Jimma University
School of Graduate Studies
Jimma Institute of Technology
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Highway Engineering Stream

# BENEFIT-COST ANALYSIS OF HIGHWAY MAINTENANCE IN JIMMA TO AGARO ROAD

A Research Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science Civil Engineering (Highway Engineering)

By: Selam Mulatu Kabeto

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By: Selam Mulatu Kabeto

Advisor: Eng. Elmer C.Agon

Co-Advisor: Mr. Girma Fikre (MSc.)

March, 2018

Jimma, Ethiopia

## DECLARATION

I, the undersigned, declare that this research is my original work and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have also been duly acknowledged.

Name: Selam Mulatu

Signature:

Date: March 2018

## ABSTRACT

*A well-developed transportation network is vital to the economic development of the country. In the history of Ethiopian road development program, almost all of the road pavements are flexible, and it demands high foreign currency for asphalt material importing from abroad. Since the cost comprises of a large portion of government's investment, a careful evaluation of the project alternatives is important to make the right choice for a particular project. In the history of Ethiopian road development program, almost all of the road pavements are flexible, and it demands high foreign currency for asphalt material importing from abroad.*

*One of the problems seen from Jimma to Agaro road is lack of maintaining the road properly and regularly. Road without regular maintenance deteriorate very quickly. If nothing is done, roads with a design life of decades will need replacing or major repair work just after a few years. Poorly maintained roads constrain mobility, significantly raise vehicle operating costs, travel time and their associated human and property costs, which again will infect the economy of the transporters. The transporters will transfer their expenses to the customers and the economy of the whole country suffer. As the road network deteriorates, the whole country loses major assets created with vast amounts of money, time and effort.*

*In this study analyzed the benefit-cost of highway maintenance in Jimma to Agaro road. The population under study was Vehicles, Passengers, Drivers and Road Segment. This population enable the researcher to obtain the necessary data for the study. This study was followed on a purposive sampling selection process and employed a mixed research approach both descriptive and analytical. During data collection, Maintenance data from ERA, Accident data from Jimma Police Commission, Travel fare data from Jimma Road Transport Authority, Travel time measured, AADT counted and Field survey of road segment was taken. After determination of pavement maintenance cost, travel time saving, vehicle operating saving and travel fare saving, the net present worth of the benefit and cost was calculated.*

*Results from a benefit-cost analysis can be used to evaluate both the monetized and non-monetized effects and impacts of alternatives when a decision needs to be made. The existing pavement condition using Pavement surface evaluation and rating system showed that from the total length 46km, 10.292km in Good, 26.898km in Fair, 4.84km in Poor and 3.97km in Very poor condition. So, based on PASER rating the result shows that the existing road condition needs more improvement. The total benefit gained from travel time saving, vehicle operating saving and transport fare saving after discounting is* $NPW_B$ *= 374,351,288.17 birr and the maintenance cost after discounting is* $NPW_C$ *= 137,931,578.4 birr. Finally the result of analysis the benefit-cost ratio greater than 1 which is 2.71 means maintenance cost after 10 years pay back and there is additional saving of benefit which show the maintenance cost is less than the benefit gained so, maintaining a road periodically saves the values of country asset not only this it reduce the reconstruction of road cost and one contribute role to increase the economic activity of the area. Recommend to the road authorities need to give more emphasis on road maintenance activity, period and quality of maintenance.*


***Key words****: Benefit-cost analysis, Maintenance cost, Travel time cost savings, Vehicle operating cost saving and Travel fare saving*

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## ACRONYMS

| | |
|---|---|
| **AADT** | Annual Average Daily Traffic |
| **AASHTO** | American Association of State Highway and Transportation Officials |
| **CBE** | Commercial Bank of Ethiopia |
| **EMFED** | Ethiopian Ministry of Finance and Economic Development |
| **ERA** | Ethiopian Road Authority |
| **ETB** | Ethiopian Birr |
| **EU** | European Union |
| **GDP** | Growth Domestic product |
| **GoE** | Government of Ethiopia |
| **MRA** | Municipal Road Authority |
| **ORF** | Office of Road Fund |
| **PASER** | Pavement Surface Evaluation and Rating |
| **PDO** | Property Damage Only |
| **RCV** | Remaining Capital Value |
| **RRA** | Regional Road Authority |
| **RNMD** | Road Network Management Directorate |
| **RSDP** | Road Sector Development Program |
| **RTA** | Road Transport Authority |
| **SADC** | Southern African Development community |
| **SNNP** | Southern Nation and Nationality of People |
| **URRAP** | Universal Rural Roads Access Program |
| **VMT** | Vehicle Miles Travelled |
| **VOC** | Vehicle Operating Cost |

# CHAPTER ONE

# INTRODUCTION

## 1.1. Background of the study

Transport and mobility are essential for economic and social development. A well-developed transportation network is vital to the economic development of the country. High quality road network increases the potential of any economic investment by helping both consumer and producer [1]. Investment creates millions of jobs. These jobs are created across a wide variety of different industries. For this reason, developed countries have devoted considerable resources to the development of high-quality transport networks which need to be adequately maintained.

A high quality road network is important for high level of economic performance. It helps to sustained economic growth, increases productivity, helps in increment regional development and increases competitiveness. The infrastructure projects brings economic benefits in long-term by raising the productivity, innovation, lower goods prices, increases income and overall creates more jobs thus bring more boom to the economy.

A well-plan transportation network helps business to expand. It allows businesses to manage their inventories and transport goods more cheaply and efficiently as well as access a variety suppliers and markets for their products making it more cost-effective for manufacturers to keep productions in and out [1].

Road plays a vital role in the socio economic development of the country by providing easy transportation for agriculture, industrial products and public transportation with tremendous reduction of travel cost and time. Long-lasting pavements that are safer, smoother, environmentally sensitive and cost-effectively constructed and maintained are an important part to modernize the Ethiopian transportation system. In Ethiopia, billions of money are spent every year to construct road but the trend and budget allocation attention for pavement condition improvement, comparing with new projects is very poor. To address the constraints, the Ethiopian government is implementing the maintenance of the road network under the Road Sector Development program (RSDP).

One of the problems seen from Jimma to Agaro road is due to lack of maintaining the road properly and regularly. The road is main Trunk road type (A5). It was constructed before 30 years and has lost its designed period. Due to prolong service year and the increasing number of traffic, the road deteriorates and has defects like a number of potholes, base failures, alligator cracks and lost its camber. In the previous years, the road potholes maintained at different times and forms different layers [2].

Road without regular maintenance deteriorate very quickly. If nothing is done, roads with a design life of decades will need replacing or major repair work after just a few years. This deterioration in return will affect the road efficiency and eventually increase the cost of maintenance or replacement if nothing is done in long run.

Current road construction methods lead to significant maintenance requirements, which can only be met at a very high cost. The continued growth in road traffic and axle loads and the pressure to restrain government spending put growing pressures on road authorities to come up with new solutions. At the same time, the cost to economies due to congestion and disruption during road works on high volume roads has become unacceptably high. "With the completion of the Interstate Highway System, highway agencies are increasingly focusing attention on reconstruction and improvement of existing highway systems. The new improvements to existing facilities are being subjected to maximum scrutiny, and a formal economic evaluation of the economic impact is becoming common place" [3].

The improvement of the road will support the provision of a wider and better range of health care services. The project will reduce travel time to health centers. The road will make it possible for health service providers especially those remote areas and the same will be for ambulatory services for emergencies.

Any analysis of highway costs necessarily includes the cost of operation, maintenance, and depreciation of its rolling stock. In the same sense, the total cost of the highway improvement is the cost to improve and maintain the cost of the highway and to operate all the vehicles there on. Thus, the planning and the design of a highway, particularly the selection of the route and choice between alternatives, can best be done, or have decision aided, by calculating the costs of vehicle operation, accidents, maintenance, time and others, in addition to calculating initial costs. These establish the economic desirability of any highway improvement [3].

Therefore, a benefit-cost analysis is need for evaluating and comparing different alternatives. Benefit-cost analyses of a highway have been used as a tool to evaluate preliminary concepts during early planning studies, to evaluate alternatives and select a preferred alternative. Alternative comparisons are done at different points in the project development process, including:

concept development, environmental documentation, design, and construction. The primary transportation –related elements that can be monetized are travel time costs, vehicle operating costs, safety costs, ongoing maintenance costs, and remaining capital value (a combination of capital expenditure and salvage value).

Results from a benefit-cost analysis, along with public input and environmental documentation, can be used to evaluate both the monetized and non-monetized effects and impacts of alternatives when a decision needs to be made.

## 1.2. Statement of the problem

Roads play a vital importance in order to make a nation grow and develop. Especially in the third world country, good maintained roads also will enhance poverty reduction by improving access between regional and rural communities and, ultimately, enhancing socio-economic growth and development [4].

In the history of Ethiopia Road Development Program, almost all of the road pavements are flexible, high amounts of budget allocated every fiscal year planning period and it demands high foreign currency for asphalt material importing from abroad. Since the cost comprises of a large portion of government investment, a careful evaluation of the alternatives is importance to make the right choice for a particular project [5].

A key principle of road maintenance is that spending money now saves future costs. As the asset deteriorate, so the cost to restore their condition increases and as the condition gets worse, so the costs to society usually become more significant. One of the problem seen from Jimma to Agaro road occur due to lack of maintaining the road properly and regularly. The road surface affected by distresses like potholes, cracks, raveling, rutting and corrugation due to these lack safety to travel, dust disturb the movement of travel and take long travel time.

Road without regular maintenance, they deteriorate very quickly. If nothing is done, roads with a design life of decades can need replacing or major repair work after just a few years. That deterioration will very fast infect road transport in general where the costs will soar [4].

Poorly maintained roads constrain mobility, significantly raise vehicle operating costs, travel time and their associated human and property costs, which again will infect the economy of transporters. The transporters will transfer their expenses to the customers and the economy of the whole country suffer. As the road network deteriorates, the whole country loses major assets created with vast amounts of money, time and effort. In this study the researcher carried out benefit-cost analysis to evaluate the fundamental merit and demerits of highway maintenance affect the user's benefit and cost.

## 1.3. Research Questions

1. What are the problem of the existing condition of the road?
2. How much cost invested to maintain the road?
3. How much is the benefit saved due to road maintenance?

## 1.4. Objective of the Study

### 1.4.1. General Objective

- The general objective of the study is to analyze the benefit-cost of highway maintenance in Jimma to Agaro road.

### 1.4.2. Specific Objective

- To assess the existing condition of the road
- To assess the maintenance cost of the road segment using present worth analysis
- To determine the saving benefit of road maintenance using present worth analysis

## 1.5. Significance of the Study

In Ethiopia road are one of the country's basic infrastructural facilities where high amount of budget are allocated every fiscal year planning period and need a careful evaluation of the alternatives. Road maintenance was traditionally viewed as a mundane topic for second rated engineers. However, its importance is beginning to be recognized today in a changed context and with a changed concept. It should have a key position in preserving the value of the road asset, providing improved service to road users and contributing to environmental quality. In fact, during the life cycle of a road, the responsibilities and life styles of people, their travel demands as well as communities will change and the road network has to be adapted to the new circumstances. Working with maintenance is still looked up on even today by professional people as a low status occupation. It has not been looked up on by universities as an intellectual subject. So, the significance of the research creating awareness to professionals.

The beneficiaries of this research are:-

- The implementing authority (ERA), which use the information to give more emphasis on maintenance of road activity.
- Educational institutions, which use the information for academic purpose.

## 1.6. Scope and Limitation of the Study

In Ethiopia, this construction industry and its management is at an infant stage, fulfilling these requirements is difficult and challenging. This research work therefore, focuses on Road Maintenance benefit and cost.

The scope of the study is restricted to the analysis of travel time saving, vehicle operating cost saving, travel fare saving, non-monetary aspect like environmental concern and economic analysis using primary and secondary data. The study is, therefore, limited to accident cost due to the data gathered is not enough to calculate the cost, environmental impact, societal benefits from road maintenance will not be fully quantifiable in this study. Because of technological differences and data availability limitations in our country. In vehicle operating saving only consider fuel and tire cost for small bus but if considering lubricant oil, depreciation of vehicle and other factor the result will be increase due to difficulty to estimate or to measure not considered others.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1. Definition

Life Cycle Cost Analysis; means a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user costs, reconstruction, rehabilitation, restoring and resurfacing costs over the life of the project segment [6].

Highway maintenance is defined as the function of preserving, repairing, and restoring a highway and keeping it in condition for safe, convenient, and economical use. Maintenance includes both physical maintenance activities and traffic service activities. The former includes activities such as patching, filling joints, and mowing. The latter includes painting pavement markings, erecting snow fences, removing snow, ice, and litter. Highway maintenance programs are designed to offset the effects of weather, vandalism, vegetation growth, and traffic wear and damage, as well as deterioration due to the effects of aging, material failures, and construction faults [7].

## 2.2. Benefit-Cost Analysis

A benefit-cost analysis is a systematic evaluation of the economic advantages (benefits) and disadvantages (costs) of a set of investment alternatives. It evaluates the fundamental merit of undertaking possible investments. The basic idea is straight forward, an investment option 'A' is worthwhile if its economic benefits exceed its economic costs. So the benefit-cost rule is: Option 'A' is economically worthwhile only if its net benefits (gross benefits minus gross costs) exceed the net benefits of the next best alternative [8].

The objective of a benefit-cost analysis is to translate the effects of an investment into monetary terms and to account for the fact that benefits generally accrue over a long period of time while capital costs are incurred primarily in the initial years.

The primary transportation-related elements that can be monetized are travel time costs, vehicle operating costs, safety costs, ongoing maintenance costs, and remaining capital value (a combination of capital expenditure and salvage value). A properly conducted benefit-cost analysis would indicate whether travel time and safety savings exceed the costs of design, construction, and the long-term increased operating costs [8].

## 2.3. Road Maintenance

Maintenance of roads is undertaken to ensure the safety of traffic and to sustain the serviceability and appearance of the road. Road maintenance involves remedying defects such as potholes that occur in the carriageway from time to time (Corrective maintenance) and providing treatments such as crack sealing which will slow the rate of deterioration (Preventive maintenance) [9].

A key principle of road maintenance is that spending money now saves future costs. As the asset deteriorate, so the cost to restore their condition increases and as the condition gets worse, so the costs to society usually become more significant. The impact of road maintenance is significant, providing safety, economic, environmental and social well-being benefits. The relative balance of the benefits (or the negative impacts when maintenance is inadequate) varies by network. Assets such as streetlights, traffic signals, traffic signs, line-marking and safety barriers support the safe and efficient operation of traffic and must be maintained [10].

Maintenance is important, and there’s some optimal allocation:-

• As roads deteriorate, speeds on the roads decrease and vehicle damage per kilometer increases

• Regular road maintenance is the most efficient method of maintaining a smooth road

• AASHTO pavement services estimates every $1 of preventative maintenance avoids $6-10 of rehabilitation [11].

### 2.3.1. Routine maintenance

The routine maintenance works on bituminous roads, whose effects on pavement performance are modelled, comprises patching, crack sealing, edge-repair, and drainage works. Drainage maintenance is an important works activity that prevents accelerated pavement deterioration.

Other routine maintenance works include vegetation control, and repairs to road appurtenances. Their effects on pavement performance are not modeled endogenously, and therefore, only their costs are considered in an analysis [6].

Table.2.1. Flexible pavement Routine maintenance schedule [5]

| Frequency in a year | Month of a Year | Routine Maintenance activities | Remarks |
|---|---|---|---|
| 1st | March | Activity Code 210-215,18 &19 | Twice (2) a year before and after the rainy season |
| | April | | |
| | May | | |
| 2nd | October | | |
| | November | | |
| | December | | |

## 2.3.2. Periodic Maintenance

The periodic maintenance works on bituminous roads comprises of preventive treatment, resealing, overlay, mill and replace and reconstruction [12]. The Periodic Maintenance is to be conducted once a year before the rain comes as per the experience of the Ethiopian Road Construction Corporation (ERCC) and Ethiopian Road Authority (ERA).

- **Preventive Treatment:** It includes fog sealing and rejuvenation. When preventive treatment is performed, any surface distress and preventive treatment age are reset to zero. It has effects of delaying the initiation of cracking and raveling, but the pavement structure and strength remains unaltered [12].
- **Resealing Works:** Resealing without shape correction can repair surface distress but cause little change to roughness or structural strength of the pavement. However, resealing with shape correction can achieve some reduction in roughness through the filling of depressions and repair of damaged areas. Resealing works resets surface distresses, surfacing age, and preventive treatment ages to zero, and thereafter the pavement condition is considered to be new [12].
- **Overlay:** It is specified using new surfacing thickness, layer strength coefficient, surface material, and construction defect indicator for bituminous surfacing. Overlay work resets surface distresses to zero, and thereafter the pavement condition is considered to be new [12].

- **Mill and Replace:** It involves the removal of all or part of the existing bituminous surfacing and replacing it with a new bituminous surfacing. It is usually performed to correct defects that have occurred mainly due to poor construction quality and the bituminous material being too rich or brittle, or where the road surface levels need to comply with some requirements related to drainage facilities. Information on new surfacing thickness, layer strength coefficient, surface material, and depth of milling are required to specify mill and replace works [12].
- **Reconstruction:** It refers to all works that require the re-specification of the surfacing and road base types. It may be specified either as a maintenance standard or as an improvement standard if the works involve the minor widening of the carriageway [12].

Table.2.2. Schedule of Periodic maintenance for flexible pavement [5]

| **Frequency in a year** | **Month of a year** | **Periodic maintenance activities** | **Remarks** |
|---|---|---|---|
| Once a year | March | Activity code 309-216 | Once every three years before the rainy season |
| | April | | |
| | May | | |

## 2.4. Asphalt pavement surface distress

Pavement condition surveys give an indication of the serviceability of the road pavements and also the physical condition of the assets. Deterioration has two general causes: environmental due to weathering and aging, and structural caused by repeated traffic loadings. Obviously, most pavement deterioration results from both environmental and structural causes [13].

There are four major categories of common asphalt pavement surface distress:

1. Surface defects: Raveling, flushing, polishing.
2. Surface deformation: Rutting, distortion—corrugation and shoving, settling, frost heave.
3. Cracks: Transverse, reflection, slippage, longitudinal, block, and alligator cracks.
4. Patches and potholes

### 2.4.1. Potholes

It is a bowl-shaped holes of various sizes in the pavement resulting from localized disintegration under traffic. It frequently appear when appropriate maintenance is not promptly applied once the distressed conditions have been detected.

Caused by the localized disintegration of the pavement surface

- Appears when appropriate maintenance is not promptly applied once a distressed conditions have been detected
- Poor mixtures and weak spots in the base or subgrade
- Weakness in the pavement resulting from too little asphalt, failure of base due to poor drainage [14]

**Recommended remedial measures**

Temporary repair through filling it with a pre-mixed asphalt patching material. Permanent repair through filling it with new base and surface material.

Fig.2.1. Potholes (Location around Bulbulo Station 40+100)

### 2.4.2. Alligator or fatigue cracking

It is an interconnecting cracks forming a series of small blocks resembling an alligator's skin or chicken wire.

It is caused by;

- Load related deterioration resulting from a weakened base course or subgrade
- Too little pavement thickness
- Overloading
- Excessive deflection of the surface over unstable (saturated) subgrade or lower courses of the pavement and repeated loads that exceed the load-carrying capacity of the pavement section [14].

**Recommended remedial measures**

For saturated base, sub-base or sub-grade, remove the wet material and install needed drainage facilities. Temporary repair can be made by applying aggregate seal coat to the affected area. For cracking from overloading, a properly designed overlay will correct the condition.

Fig.2.2. Alligator or Fatigue cracking (Location Gembe station 33+420)

### 2.4.3. Shoving and Corrugation

**Shoving**

A form of plastic movement resulting in localized bulging of the pavement surface

- Occurs at points where traffic starts and stop or on hills where vehicles break on the downgrade

- Occurs in an asphalt mixtures that lack stability
- Cause by excess asphalt; too much fine aggregate; use of round aggregates too soft an asphalt weak granular base contamination of the mix lack of aeration of liquid asphalt mix [14]

Fig.2.3. Shoving (Location Gembe-station 33+050)

**Corrugation**

A form of plastic movement typified by ripples across the asphalt pavement, attributed to excessive moisture in the subgrade, contamination of the mix and lack of aeration of liquid asphalt mix [14].

Fig.2.4. Corrugation (Location Bulbulo station 39+240)

### 2.4.4. Poor drainage surface

It is a basic fact of road maintenance that providing and maintaining adequate drainage is the most important factor in prolonging the life of the road pavement. The most effective action that can be taken by a road engineer to maintain the road pavement and prolong its life is to ensure that the pavement is adequately drained and that water does not pool on the road surface. The surface water and ground water can drain freely and quickly away from the road or under the road. Water is the worst enemy of any road. It can erode soils, weaken pavements, and destroy shoulders and slopes. It can wash-out culverts, embankments and even bridges [15].

Granular materials which are saturated with water will lose 90% of their strength resulting in pavement failures. If this is to be avoided two things are necessary, the road must have adequate drainage, and its surface must be sealed against the ingress of water. Drainage system is useless unless it can accept the water coming to it. There should be a regular system of checking drainage outlets and cleaning them to ensure they function properly [15].

Fig.2.5. Poor drainage effect on the road surface (Location Bulbulo & Gembe)

### 2.4.5. Raveling

The wearing away of the pavement surface caused by dislodging of aggregate particles or Progressive separation of aggregates particles from the surface downward or from the edges inward [14].

<u>Possible causes</u>

Lack of compaction, construction of a thin lift during cold weather, dirty or disintegrating aggregate, too little asphalt in the mix, or overheating of the asphalt mix.

- Caused by weathering and/or traffic abrasion
- Poor construction methods
- Inferior aggregates
- Poor mix design

<u>Recommended remedial measure</u>

- Surface treatment, such as seal coating, surface dressing, thin overlaying of bituminous surface course (Hot-Laid)

Fig.2.6. Raveling surface (Location- Dabesa & Harro- station 26+650 &29+450)

### 2.4.6 Rutting

The longitudinal surface depression in the wheel-paths of the asphalt pavement and creating channels.

<u>Possible problems</u>

Consolidation or lateral movements under traffic in one or more of the underlying courses or displacement in the surface layer itself [14].

<u>Recommended remedial measure</u>

Level the pavement by filling the channels with hot plant-mixed asphalt material. Follow with a thin asphalt plant-mixed overlay.

Fig.2.7. Rutting (Location - Gembe & Agaro)

## 2.5. Pavement condition rating

The condition rating systems can be grouped into two main groups namely estimated condition ratings and measured condition ratings. The estimated condition rating systems are based on observed physical conditions of the pavements while the measured condition rating systems are not only based on observations by trained raters but are also backed by physical measurements such as roughness and mathematical expressions. Examples for Estimated condition rating present serviceability rating, condition rating survey and pavement surface evaluation rating [16].

### 2.5.1. Pavement Surface Evaluation and Rating System (PASER)

The Pavement Surface Evaluation and Rating system (PASER) is one of the estimated condition rating system since it is a visual inspection to evaluate pavement surface conditions. The PASER scale is a 1-10 rating system for road pavement condition. There is a manual with photographs and descriptions that guides inspectors to choose the appropriate value on the scale that captures the conditions accurately [16]. It is developed by the University of Wisconsin-Madison Transportation Information Center. When assessed correctly, PASER ratings provide a basis for comparing the quality of roadway segments [13].

The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Understanding the cause for current conditions is extremely important in selecting an appropriate maintenance or rehabilitation technique [13].

The PASER assessment method does not require measurements of individual distresses, and thus PASER ratings cannot be disaggregated into measurements of specific distress types. The advantage to this method is that roads may be assessed quickly. A primary disadvantage is that because PASER ratings cannot be disaggregated into component distress data [33]. Table 2.3 shows a general translation of the PASER ratings.

Table 2.3: PASER ratings and maintenance requirements [16]

| **PASER Ratings** | **Description of Maintenance** |
|---|---|
| 9-10 | No maintenance needed |
| 8 | Little maintenance |
| 7 | Routine maintenance, crack sealing, minor patching |
| 5-6 | Seal Coating |
| 3-4 | Overlay |
| 1-2 | Reconstruction |

## 2.6. Country's experience on neglecting maintenance

**In Kenya,** years of inadequate maintenance left the main Nairobi – Mombasa road highly vulnerable. In 1997 heavy rain damaged two bridges and several sections of the road. The result was that the users experienced months of national disruptions as long stretches of the road became unusable in the rains and very difficult in dry weather [4].

**In Tanzania**, failure to improve a simple stream crossing caused damage to 3 kilometers of road – and led to lengthy delays. The result was a bill five times higher than would have been needed to make the original repair [4].

**Senegal Experience**, There was an expectation that roads, once failed, would be renovated by donors. Therefore maintenance was less important. This has been EU's experience all over Africa, recently announced no longer funding major roads projects [4].

**In Sub-Saharan Africa** 150 billion US dollars was spent in 3 decades building roads. Maintenance was neglected and a third of that investment has now been lost. The result is that 50 billion US dollars of key national assets are gone [4].

**In Oslo, Norway** a bridge deck did not have adequate waterproof membrane. It could have been done as a simple job for a cost of approximately 0.6 million US dollars. The job was not given preference to and was therefore not done. The result was that the whole bridge after some years had to be torn down and replaced by a new bridge. The total cost for the new bridge was 15 million US dollars. In addition came the cost for the users, because they had to travel on lengthy detours for a long period of time [4].

A recent analysis of how 85 countries allocated road maintenance funds showed that, spending 12 billion US dollars on preventive maintenance would have eliminated reconstruction costs of 40 billion US dollars. The result is that an average net cost of 330 million US dollars, are wasted on avoidable reconstruction in each country. A new road is expensive. In Norway a two-lane paved new road costs about 0.6 million US dollars per Kilometer on an average. Routine maintenance of this road costs about 10,000 US dollars per year per Kilometer. If the maintenance is neglected, it will cost five or six times as much to restore the road. Economically, it is an indefensible waste. If money is short, and it usually is, there is only one rational course of action:

- Maintain existing roads before funding new ones
- Make sure it is done today, and every day
- Tomorrow it will be much more expensive

It is often forgotten that building of roads is only a part of the total transport cost. While this total costs includes maintenance and building costs, it also includes the full cost of running vehicles on a road, an expense that climbs rapidly as the surface starts to deteriorate. It is essential to take the total transport cost into account when making decisions about your roads.

Maintenance money needs to be secured on a regular base. One way to do this is to introduce road users charge, as the fuel levy and to create an autonomous Road Fund. Many African countries have established such a Road Fund. As an example Tanzania and Zambia. Another example is Ethiopia. There a national road fund was established in 1997 to secure funds to maintain all the public roads. The major source of revenue is a fuel levy, paid directly to the Road Fund. That means that there is an extra charge of 12.5% on pump prices. It must be pointed out that the public accepted this fuel levy very quickly. There is, however, a danger that when the government is in need of money, they will throw their eyes on the road fund and wish to use the money for other purposes [4].

Maintenance is unlikely to be needed all over at the entire length of the road at the same time. The secret is to apply maintenance at the right time and in the right place. If interventions are too early or too late, money could be wasted. In the case of a new road, its condition deteriorates slowly. Only light maintenance is needed. After that time the road enters a critical phase, which may last for some years. As the running surface fails, re-sealing is needed before it is too late. Otherwise, extensive repairs costing up to 4 times as much are inevitable. This sort of problems are typically seen in networks of any kind, where the weakest point compromises the integrity of the system and thus needs priority attention. So if a bridge or just only a few meters of a road is impassable, long stretches of perfectly good roads on each side, become useless [4].

**Road works decisions sometimes based on public spectacle rather than cost effectiveness**

- When turning to donors, many countries focus on big renovation and paving, rather than periodic maintenance.
- Thinking is: In resource constrained environment, paved roads won't need so much maintenance
- These large investments don't last, due to lack of maintenance and weight limits
- Quite common to go with a 'worse first' strategy, where the poorest roads receive the highest budget for repair [11].

## 2.7. Transport development and maintenance in Ethiopia

Transport development in Ethiopia is the responsibility of the Ministry of Transport and the Ministry of Urban Development and Construction. Road sector development and maintenance is mainly executed by the Ethiopian Road Authority (ERA), Regional Road Authorities (RRAs), Municipal Road Authorities (MRAs) and the Wereda Road Desks [18].

Federal Roads, which share about 44.8% (21,849 km) of the total road network, are maintained by ERA, the remaining 26,944 km of "low level" roads (all unpaved), generally categorized as "rural roads", are under RRAs. The urban roads in the country (4,556 km) are maintained by the respective MRAs, while Addis Ababa and Dire Dawa have independent road authorities responsible for road administration. It is important to note that there is an additional network of 100,384 km of unclassified roads developed and maintained by the Local Communities (Weredas), and that under URRAP (Universal Rural Roads Access Program) [18].

Road Maintenance activities of the classified roads of the country are financed by the Office of the Road Fund (ORF), which was established to administer and allocate resources to the Road Agencies, i.e. ERA, RRAs and MRAs [18].

In 2010-2011, the revenue collected by ORF was in the order of ETB 1.14 billion and disbursement from the road fund for maintenance activities was ETB 1.02 billion, but the present revenue is not sufficient to finance the maintenance needs of the classified roads to an acceptable level to preserve the road asset. Sustainability of the new road assets therefore have some risks, and more efficient methods that provide value for money road maintenance outcomes need to be found [18].

### 2.7.1. Road Transport

Ethiopia's classified road network increased on the average by 5% per annum from its 1997 base of about 26,500 km to 37,018 km up to 2005 of which about 13.0% is paved. The ten-year Road Sector Development Program (RSDP) launched in 1997 has continued to address both the past neglect and the present capacity constraint in the road sector [17].

To execute such a very crucial project, large amount of budget will be allocated for the surfacing of pavements. In the last seventeen years (1997-2014G.C), the total length of rigid pavement constructed was only 2.3 kilometers while about 99.9% or 12,640 km are flexible pavement**.** Over the past 17 years, 41.2% of the total Ethiopian Road, RSDP expenditures was allocated for the rehabilitation and upgrading roads, 28.8% for construction of link roads, 5.7% for maintenance of

Federal roads, 8% of Regional road and 11.7% of Wereda roads, 2.8% of Institutional support projects, and other activities at the Federal level [5].

### 2.7.2. Jimma Road Network

Jimma Road Network Management Branch Directorate is currently responsible for administering **54** road segments having a total length of **2,699 Km**, which are found in Oromiya, SNNP and Gambella regional states. Out of the total road networks **996.1 Km** are Paved road (Hot mix Asphalt, Cold mix Asphalt and Double bituminous surface treatment) and **1,602.9Km** are unpaved (Both Crushed stone and Natural gravel). The terrain classification of the road network coverage is dominantly rolling. Besides, the climatic condition through which the road network traverses are dominantly temperate [2].

Roads are classified in to hierarchy of class according to the service they intended to provide. The Basis to this classification is that roads never serve independent of each other, and most travel involves movement through inter - connected network of roads [19].

Accordingly, here under listed are the functional classifications of the road networks under administration of Jimma RNMD, which are **24.58%** Trunk, **26.56%** Link, **14.08%** Main Access, and **15.96%** Collector and **18.81%** Feeder Roads [2].

### 2.7.3. Time-Related Deterioration of Pavements

A pavement will deteriorate over time due to environmental factors in the absence of truck traffic. Thermal cracking, differential heaving due to swelling subgrade or frost penetration, disintegration of surface materials due to freeze-thaw cycles, and other climatic/aging effects on materials are largely a function of the environment and will result in a loss of pavement serviceability. Pavement condition declines rapidly when initially exposed to the environmental elements, but then deteriorates at a decreasing rate over time [7].

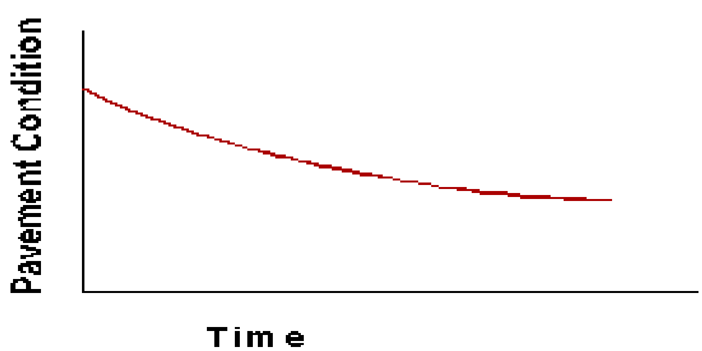



Fig.2.8. Theoretical Relationship between Loss of Pavement Serviceability and Time [7]

The need for maintenance increases as road infrastructure ages, since it becomes more fragile, less resilient and journeys are more susceptible to disruption. There is between building new roads and their need for maintenance.

### 2.7.4. Heavy-Vehicle Impact on Pavement Damage

Commonly identified pavement distress associated with heavy vehicles can be characterized as fatigue cracking and rutting. On rigid pavements damage includes transverse cracking, corner breaking, and cracking on the wheel paths. Flexible pavements and granular roads are most susceptible to rutting. In all cases, cracking and rutting increase pavement roughness and reduce pavement life. Trucking has become the most popular mode of freight transportation because of its efficiency and convenience, and this preference has resulted in increased highway maintenance costs [7].

### 2.7.5. Traffic Volume Growth

As traffic levels grow, the need for maintenance is only increased. Even for many developed countries, where the long term rate of traffic growth has slowed, attempts to maximize capacity on congested networks and to maintain mobility at higher traffic flows have led to use of increasingly complex assets to ease traffic flow. Such assets require more frequent interventions on the networks drive increased maintenance costs [10].

## 2.8. Average Annual Daily Traffic (AADT)

AADT is the average of 24-hour counts collected every day of the year. It is necessary to obtain data continuously. However, it is not feasible to collect continuous data on all roads because of the cost involved. To make reasonable estimates of annual traffic volume characteristics on an area-wide basis, different types of periodic counts, with count durations ranging from 15 minutes to continuous, are conducted; the data from these different periodic counts are used to determine values that are then employed in the estimation of annual traffic characteristics. The periodic counts usually conducted are continuous, control, or coverage counts. AADTs are used in several traffic and transportation analyses for:

a. Estimation of highway user revenues

b. Computation of crash rates in terms of number of crashes per 100 million vehicle miles

c. Establishment of traffic volume trends

d. Evaluation of the economic feasibility of highway projects

e. Development of freeway and major arterial street systems

f. Development of improvement and maintenance programs [20]

### 2.8.1. Vehicle Classification (VC)

VC records volume with respect to the type of vehicles, for example, passenger cars, two-axle trucks, or three-axle trucks. VC is used in:

a. Design of geometric characteristics, with particular reference to turning-radii requirements, maximum grades, lane widths, and so forth

b. Capacity analyses, with respect to passenger-car equivalents of trucks

c. Adjustment of traffic counts obtained by machines

d. Structural design of highway pavements, bridges, and so forth [20].

## 2.9. Highway maintenance benefits

Every nations benefit from a well performing transportation network, Road are essential for economic development of a country. For speedy transportation of commodities and quick movements, a good road network is essential. Good system of roads helps to save time considerably in all of our daily activities, serves as feeder line for other modes of transport and thus helps indirectly in their development, helps in the growth of trade and other economic activities all over the country, Improvement in the living standard of the people in that community and lower cost of maintenance of vehicles used on such roads [22].

Investing in maintenance at the right time saves significant future costs, analyses typically establish that the annual cost of maintaining a road is small fraction of the initial investment cost, usually some 2-3% for a major paved road and 5-6% for an unpaved rural road. Failing to make this rate of investment over the long life of the road risks losing the benefits for which a road was originally constructed [10].

A well- established principle which drives the need for maintenance is that spending money now saves future costs. As assets deteriorate, so the cost to restore their condition increases. Numerous studies have quantified this effect. For example, countries with low income economies spend 50% more on the network, per kilometer, than higher income economies. The World Bank has shown that delayed road maintenance expenditure in Africa increases the total vehicle operating costs by between two and three times the savings in maintenance costs. The same effect of increases in indirect costs, higher than the reductions in maintenance funding, has also been shown for mature networks in developed countries [10].

Inadequate maintenance now affects not only the present generation but places undue financial burden on future generations. Avoiding the necessary investment and management now only further exacerbates the problem and can have far-reaching economic, social and environmental impacts [10].

In highway benefit cost analysis, the usual procedure is that benefits are first estimated in physical terms and then valued in economic terms [23]. The benefit cost analysis measures the capital cost in monetary terms, 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 are: the travel that incurs costs to road users such as the time spent on travelling; costs arising from the direct costs of fuel, maintenance and depreciation [5].

### 2.9.1. Travel-Time Savings

Travel-time savings typically generate the greatest amount of benefit. After sleep and work, a major share of people's personal time is devoted to transport [23]. The value of travel time savings are the product of time spent traveling multiplied by unit costs (e.g., cents per minute or dollars per hour) [24]. Estimated using computer models, spreadsheets, and/or travel time runs, depending on the level of analysis needed and data availability [23].

The estimation of travel time savings should include both the driver and passengers in the vehicle (i.e., vehicle occupancy rates). In many cases, vehicle occupancy rates vary between peak and off-peak hours as well as between alternatives. Passenger travel time values have been estimated from the origin destination surveys based on vehicular passenger occupancy, income levels, and trip purpose. This is the benefit of the pavements gained after the maintenance when the condition of the pavement is improved. The valuation of travel time savings is calculated using standardized cost-per-hour-per-person figures for different vehicles [23].

### 2.9.2. Vehicle Operating Cost Savings

When transportation improvements are made, the cost of operating vehicles along a particular facility or set of facilities can change. Operating costs can change because the number of miles driven changes, as in the case of a shorter bypass or a reduction in circuitry or diversion of trips, or it can change because of changes in the number of stops or speed-cycle changes [23].

TRIP, an industry group, notes that deteriorated roads accelerate the depreciation of vehicles and the need for repairs because the stress on the vehicle increases in proportion to the level of roughness of the pavement surface. Similarly, tire wear and fuel consumption increase as roads deteriorate since there is less efficient transfer of power to the drive train and additional friction between the road and the tires. They estimate the average motorist in the U.S. pays $377 each year in additional vehicle operating costs as a result of driving on roads in need of repair, which varies by major urbanized area [25].

The number of vehicle-miles traveled (VMT) is the most common variable that affects vehicle operating costs. Once the change in vehicle miles is estimated, the valuation of vehicle operating costs is calculated using standardized cost-per-mile figures for different vehicles. The VOC is estimated based on prices of vehicles, types of tires for the various vehicle types on the road, fuel and lubricants costs, labor costs for drivers/crew and maintenance labor [23]. The structure and logic diagram for estimating Vehicle Operating Costs (VOC) in the base and alternate cases is shown in Figure.2.9, below.

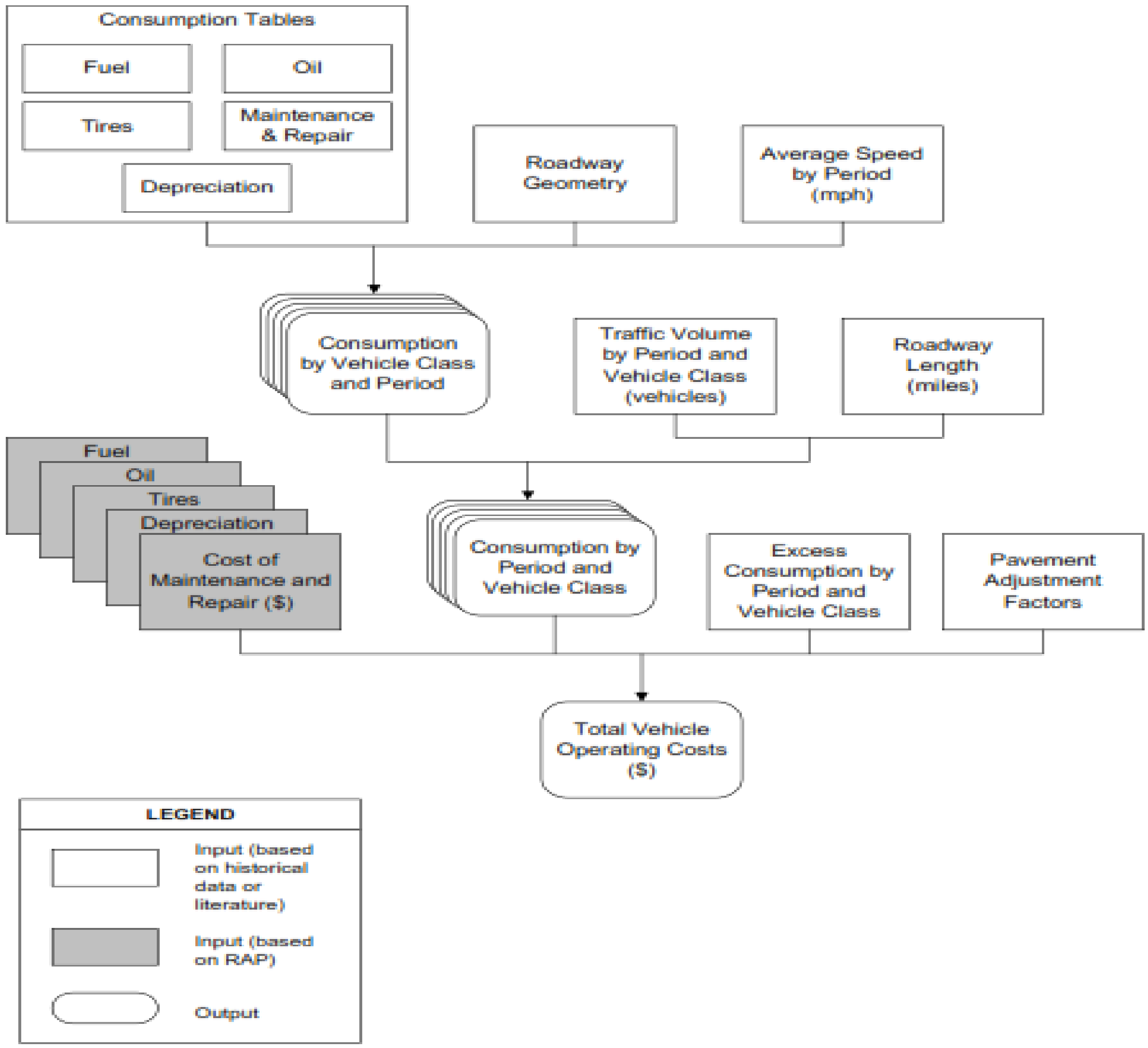



Fig.2.9. Structure and logic diagram for estimating vehicle operating cost [23]

### 2.9.3. Road Accident Cost Savings

Road accidents are one of the most important problems being faced by modern societies. Apart from the humanitarian aspect of reducing road deaths and injuries in developing countries, a strong case can be made for reducing road crash deaths on economic grounds alone, as they consume massive financial resources that the countries can ill afford to lose. The deaths of persons and serious economic loss caused by road accidents demand a continuous attention in accordance with the spectacular growth in road transportation. It is now realized that better and more efficient techniques of accident information management system are required [26].

Road traffic accidents in developing countries tend to be the major cause of fatalities and disabilities. In Ethiopia, the road traffic accident problem is now also regarded as one of the most serious social and public health problems. Annually, there is a significant loss of human and economic resources in the country for which road traffic accident is responsible. This problem is increasing from year to year at an alarming rate accompanying the rapid growth of population and the vehicles fleet [26]. Ethiopia is extremely poor with accident fatalities of 155/10,000 motor vehicles compared to 60/10,000 motor vehicles in Kenya and 17/10,000 motor vehicles in South Africa, ranking among the highest in Africa [17].

In the absence of an estimate of accident-related economic issues, it is difficult to identify the sums of money that should be invested each year on road safety countermeasures. Challenges of estimating the costs of road accidents in low income countries where vital registration and relevant statistics concerning accidents are scarce [26].

The first need for accident cost valuations is at the level of national resource planning to ensure that road safety is given adequate priority in terms of investment in its improvement. A second need for road accident cost figures is to ensure that the best use is made of any investment and most appropriate safety improvements are introduced in terms of the benefits they might generate in relation to their cost [26].

The perception of road accident problem in the country is very much related to the availability of sufficient information. Road accident data analyses and research activities on the road traffic accident problem in Ethiopia are very limited.

The Interim National Road Safety Coordination Office has listed, in its report, the reasons for high number of road traffic accidents in the country as:

- Lack of driving skills
- Poor knowledge of traffic rules and regulations
- Violation of speed limit
- Insufficient enforcement
- Lack of vehicle maintenance
- Animal drawn carts and animals frequently used main highways
- Lack of safety conscious design and planning of road network
- Disrespect of traffic rules and regulations
- Lack of general safety awareness by pedestrians [26].

Safety benefits are one of the principal benefits that can result from transportation improvements. Benefits occur when the number of crashes is reduced or the severity of the crashes is reduced on a set of facilities because of the transportation improvement [27].

Incident rates, expressed as the number of fatalities, injuries, and Property Damage Only (PDO) accidents per 100 million Vehicle Miles Traveled (VMT) are estimated under alternative highway designs (geometry) and traffic levels, and combined with accident unit costs to arrive at total accident costs, in the base and alternate cases [23]. This is illustrated in Figure 2.10, below.

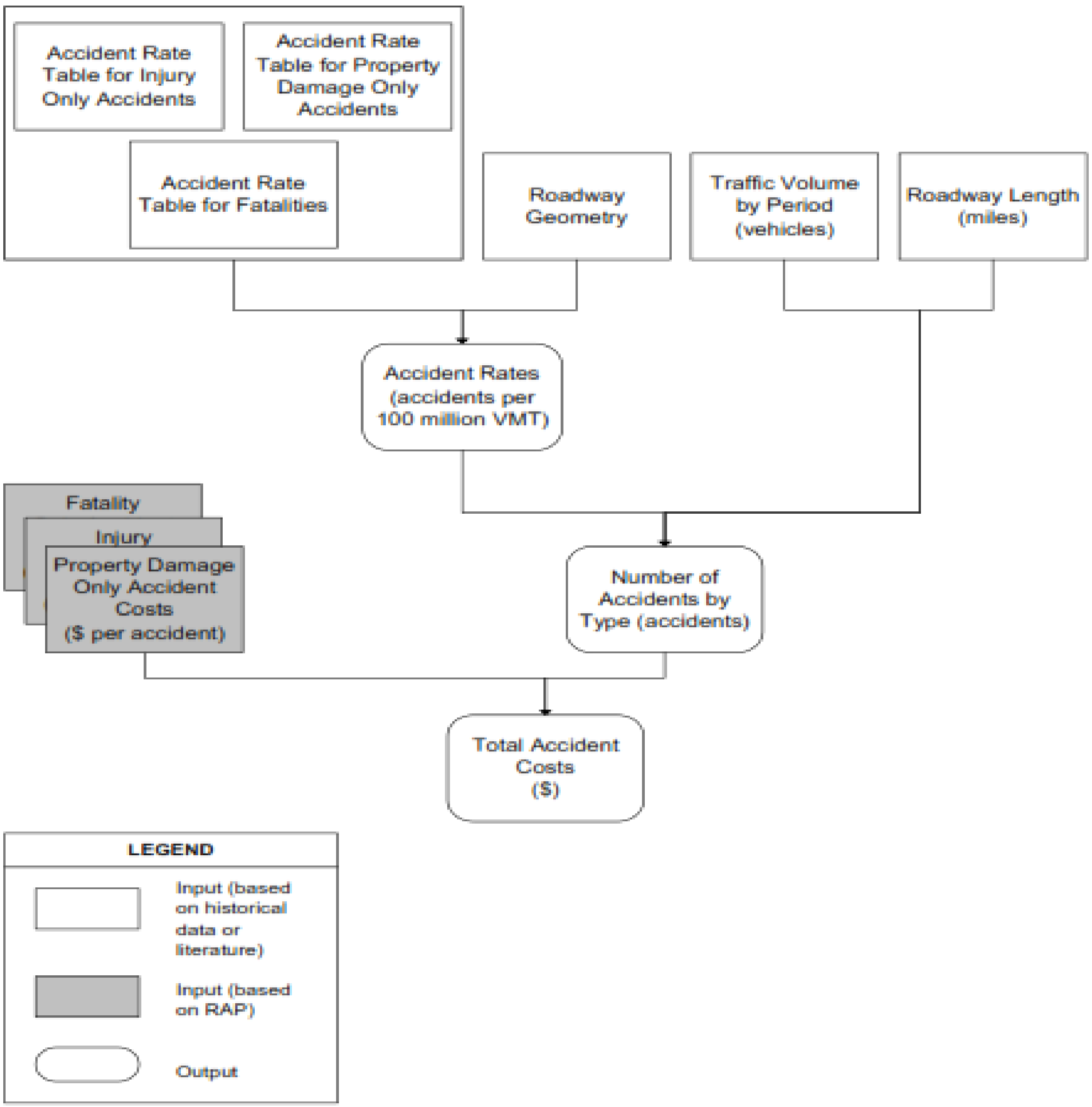



Fig.2.10. Structure and logic diagram for estimating Accident cost saving [23]

Based on the severity level a certain road traffic accident creates, road accidents are almost everywhere categorized as fatal, serious, slight or damage only. It should be noted that accident severity is defined by the most serious casualty class of any of the victims of the incident [26].

**Current Accident Severity Definition in Ethiopia**

- A fatal accident is the one in which one or more individuals die as a result of traffic accident within the same reporting year of the occurrence of the accident. This definition is somehow different from the standard definition of UN which limits within 30 days.
- A serious injury is one in which a victim sustains severe cuts, bleeding, breaks, and other damages which requires him a medical treatment as “in-patient” in hospital.
- A slight injury is the one as a result of which the victim sustains only small cuts, scratches, and other small damages which may be treated as an out-patient without requiring admission to a hospital.
- Damage only accident is the one as a result of which no person is injured only one or more vehicles involved in the accident are damaged.

Having understood benefits of costing road accidents and defining the different severity levels of accidents it is possible now to assess the various approaches available to cost road traffic accidents. Many researchers have devoted their work to the area of road accidents and traffic safety aspects. Works have been undertaken on accident characteristics, accident forecasting and better roadway and vehicular design for the improvement of road safety in different traffic and roadway conditions [26].

The important uses of accident cost are:

- To gauge the problem of accident in economic terms.
- To work out safety standards keeping in view the cost of the facility
- To calculate the optimum level of investment / expenditure on road safety management.
- To evaluate the impact of road safety improvements in economic terms.
- To include the accident cost as a part of road user cost in road project appraisal i.e., in cost /benefit analysis of road projects.
- To work out the national loss due to accidents.

The cost of an accident to the victim, to the family of the victims, to the nation, to the national economy and to the society is all different. Death of a leader in an air crash may cost a future to the grieved family while the loss to the nation cannot be estimated at all. It may bring faster development, more democratic political set up or total disturbance, loss to public property and life. Similarly the cost of social worker or a planner dying in an accident is a matter of great dispute [27].

The cost to the society is generally greater than the cost to the economy. In transportation, planning cost to the society is generally considered as a project appraisal and is carried out by using social cost-benefit analysis. The cost of accident would also differ from region to region, victim to victim and the types of the vehicles involved in the accident [27].

Table.2.4. Yearly Traffic accident in Jimma to Agaro Road (Source: Jimma Zone Police Commission)

| Year | Death | Serious injury | Simple injury | Property damage | Property damage Cost (ETB) |
|---|---|---|---|---|---|
| 2014 | 15 | 13 | 2 | 9 | 476,611 |
| 2015 | 7 | 8 | - | 1 | 439,240 |
| 2016 | 9 | 4 | 1 | 1 | 275,500 |

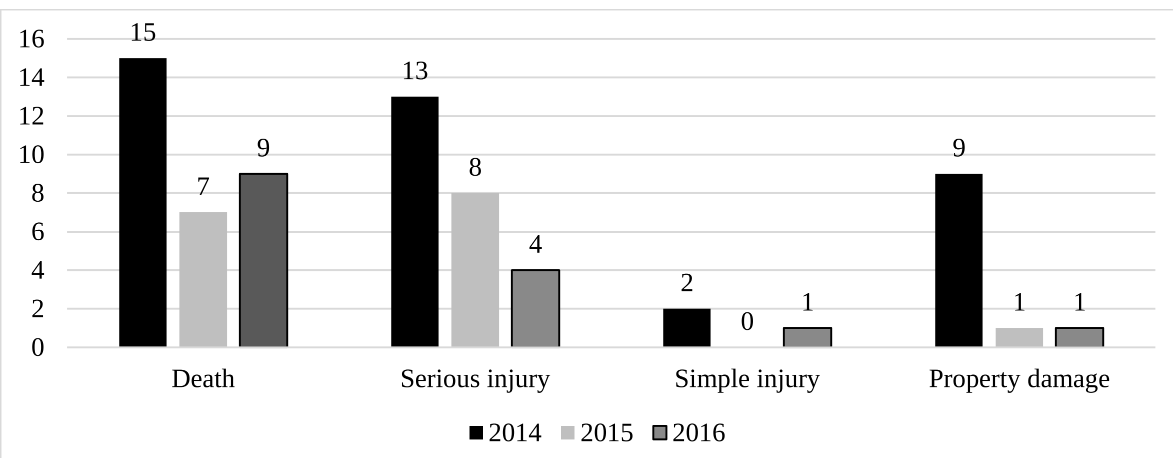



Fig.2.11. Yearly traffic accident in Jimma to Agaro Road (Source: Jimma Zone Police Commission)

The figure shows the accident on the road decrease yearly from 2014 to 2016 one factor to decrease the accident is due to condition of road the speed of driving decrease.

### 2.9.4. Environmental Impact

The primary purpose of the Environmental strategic impact assessment is to identify sensitive and valued environmental components that are likely to be significantly affected by the road project, and to ensure that all adverse environmental effects of proposed road upgrading project are adequately and appropriately considered in the design, construction and operation activities, so that the road is deemed environmentally and socially acceptable. Positive and negative environmental impacts are expected to be associated with the project. The proposed mitigation measures to alleviate the adverse effects have been recommended [17].

According to the Environmental Protection Agency, transportation accounts for one-third of all carbon dioxide emissions from fossil fuel combustion, and these emissions are particularly harmful to children's health but the impact of the transportation system on our health also extends beyond traffic crashes and air quality [25].

The nature of the operations and impacts of road maintenance are heavily dependent on local climate. Extremely cold winters, high intensity rainfall leading to flooding and high tropical temperatures all drive significantly different requirements for maintenance. As road assets age and as the impacts of more extreme weather due to climate change increase, road networks will become increasingly less resilient if road maintenance is not adequate. Sustainable maintenance should be prerequisite to the consideration of adaptation measures [10].

Drainage maintenance becomes more important as the frequency of high intensity rainfall increases. Effective timing of drainage maintenance before, during and after the wet season and around very heavy rainfall events helps alleviate failures and degradation [10].

Vehicle operation results in fuel consumption and generation of vehicle emissions. Impacts of road maintenance on vehicle operating costs will also therefore have implications for global $Co_2$ and greenhouse gas levels [10].

Dust blowing during movement of vehicles from deteriorated road which results in severe and unsafe driving conditions. Dust can impact the environment and cause health effects. Dust has caused vehicle accidents due to reduced visibility; damage to homes and increased the incidence of respiratory problems and cardiovascular conditions [28].

Fig.2.12. Dust blowing pollution (Location- Gembe exit)

### 2.10. Highway life-cycle costs

In economic terms, the cost of a transportation investment is the value of the resources that must be consumed to bring the project about. The total value of construction and any additional maintenance costs must be estimated [8].

Transportation cost is a major expenditure that is accounted after expenditure on housing. Thus reduction of fuel consumption due to maintenance of roads helps the peoples to spend less money on transportation expenditure. Further improvement in transportation system reduces the cost associated with congestion and additional wear and tear caused by poor road conditions [29].

### 2.10.1. Capital Costs

Capital costs make up the total investment required to prepare a highway improvement for service, from engineering through landscaping. Estimates of capital cost, ranging from detailed engineer's estimates to planning-level cost estimates, should be as refined as appropriate for the project's stage in the project development process [8].

Major Rehabilitation Costs within a benefit-cost analysis period, future investments may be needed to maintain the serviceability of a major transportation facility. For example, with a new or reconstructed highway, pavement overlays may be required 8, 12 or 15 years after the initial construction year. The cost of overlays or other major preservation activities should be included in the analysis and allocated to the year when they are anticipated to occur [8].

### 2.10.2. Routine Annual Maintenance Costs

When evaluating transportation investments, it is important to account for the future operating and maintenance costs of the facility. In the case of an upgraded roadway, it is necessary to estimate the additional maintenance costs that would be required for the Alternative as compared to the Base Case [8].

### 2.10.3. Remaining Capital Value (RCV)

Many components of a project retain some residual useful life beyond the benefit-cost analysis period (typically 20 years). At the end of the analysis period, the infrastructure that has been put in place generally has not been completely worn out, and will continue to provide benefits to drivers and travelers into the future. It is important to reflect this value in the analysis.

The remaining capital value is calculated by determining the percentage of useful life remaining beyond the analysis period, and multiplying that percentage by the construction cost for that component. The estimate of the remaining capital value at the end of the analysis period is then converted to a present value and subtracted from the initial capital cost [8].

## 2.11. Benefit-Cost Analysis

As its name implies, benefit-cost analysis compares the expected benefits of a project to the expected costs over the projected life of the project. Because the benefits and costs occur over time, standard financial procedures are used to create a "present value" of both costs and benefits. In this method all costs and benefits are discounted to their present worth and the ratio of benefit to cost is calculated.

**Benefits:**

- Travel time savings
- Vehicle operating cost savings
- Travel fare savings
- Accident avoidance (fatalities, injuries, property damage)

**Costs:**

- Dollar cost of construction
- Road-user costs during construction, including accidents

• Maintenance cost

Benefit-Cost Ratio = Present Value of Benefits / Present Value of Costs

A ratio greater than one indicates that benefits exceed costs [12].

### 2.11.1. Present worth method

Combines all investment cost or benefit and all annual expenses into a single present-worth sum, which represent the sum necessary at the time zero to finance the total disbursement over the analysis period. This present sum when multiplied by capital recovery factor will give the equivalent uniform annual cost or benefit.

### 2.11.2. Net present value method

In this method the stream of costs/ benefits associated with the project over an extended period of time is calculated and is discounted at a selected discount rate to give the present Benefits are treated as positive and cost as negative and the summation gives the net value present value (NPV). Any project with positive NPV is treated as acceptable. In comparing more than one project, a project with higher NPV should be accepted.

### 2.11.3. Discount Rate in Cost Analysis

Discount rate is used to convert the future benefits and costs of projects to present value. The higher the discount rate, the lower the net present worth of future costs will be [30]. Discount rates reflect the time value of money, which recognizes that wealth can be invested to generate profits (increased benefits), so current resources have greater value than future resources, even after adjusting for inflation [31].

For most transportation investments, costs are incurred in the initial years, while the benefits from the investment accrue over many years into the future. When assessing the costs and benefits of a project, it is necessary to take into account the time value of money by converting the costs and benefits that take place in different years into a common year. A discount rate of 10.23% was used in this study as recommended by Ethiopian Ministry of Finance and economic development for evaluation of project feasibilities in Ethiopia [8].

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1. Study Area

The study area was located in Oromia Regional State South Western part of Ethiopia. The study road was from Jimma to Agaro. Jimma is located at coordinates of average latitude 7°40' N, longitude of 36°50'E and altitude of 1780 meter above the mean sea level. It located at 356 km from Addis Abeba and 46km from Agaro (coordinates of 7°51'N 36°35'E and elevation of 1560 meter above mean sea level).

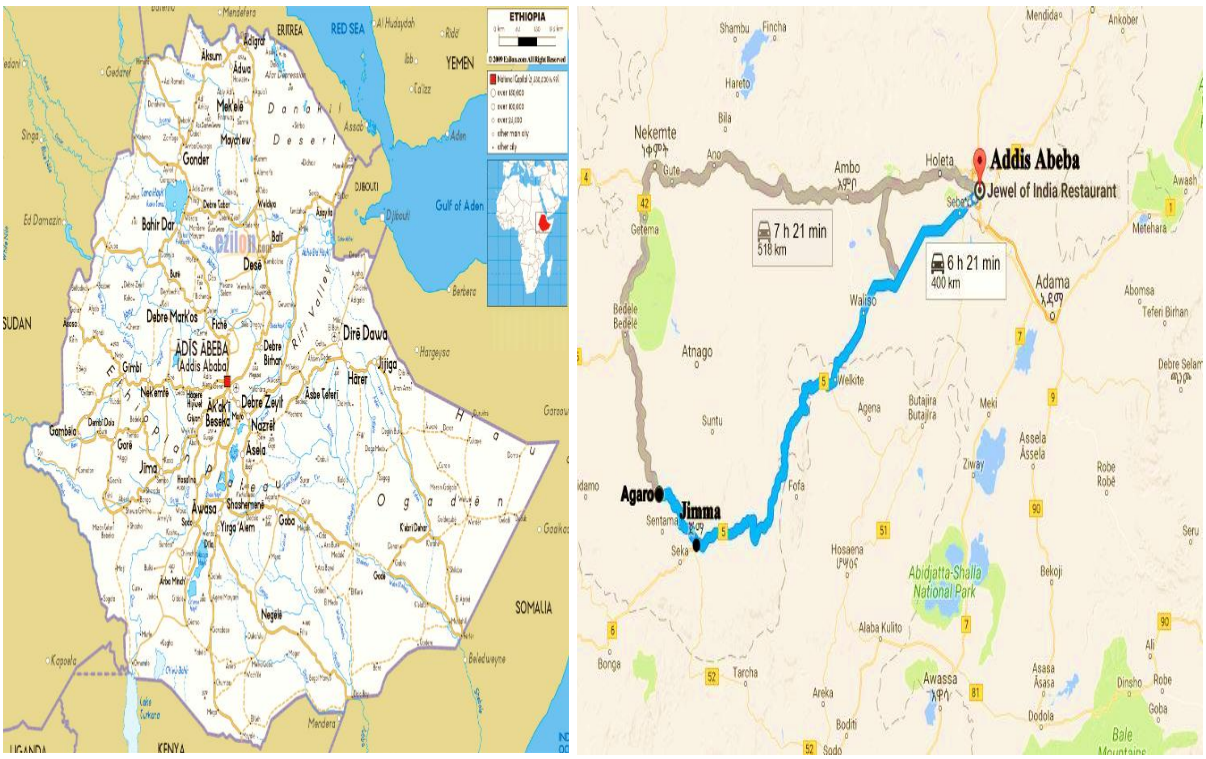



Fig.3.1 Map for study area (Source: Google map)

Jimma Zone is an important administrative Zonal center and the most coffee growing and production area. Jimma is the center and has high traffic volume that accommodates from small cars to heavy vehicles those travelling to Jimma – Agaro – Bedele – Metu – Gore – Gambella. The scope of study road Jimma to Agaro route corridor passes mostly on flat terrain. The climate is classified as temperate and humid with average annual rain fall of 1,800mm in Jimma. Most precipitation is occurring during Keremt (summer) season, between June September [32].

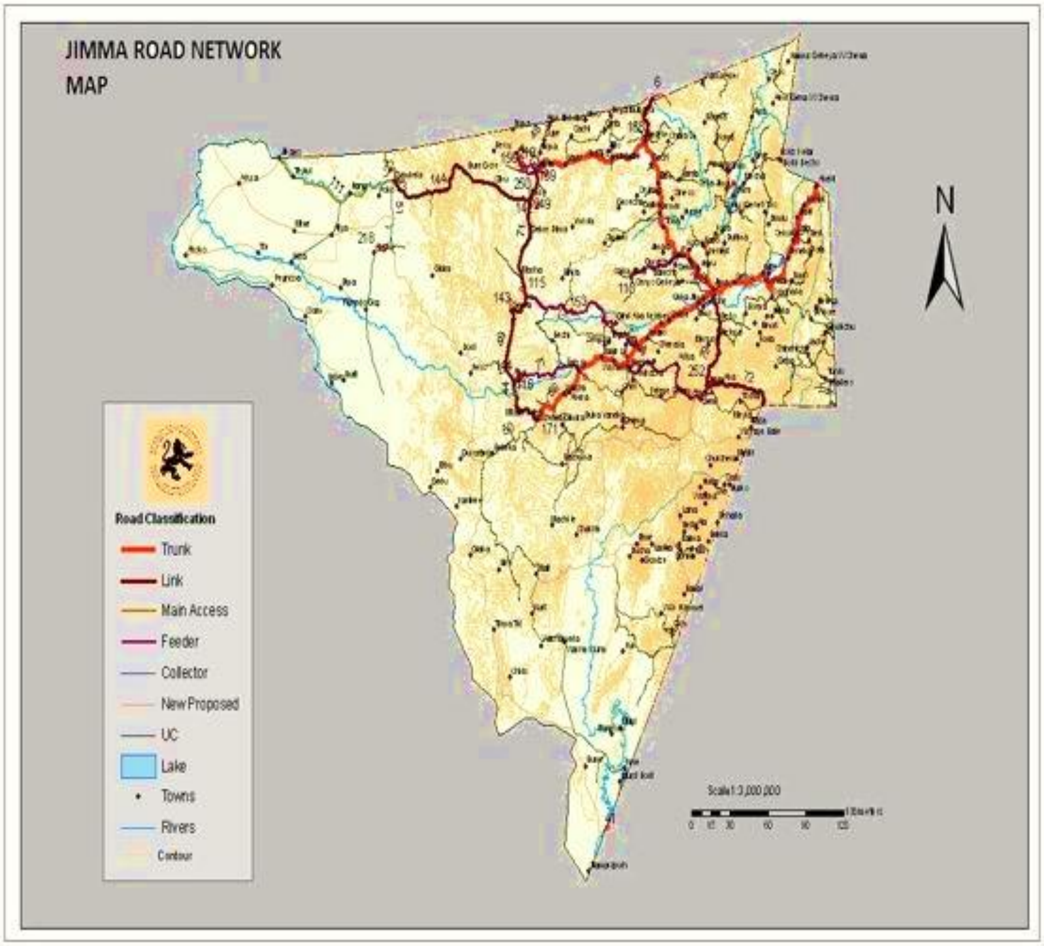



Fig.3.2. Jimma Road Network Map [32]

## 3.2. Research Design

The research was conducted by using both descriptive and analytical methods.

- Literature review
- Field observation, data collection and review of documents
- Evaluating the benefit and costs by net present value method
- Benefit cost analysis by benefit-cost ratio method then decision was made

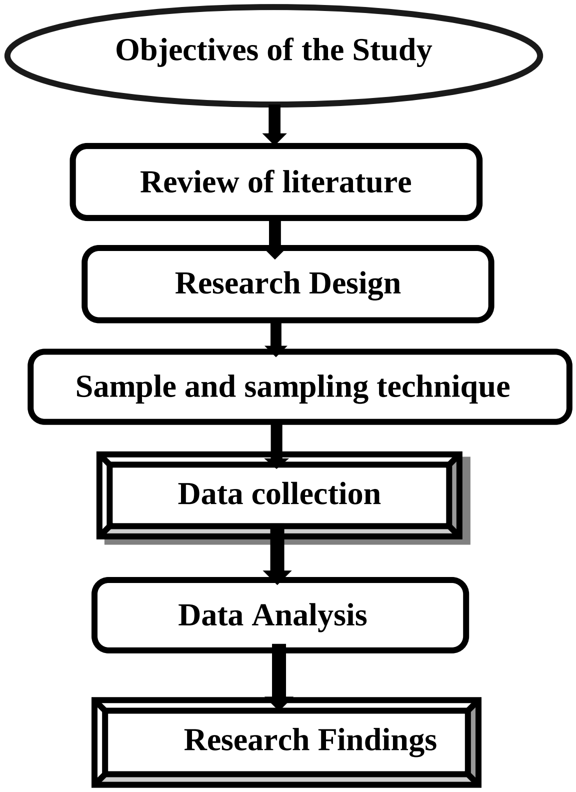



Fig.3.3. Flow chart of the study

## 3.3. Population

The population under study was vehicles, passengers, drivers and road segment. This population enabled the researcher to obtain the necessary data for the study.

## 3.4. Sample size and sampling procedure

### 3.4.1. Sample size

This study was followed on a purposive sampling selection process. It is selected by some arbitrary method because known to be representative of the total population, or it is known that it was produce well matched groups. The idea is to pick out the sample in relation to some criterion, which are considered important for the particular study. It enabled a researcher choose participants of his own interest based on education and experience. Sample taken 50 passenger and 20 Drivers arbitrary to gather data.

## 3.5. Study variables

Dependent variables

- Effect of road maintenance on user benefits and costs

Independent variables

- Maintenance cost
- Travel time saving
- Vehicle operating cost saving
- Transport fare saving
- AADT

### 3.6. Data source and collection process

This study employed a mixed research approach (qualitative and quantitative). Data (both descriptive and analytical) was obtained. The data gathered was used to interview and questionnaire to passengers and drivers about travel time cost, vehicle operating cost and safety. The output of the study was to compare the benefit-cost analysis of road before and after improvement.

During data collection

- Maintenance cost data from ERA
- Questionnaire and Informal interview with drivers and passengers: from passenger travel in this section take information like gender status, working status, purpose of travel, travel continuity, daily working hour, monthly income and comfort to travel. From drivers Trip in this direction per day, comfort to drive, average use of diesel and tire usage.
- Accident data from Jimma Police Commission: the data taken from the record office of the commission.
- Travel time measured: the data taken directly measured from small bus and bus randomly for 16 trips. The time measured from Jimma to Agaro which is from Arat Ambessa roundabout up to Agaro bus station.
- AADT counted: the vehicle count done manually for 7 days daily for one hour, not considered the night in count.
- Travel fare data from Jimma Road Transport Authority: the tariff of the travel fare data taken from the office and the paid amount taken from questionnaire.
- Field survey to assess the existing road condition: the survey done from a vehicle travelling at a speed of about 20-30 km/hr, the distresses are visually identified then classified in 9 segment to easily rate and picture captured for some severe area.

### 3.7. Data Processing and analysis

After cost determination of pavement maintenance, travel time savings, vehicle operating savings, transport fare saving. The net present worth of the road was calculated.

The net present worth formula which was used, is shown below:

$NPW_B$= TTS + VOS+TFS

$NPW_C$ =Mc

Where: $NPW_B$= Net present worth of benefit

TTS= Travel Time Saving

VOS= Vehicle Operating Saving

TFS= Transport Fare Saving

$NPW_C$= Net present worth of cost

Mc= Maintenance cost

B/C= Benefit cost ratio

**B/C= ( $NPW_B$ / $NPW_C$ )**

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

Where: n= Analysis year

i = Discount rate

P= Present worth

A= Annual worth (Annual benefit)

Table. 3.1. Parameters considered for the Benefit cost analysis

| **Parameters** | **Remarks** |
|---|---|
| Traffic Direction | (2-directions) Two lane- Two way |
| Analysis period ( Years) | 10 years |
| Beginning of analysis period | Beginning of 2017 |
| Discount Rate (%) | 10.23% (EMFED) |
| Interest rate (%) | 5% ( CBE) |

AADT (Annual average daily traffic) = $\frac{\text{Total yearly volume of vehs}}{365}$

Total yearly volume of vehs = Total weekly volume*(365/7)

Total weekly volume= the sum of vehicles volume in the week

Travel time analysis: Travel time amount is the time measured from Jimma to Agaro which is from Arat Ambessa roundabout up to Agaro bus station without deducting the time of stop during travel. After measuring the travel time deduct (DDT) the average stopping time which is duration of stop in time of travel due to reason like to take a person or things, multiply by no. of stops and then taken the average travel time from trips.

The analysis period 10 years selected because of the data availability not included the rehabilitation activity but if it is greater than 10 years must include rehabilitation cost in the analysis. Results from a benefit-cost analysis, along with public input and environmental documentation, can be used to evaluate both the monetized and non-monetized effects and impacts of alternatives when a decision needs to be made then compare the output. Finally present the results of analysis according to the research objectives.

### 3.8. Ethical consideration

The data's are only collected after ethical permission given from ERA Jimma district agencies and civil engineering department before continuing the study. The purpose of the study was clearly described to the organization and to the concerning local communities. The permission of Jimma University, Jimma Institute of Technology contact in order to precedes the research.

- Approval of research by an ethics review committee to make sure the study is not contradicting any of the above considerations.
- Follow procedure that is required to deal with concerned organization.
- When addressing the results makes sure, that on every section of report, which represent observed.

### 3.9. Plan for dissemination

The research mainly concentrates for academic purposes that are enrolled by Jimma University; the finding was presented to Jimma Institute of Technology, Civil Engineering department Highway Engineering Stream. And disseminated to Jimma university Technology library, all concerned governmental and non-governmental office.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1. Existing pavement condition

Pavement condition surveys play a vital role in the management of a pavement network. It refer to activities performed to give an indication of serviceability and physical conditions of road pavements. Pavements form a greater part of our society's infrastructure system whose proper functioning is essential for development. Similar to other types of infrastructure assets, pavements deteriorate overtime, helps agencies to schedule maintenance and rehabilitation works efficiently and enable to estimate the level of repair and rehabilitation required in terms of costs and extent of deterioration. This is because the condition ratings reflect the current condition of the pavement. Data obtained from condition surveys can be used for long-term budget planning and used to project future conditions and this serves as a guide for management decisions. The road condition survey like visualization of the carriageway, shoulder and drainage showed that is affected by pavement distresses like potholes, raveling, rutting, corrugation and fatigue cracks although no safety to travel and dustiness affect the driver to drive and the passenger to travel.

PASER uses visual inspection to evaluate pavement surface conditions. When assessed correctly, PASER ratings provide a basis for comparing the quality of roadway segments. The PASER assessment method does not require measurements of individual distresses and specific distress types. The advantage to this method is that roads may be assessed quickly. The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Recognizing defects and understanding their causes helps us rate pavement condition and select cost-effective repairs [13].

The rate at which pavement deteriorates depends on its environment, traffic loading conditions, original construction quality, and interim maintenance procedures. Poor quality materials or poor construction procedures can significantly reduce the life of a pavement. As a result, two pavements constructed at the same time may have significantly different lives, or certain portions of a pavement may deteriorate more rapidly than others. On the other hand, timely and effective maintenance can extend a pavement's life. With all of these variables, it is easy to see why pavements deteriorate at various rates and why we find them in various stages of disrepair.

Periodic inspection is necessary to provide current and useful evaluation data. To evaluate an individual pavement segment, first determine its general condition. Is it relatively new, toward the top end of the scale? In very poor condition and at the bottom of the scale? Or somewhere in between? Then, record the defects on the road segment, after that in sample areas captured photo to differentiate the distress and to know more severe areas (Some Photos are there in Annex 1). Next, think generally about the appropriate maintenance method. Use the rating categories outlined below in Table.4.1.

Finally, review the individual pavement distress and select the appropriate surface rating. Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types. Using these factors judgment of the researcher used to give pavement rating. The existing pavement condition is summarized and presented below in Table.4.2.

Table.4.1. PASER rating system [13]

| Surface rating | Visible distress | General condition / treatment measures |
|---|---|---|
| **10 Excellent** | None | New construction |
| **9 Excellent** | None | Recent overlay. Like new |
| **8 Very good** | No longitudinal cracks except reflection of paving joints. Occasional transverse cracks, widely spaced (40' or greater). All cracks sealed or tight (open less than 1/4") | Recent sealcoat or new cold mix. Little or no maintenance required. |
| **7 Good** | Very slight or no raveling, surface shows some traffic wear. Longitudinal cracks (open 1/4) due to reflection or paving joints. Transverse cracks (open 1/4") spaced 10' or more apart, little or slight crack raveling. No patching or very few patches in excellent condition | First signs of aging. Maintain with routine crack filling |
| **6 Good** | Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open 1⁄4"–1⁄2"), some spaced less than 10'. First sign of block cracking. Sight to moderate flushing or polishing. Occasional patching in good condition. | Shows signs of aging. Sound structural condition. |
| **5 Fair** | Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open 1/ 2") show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50% of surface. | Surface aging. Sound structural condition. Needs sealing or thin non-structural overlay (less than 2") |

| | | |
|---|---|---|
| | Extensive to severe flushing or polishing. Some patching or edge wedging in good condition. | |
| **4** **Fair** | Severe surface raveling. Multiple longitudinal and transverse cracking with slight raveling. Longitudinal cracking in wheel path. Block cracking (over 50% of surface). Patching in fair condition. Slight rutting or distortions (1/2" deep or less) | Significant aging and first signs of need for strengthening. Would benefit from a structural overlay (2" or more) |
| **3** **Poor** | Closely spaced longitudinal and transverse cracks Often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25% of surface). Patches in fair to poor condition. Moderate rutting or distortion (1" or 2" deep). 25% of surface) Patches in fair to poor condition Occasional potholes. | Needs patching and repair prio r to major overlay, Milling and removal of deterioration exten ds the life of overlay. |
| **2** **Very poor** | Alligator cracking (over 25% of surface). Severe distortions (over 2" deep) Extensive patching in poor con dition. Potholes. | Severe deterioration. Needs reconstruction with extensive base repair, Pulverization of ol d pavement is effective. |
| **1** **Failed** | Severe distress with extensive loss of surface integrity. | Failed. Needs total reconstruction. |

Table 4.2. Existing pavement condition rating

| Location | Road section | Observed problem | Pavement rating | Recommended remedies |
|---|---|---|---|---|
| Jimma to Kera | 0+000 to 5+100 | Fatigue cracks, Slight Rutting | **6** **Good** | Shows signs of aging. Sound structural condition. Surface treatment, such as seal coating, surface dressing, thin overlaying of bituminous surface |
| Kera to Mazoria | 5+100 to 11+150 | Fatigue cracks, potholes, Slight Rutting | **5** **Fair** | Surface aging sound structural condition needs sealing or thin non-structural overlay. level the pavement by filling |

| | | | | |
|---|---|---|---|---|
| | | | | the channels with hot mix asphalt material |
| Mazoria to Alemayew | 11+150 to 16+342 | Fatigue cracks, Corrugation | **7** **Good** | First signs of aging. Maintain with routine crack filling. |
| Alemayew to Yebu | 16+342 to 21+810 | Potholes, Slight Raveling, Fatigue cracks | **4** **Fair** | Significant aging and first signs of need for strengthening would benefit from a structural overlay. Surface treatment, such as seal coating , surface dressing, thin overlaying of bituminous surface |
| Yebu to Dabesa | 21+810 to 26+650 | Potholes, fatigue cracks, Raveling | **3** **Poor** | Needs patching and repair prior to major overlay, milling and removal of deterioration extends the life of overlay. |

| | | | | |
|---|---|---|---|---|
| Dabesa to Harro | 26+650 to 29+450 | Potholes, fatigue cracks, Raveling, Edge failure | **4** **Fair** | Significant aging and first signs of need for strengthening would benefit from a structural overlay. Surface treatment, such as seal coating , surface dressing, thin overlaying of bituminous surface |
| Harro to Gembe | 29+450 to 33+420 | Potholes, Corrugation, fatigue cracks, Severe surface raveling, Edge failure | **2** **Very poor** | Severe deterioration. Needs reconstruction with extensive base repair. |
| Gembe to Bulbulo | 33+420 to 40+100 | Potholes, Corrugation, Rutting, Fatigue cracks, Raveling, Edge failure | **4** **Fair** | Significant aging and first signs of need for strengthening would benefit from a structural overlay. Level the pavement by filling the channels with hot plant-mixed asphalt material. Follow with a thin asphalt Surface treatment plant-mixed overlay |
| Bulbulo to Agaro | 40+100 to 46+000 | Potholes, Rutting, fatigue cracks, | | Surface aging sound structural condition needs sealing or thin non- |

| | | | | |
|---|---|---|---|---|
| | | corrugation, Slight Raveling | **5** **Fair** | structural overlay Level the pavement by filling the channels with hot plant-mixed asphalt material. Follow with a thin asphalt plant-mixed overlay. |

Table.4.3. Summary of road condition

| **Location** | **Road section** | **Length in Km** | **PASER Rating of the road condtion** |
|---|---|---|---|
| Jimma to Kera | 0+000 to 5+100 | **5.100** | **6-Good** |
| Kera to Mazoria | 5+100 to 11+150 | **6.050** | **5-Fair** |
| Mazoria to Alemayew | 11+150 to 16+342 | **5.192** | **7-Good** |
| Alemayew to Yebu | 16+342 to 21+810 | **5.468** | **4-Fair** |
| Yebu to Dabesa | 21+810 to 26+650 | **4.840** | **3-Poor** |
| Dabesa to Harro | 26+650 to 29+450 | **2.800** | **4-Fair** |
| Harro to Gembe | 29+450 to 33+420 | **3.970** | **2-Very poor** |
| Gembe to Bulbulo | 33+420 to 40+100 | **6.680** | **4-Fair** |
| Bulbulo to Agaro | 40+100 to 46+000 | **5.900** | **5-Fair** |
| | Total length in Km | **46.000** | |

From the total length 46km using PASER rating 10.292Km in Good condition, 26.898Km in Fair condition, 4.84Km in Poor condition and 3.97Km in Very poor condition. The condition in percentage 22.37% Good, 58.47% Fair, 10.52% Poor, 8.63% Very poor.

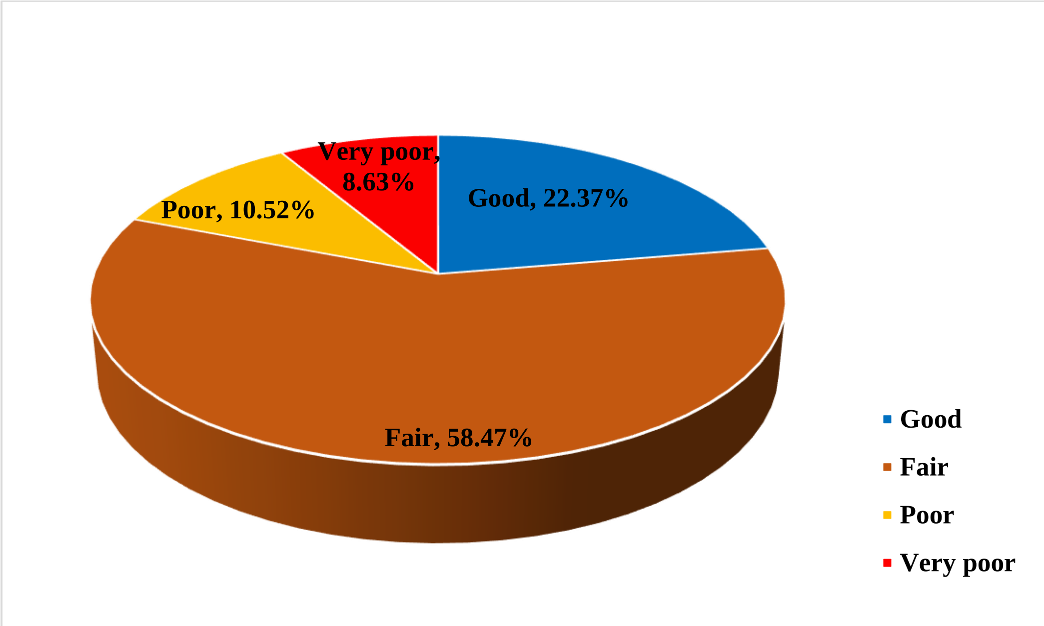



Fig.4.1. Pavement Condition Rating

## 4.2. AADT analysis

AADT is the average of 24-hour counts collected every day of the year. It is necessary to obtain data continuously. To make reasonable estimates of annual traffic volume characteristics on an area-wide basis, different types of periodic counts, with count durations ranging from 15 minutes to continuous, are conducted; the data from these different periodic counts are used to determine values that are then employed in the estimation of annual traffic characteristics.

No. of vehicles in a year divided by 365. For the road from Jimma to Agaro the researcher count the vehicle done manually for 7 days Monday up to Sunday daily for one hour by 15 minute interval and considered only the day time up to 12hr, not considered the night in count.

The count station Agaro around Gomma Administration Office station 43+750 and Jimma station 350 meter away from Arat ambesa roundabout (0+350). From the Table.4.4 below in Jimma count station Saturday from 3:00 - 3:15 am and 3:30 - 3:45 am time got the maximum vehicle sum 41 and the minimum got on Friday 4:45-5:00 am time is 30 in 15 minute count. From Agaro count station Tuesday from 4:45 - 5:00 am got the max vehicle sum 35 and the min vehicle sum got Sunday 8:45-9:00 am is 23 in 15 minute count. From the daily volumes the max got Saturday 1932 vehs and the min 1644 vehs in Jimma count station and from Agaro count station the max got in Tuesday 1512 vehs and the min got in Sunday 1260 vehs.

Table.4.4. AADT analysis of Jimma-Agaro road

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **AADT Analysis** | | | | | | |
| **Monday 28 Aug 2017** | | | | | | | | | | |
| **Jimma station** | | | | | | | | | | |
| **Direction** | Time | Car | Small Bus | Large Bus | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | Sum | Daily volume of vehs |
| Jim-Aga lane | 5:00 - 5:15 am | | 9 | | 7 | 1 | 2 | | 19 | |
| Aga-Jim lane | | | 8 | | 5 | 2 | | | 15 | |
| | | | | | | | | | 34 | |
| Jim-Aga lane | 5:15 - 5:30 am | 1 | 13 | | 1 | 1 | 3 | | 19 | |
| Aga-Jim lane | | 1 | 9 | | 4 | 3 | 1 | | 18 | |
| | | | | | | | | | 37 | |
| Jim-Aga lane | 5:30 - 5:45 am | 2 | 11 | | 3 | 5 | 1 | | 22 | |
| Aga-Jim lane | | | 7 | | 4 | 4 | 3 | | 18 | |
| | | | | | | | | | 40 | |
| Jim-Aga lane | 5:45 - 6:00 am | 1 | 6 | | 5 | 2 | 1 | 1 | 16 | |
| Aga-Jim lane | | 2 | 3 | 2 | 4 | 4 | 2 | | 17 | |
| | | | | | | | | | 33 | |
| | | | | | | | | | 144 | 1728 |
| **Tuesday 29 Aug 2017** | | | | | | | | | | |
| **Agaro Station** | | | | | | | | | | |
| Jim-Aga lane | 4:00 - 4:15 am | 1 | 8 | | 1 | 1 | | | 11 | |
| Aga-Jim lane | | | 11 | | 2 | 1 | 2 | | 16 | |
| | | | | | | | | | 27 | |
| Jim-Aga lane | 4:15 - 4:30 am | | 15 | | 1 | 6 | | | 22 | |
| Aga-Jim lane | | | 5 | | 1 | 3 | | | 9 | |
| | | | | | | | | | 31 | |
| Jim-Aga lane | 4:30 - 4:45 am | 1 | 8 | | 4 | 2 | 1 | | 16 | |
| Aga-Jim lane | | | 12 | | 1 | 4 | | | 17 | |
| | | | | | | | | | 33 | |
| Jim-Aga lane | 4:45 - 5:00 am | | 9 | 1 | 3 | | 2 | | 15 | |
| Aga-Jim lane | | 1 | 12 | | 5 | 2 | | | 20 | |
| | | | | | | | | | 35 | |
| | | | | | | | | | 126 | 1512 |
| **Wensday 30 Aug 2017** | | | | | | | | | | |
| **Jimma Station** | | | | | | | | | | |
| Jim-Aga lane | 6:00 - 6:15 am | | 15 | | 3 | | 2 | 1 | 21 | |
| Aga-Jim lane | | 2 | 7 | | 4 | | | | 13 | |
| | | | | | | | | | 34 | |
| Jim-Aga lane | 6:15 - 6:30 am | 1 | 6 | | 2 | | 1 | | 10 | |
| Aga-Jim lane | | 1 | 17 | | 6 | | 2 | | 26 | |
| | | | | | | | | | 36 | |
| Jim-Aga lane | 6:30 -6:45 am | | 7 | 1 | 7 | 3 | 1 | | 19 | |
| Aga-Jim lane | | | 12 | | 4 | | | | 16 | |
| | | | | | | | | | 35 | |
| Jim-Aga lane | 6:45 -7:00 am | | 10 | 1 | 5 | 2 | 2 | | 20 | |
| Aga-Jim lane | | | 9 | | 6 | 1 | | | 16 | |
| | | | | | | | | | 36 | |
| | | | | | | | | | 141 | 1692 |
| **Thursday 31 Aug 2017** | | | | | | | | | | |
| **Agaro Station** | | | | | | | | | | |
| Jim-Aga lane | 8:00 - 8:15 am | | 12 | | 6 | 1 | | 1 | 20 | |
| Aga-Jim lane | | | 7 | | 3 | | 1 | | 11 | |
| | | | | | | | | | 31 | |
| Jim-Aga lane | 8:15 - 8:30 am | | 4 | | 2 | 3 | | 3 | 12 | |
| Aga-Jim lane | | | 10 | | 3 | | | | 13 | |
| | | | | | | | | | 25 | |
| Jim-Aga lane | 8:30 - 8:45 am | | 6 | | 5 | | 2 | | 13 | |
| Aga-Jim lane | | 2 | 8 | | 3 | 1 | 1 | | 15 | |
| | | | | | | | | | 28 | |
| Jim-Aga lane | 8:45 - 9:00 am | 2 | 12 | | 5 | 2 | | | 21 | |
| Aga-Jim lane | | 1 | 8 | | 3 | | | | 12 | |
| | | | | | | | | | 33 | |
| | | | | | | | | | 117 | 1404 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Friday 01 Sept 2017** | | | | | | | | | | |
| **Jimma Station** | | | | | | | | | | |
| Jim-Aga lane | 4:00 - 4:15 am | 2 | 7 | | 2 | 1 | 2 | | 14 | |
| Aga-Jim lane | | | 12 | | 6 | 5 | 1 | | 24 | |
| | | | | | | | | | 38 | |
| Jim-Aga lane | 4:15 - 4:30 am | | 12 | | 5 | 3 | 1 | 1 | 22 | |
| Aga-Jim lane | | 1 | 8 | 1 | 3 | 2 | | | 15 | |
| | | | | | | | | | 37 | |
| Jim-Aga lane | 4:30 - 4:45 am | 1 | 6 | | 6 | 3 | 2 | | 18 | |
| Aga-Jim lane | | | 8 | 1 | 4 | 1 | | | 14 | |
| | | | | | | | | | 32 | |
| Jim-Aga lane | 4:45 - 5:00 am | | 6 | | 3 | 2 | | | 11 | |
| Aga-Jim lane | | 3 | 5 | 2 | 4 | 1 | 2 | 2 | 19 | |
| | | | | | | | | | 30 | |
| | | | | | | | | | 137 | 1644 |
| **Saturday 02 Sept 2017** | | | | | | | | | | |
| **Jimma Station** | | | | | | | | | | |
| Jim-Aga lane | 3:00 - 3:15 am | 2 | 12 | 1 | 4 | 2 | 1 | | 22 | |
| Aga-Jim lane | | 1 | 10 | | 5 | | 2 | 1 | 19 | |
| | | | | | | | | | 41 | |
| Jim-Aga lane | 3:15 - 3:30 am | 1 | 13 | 1 | 5 | 2 | | | 22 | |
| Aga-Jim lane | | | 9 | | 6 | 1 | 2 | | 18 | |
| | | | | | | | | | 40 | |
| Jim-Aga lane | 3:30 - 3:45 am | 2 | 11 | | 6 | 3 | 1 | 1 | 24 | |
| Aga-Jim lane | | | 10 | 1 | 4 | 2 | | | 17 | |
| | | | | | | | | | 41 | |
| Jim-Aga lane | 3:45 - 4:00 am | | 9 | | 5 | 5 | | | 19 | |
| Aga-Jim lane | | 1 | 11 | | 5 | | 2 | 1 | 20 | |
| | | | | | | | | | 39 | |
| | | | | | | | | | 161 | 1932 |
| **Sunday 03 Sept 2017** | | | | | | | | | | |
| **Agaro Station** | | | | | | | | | | |
| Jim-Aga lane | 8:00 - 8:15 am | | 6 | | 2 | 1 | 2 | | 11 | |
| Aga-Jim lane | | | 9 | | 4 | 3 | 1 | 1 | 18 | |
| | | | | | | | | | 29 | |
| Jim-Aga lane | 8:15 - 8:30 am | 1 | 8 | 1 | 2 | 1 | 1 | | 14 | |
| Aga-Jim lane | | 1 | 6 | | 3 | 3 | | | 13 | |
| | | | | | | | | | 27 | |
| Jim-Aga lane | 8:30 - 8:45 am | | 7 | | 3 | 3 | 1 | | 14 | |
| Aga-Jim lane | | | 5 | | 4 | 2 | 1 | | 12 | |
| | | | | | | | | | 26 | |
| Jim-Aga lane | 8:45 - 9:00 am | | 6 | | 3 | 3 | 1 | 1 | 14 | |
| Aga-Jim lane | | 1 | 5 | | 2 | 1 | | | 9 | |
| | | | | | | | | | 23 | |
| | | | | | | | | | 105 | 1260 |

Total Weekly volume= 1728+1512+1692+1404+1644+1932+1260 = 11172 vehs

Total Yearly volume of vehs = 11172 vehs*(365/7) = 582540 vehs

$$\textbf{AADT} = \frac{\text{Total yearly volume of vehs}}{365} = \underline{\mathbf{1596}}\ \textbf{Veh\textbackslash day}$$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sum of vehicles | 36 | 497 | 13 | 214 | 104 | 53 | 14 | 931 |
| % composition of vehicles | 3.87% | 53.38% | 1.40% | 22.99% | 11.17% | 5.69% | 1.50% | |

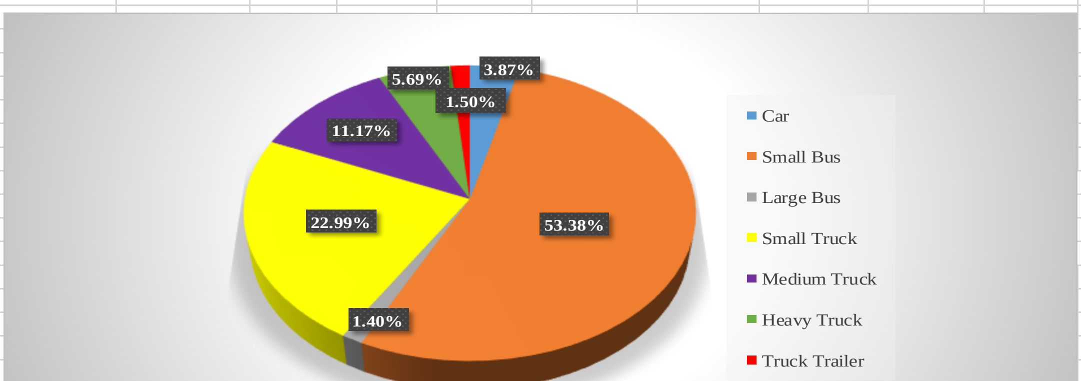



**Fig.4.2. Composition of vehicle**

Table.4.5. Composition of vehicles

| Vehicle type | AADT | Composition | No. of Vehicle |
|---|---|---|---|
| Car | 1596 | 3.87% | 62 |
| Small Bus | 1596 | 53.38% | 852 |
| Large Bus | 1596 | 1.40% | 22 |
| Small Truck | 1596 | 22.99% | 367 |
| Medium Truck | 1596 | 11.17% | 178 |
| Heavy Truck | 1596 | 5.69% | 91 |
| Truck Trailer | 1596 | 1.50% | 24 |

## 4.3. Maintenance Cost

The cost of maintenance data taken from ERA Jimma district. From the maintenance project begins from round about four Lions at station km 356+00 from Addis Abeba and terminates at 426+000 with a total project length 70km. The project route corridor passes mostly on flat terrain. From this the scope consider only from Jimma to Agaro road which is 46Km. The construction of Jimma-Agaro- Dedessa capital project granted to ECWC Jimma district with an estimated cost of 34.5 million ETB [32]. From 70Km project the Jimma to Agaro road 46Km by analyses the estimated cost is 22.67 million ETB.

Assumption this maintenance cost as annual cost of maintenance for Jimma to Agaro road=22.67 million ETB.

## 4.4. Travel time saving analysis

This is the benefit gained after the condition of the pavement improved. The table.4.5 shown below describe the travel time analysis. The data taken directly measured from small bus and bus randomly for 16 trips. The direction of travel from Jim to Aga means the small bus begin to travel from Jimma and stop in Agaro also Aga to Jim means the vehicle begin to travel from Agaro and stop in Jimma. The number of passenger on the small bus including the driver are as shown on the table below from that the smallest is 14.

Travel time amount is the time measured from Jimma to Agaro which is from Arat Ambessa roundabout up to Agaro bus station without deducting the time of stop during travel. After measuring the travel time deduct (DDT) the average stopping time which is duration of stop in time of travel due to reason like to take a person or things, multiply by no. of stops and then taken the average travel time from trips.

The 10th column below in table.4.6. Indicate the minute the small bus take to travel from Jimma to Agaro which is the time vehicles travel without stop (Travel time in minute minus the DDT value). The average travel time in minute got from take the average of column 10 (which is the time the small bus take to travel without stop in travel). The average travel time in minute is 67 minute.

Table.4.6. Travel time analysis

| | | | | Travel Time analysis | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Date | Direction | Vehicle Type | No. of passanger | No. of stops | Avg. stopping time(Sec) | Travel time amount | Travel time in minute | DDT (5*6) | (8-9) |
| 3/25/2017 | Jim to Aga | Small Bus | 15 | 8 | 30 | 1hr:19min | 79 | 4 | 75 |
| 3/29/2017 | Aga to Jim | Small Bus | 15 | 6 | 30 | 1hr:05min | 65 | 3 | 62 |
| 3/30/2017 | Jim to Aga | Small Bus | 15 | 8 | 30 | 1hr:11min | 71 | 4 | 67 |
| 4/3/2017 | Aga to Jim | Small Bus | 17 | 2 | 30 | 59min | 59 | 1 | 58 |
| 4/3/2017 | Jim to Aga | Small Bus | 16 | 3 | 30 | 1hr:03min | 63 | 1.5 | 61.5 |
| 4/6/2017 | Jim to Aga | Small Bus | 15 | 8 | 30 | 1hr:14min | 74 | 4 | 70 |
| 4/7/2017 | Aga to Jim | Small Bus | 15 | 8 | 30 | 1hr:04min | 64 | 4 | 60 |
| 4/8/2017 | Jim to Aga | Small Bus | 16 | 8 | 30 | 1hr:02min | 62 | 4 | 58 |
| 7/10/2017 | Aga to Jim | Small Bus | 17 | 8 | 30 | 1hr:09min | 69 | 4 | 65 |
| 7/12/2017 | Aga to Jim | Small Bus | 17 | 7 | 30 | 1hr:04min | 64 | 3.5 | 60.5 |
| 7/12/2017 | Jim to Aga | Small Bus | 18 | 12 | 30 | 1hr:14min | 74 | 6 | 68 |
| 7/25/2017 | Aga to Jim | Small Bus | 16 | 16 | 30 | 1hr:33min | 93 | 8 | 85 |
| 7/25/2017 | Jim to Aga | Small Bus | 14 | 11 | 30 | 1hr:15min | 75 | 5.5 | 69.5 |
| 7/26/2017 | Aga to Jim | Small Bus | 15 | 7 | 30 | 1hr:04min | 64 | 3.5 | 60.5 |
| 7/26/2017 | Jim to Aga | Small Bus | 16 | 6 | 30 | 1hr:14min | 74 | 3 | 71 |
| 7/31/2017 | Aga to Jim | Small Bus | 16 | 8 | 30 | 1hr:05min | 65 | 4 | 61 |
| 7/31/2017 | Jim to Aga | Small Bus | 16 | 11 | 30 | 1hr:08min | 68 | 5.5 | 62.5 |
| 8/8/2017 | Aga to Jim | Small Bus | 15 | 8 | 30 | 1hr:09min | 69 | 4 | 65 |
| 8/8/2017 | Jim to Aga | Small Bus | 16 | 9 | 30 | 1hr:06min | 66 | 4.5 | 61.5 |
| 8/12/2017 | Aga to Jim | Small Bus | 15 | 11 | 30 | 1hr:19min | 79 | 5.5 | 73.5 |
| 8/12/2017 | Jim to Aga | Small Bus | 16 | 4 | 30 | 1hr:02min | 62 | 2 | 60 |
| 8/19/2017 | Aga to Jim | Small Bus | 16 | 6 | 30 | 1hr:08min | 68 | 3 | 65 |
| 8/24/2017 | Jim to Aga | Small Bus | 17 | 6 | 30 | 1hr:07min | 67 | 3 | 64 |
| 8/28/2017 | Aga to Jim | Small Bus | 15 | 8 | 30 | 1hr:13min | 73 | 4 | 69 |
| 8/28/2017 | Jim to Aga | Small Bus | 16 | 10 | 30 | 1hr:14min | 74 | 5 | 69 |
| 9/3/2017 | Aga to Jim | Bus | 65 | 2 | 30 | 1hr:16min | 76 | 1 | 75 |
| 9/8/2017 | Jim to Aga | Bus | 52 | 4 | 30 | 1hr:19min | 79 | 2 | 77 |
| 9/14/2017 | Aga to Jim | Small Bus | 15 | 10 | 30 | 1hr:16min | 76 | 5 | 71 |
| 9/14/2017 | Jim to Aga | Small Bus | 16 | 5 | 30 | 1hr:07min | 67 | 2.5 | 64.5 |
| 9/17/2017 | Aga to Jim | Small Bus | 18 | 8 | 30 | 1hr:10min | 70 | 4 | 66 |
| 9/17/2017 | Jim to Aga | Small Bus | 16 | 9 | 30 | 1hr:09min | 69 | 4.5 | 64.5 |
| 9/22/2017 | Jim to Aga | Small Bus | 16 | 6 | 30 | 1hr:14min | 74 | 3 | 71 |
| | | AVERAGE TRAVEL TIME IN MINUTE | | | 66.578125 | 1hr:07min | | | |

**Data gathered from Questionnaire**

Sample taken 50 Passengers and 20 Drivers for Questionnaire.

From Passengers

- From 50 Passengers gender status 34 man and 16 woman. Their work status 8 student, 18 working in government and 24 working there private work.

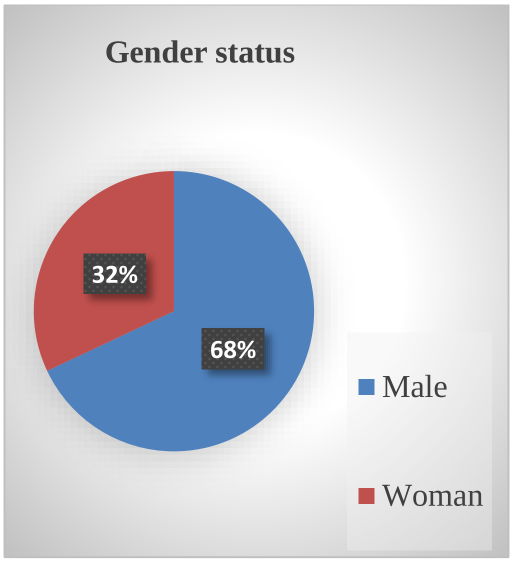



Fig.4.3. Gender status

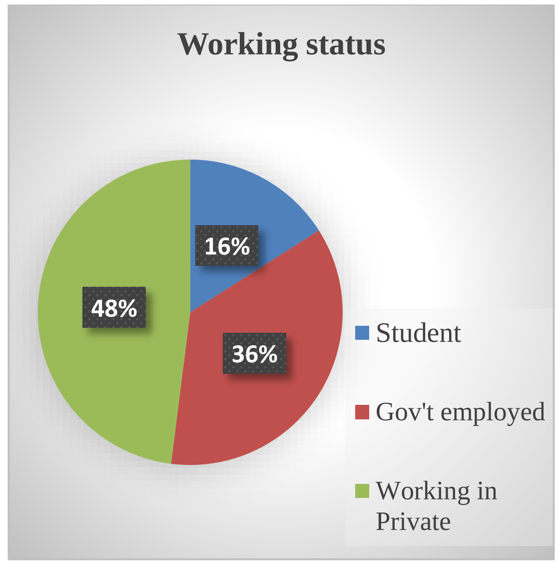



Fig.4.4. Working status

- Purpose of travel from Agaro to Jimma 41 for work, 3 for recreational and 6 going to home and travel continuity to Jimma to Agaro from 50 passengers 6 of them travel daily, 19 weekly , 10 in half month,14 monthly and 1 yearly.

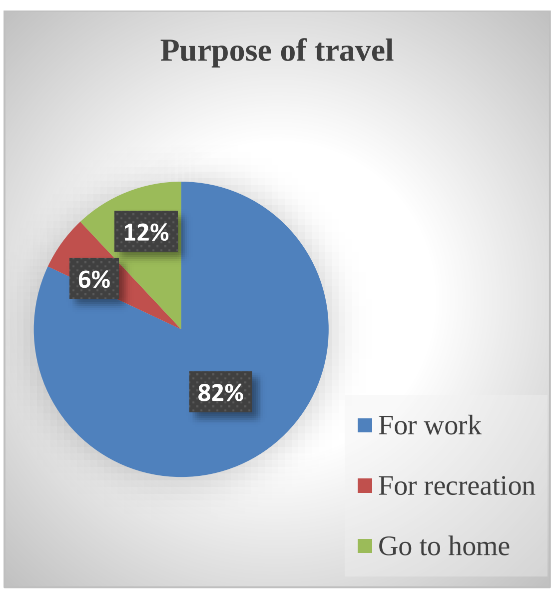



Fig.4.5. Purpose of travel

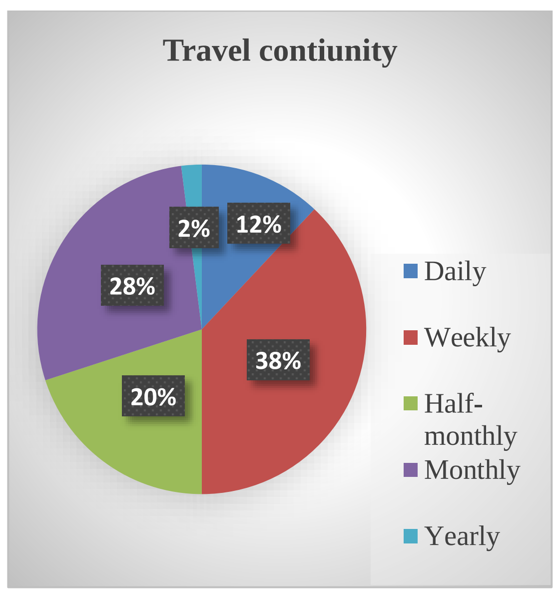
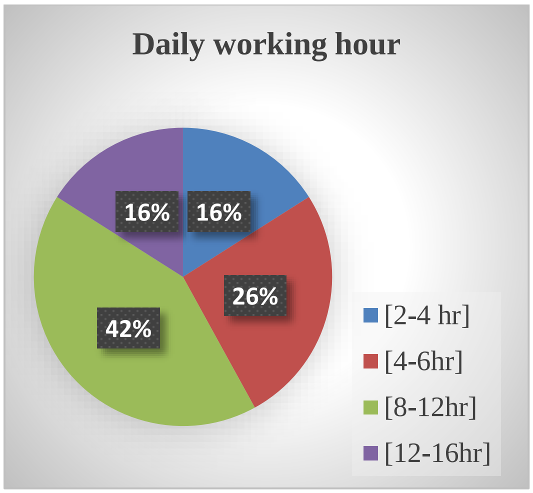



Fig.4.6. Travel continuity

- Daily working hour from 50 passengers 8 of them 2-4hr in work, 13 of them 4-6hr in work, 21 of them 8-12hr in work and 8 of them 12-16hr in work and their monthly income of passengers from 50, 6 of them gain 600-1500birr per month, 12 of them gain 1500-3500birr per month, 20 of them gain 3500-6000birr per month and 12 of them gain 6000-10000birr per month.



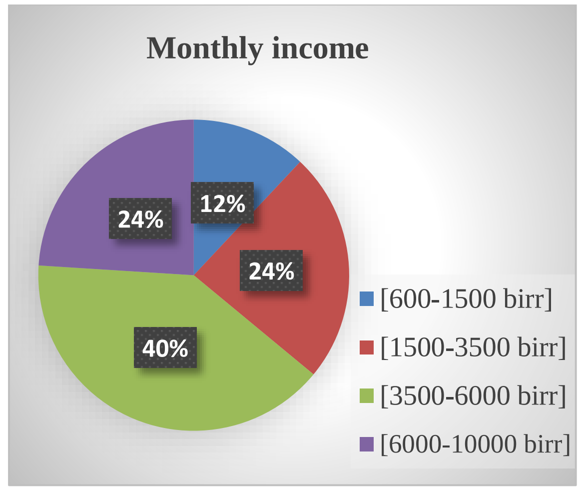




Fig.4.7. Daily working hour Fig.4.8. Monthly income

- Comfortable to travel on this road 7 of them Neutral and 43 of them say not comfortable to travel

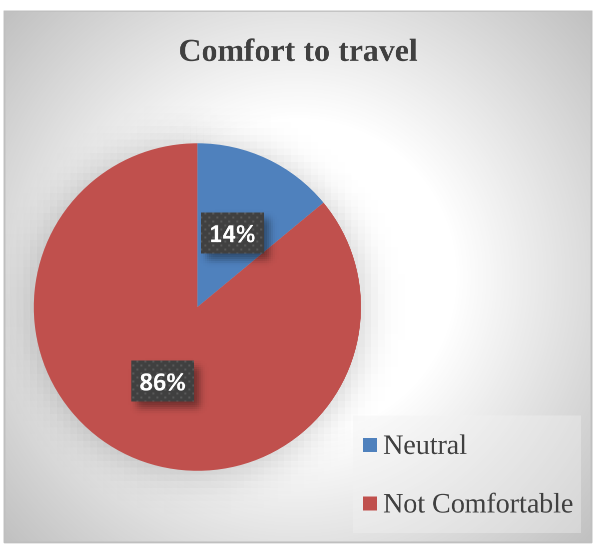
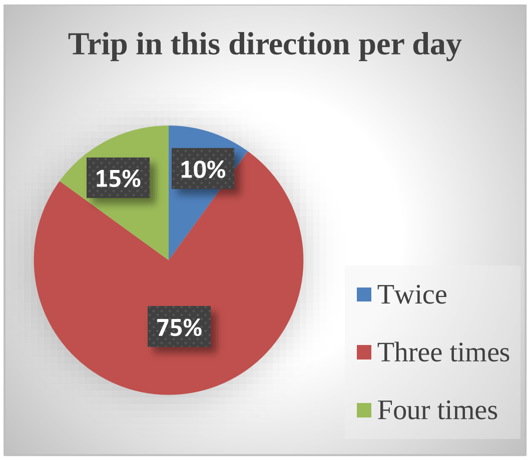



Fig.4.9. Comfort to travel

- The cost of transportation all of them said 20 birr for a person in one travel but the tariff from government is 16.58 birr.

From Drivers

- How often do you make this same trip in this direction per day? 2 of them twice, 15 of them 3 times and 3 of them 4 times.
- Comfortable to drive on this road 2 of them Neutral and 18 of them say not comfortable to drive.



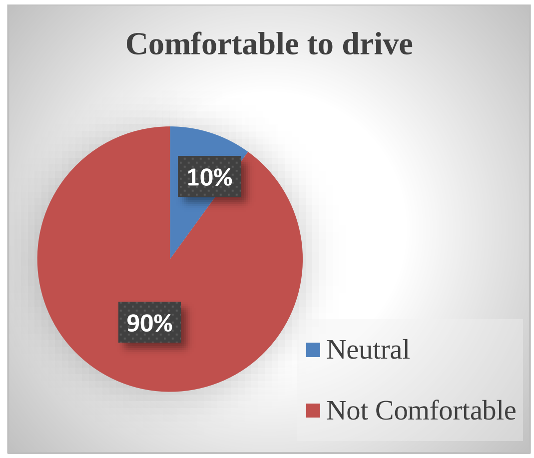




Fig.4.10. Trip in this direction per day     Fig.4.11. Comfortable to drive

- From all drivers asked the average daily small bus use of diesel is 48 liter for 270 Km.
- From informal interview with drivers most of them said tire changed after 4 month usage now but the road in good condition before used for 6 month. The price for one tire is 2300 birr.

**Travel Time Saving Analysis**

From Questionnaire

$$\text{Average monthly income} = \frac{(1050*6) + (2500*20) + (4750*12) + (8000*12)}{50}$$

$$= \frac{209300}{50}$$

Average monthly income = 4186 birr/month

Average daily income=4186/30=139.53

=140birr/day

$$\text{Average passenger working hour} = \frac{(3*8) + (5*13) + (10*21) + (14*8)}{50}$$

Average passenger working hour = 8.22 hr= 8hr and 13 minute

Average income per hour =140/8.22=17.03birr/hr

Average income per minute =17.03/60=0.28cent/min

From Table 4.5. Average travel time from Jimma to Agaro = 1hr: 07min=67minute

From (Distancesto.com) travel time calculator Total travel time from Agaro to Jimma 45min which is the amount of time you can expect to travel to your destination. Note that road work, weather conditions and other factors can affect this estimate.

After improvement of road it reduce =67min-45min= 22 minute

=0.28cent/min*22min= 6.16 birr

For Car

=6.16 birr*62 vehicles*4 passenger=1,527.68birr/day

=1527.68*365= 557,603.2birr/year

For Small bus

=6.16 birr*852vehicles*14 passenger= 73,476.48birr/day

=73,476.48*365= 26,818,915.2birr/year

For Large Bus

=6.16 birr*22vehicles*65 passenger=8,808.8birr/day

=8,808.8*365= 3,215,212birr/year

For Small Truck

=6.16 birr*367*4 passenger=9,042.88birr/day

=9,042.88*365= 3,300,651.2birr/year

For Medium Truck

=6.16 birr*178*2 passenger= 2,192.96birr/day

=2,192.96*365= 800,430.4birr/year

For Heavy Truck

=6.16 birr*91*2 passenger= 1,110.2birr/day

=1110.2*365= 405,223birr/year

For Truck Trailer

=6.16 birr*24*2 passenger=295.68birr/day

=295.68*365= 107,923.2 birr/year

The Total travel time saved in birr = 557,603.2 + 26,818,915.2+ 3,215,212 + 3,300,651.2 + 800,430.4+ 405,223+107,923.2 = 35,205,958.2 birr/year

## 4.5. Vehicle Operating Saving Analysis

Most of the types of fuel that are being used for all types of vehicles are petrol and diesel. Ethiopia's consumption of fuel is largely attributed to transport industries rather than some other economic sectors in the country.

**Fuel cost**

From questionnaire the average daily small bus use of Diesel is 48 liter for 270 Km.

1 liter = 16.74 birr

48/270 = 0.178liter/km

From this assume all vehicles use 0.178liter/km means the efficiency of all vehicles are equal.

The annual fuel consumption becomes:

Cost of fuel per day = (0.178 li/km)*(46km*1596)*(16.74birr/liter)

= 218,759.123 birr/day

The annual fuel consumption becomes:

Cost of fuel per year =218,759.123 birr/day * 365 days = 79,847,080.085 birr/year

FHWA (Federal highway administration) during wesTrack study (Sime etal, 2001). Results from this study indicated that trucks running on slightly smoother pavement could reduce fuel consumption by 4.5%.

= 79,847,080.085*4.5% = 3,593,118.60 birr/year

**Tire Cost**

For small Bus

From informal interview with drivers most of them said tire changed after 4 month usage now but the road in good condition before used for 6 month.

4 month means tire changed 3 times yearly

6 month means tire changed 2 times yearly

One tire price 2300 birr

For 4 month= 2300 birr * 4 tire * 3 * 852=23,515,200 birr/year

For 6 month= 2300 birr * 4 tire * 2 * 852=15,676,800 birr/year

The Difference of them is the saving due to improvement of the road= 7,838,400 birr/year

The sum of the two which is fuel cost and tire cost will give the vehicle operating saving

= 3,593,118.60 + 7,838,400= 11,431,518.60birr/year

The Total vehicle operating saving =11,431,518.60 birr/year

## 4.6. Transport Fare Saving Analysis

Transport fare is a fee paid by passenger for use of a public transport system. The fare paid is a contribution to the operational costs of the transport system involved

Transport fare of small bus

Tariff= 16.58 birr

Price paid for travel due to bad condition road = 20 birr

The difference between them=3.42 birr which is additional payment taken from passenger by vehicle owner due to bad road condition

Total Additional transport fare in day= 852veh*3.42 birr*14 passenger= 40,793.76 birr/day

Total additional transport fare in year= 40,793.76birr/day*365 = 14,889,722.4 birr/year

## 4.7. Benefit-Cost Ratio

Benefit-Cost Analysis places a value on each incremental benefit and costs of each option. These are summed and compared. The results can be presented as a ratio, with benefits divided by costs. Simple Payback is similar to a Benefit-Cost Ratio. It indicates the time period required for benefits to repay an investment. However, these methods are affected by how benefits and costs are incorporated in the analysis. For example, some impacts can be considered either a reduction in benefits or an increase in costs, which is used will change the ratio.

The result of the benefit-cost analysis can be shown as benefit-cost ratio and/or as net present value. These results show if the alternative is economically justified compared to the base case.

After the future streams of costs and benefits are discounted, the sum of the discounted benefits is divided by the sum of the discounted cost. If the result is greater than or equal to 1.0, the infrastructure improvement is economically justified [14].

If B/C>=1, accept the project as economically acceptable for the estimates and discount rate applied.

If B/C<=1, the project is not economically acceptable

The net present worth formula which will be use, is shown below:

$NPW_B$= TTS + VOS+TFS

$NPW_C$ =Mc

Where: $NPW_B$= Net present worth of benefit

TTS= Travel Time Saving

VOS= Vehicle Operating Saving

TFS= Transport Fare Saving

$NPW_C$= Net present worth of cost

Mc= Maintenance cost

B/C= Benefit cost ratio

**B/C= ($NPW_B$ / $NPW_C$ )**

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

n= Analysis year

i = discount rate

P= present worth

A= Annual worth (Annual benefit)

Parameters considered for the benefit cost analysis

| **Parameters** | **Remarks** |
| --- | --- |
| Traffic Direction | (2-directions) Two lane- Two way |
| Analysis period ( Years) | 10 years |
| Beginning of analysis period | Beginning of 2017 |
| Discount Rate (%) | 10.23% (EMFED) |
| Interest rate (%) | 5% ( CBE) |

Sum of the three saving = 35,205,958.2 birr/year + 11,431,518.60 birr/year + 14,889,722.4 birr/year = 61,527,199.2 birr/year

Annual benefit ($A_b$) = 61,527,199.2 birr/year

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

$$= 61,527,199.2\left[\frac{(1+0.1023)^{10}-1}{0.1023(1+0.1023)^{10}}\right]$$

P= 61,527,199.2[6.08432194271895]

P=374,351,288.17

$NPW_B$ = 374,351,288.17 birr

Annual maintenance cost ($A_c$) = 22,670,000 birr

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

$$P = 22,670,000\left[\frac{(1+0.1023)^{10}-1}{0.1023(1+0.1023)^{10}}\right]$$

P=22,670,000[6.08432194271895]

P=137,931,578.4

$NPW_C$ = 137,931,578.4 birr

B/C= ($NPW_B$ / $NPW_C$ )

**B/C= (**374,351,288.17)/ (137,931,578.4) =

**B/C= 2.71**

If B/C>=1, accept the project as economically acceptable for the estimates and discount rate applied. It indicates the time period required for benefits to repay an investment. These results show if the alternative is economically justified compared to the base case. After the future streams of costs and benefits are discounted, the sum of the discounted benefits is divided by the sum of the discounted cost. B/C=2.71 means the maintenance cost after 10 years pay back and there is additional saving of benefit which show the maintenance cost is less than the benefit gained so, maintaining a road periodically and regularly saves the values of passengers and drivers gained benefit.

Therefore, road maintenance is that spending money now saves future costs. As the asset deteriorate, so the cost to restore their condition increases and as the condition gets worse, so the costs to society usually become more significant. Maintained road significantly increase economic productivity and development, Increased quality of life, less dust, cleaner environment, lower vehicle operating expenses for users, Savings in time to people, goods and vehicles increased safety and skid resistance, positive economic development, People want to live, work and drive on paved roads, so increased economic activity will follow them.

# CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

## CONCLUSIONS

Based on the result of the research study the researcher conclude that a high quality road network is important for high level of economic performance. It helps in sustained economic growth, increases the productivity, helps in increment in regional development and increases competitiveness. Without proper maintenance the high value of any road network can be quickly eroded and road users and society can experience significant adverse impacts if a road network is in poor condition. The existing pavement condition using Pavement surface evaluation and rating system showed that from the total length 46km, 10.292km in Good, 26.898km in Fair, 4.84km in Poor and 3.97km in Very poor condition. The condition in percentage 22.37% in Good, 58.47% in Fair, 10.52% in Poor, 8.63% in Very poor condition so, the percentage result shows that the existing road condition needs more improvement. Cost effective treatment to an existing road way system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without increasing structural capacity).

The fuel consumption and the tire wear increase as roads deteriorates reduction of fuel consumption due to maintenance of roads helps the peoples to spend less money on transportation expenditure. The total benefit gained from travel time saving, vehicle operating saving and transport fare saving after discounting is $NPW_B$ = 374,351,288.17 birr and the maintenance cost after discounting is $NPW_C$ = 137,931,578.4 birr.

The benefit-cost ratio greater than 1 which is 2.71 means maintenance cost after 10 years pay back and there is additional saving of benefit which show the maintenance cost is less than the benefit gained so, maintaining a road periodically and regularly saves the values of passengers and drivers gained benefit not only this it reduce the reconstruction of road cost and one contribute role to increase the economic activity of the area. It shows the influence of the road quality in transport economic terms and demonstrate the economic effects of road maintenance.

# RECOMMENDATIONS

- The Road Authorities need to give more emphasis on road maintenance activity, period of maintenance and quality of maintenance.
- Working with maintenance is still looked upon even today by professional as a low status occupation and maintenance has not been looked upon by Universities as an intellectual subject but need more emphasis on these area.
- The study area road need Road signs in curves, speed limit signs, shoulder repair and ditch works, retaining structure especially in Gembe and Bulbulo area.
- Absence of contractors working in road maintenance and adequate equipment are the problem for ERA to execute periodically so, need contractors in road maintenance work.
- The Road Authorities have not been able to document the consequences of what will happen to the roads when there is a lack of maintenance.
- In Ethiopia Road maintenance is politically unattractive – new road construction and road rehabilitation are more “visible” and produce greater political prestige billions of ETB are spent for construction but, the trend and budget allocation for road maintenance, comparing with new projects is very poor. Its need to give more emphasis for road maintenance to save huge amount of county budget.
- From government little funds have been devoted to maintenance, Example in previous year in Ethiopia total fund for road construction 46 billion for maintenance only 1 billion but not only the lack of funding that has to be solved, the decision makers want to be sure that the allocated funds to road maintenance are not properly used. Example in previous year for ERA Jimma district fund 126 million birr for maintenance but the executed birr only 9 million and the remaining disbursement fund.
- Need improvement in the overall management of road maintenance activities and Competence-based education and training of human resources in the road maintenance sector.

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## ANNEX 1

**Road defects of severe area photos in the study road segment**

Photo from Agaro to Bulbulo section (42+030)

Photo from Agaro to Bulbulo section (40+330)

Photo from Bulbulo to Gembe section (39+565)

Photo from Agaro to Bulbulo section (42+030)

Photo from Bulbulo to Gembe section (38+510)

Photo from Bulbulo to Gembe section (39+600)

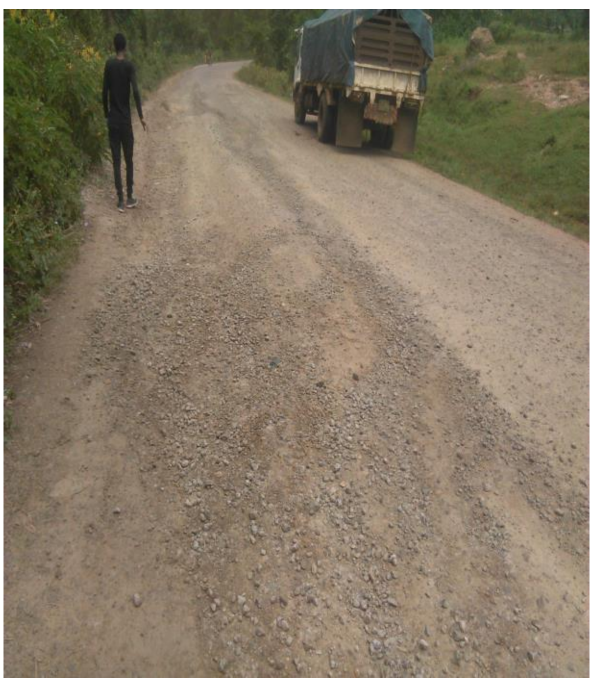

Photo from Gembe to Harro section (32+500)

Photo from Gembe to Harro section (33+650)

Photo from Dabesa to Yebu section (26+550)

Photo from Yebu to Alemayew section (21+780)

Photo from Gembe to Harro section (33+330)

Photo from Yebu to Alemayew section (21+013)

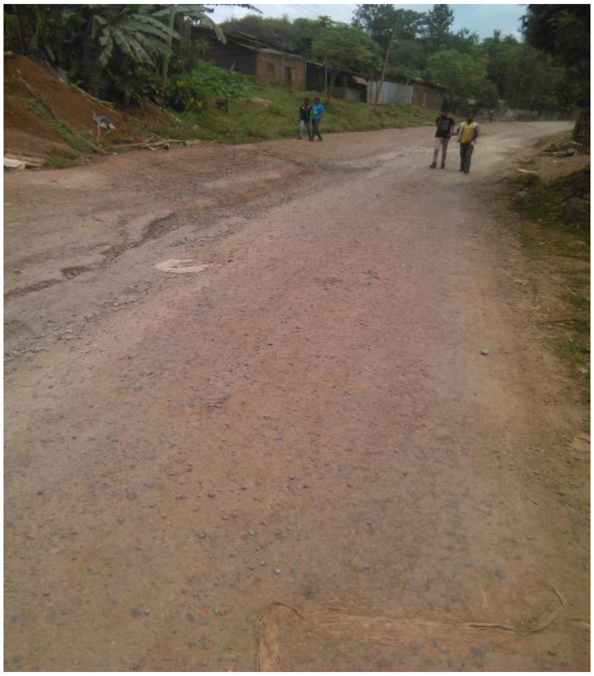

Photo from Gembe to Harro section (32+400)

Photo from Gembe to Harro section (32+400)

Photo from Harro to Dabessa section (29+480)

Photo from Mazoria to Kera section (8+340)

## ANNEX 2

## Questionnaire

**For Passenger**

1. Gender

   ☐ Male ☐ Female

2. What was your work status?

   ☐ Student ☐ Merchant ☐ Government employed ☐ Private work ☐ other

3. What was the purpose of this trip?

   ☐ For work ☐ For social related or recreational purpose ☐ Go to home

   ☐ For Business related ot☐er

4. How often do you make this same trip in this direction?

   ☐ Daily ☐ Weekly ☐ Monthly ☐ Yearly

5. How much time did you spend in work daily?

   ☐ 2-4hr ☐ 4-6hr ☐ 8-12hr 1☐16hr ☐ Other……………..

6. Which category best represents your personal monthly income?

   ☐ 600-1500 ☐ 1500-3500 ☐ 3500-6000 ☐ 6000-10000 ☐ Other

7. It's comfortable to travel on this road?

   ☐ Agree ☐ Neutral ☐ Dis-agree

8. What was the amount of fare for travel?

   ……………

9. In overall what was your Remark on the road?

   ………………………..

**Questionnaire**

**For Drivers**

1. How often do you make this same trip in this direction per day?

   ☐ 2 ☐4 ☐6 ☐ 8 ☐ Other

2. It's comfortable to travel on this road?

   ☐ Agree ☐Neutral ☐Dis-agree

3. How many liter of Benzene or Diesel use daily? ……………….

   ☐Benzene ☐ Diesel

4. How much time did you spend traveling to Jimma or Agaro?

5. How often time did you use once changed motor oil?

6. How often time did you use once changed tire?

7. If road are good or maintain effectively which parts are minimize?

8. How to compare Jimma to Agaro trip to other trips?

9. What are the advantage of maintaining the road effectively to the passengers and drivers?

10. Which category best represents your personal monthly income?

    ☐600-1500 ☐1500-3500 ☐ 3500-6000 ☐6000-10000 ☐Other

11. How fast did you seem to be going for most of your trips? ………………

12. In which area most of the time accident happen? / reason?

13. Condition of the existing road?

| Location | Very Good | Good | Bad | Very Bad |
|---|---|---|---|---|
| Jimma-Mazoria | | | | |
| Mazoria-Alemayew | | | | |
| Alemayew-Yebu | | | | |
| Yebu-Dabesa | | | | |
| Dabesa-Harro | | | | |
| Harro-Gembe | | | | |
| Gembe-Bulbulo | | | | |
| Bulbulo-Agaro | | | | |

14. In overall what was your Remark on the road?