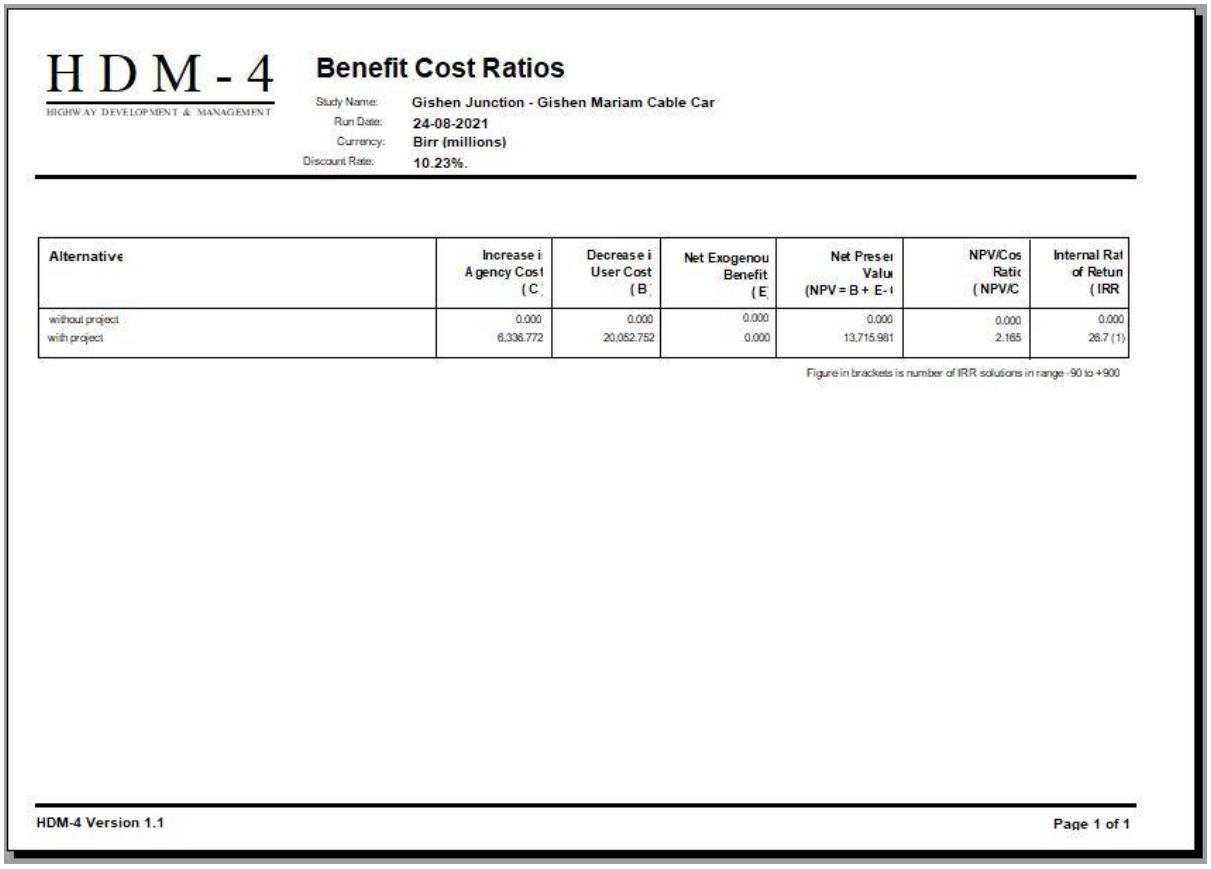
This report shows total economic benefits using the following:
Currency: Birr (millions).
Discount rate: 10%.
Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	9,635	0	0	94,127.33	8.28	0	0	0.00	84,500.51
Discounted	6,337	0	0	20,046	7	0	0	0	13,716

Economic Internal Rate of Return (EIRR) = 26.7% (No. of solutions = 1)

HDM-4 Version 1.1 Page 1 of 1



HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

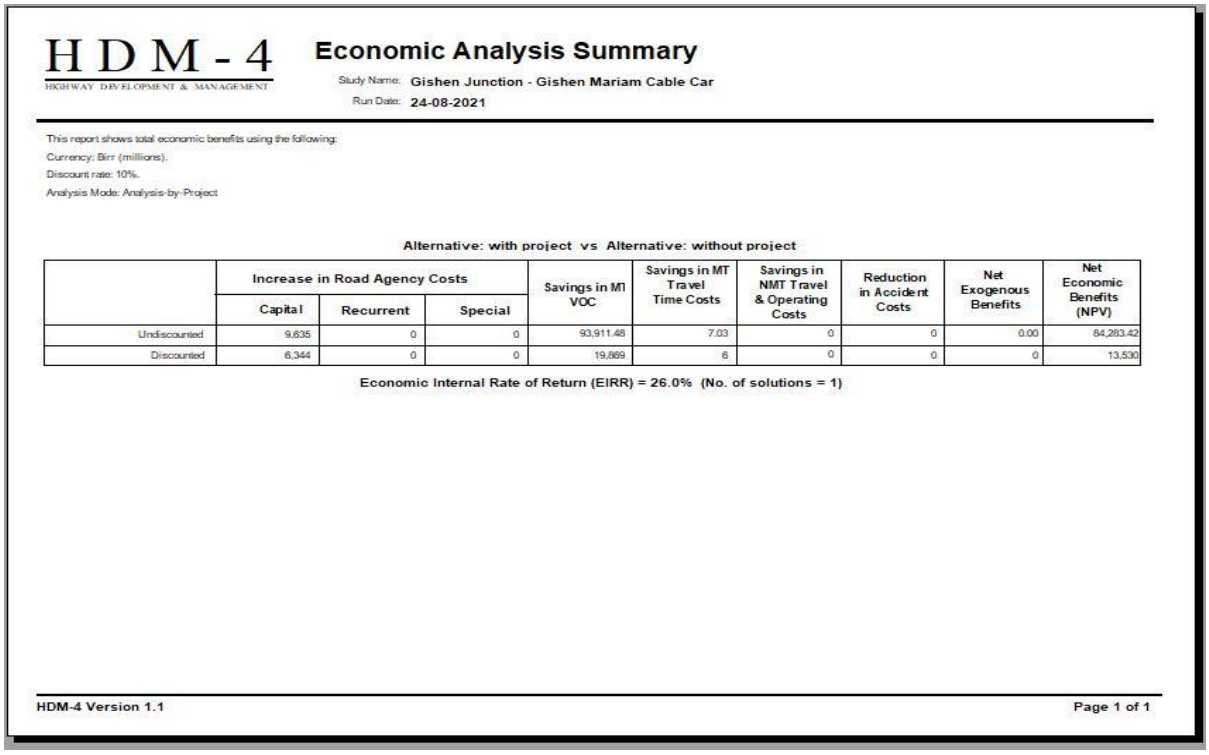
Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Presei Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retun (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	6,336.772	20,052.752	0.000	13,715.981	2.165	26.7 (1)

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

HDM-4 Version 1.1 Page 1 of 1

- Increase cost and benefit by 20% for cable car



HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021

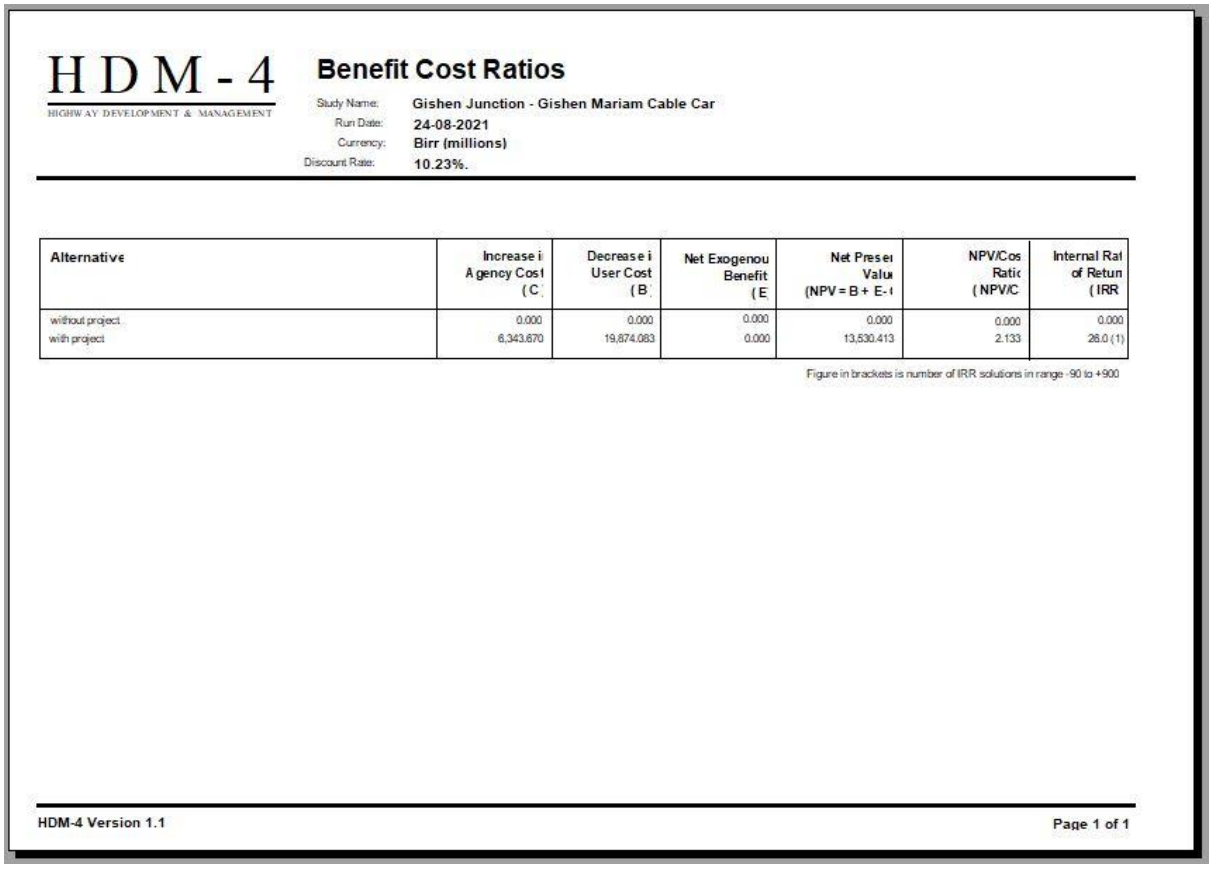
This report shows total economic benefits using the following:
Currency: Birr (millions).
Discount rate: 10%.
Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	9,635	0	0	93,911.48	7.03	0	0	0.00	84,283.42
Discounted	6,344	0	0	19,869	6	0	0	0	13,530

Economic Internal Rate of Return (EIRR) = 26.0% (No. of solutions = 1)

HDM-4 Version 1.1 Page 1 of 1



HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Prese Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retun (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	6,343.870	19,874.083	0.000	13,530.413	2.133	26.0 (1)

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

HDM-4 Version 1.1 Page 1 of 1

- Base case scenarios for Road way

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018

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

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-41.73	0.00	-10.97	-0.01	0.00	0.00	0.00	30.76
Discounted	0.00	-17.47	0.00	-9.72	0.00	0.00	0.00	0.00	7.74

Economic Internal Rate of Return (EIRR) = 29.2% (No. of solutions = 2)

HDM-4 Version 1.1 Page 1 of 1

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-17.470	-9.728	0.000	7.742	-0.443	29.2 (2)

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

HDM-4 Version 1.1 Page 1 of 1

- Increase 20% cost for Road way

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018

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

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-36.13	0.00	-10.97	-0.01	0.00	0.00	0.00	25.16
Discounted	0.00	-15.54	0.00	-9.72	0.00	0.00	0.00	0.00	5.81

Economic Internal Rate of Return (EIRR) = 24.8% (No. of solutions = 2)

HDM-4 Version 1.1 Page 1 of 1

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

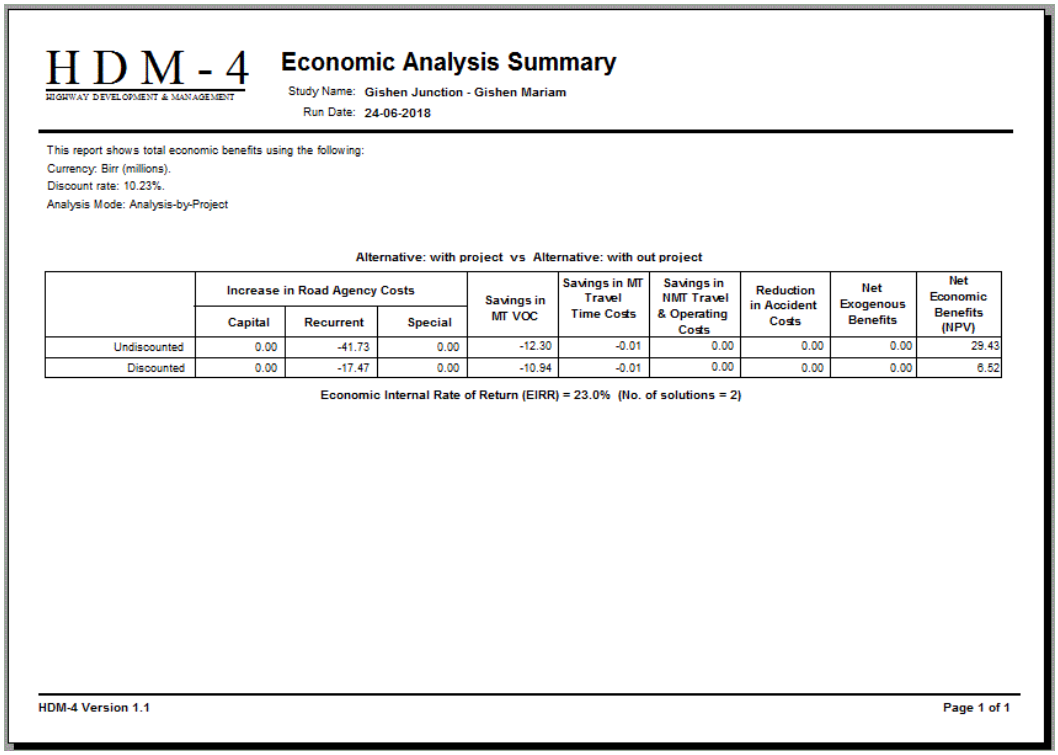
Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-15.538	-9.728	0.000	5.810	-0.374	24.8 (2)

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

HDM-4 Version 1.1 Page 1 of 1

- Decrease 20% Benefit for roadway



H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018

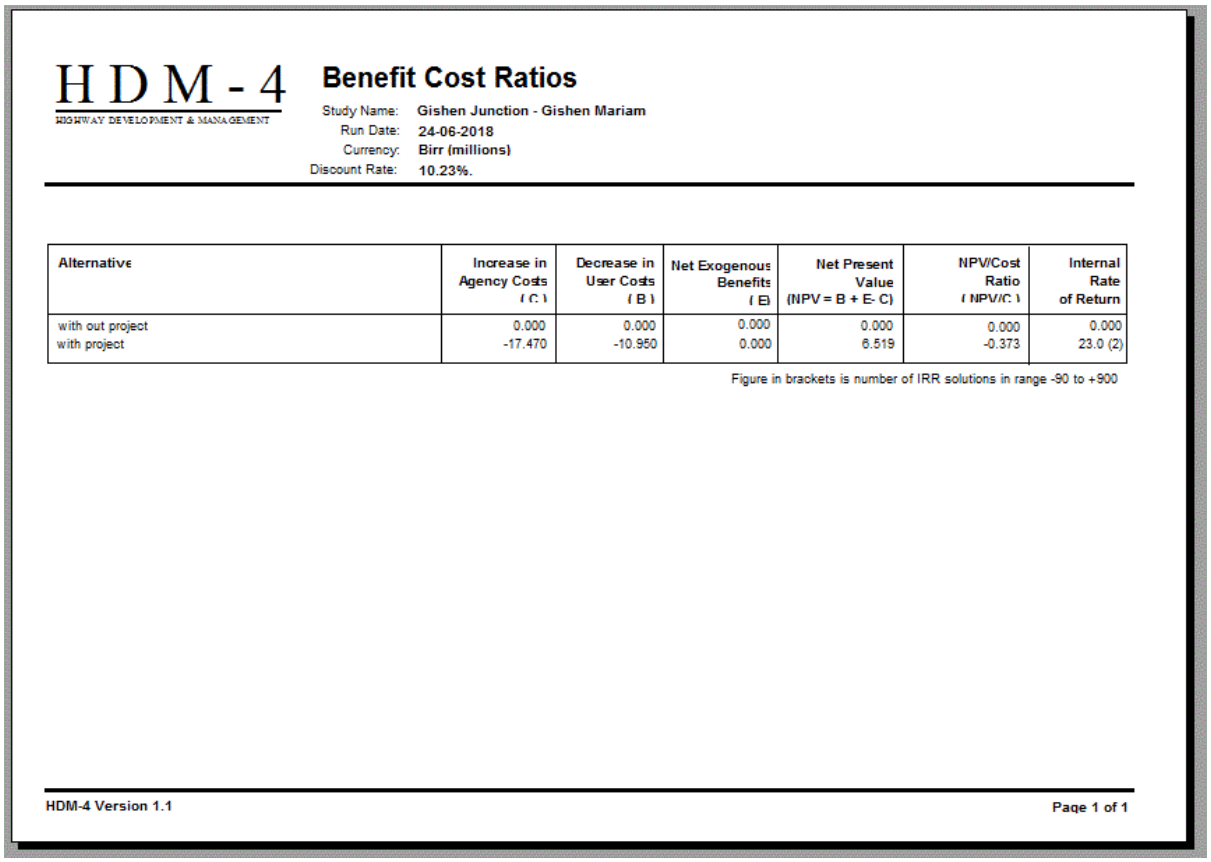
This report shows total economic benefits using the following:
Currency: Birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-41.73	0.00	-12.30	-0.01	0.00	0.00	0.00	29.43
Discounted	0.00	-17.47	0.00	-10.94	-0.01	0.00	0.00	0.00	6.52

Economic Internal Rate of Return (EIRR) = 23.0% (No. of solutions = 2)

HDM-4 Version 1.1 Page 1 of 1



H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-17.470	-10.950	0.000	6.519	-0.373	23.0 (2)

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

HDM-4 Version 1.1 Page 1 of 1

- Increase cost and benefit by 20% for cable car

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018

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

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-41.73	0.00	-14.67	-0.01	0.00	0.00	0.00	27.05
Discounted	0.00	-17.47	0.00	-13.05	-0.01	0.00	0.00	0.00	4.41

Economic Internal Rate of Return (EIRR) = 17.0% (No. of solutions = 2)

HDM-4 Version 1.1 Page 1 of 1

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam
Run Date: 24-06-2018
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-17.470	-13.058	0.000	4.412	-0.253	17.0 (2)

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

HDM-4 Version 1.1 Page 1 of 1

APPENDIX 04

APPENDIX 05

APPENDIX 06

APPENDIX 01

ቃለ - ጉባኤ

የቀበሌ ጽ/ቤ— ባሻን፡ ሀገረ ጽዮን፡ መንገድ፡ 3575፡ ጀሬ ሶ
የጽሕፈቱ፡ ሃላፊ፡ በተመለከተ፡ የዲሬ፡ ቃለ ጉባኤ፡

የአባላት፡ ቦታ፡ የአበሽ፡ ጉባኤ፡ ክፍል
ቀንና ሰዓት ፡ 08/08/2010
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2.	አቶ በላቸው፡ ደሳ፡ አለሙ	የአበሽ ጉ/ም/ሊ/መ	0920-241541	
3.	ሊቀመዘምራን ዘርፉ ገ/መስቀል	የአበሽ ጉ/ሊ/ጸሐፊ	0921042741	
4.	ሊቀ ሰ/ብርሃን ቀሲስ መርዕድ አለሙ	የአበሽ/ጉ/ገ/ያዥ	0922745293	
5.	ቀሲስ፡ ገብረመድህን ፀጋዬ	የሰ/ት/ቁ/ጸሐፊ	0919914773	
6.	በላይ፡ ወንድሙ አለሙ፡ አለማየሁ	የአበባሪ፡ ሰብሳቢ	0945 188365	
7.	መምሬ፡ ዘሪሁን፡ ወልደ ትንሣኤ፡ ዘውዱ	የሰ/ጉ/ አባል	0913 994579	
8.	መምሬ፡ ዘላለም፡ በቀለ	የሰ/ጉ/ ″	0912714048	
9.	ዐዛዥ፡ መዝሙር፡ ደምሴ	የሰ/ጉ/ቁጥጥር	0920208149	
10.	ቀሲስ፡ በርሄ፡ ዘውዴ	የሰ/ጉ፡ አባል	0920 387433	
11.	ዲ/ን ብሩክ ታደሰ፡ በርሄ	″ ″	0920199160	
12.	ቀሲስ፡ መንግስቱ፡ አበራ	″ ″	0920487813	
13	አቶ ደመቀ ማርቆስ	ሰበካ ጉባኤ ተወካይ	0911 34 37 68	
14	አቶ ካሳ ኢብርሃ	″	0911 77 51 80	
15	አቶ ታደሰ ገብሬ	″	0912 37 49 34	
16	አቶ አበራ አበበ	″	0945 92 95 02	

የአሁሰሰ፡ [illegible]

1ኛ) ስለ፡ ቀለፀሎት - ዓመት፡ መጀመሪያ፡ [illegible] ፡ [illegible]
ከዓመት፡ [illegible] [illegible]፡ መጀመሪያ፡ ለበዓ፡ ጉባኤ፡
እንደሚገባ፡ ለካህናት፡ ገለፃ፡ መደረግ፡

2ኛ) የመንገዱ፡ መሸኛ፡ መቋረጥ፡ መቀበት፡ መደረግ

3ኛ) እንዲሁም፡ መንገዶች፡ ገዳ፡ መለየት፡

4ኛ) ካተጋሩ፡ እንዲሁም፡ እስካሁን፡ ጠቅላላ፡ ያለው፡ ስለ
ር፡ መለየት መቀጠም መመለስ

5ኛ) የመንገዱ፡ ጠቅላላ፡ ለበተክርስቲያኑ፡ እንዲሁም
ለአገልግሎት፡ ንቁ፡ [illegible]፡

6ኛ) ፊርማ

ከበደ ወልደ ዮሐንስ
ወልደ ገብረ ሚካኤል
ካሳሁን ካሳሁን
ተስፋዬ ጥበበ

የተወሰዱ: ውሳኔዎች

1ኛ) ስለ: ቀበሌን - ግሽን: ለማርደግም: መንገድ: ፕሮጀክት: 35ቶ5: ዶላር
ዓመት: ሥራ: ከግሽን: ቀበሌ ከበረ: ለማርደግም: ለዚህ: ንብረት
አገልግሎ: ለህዝብ: እንዲሆንም: ከአካባቢ: ነዋሪዎች: ጋር: ተገናኝቶ
ከተወያየ: በኋላ:
 የሰበሰ: ንብረቱ: አገልግሎ: ለህዝብና: የአካባቢ: ነዋሪዎች: ሥራ
እንዲስተካከል: እንዲቀበሉ: ሥራውን: በተመለከተ: ከመመደብ: የቀበሌ
የክልል ምክር: ከማህበራት: እንዲያስተናግዱ: በማረጋገጥ:
ጋር: የህዝብ ነዋሪ: እንዲሁ: አለብን: እንዲመረጡ ወደፊት:
ቀጥሎ: ገብተናል::

2ኛ) የቀበሌን - ግሽን: ለማርደግም: መንገድ: ፕሮጀክት: መደብ
ቀበሌን: መንገድ (ግሽን: መንገድ) ለሁሉ: መሰረት
ይሰጥ: ግሽን ብር (ቢሮክ: ሥራ) መቀበል: ለዚህ: ለሙ
አገልግ: ለማከናወን: እንዲሰሩ: ወስነናል::

3ኛ) ተለዘለዘሉዎች: በመቀበል: 3 (ሦስት) ከማህበራት: ከቀበሌው:
 1ኛ) ቀበሌ - አበዛኝ - ጁሌ - አበቀኝ - ገመቹ -
 ሙቀሜት - ጁጁሮ - አንጎበይ ብር - አደሬሶ - ግሽን:
 2ኛ) ቀበሌን - አበዛኝ: ለጁርቶ: ጋለሞን: ቡድን: ለመተው
 በመገባ - ዘሀም - አንጎበይብር - አደሬሶ - ግሽን:
 3ኛ) ቀበሌን - ጁለሙ - ፖጌ - አንጎበይ: ብር - አደሬሶ
 - ግሽን: ዩኒት: የቻሉ:

4ኛ) ከተጠቀሱት: ከማህበራት: መሠረት: ለተክ: ቀጥር: 1 የተጠቀሰው
ማህበርም: ቀበሌ - አበዛኝ - ጁሌ - አበቀኝ - ገመቹ - ሙቀሜት
ጁጁሮ - አንጎበይ: ብር - አደሬሶ - ግሽን: የተመረጠ: ለሆን:
እንዲከናወን: መደረግ: ምክር: ግምት: በማስገባት: ከሌሎች: ከማህበ
ራትም: የመጠቀም: እንደሆነ: እንዲሰጥበር: ተገልፀዋል::

5ኛ) የመንገዱ፡ ጠቀሜታ፡ ለቤተክርስቲያኒቱ፡ አመለካከት፡ ለአካባቢ፡
ነዋሪዎች ፡ ሰፊ ቋታ፡ የሚያስተላልፈን፡ ተቀብለዋል።

ሀ) ቀዩ፡ የባለን፡ ወሰናችም፡ የመሄጃ፡ አንደምዳይ፡ እንደሀገራችም፡ የሚከፍለው
ህዝብ፡ መንገድና የመለቀቅ፡ ዘላቂ፡ የሚገኛቸው፡ መሬቱን፡
ተሰጥቷል፡ እቅዱ፡ ለጠቅም፡ ዘዴት፡ ይከፈ፡ ሙሉ መንገድ ነው
ያቲሪስት፡ ፍላጎት፡ የሚያደርስበት፡ ለተቀበለ፡ ሰፊ፡ ሺሀን
ለተከቀ፡ በንግድ፡ መሰዎች መለክርም21 ፣ 3ና21፣ መጋቢት 10
አና፡ ሰዒ፡ 21 የሚኖረው፡ ፍላጎት፡ ከፍተኛ፡ ለመሬት
ዘዴት፡ ያካፍለው፡ (ለፖ) የሚወጣሉ፡ ተፈክርካሪዎች
ቀመጠሉ።
ለጠቀሰቀ፡ ቀዩ፡ የሀዝቡ፡ ያቲሪስት፡ ፍላጎት፡ ሚያስተናግድ
ቀጣይ፡ ዘንድ፡ የመንገዱ፡ ኩለኩሉንታና፡ ጎደፊም፡ እናዲያ
ለጠቅም፡ የቀኪ፡ ነው።

ለ) ለባለን፡ ሚሪንያዎች፡ ከአካባቢው፡ ከ 15 ቀበሌዎች፡ ለከቀ
ተጠቃሚ፡ ናቸው፡ ቀዩም፡ የአካባቢ፡ ሚያስበረታታ
የቤተክርስቲያኒቱ፡ ሚያሳብለለ፡ ይጠቀማል።

ሐ) የሚያደርጋ፡ ሰዐ ሚያገለግለ አዛ ዘይና፡ ንግግር፡ መሣሪያ
ለአገልግሎት፡ እንዲሁም፡ ሚያገለግሉና፡ ሚገኙባቸው፡ ለሰተው
እንዲሁ ጫርሽ፡ ጫናተኛ፡ ንቃም፡ ቀሠጠለ።

መ) መንገዱ፡ ለሚሠራበት፡ ከተሠራም፡ በኋላ፡ ከአካባቢ
ህዝብም፡ ጋር፡ ከቤተክርስቲያኒቱ፡ ሚዳላል፡ የሥራ፡ 0ፎር
ቀጣይነት፡ ለተመሠረተ፡ ሆነች፡ አካባቢው፡ ለዲ፡
ኩራ፡ ክብር፡ ፍላጎት፡ እንደሚቀይር፡ ቀርቧል።

6ኛ) ኩራት፡ ያተኛለ፡ ጉዳዮች፡ ካቀ፡ ሰለቆን፡ እንተመሰረን፡ ለሚ
ያስማስተኩትን፡ የመሥራት፡ ህብረት፡ አቅርበናል።

ሀ- የመሪና፡ ሚያቀርብ፡ ሽፋር፡ ለእክ፡ ለመተከከል፡ መንገድ፡ ለተመሠረተ፡ የመ
ሚያቀርብ፡ እንደሚሆን፡ ጸሐፊ፡ ሰኔት፡ መናፈሻዎች ሚከተለው

ለ- ህዝቡ፡ ፀ- አስቀድሞ ሚገኘው፡ አካባቢ 3ኛ) መሰረቱ፡ ገበያ

ለንዲያዊት

ከ- ለተመሠረተ፡ ለንግድ፡ ለሚሆን፡ የመሬቱ፡ ፍላጎት፡ እናሲያ

ካንሰሮ፡ እስከ ማሽን፡ ድረስ፡ እንዲሁን፡ የመንግሥ፡ መተዳደሪያ
ጽሑፍ፡ ከመደቡ፡ ሙሉ መሠረት፡ ለአገልግሎት፡ ቀድሞ፡ ከማስተካከያ
ከመሰ፡ ሙሉ መረጃ፡ እንዲሰጡን፡ ተመስገን፡ የመንግሥ
ለቀረ፡ ሊደረስ፡ በማቅረብ፡ ቢሆ፡ ካለ፡ እንዲወሰን
እንዲሰጠን፡

ሐ - ምዕመናን፡ ካሉ ተክለ፡ ወርቅነህ፡ ከመዝገብ፡ ጋር፡ በከመፍጠን
ለዝንጉም፡ ከቀደ፡(ለቀን፡ ከቀደ) የአማኑ፡ መንግሥ፡
እንደሚወሰን፡ እንዲጠብቁልን

መ - መምህራን፡ ሠርተን፡ ቀሪው፡ እንዲሁም፡ ለዚ፡ ለመ
ከብዛ፡ ሙሉ ካህናት፡ እየተሰጠ፡ እንዲጠብቁ፡ ቢሆ፡ የመዝገብ፡
ማዘዣ፡ ቢሆ፡ እንዲወሰን፡ እንዲጠብቁልን፡

APPENDIX 02

Estimated Construction cost of Cable car					
Pay Item	**Description**	**Unit**	**Estimated Qty**	**Rate**	**Amount (ETB)**
	8100: FOUNDATION FOR STRUCTURES				
81.01	Additional foundation investigations				
(a)	Geotechnical Investigation , Foundation Investigation fixed cost	PS	1.00	400,000.000	400,000.000
(b)	Percentage allowed for overhead & profit on item 81.01 (a)	%	25.00%		100,000.000
81.02	Excavation of material				
(a)	Excavation of soft material irrespective of depth	m^3	299.20	133.97	40,084.72
(b)	Excavation of hard material irrespective of depth range	m3	149.60	326.70	48,875.06
81.05	Backfill to excavations utilizing				-
	(a) materials from the excavation	m^3	89.76	170.242	15,280.92
	(b) Imported material	m^3		327.713	-
	(d) Rock Fill	m^3		400.081	-
(d)	Mass concrete (C-15) with plums of stone (Cyclopean Concrete) for Retaining walls	m^3	19.50	3,284.382	64,045.46
	8100 - Total				**668,286.16**
83.01	Steel reinforcement for structure				-
	(b) High yield stress steel bars (Deformed (Grade 420)	ton	1.17	78233.76863	91,363.46
	c) Sheating material	m2		25	-
	8300 - Total				**91,363.46**
84.01	Cast in situ concrete for structures				
(a)	Class 30/20 concrete in superstructure, approach slab, abutment seats & back walls. Peir caps, including formwork and class F1 & F2 finish	m^3	125.41	6,179.278	774,955.614
(c)	Cyclopean concrete (60% Grade 20/20 concrete and 40% stone plums /rock) for bridges	m^3	312.23	3,088.999	964,478.211
	8400 - Total				**1,739,433.82**
	total Cost for One Peir				**2,499,083.44**
	Contigouncy (10%)				**249,908.34**
	total Cost for One Peir				**2,748,991.78**
	PIRE	Number	10.00	2,748,991.785	**27,489,917.85**
	Track components				**7,879,960.00**
	Total Construction Cost				**35,369,877.85**
	Contigouncy (10%)				**14,147,951.14**
	Total Construction Cost				**49,517,828.99**
	Total Construction Cost Per KM				**7,390,720.74**

Estimated Construction cost of Cable car			
Pay Item	Description	Unit	Estimated Qty
	8100: FOUNDATION FOR STRUCTURES		
81.01	Additional foundation investigations		
(a)	Geotechnical Investigation , Foundation Investigation fixed cost	PS	1.00
(b)	Percentage allowed for overhead & profit on item 81.01 (a)	%	25.00%
81.02	Excavation of material		
(a)	Excavation of soft material irrespective of depth	m^3	299.20
(b)	Excavation of hard material irrespective of depth range	m3	149.60
81.05	Backfill to excavations utilizing		
	(a) materials from the excavation	m^3	89.76
	(b) Imported material	m^3	
	(d) Rock Fill	m^3	
(d)	Mass concrete (C-15) with plums of stone (Cyclopean Concrete) for Retaining walls	m^3	19.50
	8100 - Total		
83.01	Steel reinforcement for structure		
	(b) High yield stress steel bars (Deformed (Grade 420)	ton	1.17
	c) Sheating material	m2	
	8300 - Total		
84.01	Cast in situ concrete for structures		
(a)	Class 30/20 concrete in superstructure, approach slab, abutment seats & back walls. Peir caps, including formwork and class F1 & F2 finish	m^3	125.41
(c)	Cyclopean concrete (60% Grade 20/20 concrete and 40% stone plums /rock) for bridges	m^3	312.23
	8400 - Total		
	total Cost for One Peir		
	Contigouncy (10%)		
	total Cost for One Peir		
	PIRE	Number	10.00
	Track components		
	Total Construction Cost		
	Contigouncy (10%)		
	Total Construction Cost		

Total Construction Cost Per KM		

Rate	Amount (ETB)
400,000.000	400,000.000
	100,000.000
133.97	40,084.72
326.70	48,875.06
	-
170.242	15,280.92
327.713	-
400.081	-
3,284.382	64,045.46
	668,286.16
	-
78233.76863	91,363.46
25	-
	91,363.46
6,179.278	774,955.614
3,088.999	964,478.211
	1,739,433.82
	2,499,083.44
	249,908.34
	2,748,991.78
2,748,991.785	**27,489,917.85**
	7,879,960.00
	35,369,877.85
	14,147,951.14
	49,517,828.99

	7,390,720.74

Pay Item	Description	Unit	Estimated Qty	Rate	Amount (ETB)
	8100: FOUNDATION FOR STRUCTURES				
81.01	Additional foundation investigations				
(a)	Geotechnical Investigation , Foundation Investigation fixed cost	PS	1.00	400,000.000	400,000.000
(b)	Percentage allowed for overhead & profit on item 81.01 (a)	%	25.00%		100,000.000
81.02	Excavation of material				
(a)	Excavation of soft material irrespective of depth	m^3	299.20	133.97	40,084.72
(b)	Excavation of hard material irrespective of depth range	m3	149.60	326.70	48,875.06
81.05	Backfill to excavations utilizing				-
	(a) materials from the excavation	m^3	89.76	170.242	15,280.92
	(b) Imported material	m^3		327.713	-
	(d) Rock Fill	m^3		400.081	-
(d)	Mass concrete (C-15) with plums of stone (Cyclopean Concrete) for Retaining walls	m^3	19.50	3,284.382	64,045.46
	8100 - Total				**668,286.16**
83.01	Steel reinforcement for structure				-
	(b) High yield stress steel bars (Deformed (Grade 420)	ton	1.17	78233.76863	91,363.46
	c) Sheating material	m2		25	-
	8300 - Total				**91,363.46**
84.01	Cast in situ concrete for structures				
(a)	Class 30/20 concrete in superstructure, approach slab, abutment seats & back walls. Peir caps, including formwork and class F1 & F2 finish	m^3	125.41	6,179.278	774,955.614
(c)	Cyclopean concrete (60% Grade 20/20 concrete and 40% stone plums /rock) for bridges	m^3	312.23	3,088.999	964,478.211
	8400 - Total				**1,739,433.82**
	total Cost for One Peir				**2,499,083.44**
	Contigouncy (10%)				**249,908.34**
	total Cost for One Peir				**2,748,991.78**
	PIRE	Number	6.00	2,748,991.785	**16,493,950.71**
	Track components(Rolling stock)		6.7	44,000,000.00	**294,800,000.00**
	Total Construction Cost				**311,293,950.71**
	Contigouncy (10%)				**124,517,580.28**
	Total Construction Cost				**435,811,530.99**
	Total Construction Cost Per KM				**65,046,497.16**

H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam Cable Car**

Run Date: **24-08-2021**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	9,835	0	0	93,911.48	7.03	0	0	0.00	84,283.42
Discounted	6,344	0	0	19,869	6	0	0	0	13,530

Economic Internal Rate of Return (EIRR) = 26.0% (No. of solutions = 1)

H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam Cable Car**

Run Date: **24-08-2021**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	9,635	0	0	94,127.33	8.28	0	0	0.00	84,500.51
Discounted	6,337	0	0	20,046	7	0	0	0	13,716

Economic Internal Rate of Return (EIRR) = 26.7% (No. of solutions = 1)

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam Cable Car**

Run Date: **24-08-2021**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	8,029	0	0	115,462.18	3.89	0	0	0.00	107,438.62
Discounted	5,532	0	0	24,154	3	0	0	0	18,625

Economic Internal Rate of Return (EIRR) = 31.7% (No. of solutions = 1)

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam Cable Car**

Run Date: **24-08-2021**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: without project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	8,029	0	0	115,727.52	4.47	0	0	0.00	107,702.75
Discounted	5,525	0	0	24,372	4	0	0	0	18,851

Economic Internal Rate of Return (EIRR) = 33.1% (No. of solutions = 1)

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Preser Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retun (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	6,343.670	19,874.083	0.000	13,530.413	2.133	26.0 (1)

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

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Preser Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retun (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	5,524.678	24,376.066	0.000	18,851.388	3.412	33.1 (1)

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

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Preser Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retun (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	6,336.772	20,052.752	0.000	13,715.981	2.165	28.7 (1)

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

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Gishen Junction - Gishen Mariam Cable Car
Run Date: 24-08-2021
Currency: Birr (millions)
Discount Rate: 10.23%.

Alternative	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenou Benefit (E	Net Preser Valu (NPV = B + E-	NPV/Cos Ratic (NPV/C	Internal Rat of Retur (IRR
without project	0.000	0.000	0.000	0.000	0.000	0.000
with project	5,531.577	24,157.055	0.000	18,625.478	3.367	31.7 (1)

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

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam**

Run Date: **24-06-2018**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10.23%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-41.73	0.00	-14.67	-0.01	0.00	0.00	0.00	27.05
Discounted	0.00	-17.47	0.00	-13.05	-0.01	0.00	0.00	0.00	4.41

Economic Internal Rate of Return (EIRR) = 17.0% (No. of solutions = 2)

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam**
Run Date: **24-06-2018**

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

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-41.73	0.00	-12.30	-0.01	0.00	0.00	0.00	29.43
Discounted	0.00	-17.47	0.00	-10.94	-0.01	0.00	0.00	0.00	6.52

Economic Internal Rate of Return (EIRR) = 23.0% (No. of solutions = 2)

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam**

Run Date: **24-06-2018**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10.23%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-36.13	0.00	-10.97	-0.01	0.00	0.00	0.00	25.16
Discounted	0.00	-15.54	0.00	-9.72	0.00	0.00	0.00	0.00	5.81

Economic Internal Rate of Return (EIRR) = 24.8% (No. of solutions = 2)

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Gishen Junction - Gishen Mariam**

Run Date: **24-06-2018**

This report shows total economic benefits using the following:

Currency: Birr (millions).

Discount rate: 10.23%.

Analysis Mode: Analysis-by-Project

Alternative: with project vs Alternative: with out project

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	0.00	-41.73	0.00	-10.97	-0.01	0.00	0.00	0.00	30.76
Discounted	0.00	-17.47	0.00	-9.72	0.00	0.00	0.00	0.00	7.74

Economic Internal Rate of Return (EIRR) = 29.2% (No. of solutions = 2)

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: **Gishen Junction - Gishen Mariam**
Run Date: **24-06-2018**
Currency: **Birr (millions)**
Discount Rate: **10.23%.**

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-17.470	-10.950	0.000	6.519	-0.373	23.0 (2)

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

H D M - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: **Gishen Junction - Gishen Mariam**
Run Date: **24-06-2018**
Currency: **Birr (millions)**
Discount Rate: **10.23%.**

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-17.470	-13.058	0.000	4.412	-0.253	17.0 (2)

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

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: **Gishen Junction - Gishen Mariam**
Run Date: **24-06-2018**
Currency: **Birr (millions)**
Discount Rate: **10.23%.**

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-15.538	-9.728	0.000	5.810	-0.374	24.8 (2)

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

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: **Gishen Junction - Gishen Mariam**
Run Date: **24-06-2018**
Currency: **Birr (millions)**
Discount Rate: **10.23%.**

Alternative	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E- C)	NPV/Cost Ratio (NPV/C)	Internal Rate of Return
with out project	0.000	0.000	0.000	0.000	0.000	0.000
with project	-17.470	-9.728	0.000	7.742	-0.443	29.2 (2)

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

ለምመናን እና ለሾፌሮች የተዘጋጀ መጠይቅ

1.0 እድሜ

ሀ. 0 – 18 ☐ ለ. 19 – 30 ☐

ሐ. 31 –42 ☐ መ.42 –62 ☐

ሰ. 63 – 70 ☐ ረ. 71 ና በላይ ☐

2.0 የሃይማኖት ሁኔታ

ሀ. ኦርቶዶክስ ☐ ለ. ሙስሊም ☐

ሐ. ካቶሊክ ☐ መ.ፕሮቲስታንት ☐

ሰ. ሌላ ☐

3.0 የትምህርት ደረጃ ሀ. ያልተማረ/ያልተማች ☐

ለ. አንደኛ ደረጃ/ 1-8 ክፍል ☐

ሐ. ሁለተኛ ደረጃ/ 9-12 ☐

መ.ዲፕሎማ እና ከዛ በላይ ☐

4.0 የስራ ሁኔታ ሀ. ደሞዝተኛ /ተቀጣሪ ☐

ለ. ነጋዴ ☐

ሐ. የቤት እመቤት ☐

መ. ሌላ ☐

5.0 ወደ ግሸን ማርያም በምን መጡ

ሀ. በግል መኪና ☐ ለ. በህዝብ መኪና ☐ ሐ. በእግር ☐

6.0 ወደ ግሸን ማርያም ሲመጡ መነሻዎ ከየት ነው?

7.0 ወደ ግሸን ማርያም ለምን መጡ?

ሀ. ለንግስ /ቤተክርስቲያን ☐ ለ. ለመነብኘት/ሃገር ለማየት ☐ ሐ. ቤተሰብ ለመጠየቅ ☐ ለመሳለም

መ. ሌላ ☐

8.0 ወደ ግሸን ማርያም ሲመጡ ለስተኛ ግዜ ነው

ሀ. ለመጀመሪያ ግዜ ☐ ለ. ለሁለተኛ ግዜ ☐ ሐ.ለሶስተኛ ግዜ እና ከዛበላይ ☐

9.0 ከአስፋልት ማለትም ከደሴ ኩታበር መንገድ ወደ ግሸን ማርያም የሚሄደው የጠጠር መንገድ ሁኔታ እንዴት ይገልጹታል?

ሀ. እጅግ በጣም ጥሩ ☐ ለ. በጣም ጥሩ ☐ ሐ.ጥሩ ☐ መ.አስቸጋሪ ☐ ሰ. በጣም አስቸጋሪ ☐

ረ. እጅግ በጣም አስቸጋሪ ☐

10.0 ወደ ግሽን ማርያም ሲመጡ ምን አጋጥሞታል?

11.0 ከዚ በኃላ ወደ ግሽን ማርያም ተመልሰው ይመጣሉ?

ሀ. አዎ ☐ ለ. አይ ☐

12.0 በተራ ቁጥር 7.0 ላይ ላለው መልስዎ አይ ከሆነ ለምን?

ሀ. የመንገዱ አስቸጋሪነት ☐ ለ. የአቅም ማነስ/በገንዘብ ☐ ሐ.የአቅም ማነስ/በጉልበት ☐

መ.የትራንስፖርት አቅርቦት እጥረት ☐

13.0 ከደሴ ወደ ኩታበር በሚወስደው አስፋልት መንገድ ላይ ፣ልዩ ስሙ ቆላዲት ከሚባል ቦታ ተነስቶ ወደ ግሽን ማርያም የሚወስድው የጠጠር መንገድ በመኪና ከመተቀም ይልቅ ተንጠልጣይ መኪና ሆኖ በአጠረ ርዝመት ቢሰራ ይጠቀማሉ?

ሀ. አዎ ☐ ለ. አይ ☐

14.0 በተራ ቁጥር 13.0 ላይ ላለው መልስዎ አይ ከሆነ ለምን?

ሀ. በአስቸጋሪው መንገድ መሄድ በረከት ያስገኝልኛል ብዬ ስለማስብ ☐

ለ.ተንጠልጣይ መኪና ተጠቅሜ ስለማላውቅ ያስፈራኛል ☐

ሐ. የመሬት ከፍታ ያስፈራኛል ☐

መ. ውድ ይሆናል ብዬ ስለማስብ ☐

ሰ.ሌላ

ስለትብብርዎ ምስጋናዬን አቀርባለሁ::

ለአካባቢ ነዋሪዎች የተዘጋጀ መጠይቅ

1.0 እድሜ

ሀ. 0 – 18 ☐ ለ. 19 – 30 ☐

ሐ. 31 –42 ☐ መ.42 –62 ☐

ሰ. 63– 70 ☐ ረ. 71 ና በላይ ☐

2.0 የሃይማኖት ሁኔታ

ሀ. ኦርቶዶክስ ☐ ለ. ሙስሊም ☐

ሐ. ካቶሊክ ☐ መ. ፕሮቲስታንት ☐

ሰ. ሌላ ☐

3.0 የትምህርት ደረጃ ሀ. ያልተማረ/ያልተማች ☐

ለ. አንደኛ ደረጃ/ 1-8 ክፍል ☐

ሐ. ሁለተኛ ደረጃ/ 9-12 ☐

መ.ዲፕሎማ እና ከዛ በላይ ☐

4.0 የስራ ሁኔታ ሀ. ደሞዝተኛ /ተቀጣሪ ☐

ለ. ነጋዴ ☐

ሐ. የቤት እመቤት ☐

መ. በቀን ገቢ የምተዳደር ☐

5.0 የየት አካባቢ ነዋሪ ነዎት

ሀ. ከቆላዲት እስከ ግሸን ማርያም ባለው የጠጠር መንገድ አካባቢ ☐

ለ. ከሌላ አካባቢ ☐

ሐ. ሌላ ☐

6.0 ወደ ግሸን ማርያም ቤተክርስቲያን በምን ይሄዳሉ?

ሀ. በግል መኪና ☐ ለ. በህዝብ መኪና ☐ ሐ. በእግር ☐

7.0 ከቆላዲት እስከ ግሸን ማርያም ያለውን የጠጠር መንገድ በቀን ስንት ግዜ ይመላለሳሉ?

ሀ. አንድ ግዜ ☐ ለ. ሁለት ግዜ ☐ ሐ. ከሁለት በላይ ☐

8.0 ከቆላዲት እስከ ግሸን ማርያም የጠጠር መንገድ ሲመላለሱ ያጋጠመዎተ ካለ?

9.0 ከአስፋልት ማለትም ከደሴ ኩታበር መንገድ ወደ ግሸን ማርያም የሚሄደው የጠጠር መንገድ ሁኔታ እንዴት ይገልጹታል?

ሀ. እጅግ በጣም ጥሩ ☐ ለ. በጣም ጥሩ ☐ ሐ.ጥሩ ☐ መ.አስቸጋሪ ☐ ሰ. በጣም አስቸጋሪ ☐

ረ. እጅግ በጣም አስቸጋሪ ☐

10.0 በተራ ቁጥር 9.0 ላይ ላለው መልስዎ ከመ እስከ ረ ድረስ ከሆነ ተቀያሪ ወይም ተለዋጭ የትራንስፖርት አይነት ቢሰራ ይጠቀማሉ ወይ?

ሀ. አዎ ☐ ለ. አይ ☐

11.0 በተራ ቁጥር 10.0 ላይ ላለው መልስዎ አይ ከሆነ ለምን?

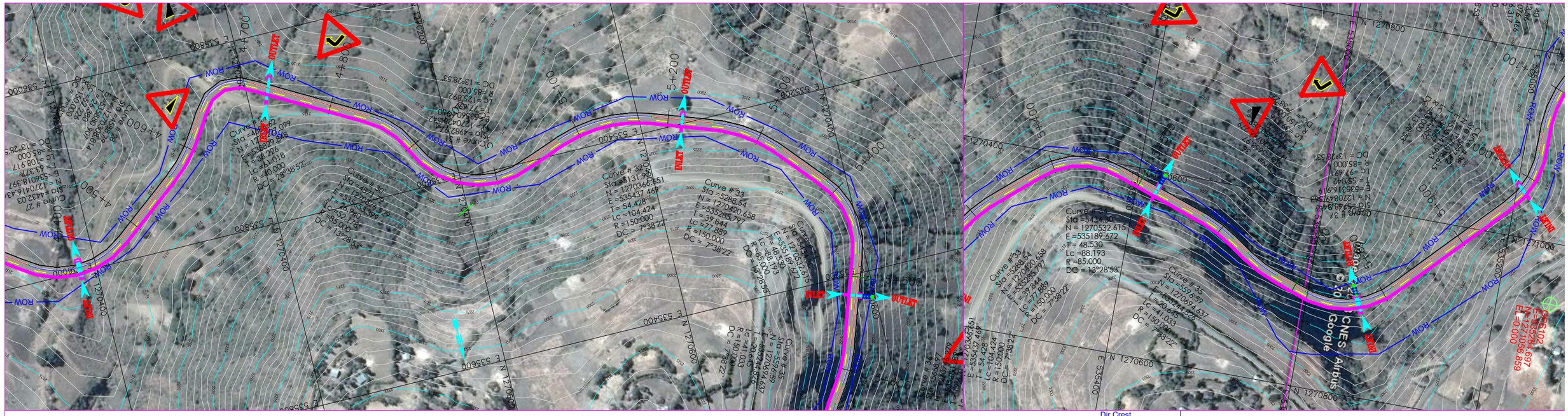
ሀ. በአስቸጋሪው መንገድ መሄድ በረከት ያስገኝልኛል ብዬ ስለማስብ ☐

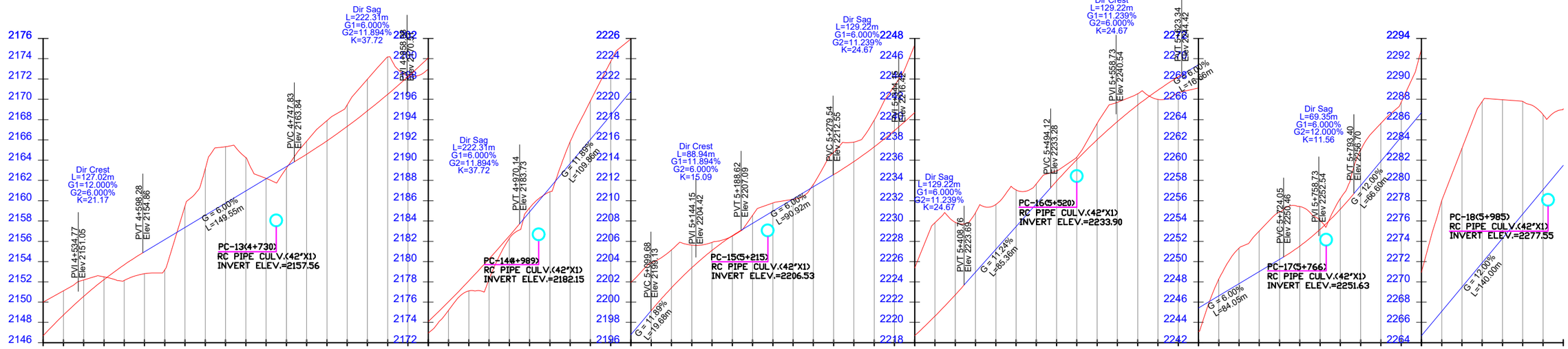
ለ.ተንጠልጣይ መኪና ተጠቅሜ ስለማላውቅ ያስፈራኛል ☐

ሐ. የመሬት ከፍታ ያስፈራኛል ☐

መ. ውድ ይሆናል ብዬ ስለማስብ ☐

ስለትብብርዎ ምስጋናዬን አቀርባለሁ፡፡





Station:	4+500	4+520	4+540	4+560	4+580	4+600	4+620	4+640	4+660	4+680	4+700	4+720	4+740	4+760	4+780	4+800	4+820	4+840	4+860	4+880
Proposed:	2146.686	2148.720	2150.565	2152.221	2153.689	2154.968	2156.168	2157.368	2158.568	2159.768	2160.968	2162.168	2163.368	2164.587	2165.905	2167.328	2168.858	2170.494	2172.235	2174.083
Existing:	2150.002	2151.115	2152.185	2152.495	2152.141	2152.801	2153.198	2159.473	2163.165	2165.329	2164.262	2162.200	2163.213	2165.881	2167.899	2169.454	2171.985	2174.178	2172.326	2172.958

Station:	4+900	4+920	4+940	4+960	4+980	5+000	5+020	5+040	5+060	5+080	5+100	5+120	5+140	5+160	5+180	5+200	5+220	5+240	5+260
Proposed:	2176.037	2178.097	2180.263	2182.535	2184.900	2187.279	2189.657	2192.036	2194.415	2196.794	2199.172	2201.414	2203.391	2205.103	2206.550	2207.775	2208.975	2210.175	2211.375
Existing:	2175.187	2177.111	2178.248	2182.272	2185.299	2186.884	2191.808	2195.844	2199.720	2201.963	2203.856	2205.142	2205.618	2205.892	2206.519	2208.555	2209.770	2210.134	2211.618

Station:	5+280	5+300	5+320	5+340	5+360	5+380	5+400	5+420	5+440	5+460	5+480	5+500	5+520	5+540	5+560	5+580	5+600	5+620	5+640
Proposed:	2212.575	2213.859	2215.306	2216.915	2218.687	2220.620	2222.716	2224.948	2227.196	2229.443	2231.691	2233.932	2236.051	2238.008	2239.802	2241.435	2242.905	2244.213	2245.416
Existing:	2214.769	2215.786	2217.927	2221.337	2225.373	2229.835	2229.874	2230.817	2231.621	2233.063	2233.667	2234.947	2236.293	2239.614	2241.702	2242.545	2241.984	2242.662	2243.110

Station:	5+660	5+680	5+700	5+720	5+740	5+760	5+780	5+800	5+820	5+840	5+860	5+880	5+900	5+920	5+940	5+960	5+980	6+000
Proposed:	2246.616	2247.816	2249.016	2250.216	2251.526	2253.175	2255.170	2257.492	2259.892	2262.292	2264.692	2267.092	2269.492	2271.892	2274.292	2276.692	2279.092	2281.492
Existing:	2248.250	2251.329	2253.004	2254.890	2255.430	2254.065	2256.226	2260.991	2263.629	2265.689	2270.948	2278.000	2283.170	2287.802	2287.961	2287.787	2286.493	2287.066

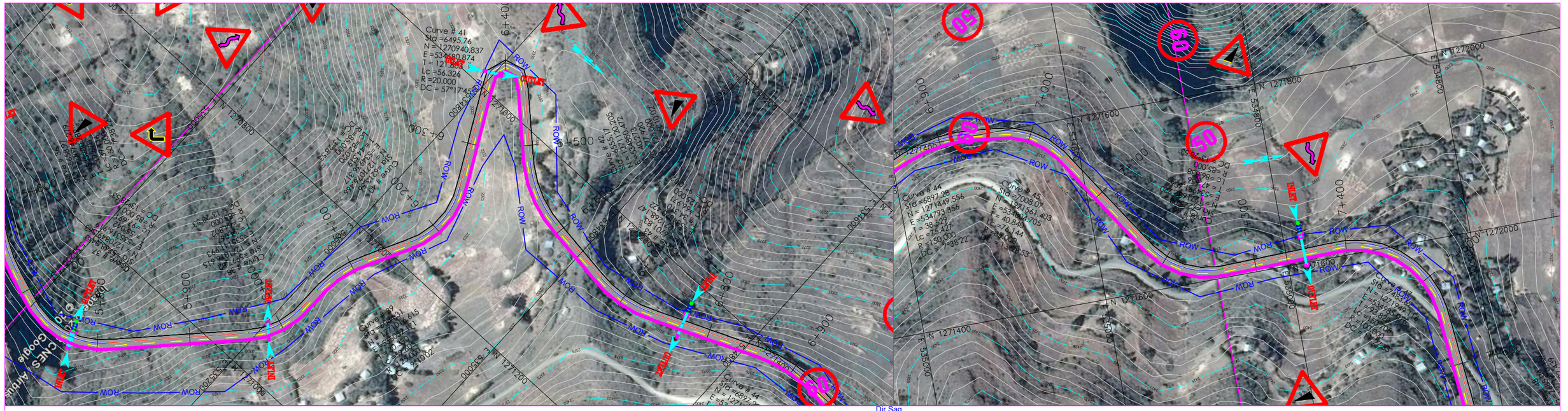
Curvature:

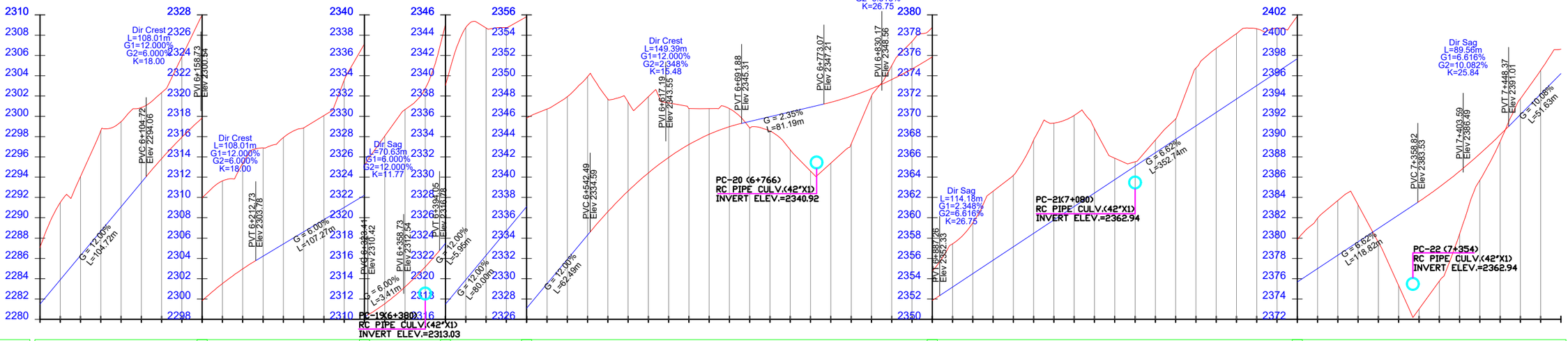
Vertical:

Superelevation:

TITLE

Km 4+500 TO Km 6+000





Station:	6+000	6+020	6+040	6+060	6+080	6+100	6+120	6+140	6+160	6+180	6+200	6+220	6+240	6+260	6+280	6+300
Proposed:	2281.492	2283.892	2286.292	2288.692	2291.092	2293.492	2295.827	2297.946	2299.843	2301.518	2302.971	2304.216	2305.416	2306.616	2307.816	2309.016
Existing:	2287.066	2291.503	2294.081	2298.600	2299.475	2300.861	2302.337	2305.886	2309.964	2311.641	2313.375	2314.889	2315.902	2316.859	2318.069	2321.552

Station:	6+320	6+340	6+360	6+380	6+400	6+420	6+440	6+460	6+480	6+500	6+520	6+540	6+560	6+580	6+600	6+620
Proposed:	2310.216	2311.532	2313.184	2315.176	2317.492	2319.892	2322.292	2324.692	2327.092	2329.492	2331.892	2334.292	2336.593	2338.637	2340.424	2341.951
Existing:	2325.138	2328.054	2330.657	2332.733	2339.048	2344.745	2344.703	2344.740	2345.824	2346.718	2347.930	2349.903	2347.710	2347.407	2347.937	2347.321

Station:	6+640	6+660	6+680	6+700	6+720	6+740	6+760	6+780	6+800	6+820	6+840	6+860	6+880	6+900	6+920	6+940
Proposed:	2343.220	2344.231	2344.984	2345.499	2345.968	2346.438	2346.908	2347.386	2347.982	2348.728	2349.623	2350.668	2351.862	2353.175	2354.499	2355.822
Existing:	2346.770	2346.756	2346.762	2344.865	2344.549	2342.696	2340.597	2341.388	2343.268	2347.980	2350.999	2353.381	2354.757	2357.430	2359.503	2362.620

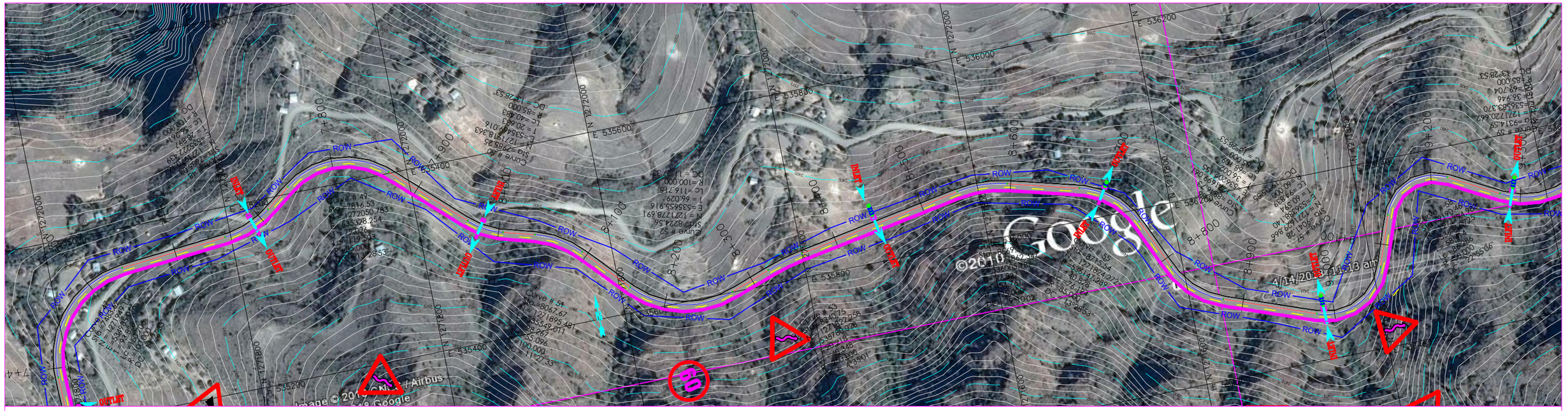
Station:	6+960	6+980	7+000	7+020	7+040	7+060	7+080	7+100	7+120	7+140	7+160	7+180	7+200	7+220	7+240
Proposed:	2357.145	2358.468	2359.791	2361.115	2362.438	2363.761	2365.084	2366.407	2367.731	2369.054	2370.377	2371.700	2373.023	2374.347	2375.670
Existing:	2364.174	2367.654	2369.337	2370.091	2368.789	2365.872	2365.522	2367.670	2369.745	2374.746	2376.696	2378.157	2378.626	2378.684	2379.862

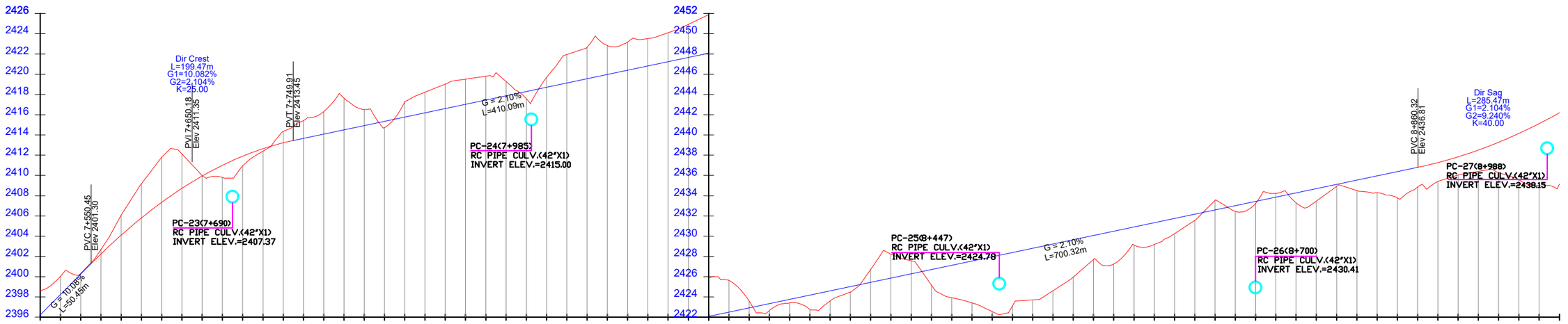
Station:	7+260	7+280	7+300	7+320	7+340	7+360	7+380	7+400	7+420	7+440	7+460	7+480	7+500
Proposed:	2376.993	2378.316	2379.639	2380.963	2382.286	2383.609	2385.019	2386.584	2388.303	2390.177	2392.180	2394.196	2396.213
Existing:	2381.958	2383.709	2383.261	2379.591	2375.301	2373.004	2375.758	2380.389	2385.699	2389.512	2393.740	2396.531	2398.624

TITLE

PP - 05 / F

Km 6+000TO Km 7+500





Station:	Proposed:	Existing:
7+500	2396.213	2398.624
7+520	2398.229	2400.032
7+540	2400.245	2400.326
7+560	2402.243	2402.678
7+580	2404.103	2406.075
7+600	2405.803	2409.182
7+620	2407.343	2411.802
7+640	2408.723	2412.115
7+660	2409.943	2409.986
7+680	2411.003	2409.797
7+700	2411.903	2410.952
7+720	2412.643	2412.397
7+740	2413.223	2414.364
7+760	2413.664	2415.423
7+780	2414.084	2416.312
7+800	2414.505	2417.633
7+820	2414.926	2416.517
7+840	2415.347	2414.734
7+860	2415.767	2417.262
7+880	2416.188	2418.219
7+900	2416.609	2419.021
7+920	2417.029	2419.521
7+940	2417.450	2419.816
7+960	2417.871	2419.284
7+980	2418.292	2417.587
8+000	2418.712	2419.695
8+020	2419.133	2421.941
8+040	2419.554	2422.659
8+060	2419.975	2422.834
8+080	2420.395	2423.174
8+100	2420.816	2423.519
8+120	2421.237	2424.103
8+140	2421.657	2424.928
8+160	2422.078	2425.878
8+180	2422.499	2425.639
8+200	2422.920	2423.599
8+220	2423.340	2422.658
8+240	2423.761	2423.418
8+260	2424.182	2422.767
8+280	2424.602	2423.607
8+300	2425.023	2424.485
8+320	2425.444	2426.707
8+340	2425.865	2428.233
8+360	2426.285	2427.573
8+380	2426.706	2425.175
8+400	2427.127	2423.922
8+420	2427.547	2423.410
8+440	2427.968	2422.545
8+460	2428.389	2423.122
8+480	2428.810	2423.710
8+500	2429.230	2424.620
8+520	2429.651	2425.965
8+540	2430.072	2427.705
8+560	2430.493	2427.254
8+580	2430.913	2429.130
8+600	2431.334	2429.183
8+620	2431.755	2430.247
8+640	2432.175	2431.563
8+660	2432.596	2433.553
8+680	2433.017	2432.447
8+700	2433.438	2433.234
8+720	2433.858	2434.224
8+740	2434.279	2433.297
8+760	2434.700	2433.473
8+780	2435.120	2434.914
8+800	2435.541	2434.508
8+820	2435.962	2434.293
8+840	2436.383	2433.794
8+860	2436.803	2434.860
8+880	2437.273	2435.404
8+900	2437.842	2436.045
8+920	2438.511	2436.403
8+940	2439.280	2436.282
8+960	2440.149	2435.584
8+980	2441.118	2434.991
9+000	2442.187	2435.144

Curvature:

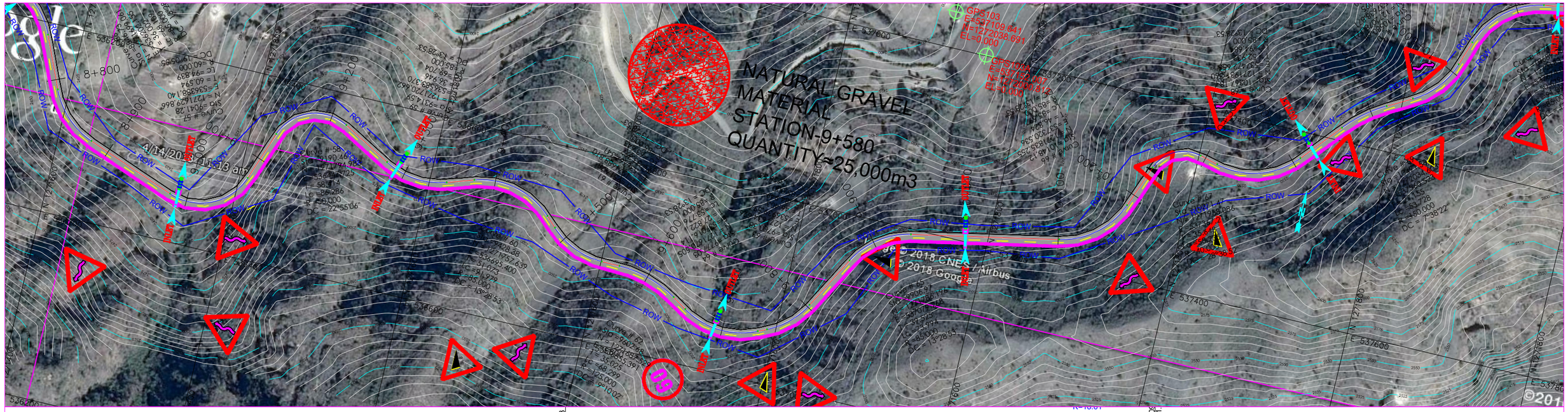
Vertical:

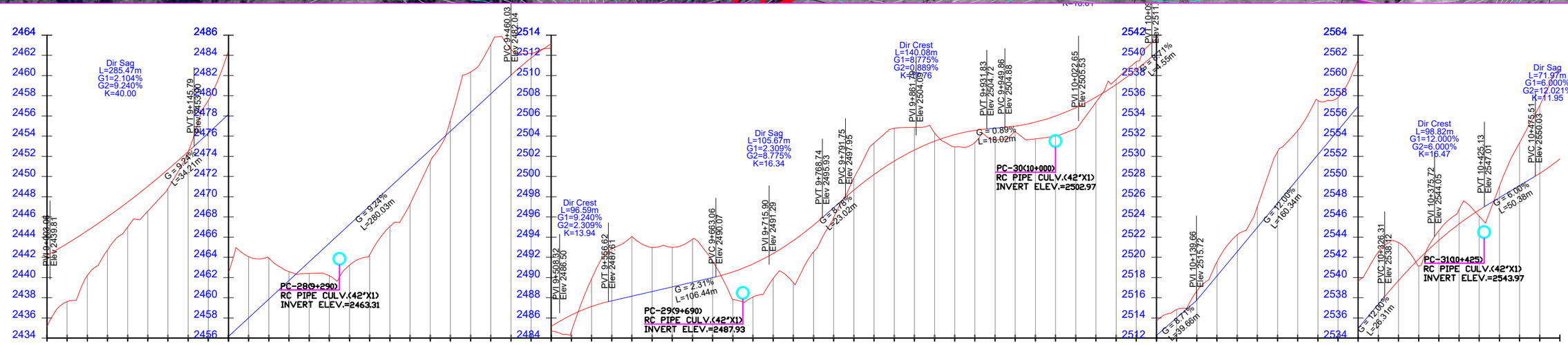
Superelevation:

TITLE

PP - 06 / F

Km 7+500TO Km 9+000





Station:	9+000	9+020	9+040	9+060	9+080	9+100	9+120	9+140	9+160	9+180	9+200	9+220	9+240	9+260	9+280	9+300	9+320	9+340	9+360
Proposed:	2442.187	2443.356	2444.625	2445.994	2447.463	2449.032	2450.701	2452.470	2454.314	2456.162	2458.010	2459.858	2461.706	2463.554	2465.402	2467.250	2469.098	2470.946	2472.794
Existing:	2435.144	2437.611	2440.192	2442.710	2444.986	2446.574	2448.816	2452.453	2457.541	2462.459	2464.062	2463.917	2462.581	2462.402	2462.173	2463.229	2464.253	2467.058	2469.253

Station:	9+380	9+400	9+420	9+440	9+460	9+480	9+500	9+520	9+540	9+560	9+580	9+600	9+620	9+640	9+660	9+680	9+700	9+720	9+740
Proposed:	2474.642	2476.490	2478.338	2480.186	2482.034	2483.739	2485.157	2486.287	2487.131	2487.692	2488.154	2488.616	2489.078	2489.540	2490.002	2490.551	2491.343	2492.379	2493.660
Existing:	2473.465	2477.574	2482.341	2485.076	2484.620	2484.198	2484.695	2484.662	2489.865	2492.843	2494.062	2492.986	2492.997	2493.796	2491.622	2487.830	2488.076	2489.902	2489.494

Station:	9+760	9+780	9+800	9+820	9+840	9+860	9+880	9+900	9+920	9+940	9+960	9+980	10+000	10+020	10+040	10+060	10+080	10+100	10+120
Proposed:	2495.186	2496.917	2498.653	2500.203	2501.527	2502.627	2503.501	2504.149	2504.573	2504.790	2504.996	2505.390	2505.999	2506.824	2507.863	2509.117	2510.586	2512.264	2514.007
Existing:	2492.536	2495.945	2499.863	2503.322	2504.783	2504.869	2504.333	2502.943	2503.380	2503.637	2504.428	2503.730	2504.024	2504.729	2507.349	2509.619	2511.376	2513.694	2514.825

Station:	10+140	10+160	10+180	10+200	10+220	10+240	10+260	10+280	10+300	10+320	10+340	10+360	10+380	10+400	10+420	10+440	10+460	10+480	10+500
Proposed:	2515.760	2518.160	2520.560	2522.960	2525.360	2527.760	2530.160	2532.560	2534.960	2537.360	2539.703	2541.816	2543.685	2545.312	2546.696	2547.903	2549.103	2550.312	2551.754
Existing:	2516.655	2519.548	2522.230	2525.028	2530.448	2532.544	2535.513	2535.833	2539.550	2542.542	2543.457	2541.129	2544.645	2546.732	2546.064	2549.040	2553.361	2557.027	2560.631

Curvature:

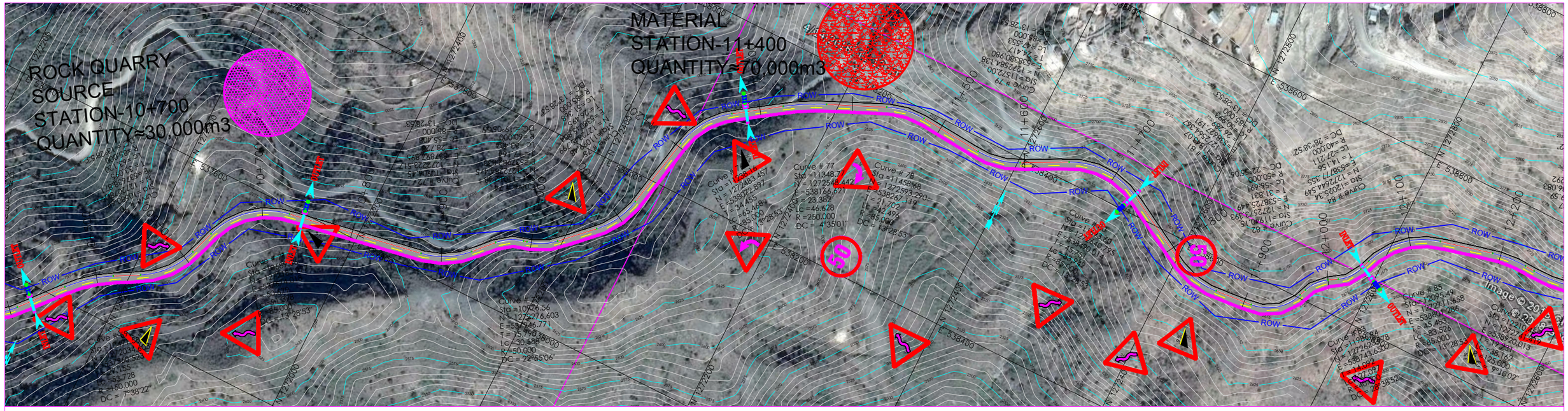
Vertical:

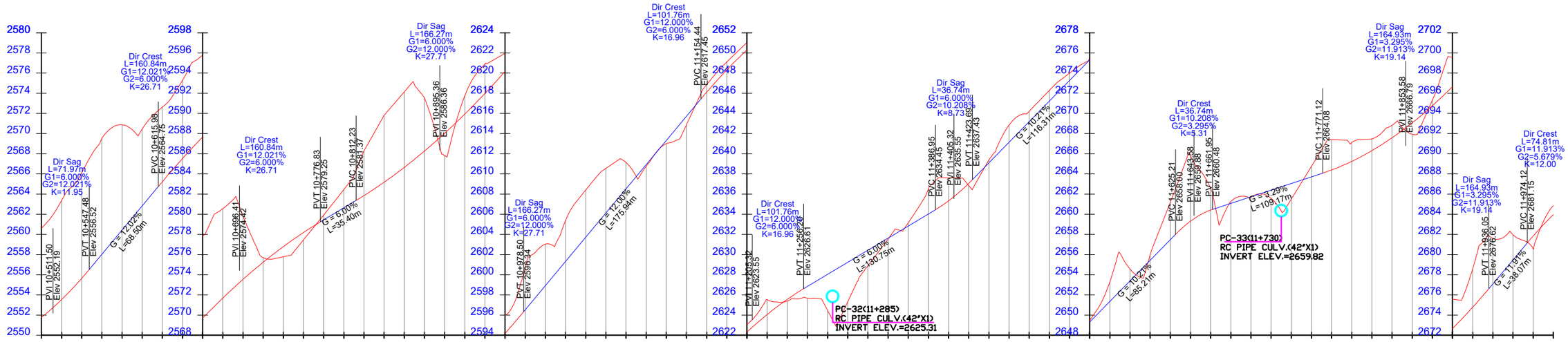
Superelevation:

TITLE

PP - 07 /   F

Km 10+500TO Km 12+000





Station:	10+500	10+520	10+540	10+560	10+580	10+600	10+620	10+640	10+660	10+680
Proposed:	2551.754	2553.531	2555.643	2558.024	2560.428	2562.833	2565.234	2567.533	2569.683	2571.682
Existing:	2560.631	2563.355	2566.104	2569.543	2570.882	2570.457	2572.632	2575.285	2577.806	2580.550

Station:	10+700	10+720	10+740	10+760	10+780	10+800	10+820	10+840	10+860	10+880
Proposed:	2573.533	2575.233	2576.784	2578.184	2579.437	2580.637	2581.848	2583.177	2584.649	2586.266
Existing:	2579.846	2575.685	2575.780	2577.460	2579.924	2582.442	2586.286	2589.805	2592.131	2591.544

Station:	10+900	10+920	10+940	10+960	10+980	11+000	11+020	11+040	11+060	11+080
Proposed:	2588.027	2589.933	2591.983	2594.177	2596.516	2598.916	2601.316	2603.716	2606.116	2608.516
Existing:	2585.834	2591.744	2594.902	2595.961	2600.720	2603.038	2605.388	2608.390	2610.544	2611.139

Station:	11+100	11+120	11+140	11+160	11+180	11+200	11+220	11+240	11+260	11+280
Proposed:	2610.916	2613.316	2615.716	2618.107	2620.323	2622.304	2624.048	2625.557	2626.835	2628.035
Existing:	2610.764	2613.007	2614.901	2618.860	2621.113	2623.030	2625.522	2625.388	2625.662	2624.437

Station:	11+300	11+320	11+340	11+360	11+380	11+400	11+420	11+440	11+460	11+480
Proposed:	2629.235	2630.435	2631.635	2632.835	2634.035	2635.332	2637.060	2639.094	2641.136	2643.177
Existing:	2625.323	2628.896	2631.544	2633.159	2636.521	2637.616	2636.840	2639.379	2642.855	2644.222

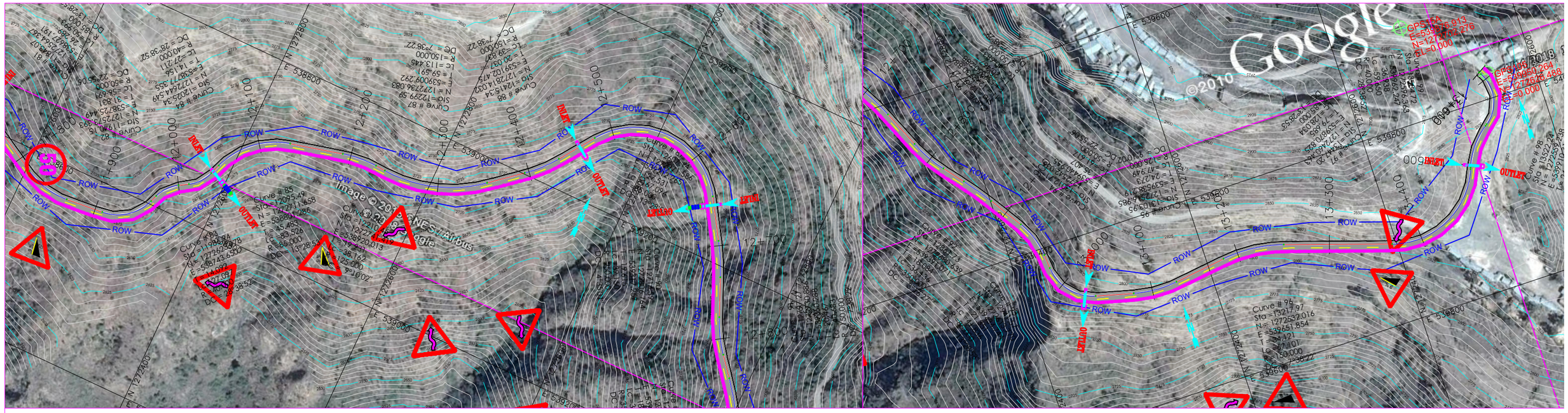
Station:	11+500	11+520	11+540	11+560	11+580	11+600	11+620	11+640	11+660	11+680
Proposed:	2645.219	2647.261	2649.302	2651.344	2653.386	2655.427	2657.469	2659.305	2660.413	2661.076
Existing:	2646.301	2647.989	2649.438	2653.293	2654.556	2655.949	2661.205	2665.823	2662.564	2661.270

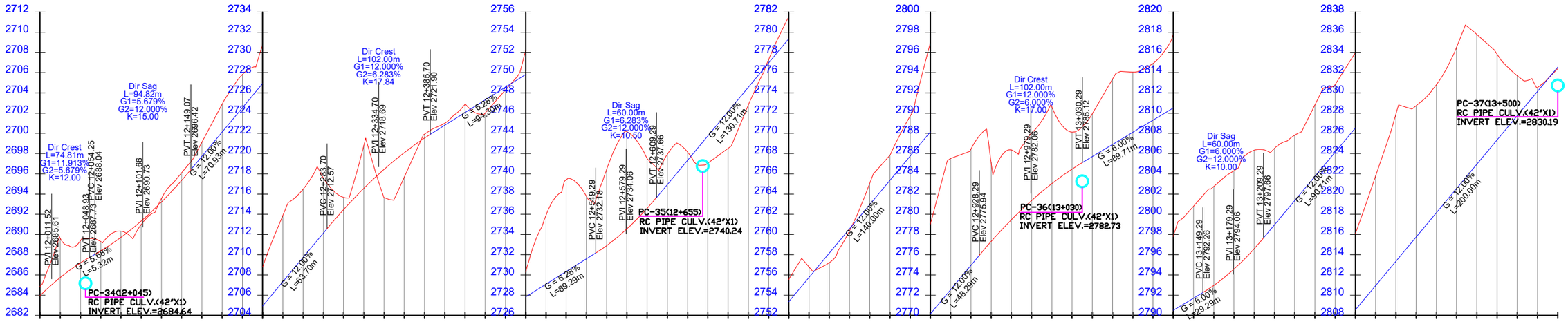
Station:	11+700	11+720	11+740	11+760	11+780	11+800	11+820	11+840	11+860	11+880
Proposed:	2661.735	2662.394	2663.053	2663.712	2664.391	2665.247	2666.313	2667.587	2669.070	2670.763
Existing:	2661.689	2661.574	2661.509	2664.770	2667.401	2667.139	2667.482	2668.830	2667.927	2671.338

Station:	11+900	11+920	11+940	11+960	11+980	12+000
Proposed:	2672.664	2674.775	2677.090	2679.472	2681.841	2683.958
Existing:	2675.576	2678.588	2681.605	2681.955	2680.580	2684.855

TITLE

Km 10+500 TO Km 12+000





Station:	12+000	12+020	12+040	12+060	12+080	12+100	12+120	12+140	12+160	12+180	12+200	12+220	12+240	12+260	12+280	12+300	12+320	12+340	12+360
Proposed:	2683.958	2685.743	2687.194	2688.374	2689.720	2691.332	2693.211	2695.357	2697.730	2700.130	2702.530	2704.930	2707.330	2709.730	2712.130	2714.455	2716.561	2718.442	2720.099
Existing:	2684.855	2689.611	2689.403	2689.298	2690.338	2690.997	2693.560	2696.107	2699.124	2702.876	2705.820	2708.771	2713.882	2716.469	2717.610	2715.670	2720.795	2715.642	2717.691

Station:	12+380	12+400	12+420	12+440	12+460	12+480	12+500	12+520	12+540	12+560	12+580	12+600	12+620	12+640	12+660	12+680	12+700	12+720	12+740
Proposed:	2721.531	2722.797	2724.054	2725.310	2726.567	2727.824	2729.081	2730.337	2731.594	2732.905	2734.557	2736.589	2738.948	2741.348	2743.748	2746.148	2748.548	2750.948	2753.348
Existing:	2721.927	2723.007	2724.872	2724.028	2726.305	2730.269	2735.896	2739.412	2737.794	2740.463	2744.164	2741.504	2741.935	2742.144	2741.046	2742.511	2746.799	2751.290	2755.532

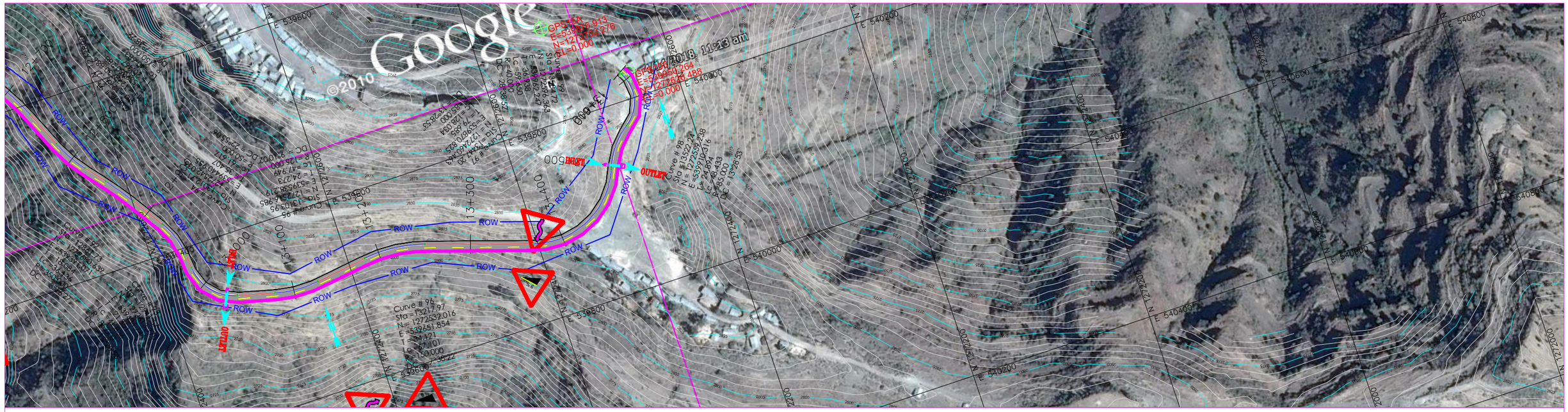
Station:	12+760	12+780	12+800	12+820	12+840	12+860	12+880	12+900	12+920	12+940	12+960	12+980	13+000	13+020	13+040	13+060	13+080	13+100	13+120
Proposed:	2755.748	2758.148	2760.548	2762.948	2765.348	2767.748	2770.148	2772.548	2774.948	2777.308	2779.452	2781.361	2783.035	2784.474	2785.705	2786.905	2788.105	2789.305	2790.505
Existing:	2756.790	2757.204	2760.361	2765.066	2767.847	2771.733	2779.014	2785.528	2786.448	2785.131	2786.358	2788.036	2790.608	2788.121	2789.950	2793.369	2794.055	2794.917	2797.813

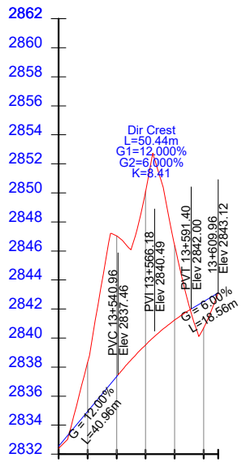
Station:	13+140	13+160	13+180	13+200	13+220	13+240	13+260	13+280	13+300	13+320	13+340	13+360	13+380	13+400	13+420	13+440	13+460	13+480	13+500
Proposed:	2791.705	2792.963	2794.577	2796.591	2798.948	2801.348	2803.748	2806.148	2808.548	2810.948	2813.348	2815.748	2818.148	2820.548	2822.948	2825.348	2827.748	2830.148	2832.548
Existing:	2800.797	2802.749	2804.305	2806.338	2806.519	2807.817	2810.809	2812.836	2816.097	2821.816	2827.899	2828.727	2830.803	2834.514	2835.786	2833.828	2831.694	2830.538	2832.397

TITLE

PP - 09 / F

Km 12+000TO Km 13+500



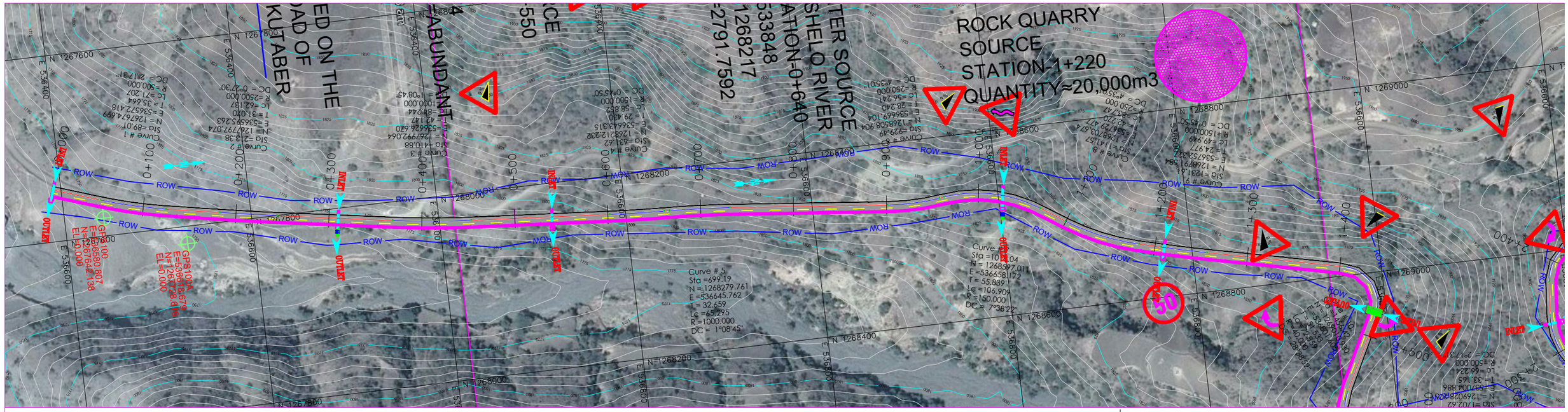


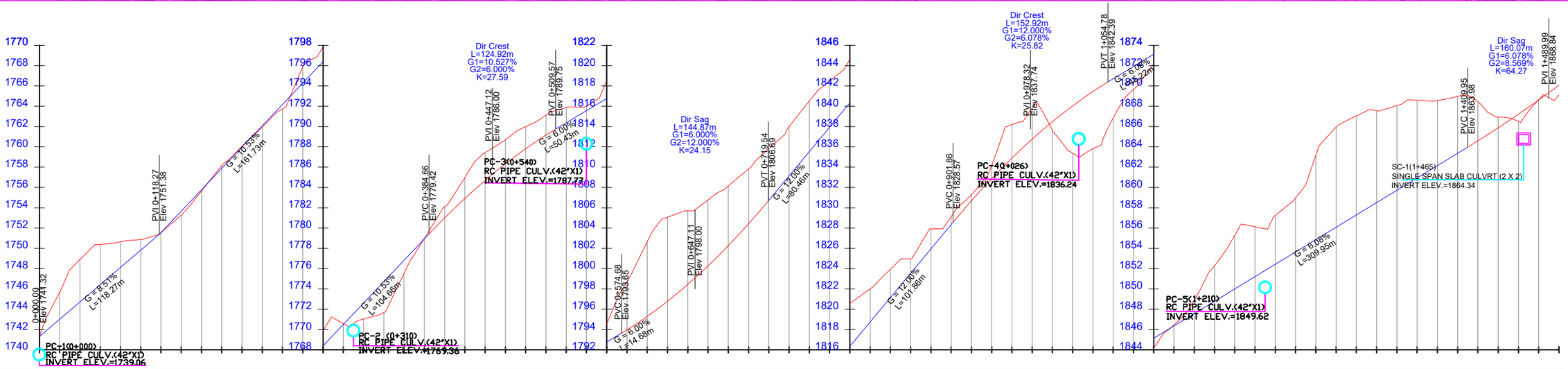
Station:	13+500	13+520	13+540	13+560	13+580	13+600	13+610
Proposed:	2832.548	2834.948	2837.348	2839.532	2841.241	2842.519	2843.116
Existing:	2832.397	2838.323	2847.035	2850.105	2846.384	2840.697	2843.116
Curvature:	R 85.00		L 2.00	R -40.00		L 2.53	
Vertical:	L=331.67 G=12.00%		L=50.44 R=841		L=18.56 G=6.00%		
Superelevation:							

TITLE

PP - 10 / F

Km 13+500TO Km 13+610





Station:	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+220	0+240	0+260	0+280
Proposed:	1741.316	1743.017	1744.719	1746.421	1748.123	1749.825	1751.562	1753.667	1755.773	1757.878	1759.984	1762.089	1764.195	1766.300	1768.405
Existing:	1741.316	1745.710	1748.906	1750.373	1750.643	1750.860	1751.538	1753.282	1755.646	1758.167	1760.058	1761.938	1763.732	1767.933	1769.863

Station:	0+300	0+320	0+340	0+360	0+380	0+400	0+420	0+440	0+460	0+480	0+500	0+520	0+540	0+560
Proposed:	1770.511	1772.616	1774.722	1776.827	1778.933	1780.995	1782.917	1784.694	1786.326	1787.813	1789.155	1790.371	1791.571	1792.771
Existing:	1770.575	1771.037	1771.674	1775.550	1778.973	1782.110	1784.983	1787.444	1788.700	1789.990	1791.132	1791.877	1792.030	1794.539

Station:	0+580	0+600	0+620	0+640	0+660	0+680	0+700	0+720	0+740	0+760	0+780	0+800
Proposed:	1793.977	1795.304	1796.797	1798.455	1800.279	1802.269	1804.424	1806.745	1809.145	1811.545	1813.945	1816.345
Existing:	1798.719	1802.675	1805.075	1805.687	1806.768	1808.140	1809.814	1811.829	1813.986	1816.504	1818.487	1820.569

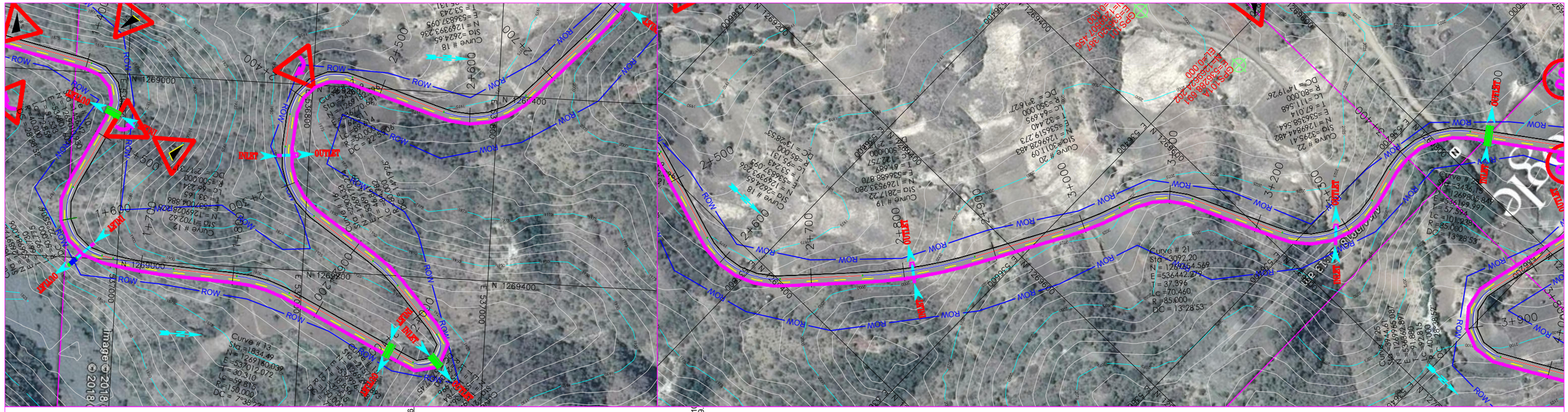
Station:	0+820	0+840	0+860	0+880	0+900	0+920	0+940	0+960	0+980	1+000	1+020	1+040	1+060	1+080	1+100
Proposed:	1818.744	1821.144	1823.544	1825.944	1828.344	1830.681	1832.863	1834.890	1836.762	1838.479	1840.042	1841.449	1842.707	1843.923	1845.139
Existing:	1822.006	1823.940	1824.954	1827.913	1829.116	1831.285	1834.159	1838.199	1839.864	1837.602	1835.375	1835.821	1838.866	1841.656	1844.195

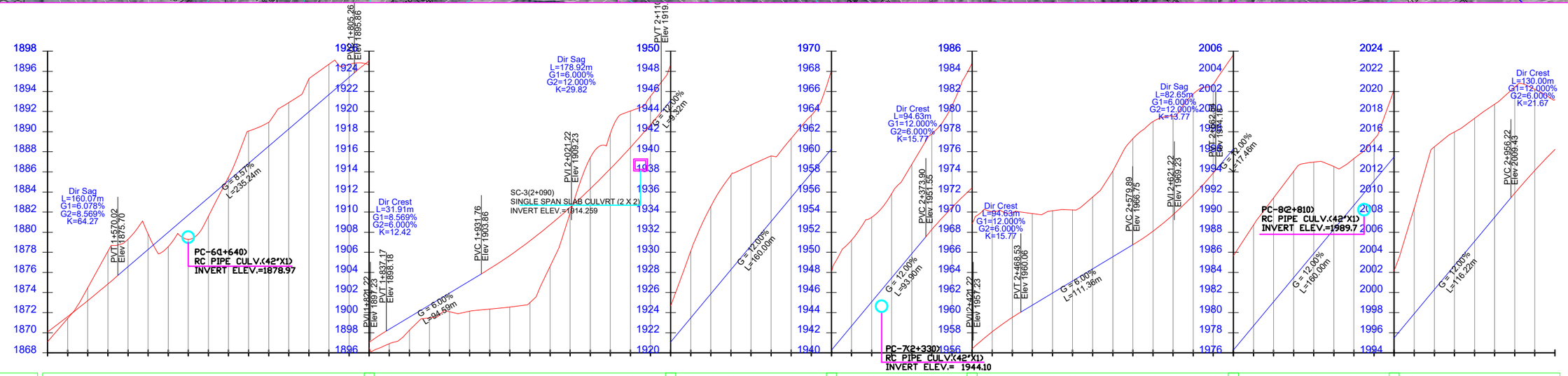
Station:	1+120	1+140	1+160	1+180	1+200	1+220	1+240	1+260	1+280	1+300	1+320	1+340	1+360	1+380	1+400	1+420	1+440	1+460	1+480	1+500
Proposed:	1846.354	1847.570	1848.785	1850.001	1851.217	1852.432	1853.648	1854.864	1856.079	1857.295	1858.511	1859.726	1860.942	1862.158	1863.373	1864.597	1865.875	1867.215	1868.618	1870.082
Existing:	1846.455	1848.892	1852.283	1855.269	1856.134	1857.242	1858.953	1863.176	1865.938	1867.047	1867.571	1868.070	1868.591	1868.572	1868.979	1868.452	1866.936	1866.520	1868.640	1869.116

TITLE

PP - 01 / F

Km 0+000 TO Km 1+500





Station:	1+500	1+520	1+540	1+560	1+580	1+600	1+620	1+640	1+660	1+680	1+700	1+720	1+740	1+760	1+780	1+800	1+820	1+840	1+860
Proposed:	1870.082	1871.609	1873.199	1874.850	1876.556	1878.270	1879.983	1881.697	1883.411	1885.125	1886.838	1888.552	1890.266	1891.980	1893.693	1895.407	1897.033	1898.352	1899.552
Existing:	1869.116	1871.428	1874.478	1878.115	1879.289	1879.818	1878.551	1879.283	1881.563	1885.474	1890.061	1890.923	1892.895	1895.265	1896.708	1896.683	1896.491	1896.916	1898.250

Station:	1+880	1+900	1+920	1+940	1+960	1+980	2+000	2+020	2+040	2+060	2+080	2+100	2+120	2+140	2+160	2+180	2+200	2+220	2+240
Proposed:	1900.752	1901.952	1903.152	1904.364	1905.686	1907.142	1908.733	1910.458	1912.317	1914.310	1916.437	1918.698	1921.079	1923.479	1925.879	1928.279	1930.679	1933.079	1935.479
Existing:	1899.478	1900.091	1900.144	1900.357	1900.559	1900.998	1904.602	1909.901	1915.413	1917.808	1920.055	1921.533	1924.651	1930.112	1934.581	1937.684	1938.685	1939.596	1941.333

Station:	2+260	2+280	2+300	2+320	2+340	2+360	2+380	2+400	2+420	2+440	2+460	2+480	2+500	2+520	2+540	2+560	2+580	2+600	2+620
Proposed:	1937.879	1940.279	1942.679	1945.079	1947.479	1949.879	1952.267	1954.463	1956.405	1958.094	1959.529	1960.752	1961.952	1963.152	1964.352	1965.552	1966.752	1968.099	1969.736
Existing:	1943.616	1948.060	1951.205	1953.473	1955.828	1958.760	1961.781	1964.580	1968.835	1970.052	1969.951	1969.848	1970.129	1970.216	1971.498	1974.052	1977.309	1979.006	1979.535

Station:	2+640	2+660	2+680	2+700	2+720	2+740	2+760	2+780	2+800	2+820	2+840	2+860	2+880	2+900	2+920	2+940	2+960	2+980	3+000
Proposed:	1971.664	1973.881	1976.279	1978.679	1981.079	1983.479	1985.879	1988.279	1990.679	1993.079	1995.479	1997.879	2000.279	2002.679	2005.079	2007.479	2009.876	2012.149	2014.237
Existing:	1981.754	1982.715	1985.649	1988.717	1991.421	1994.060	1994.975	1994.529	1995.324	1997.235	2002.164	2008.397	2014.480	2015.968	2017.329	2018.735	2020.443	2020.225	2019.186

Curvature:

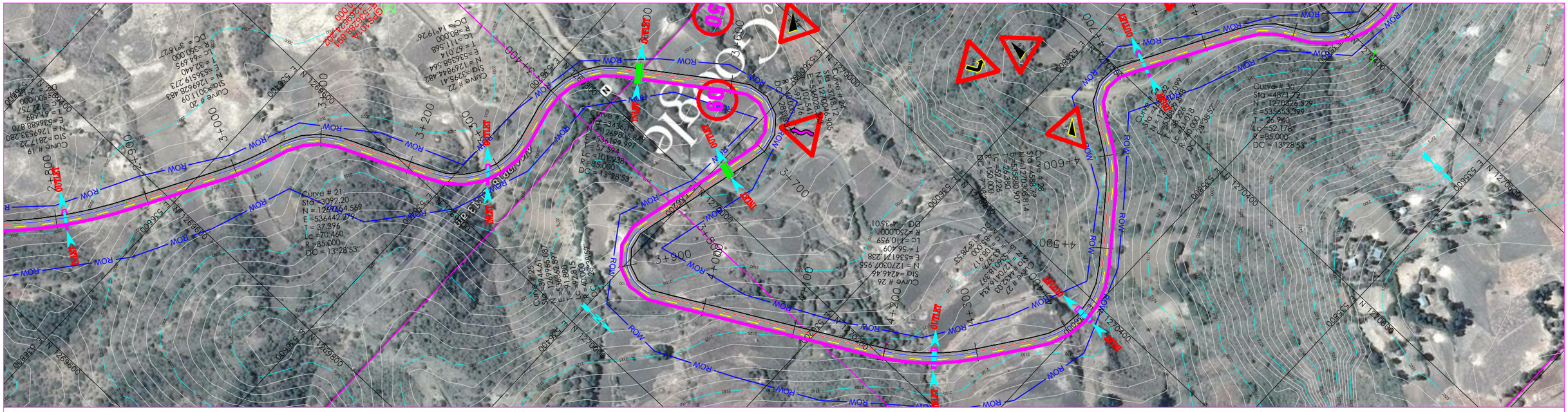
Vertical:

Superelevation:

TITLE

PP - 02 / F

Km 1+500 TO Km 3+000



TITLE

PP - 03 / F

Km 3+000 TO Km 4+500

APPENDIX 05