ROAD CONDITION ASSESSMENT, MAINTENANCE PROBLEMS AND ASSET MANAGEMENT PLAN (CASE OF SOUTH OROMIA UIIDP CITIES)

By Seifu Tadesse Geda

A Thesis Submitted to the department of Civil Engineering for the Partial Fulfillment of The Requirement for The Degree of Masters
(Specialization in Construction Engineering and Management)
School of Civil Engineering and Architecture

Office of Graduate Studies
Adama Science and Technology University

September, 2022
Adama, Ethiopia

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DECLARATION

I hereby declare that this Master thesis entitled **"Road Condition Assessment, Maintenance Problems and Asset Management Plan (Case of South Oromia UIIDP Cities)"** is my original work. **"**That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Seifu Tadesse Geda		
Name of student	Signature	Date

RECOMMENDATION

I/we, the major advisor(s)/supervisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled **"Road Condition Assessment, Maintenance Problems and Asset Management Plan (Case of South Oromia UIIDP Cities)"** prepared under my/our guidance **Bahiru Bewket (PHD)** by **Seifu Tadesse Geda** submitted in partial fulfillment of the requirements for the degree of Mater's of Science in **Construction Engineering and Management**. Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

Bahiru Bewket (PHD)		
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Co-advisor/Co-supervisor	Signature	Date

APPROVAL SHEET

I/we, the advisors of the thesis entitled **"Road Condition Assessment, Maintenance Problems and Asset Management Plan (Case of South Oromia UIIDP Cities)"** and developed by Seifu Tadesse Geda hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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APPROVAL OF BOARD OF REVIEWERS

We, the undersigned, members of the Board of Reviewers of the thesis by Seifu Tadesse Geda have read and evaluated the thesis entitled **"Road Condition Assessment, Maintenance Problems and Asset Management Plan (Case of South Oromia UIIDP Cities)"** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Construction Engineering and Management.**

Chairperson	Signature	Date
Reviewer 1	Signature	Date
Reviewer 2	Signature	Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
School Dean	Signature	Date
Office of Postgraduate Studies, Dean	Signature	Date

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ABSTRACT

To facilitate the socio-economic growth of one's country, the importance of well-conditioned road networks with the proper road maintenance practice is very significant. However, most of the federal roads are not in good condition. The general objective of this research study was to assess the road condition assessment; maintenance problems and asset management plan (case of South Oromia cities) that overcomes the drawbacks of the city municipality. A descriptive design was employed where both qualitative and quantitative methods were used in the study. Random sampling method was used for selecting study populations and judgmental sampling technique was used to select respondents from the road categories infrastructure. A desk study, questionnaire survey, interview, and literature review were employed to collect primary and secondary data. Based on the data collected from the respondents; city administration, contractors, consultant and other users the samples and questionnaire analyzed indicate that the road condition assessment are, the concrete and steel bridge condition with excellent value of ACI=88.57%; cobblestones road with ACI value=83.93%, asphalt road with value ACI=77.45% and curb and gutter, drainage sumps and footpath with value ACI=75.08% that were repaired with normal maintenance procedure and the component does not exhibit any signs of deterioration. Accordingly a total of thirty (30) top-ranked problems are identified as the most significant existing problems on the road maintenance problems. Among them the study finding indicated that lack of effective budget, insufficient road condition survey with lack of appropriate project prioritization mechanism under client related problems, insufficient data collection and condition survey before road maintenance, quality assurance/control problems and poor monitoring and controlling under consultant related problems, Poor labour supply and productivity, poor communication and coordination of the contractor with other parties and high turnover of contractor's staff under contractor related problems are the top ranked problems on road maintenance. The result reveals for the establishment of GIS Asset Management Plan of cities designed and managed using ArcGIS 10.7 and Arc-GIS 10.5 software databases. Stakeholders are recommended to give all due attention towards the condition assessment of road infrastructure components and to the most significant problems in road maintenance.

Key Words: -Asset Management Plan, Condition assessment, Maintenance Problems

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LIST OF ACRONYMS

AASHTO: American Association of State Highway and Transportation Officials

ArcGIS: Aeronautical Reconnaissance Coverage Geographic Information System

AHP: Analytic Hierarchy Process

APA: Annual Performance Assessment

ADB: Asian Development Bank

AMP: Asset Management Plan

ACI: Asset Condition Index

ARAN: Automated Roadway Analyzer

DDF: District Development Fund

EELPA: Ethiopian Electric light and power Authority

ERA: Ethiopian Roads Authority

ETC: Ethiopian Telecommunication Corporation

FIIDCA: Federal Integrated Infrastructure development coordinating agency

GIS: Geographical Information System

GPR: Ground-Penetrating Radar

IAM: Infrastructural Asset management

IAMP: Infrastructural Asset management Plan

LOS: Level of Service

MBC: Method-Based Contracting

MOF: Ministry of Finance

MOT: Ministry of Transport

NZTA: New Zealand Transport Agency

PBC: Performance-Based Contracting

PPP: Public Private Partnership

RAMS: Road Asset Management System

RII: Relative Importance Index

RSDP: Road Sector Development Program

SANRAL: South African National Road Agency Ltd.

SMART: Simple Multi-Attribute Rating Technique

SNNPS: South Nation Nationalities People Society

SSA: Sub-Saharan Africa

USA: United States of America

USDOT: United States Department of Transportation

UIIDP: Urban Institutional Infrastructure Development Program

ULG: Urban Local Governments

ULGDP: Urban Local Government Development Program

VOC: Vehicle Operating Costs

WB: World Bank

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Road infrastructure is the backbone of economic development of any country. A good road network facilitates trade and cooperation. It also provides access to markets in addressing socioeconomic challenges by providing access to employment opportunities (World Bank, 2014).

It is known that roads are among the most important public assets in many countries. They are of vital importance to make a nation grow and develop. Especially in the developing world, well-maintained roads, well assessed inventory condition rating should enhance poverty reduction by improving access between regional and rural communities and, ultimately, enhancing socio-economic growth and development (Temesgen.G, 2016).

Recognizing this, the government of Ethiopia has launched Road Sector Development Program (RSDP) Phase-I to Phase-V for rehabilitation and upgrading of existing roads and expansion of the road network. As a result of RSDP, the federal road network coverage has grown from 13,000 Km to 29,106 km out of which about 60% is paved while 40% is unpaved as per the ERA road asset database (2019/20). These road networks constitute one of the largest national assets which need to be preserved, and ERA has a responsibility to maintain, improve, replace and preserve these assets. In view of preserving, maintaining, and improving the existing road network to enable its continued use by traffic efficiently and safely, Road Asset Management (RAM) department has been established under ERA to undertaking the mentioned responsibility (World Highways, 2015).

A well-conditioned road network in a country brings many tangible and intangible advantages to all road uses. To keep the roads well-conditioned, a well-planned maintenance program is essential. If maintenance of the road is not implemented at the right place and right time, it may cause many problems (Malkanthi et al., 2012).

A recent study by the two consultants hired by ERA to undertake the detailed condition survey of the federal roads reveals that about 74% of paved roads and 86% of unpaved roads are not in good condition; out of these, about 37% of paved roads and 38% of unpaved roads are in poor and very poor condition (not safe for driving). It is tipped that, there are many challenges to carry out the maintenance work to the required level. A little attention for road maintenance, budget, and sector capacity are some of the constraints

encountered in the current road maintenance practice (Dana and Hitcon Consulting Engineering, 2016).

Many countries, especially Sub-Saharan Africa do not have a well-established maintenance plan. The leading problem in this regard is the institutional related problems; such as institutional framework, human resource constraints, lack of clearly defined responsibilities, inefficient management structures, weak management systems and inadequate financing arrangement. However, the problems shown in technical paper are too general and do not reflect all the problems observed in the case of Ethiopia. Thus, it is important to identify all the root causes for not having the proper road maintenance practice in the federal roads of Ethiopia (Heggie's, 2005).

Condition assessment of infrastructure is the evaluation of the assets throughout the period of their service validity. The condition of the asset refers to the measurement of the asset's physical state, while the performance of the asset refers to the capability of the asset to produce the required level of service to the users. These evaluations are critical for providing crucial information regarding the asset management of the asset (Ahmed M. Omar, 2017).

The research contributes to restructuring the inspection and condition assessment processes, providing a better understanding of the interactions among IAM components, integrating capital renewal and maintenance data, and developing a practical condition assessment method that is economical, less subjective, and suitable for use by individuals with less experience. This project provides an overview on the condition assessment mechanism of all categories of municipal infrastructural asset management the way of maintenance valuation and forecast.

In this research also, a clear identification of the problems and ranking the identified problems of the road maintenance in the case of city municipalities of Oromia has been carried out. The problems on road maintenance led to poor road maintenance in municipal, which have negative effects on road function.

1.2 Statement of the Problem

Road transport is the dominant mode of transportation in the country and accounts for more than 95% of freight and passenger movements. By the end of 2013, Ethiopia had 99522 km road network of roads. The road density was 90.5 km of road per 1000 square km of area (ERA, 2014). Road density in Ethiopia was low when compared with other

developing countries, such as Latin America and Asia with 120 km and 180 km respectively per 1000 km square area. Not only the above indicators in the case of Ethiopia are low but even those available road infrastructures are not well utilized because of low traffic operating on them and also low vehicle-kilometer coverage (Campbell, 2009).

The majority of the roadways within the township lack proper drainage. This is due in part to the naturally flat topography of the area. To achieve proper drainage, it would be best to have ditching alongside the roadway at a minimum depth of 1 foot below the road surface. Standing water on a road surface can cause premature damage to the road surface. This is due to saturation of the base material below the surface. As the base material becomes saturated, it loses strength, thus diminishing the required support of the surface (Boulder, 2017).

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 road 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 intervention on the road and driver increases maintenance costs. With the low rates of growth in network length through the countries, the expectations would therefore be that maintenance becomes a larger share of the total spend on the road infrastructure. The need for maintenance increases as road infrastructure ages, since it becomes more fragile, less resilient and journeys are more susceptible to disruption (World Road Association, 2014).

The chronic underfunding and lack of maintenance can very quickly jeopardize the huge asset which has been built at great expense and effort in the last decades. As a consequence it can no more serve the required level of service. As a matter of fact shortfall in investment for maintenance of the road infrastructure and its dramatic consequences huge deterioration of the network results in, higher risks of accidents, problems of congestion, increased noise and a reduced service to society. The condition assessment in asset management system provides preventive, periodic and routine maintenance activities in addition to an emergency maintenance, which requires urgent need of maintenance (Robinson, 2000).

As stated in proclamation number 857/2014 with the objective of coordinating the execution of integrated infrastructure development works in accordance with roads master plan and to develop formula for the assessment of compensation for properties to be

removed and landholdings to be expropriated due to integrated infrastructure development works. The problem can only be avoided through an effective asset management system which can apply in a holistic road management approach. Therefore, we need a well-defined government asset management policies, regulation and strategies (Yetnayet, 2017).

The research has been motivated by the specific challenges inherent in the current process: The lack of integration between maintenance/repair and capital renewal functions, the need for efficient inspection planning and the need for less subjective condition assessment, a reactive maintenance/repair program for continuously maintaining the operability of the road inventory.

The reason for this research needs to be conducted is to assess and identify the road condition assessment, maintenance problems and asset management plan and to enable them overcome such problems and make them progress while being active participants of the construction industry. This research would also help to understand what the concerned stakeholders should do to contribute for the progress of this road asset management plan road network and then recommends a better way of road ownership and management for sustainable social and economic development of country.

1.3 Objectives of the Study

1.3.1 General Objective of the Study

- To assess road condition assessment, maintenance problems and asset management plan (case of south Oromia UIIDP cities)

1.3.2 Specific Objectives of the Study

- To determine the physical condition of road components by using asset condition index (ACI)
- To identify the problems of road maintenance (case of south Oromia UIIDP cities)
- To assess road Asset Management Plan in the selected cities.

1.4 Research Questions

The principal research questions of the study were including;

- How the physical condition of road components can determined by using ACI method?
- What are the existing problems of road maintenance in the selected towns?
- How do the cities implement Asset Management Plan?

1.5 Significance of the Study

The investigation to be conducted is useful for stakeholders and for the ULG's for the decision making purpose of infrastructural asset maintenance plan. In addition, it illustrates the asset inventory template, condition assessment and scaling method for the deteriorated asset type. Finally indicate the assets management database road method by using ArcGIS software for sustainable infrastructural asset management follow up and tracking the information.

It is used to plan and quantify the maintenance required on the road network and to prepare the annual work program. It can also be used to highlight recurrent and periodic maintenance requirements.

It benefit different stakeholders involving in construction projects in general and particularly for road construction projects, related to road asset inventory and condition assessment methods, and helps all the stakeholders to know the maintenance of deficit routine and periodic maintenance in construction of road and to take remedial measures to prevent the occurrence of the budget problems.

The study can be merged with others done in other nations for comparison of condition and maintenance problems of road infrastructure asset management plan in the road sector in order to facilitate worldwide exploration on strategy to improve the asset management plan problem.

The basic premise of infrastructure asset management plan in the city is to intervene at strategic points in an asset's life cycle to maximize the expected service life, and thereby maintain its performance.

1.6 The Scope of the Study

The scope of this study was limited and focused on the Urban Institutional & Infrastructure Development Program (UIIDP) cities of South Oromia and some ULGs of second Urban Local Government Development Program (ULGDP II). ULGDP II has been operated from 20013/14 to 2017/18 and UIIDP was from 2018/2019 to the Current. Thirteen (13) urban local governments (ULGs) (Batu/Ziway, Shashemene, Robe, Nagelle Arsi, Dodola, Bokoji, Goba, Ginnir, Adola Woyu, Shakiso, Nagelle/Borena, Bule Hora ande Yabello) in South Oromia Regional State.

This study mainly deals with condition assessment method and maintenance problems of some ULGDP II and UIIDP city of south Oromia ULG's. To this end, the main focus of the study includes: assessment of data for strategic category of asset condition scaling,

calculating the maintenance problem based on the questionaries' assessed, and maintenance deficit.

1.7 The Limitation of the Study

Some respondents might reluctant in giving information for fear of victimization. Also, some respondents also don't want to give enough time to answer the questionnaire because said we are busy with office work. Some respondents give some inconsistency in a response as not finish all the questions in the required time. In such cases, some logical deductions are made on that particular questions were rejected and some respondents would not punctual in returning the questionnaires. The researcher was managed all these limitations by explaining the goal and the expected outcome of the survey to the respondents.

Due to limitation of resources, budgets and time the study was limited to selected places in road construction sector in Ethiopia although there are many respondents involved in other infrastructural projects in the country.

CHAPTER TWO

LITRATURE REVIEW

2.1 Introduction

Road Infrastructure includes a broad category of assets that are usually owned by the government or by large firms and that provide the basic facilities, services, and installations needed for the functioning of a community or society. Therefore, infrastructure touches almost all aspects of life, including transportation, communication systems, water services, schools, and hospitals. Managing infrastructure, however, is highly challenging due to the generally large size of the facilities, complex nature, and high costs.

Condition assessment is defined as "a process of systematically evaluating an organization's capital assets in order to project repair, renewal, or replacement needs that is preserve their ability to support the mission or activities are assigned to serve." Condition assessment is the most important function in the asset management process as it forms the basis of or the starting point for other functions such as the decisions to repair or replace (Shipra Singh Ahluwalia 2008).

As new infrastructure is commissioned the town accepts the responsibility of operating and maintaining the infrastructure according to operation and maintenance standards to ensure that the infrastructure is safe and reliable. Operations staff provides the day to day support required to operate infrastructure. In some cases, operations costs are minor, or they can be substantial and technically complex. For example, underground pipes require almost no operational support while a treatment plant or pumping station may require full-time staff to operate the facility safely and efficiently. Maintenance expenses include periodic preventive maintenance to ensure that the infrastructure can provide reliable service throughout the life of the asset and corrective maintenance that is required to repair defective assets as and when needed. The amount of operation and maintenance resources required in any period is a function of the current inventory of infrastructure and total operation and maintenance needs required for each asset. As the Town's inventory of infrastructure grows, total operation and maintenance requirements would also grow (AECO, 2014).

2.2 Condition Assessment of Road Infrastructural Asset

Condition assessment is the basis for determining the level of preventive maintenance needed for a building's systems and components. If a condition assessment is performed on

a regular basis, then the assessment is much easier. A data collection process with the goal of conducting a comprehensive inventory meets the needs of the entire district management effort in a coordinated manner and thereby avoids the need for redundant collection efforts (NCES, 2003b). The literature (Lewis and Payant 2000; NCES 2003 b; DfES, 2003) states that all inspection team members be well trained in the inspection procedures and be qualified to conduct the inspection. Someone who is intimately familiar with the facility being assessed should accompany the inspector, a custodian or maintenance staff member who works in the facility on a regular basis.

Depending on the user's guidelines for condition rating, a suitable scale is produced. The scale can be represented as numbers (1-5 or 0-100%) or alphabets (A+ to F). There are three rating models that describe the assets based on the required practices. The first model is known as The Simple Condition Rating Model. The International Infrastructure Management Manual (NAMSG, 2011) and Asset Management Condition Grading Standards (Saskatchewan Ministry of Municipal Affairs) represent the first model as a top-down system. This approach is typically used to represent information about asset register information, geological maps, performance monitoring data, etc. Any further descriptions require a more sophisticated approach.

Table 2.1: Simple condition rating model (NAMSG, 2011)

Rank	**Description of Condition**
1	Very Good Condition Only normal maintenance required
2	Minor Defects Only Minor maintenance required (5%)
3	Maintenance Required to Return to Accepted Level of Service Significant maintenance required (10-20%)
4	Requires Renewal Significant renewal/upgrade required (20-40%)
5	Asset Unserviceable Over 50% of asset requires replacement

The second model of condition grading is called the intermediate approach. The intermediate approach enhances the ranking of assets based on significant factors or problems. The scale utilized in this model is expanded to indicate certain significance

within a certain condition. This approach uses the expansion to befit information like asset types, failure modes, evidence of distress, etc. The assessment of assets included in the model is usually visually assessed. The international infrastructure management manual (NAMSG, 2011) represents a model that describes the level of maintenance needed for the assets.

Table 2.2: Intermediate condition rating model (NAMSG, 2011)

Rank	**Description of Condition**	
3.0	Level of service maintenance	Minor
3.4		Average
3.8		Significant
4.0	Requires Major Upgrade	Minor
4.2		Average
4.4		Medium
4.6		Substantial
4.8		Significant
5.0	Asset Basically Unserviceable	Minor
5.2		Average
5.4		Medium
5.6		Substantial
5.8		Significant

The third model is a Sophisticated Condition Assessment Model (advanced approach). This approach develops a sophisticated condition monitoring for assets. The produced model includes a detailed expansion of the assessment. Unlike the first and second methods, the data acquired is more advanced by virtue of the non-destructive techniques in combination with visual assessment employed. These advanced procedures allow users to assess up to ten different parameters with more detailed scales (example: 0-1000). The scale can be simplified to a basic grading of 1 to 5 if needed. Among the applications of the advanced model are multiple-faceted ranking systems, like Pavement Management Systems; specification for assessing roughness, deflection, rutting and surface texture. The advanced condition assessment may not be eligible for all assets since some factors or financial availability and time are involved (NAMSG, 2011).

Table 2.3: Advanced condition rating model (NAMSG, 2011)

Base Ranking	Roads (0 - 100)	Drains, sewers (0 - 200)	Water Mains (0 - 500)	Buildings (0 – 10)	Parks (0 – 125)	Plant (0 – 100)
1	0-200	0-40	0-100	0-2	0-25	0-20
2	200-400	40-80	100-150	2-4	25-50	20-40
3	400-600	80-120	150-200	4-6	50-75	40-60
4	600-800	20-160	200-300	6-8	75-100	60-80
5	800-1000	160-200	300-500	8-10	100-125	80-100

Another term that is important to consider is the Level of Service (LOS). Many agencies report the condition of assets in terms of the LOS that is being provided. In this approach, the LOS must be defined for each asset. In some cases, levels of service are reported in terms of letters similar to those used in a report card (such as A, B, C, D, and F). It may also be reported using a numerical system with "1" being the highest level of service and "5" being the lowest. In general, LOS is defined in terms related to customer services, such as safety, convenience, aesthetics, comfort, or mobility (Zimmerman, 2007).

The techniques used in the model generate solutions to complicated problems by assembling the information and data available to a hierarchical system. The information includes thoughts, knowledge, experience and professional judgments. This generates a comparative model which utilizes considerations for both qualitative and quantitative human decision-making processes (Al Barqawi and Zayed, 2006).

Simple Multi-Attribute Rating Technique (SMART) is a decision-making theory developed by (Lootsma, 1997). This method determines the evaluations of various factors. This is done by assigning a value to each factor on a unified scale (Salman, 2011). This was result in a score which is multiplied by the weight of the factor to produce a rating. This method has been redeemed essential for the condition assessment of roads. This is because roads have multiple factors that should be considered during the condition computation.

There are four main factors in the investigation and assessment of roads. The first factor is the structural capacity of the roads. The structural capacity is mainly focused on the pavement in which determined by field test with equipment such as Benkelman Beam, and the Falling Weight Deflect meter. Such tests are conducted by measuring pavement

deflections under a load. The second factor for consideration is the condition. The condition is usually inspected visually to measure the pavement distress. Surface defects, cracking, patching are the most recurrent defects. The third factor is pavement roughness. Pavement roughness is an indicator of the level of serviceability and riding comfort. In the past, roughness was measured by driving along the road and generating Riding Comfort Index (RCI) from the expert's opinion (Saskatchewan Ministry of Municipal Affairs, 2014).

2.2.1 Condition Assessment Systems and Process

Maintenance can only be effectively managed if the maintenance demand is properly quantified, and then (Department for Victoria community, 2004) pointed out that the quantification of maintenance demand is governed by the need to define the gap between the current condition and the desired condition." A five point color-coded rating system has been developed and refined through experience gained during the initial and follow up assessments and sustained research and development. Condition assessments are conducted at element costs associated with the maintenance actions related to the relevant condition ratings and the current condition and the associated risk are also shown in the table 2.4 below, the proposed five-point color-coded condition assessment rating is shown.

Table 2.4: Condition assessment ratings

Condition Rating	Condition	Action Required	Description
5	Very Good	Planned Preventive Maintenance	The component is either new or has recently been maintained, does not exhibit any signs of deterioration.
4	Good	Condition based Maintenance	The components exhibits superficial wear and tear, minor defects, minor signs of deterioration to surface finishes.
3	Fair	Repairs	Component has been subjected to abnormal use or abuse, and its poor state of repair is beginning to affect surrounding elements.
2	Bad	Rehabilitation	Substantial sections have deteriorated badly, suffered structural damages or require renovations. There is a serious risk of imminent failure.
1	Very Bad	Replacement	The component has failed, is not operational or deteriorated to the extent that does not justify repairs.

Similar five-point color coded ratings have been developed for other performance evaluation criteria, such as functional suitability and risk. The above condition assessment ratings are also linked to the related maintenance actions and types as shown in table 2.5 below.

Table 2.5: Condition ratings and related maintenance actions

Rating	Condition	Action Required	Maintenance Type
5	Very Good	Preventive Maintenance	Normal Maintenance
4	Good	Condition based Maintenance	
3	Fair	Repairs	Backlog Maintenance
2	Bad	Rehabilitation	
1	Very Bad	Replacement	

The distribution of the defects is based on its effect on the road, depending on its influence on the structure, construction, and environment or miscellaneous. By reviewing Airfield Pavement Inspection Reference Manual (Municipality, 2017), the distress found related to the roads have been selected carefully to be part of each category. The structure category relates to the defects that influence the layers of the road and design, such as the deformation, holes, cracks, and curvature. Some of the structure defects can be visually inspected if the damage is in the pavement layer or the top of the base layer. For deeper damages, inspection technologies must be used.

The construction category contains the defects that are resulted from construction works. This category includes defects such as the patch and utility cut patch, intruding connection, point of repair component and attached deposits. This category usually affects the pavement layer and the top of the base layer. The defects can be inspected visually. Environmental category contains the defects that contribute to environmental problems, like swelling, raveling and weathering and surface cleaning. These defects can be seen and inspected visually due to its effect of the pavement layer. The final category is the miscellaneous category. This category contains defects such as Instructional lining, Oil spillage, and Rutting. These defects are caused by usage, wear, and tear of the road. Each category contains a number of distresses to create the failure hierarchy. Fig (2.1) shows the first level of the failure hierarchy and Fig (2.2) illustrates the final failure hierarchy including the first and second level (Municipality, 2017).

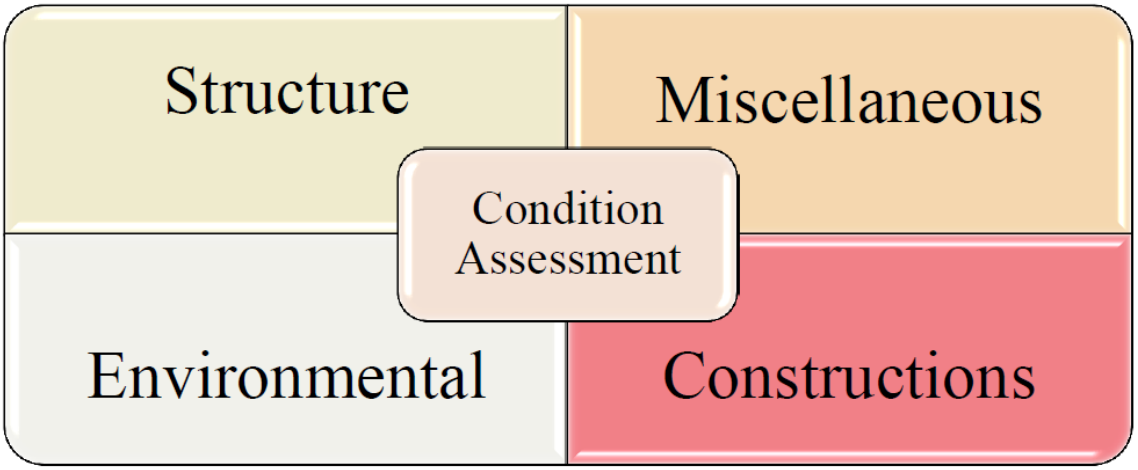

Figure 2.1: Defects categories

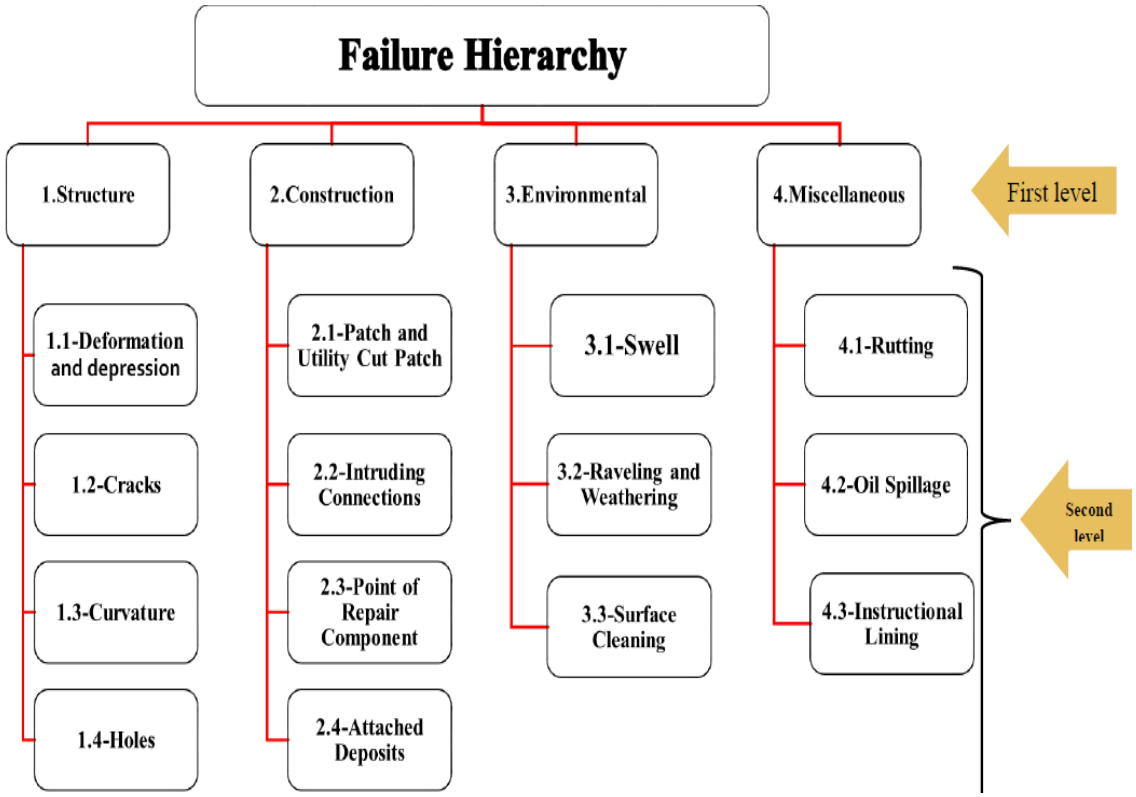

Figure 2.2: Failure hierarchy

2.3 Definition of Road Maintenance

Road maintenance is defined as routine, periodic and emergency works to keep pavements, shoulders, slopes, drainage facilities and structures in as near as possible to their as constructed or renewed condition to ensure its design life is attained. Road maintenance "comprises activities to keep pavement, shoulders, slopes, drainage facilities and all other structures and property within the road margins as near as possible to their as-constructed or renewed condition (Gagblezu, 2018)."

Highway maintenance is typically defined as including work such as repair of travel way surfaces, shoulders, roadsides, drainage facilities, bridges, tunnels, signs, markings, lighting fixtures, and truck weighing and inspection facilities; traffic services such as lighting and signal operation, and snow and ice control; and operation of roadside rest areas, movable span bridges, and the like (AASHTO, 1987).

Pavement maintenance work is performed from time to time to keep a pavement, under normal conditions of traffic and forces of nature, as nearly as possible in its as-constructed condition. It is the art of keeping pavements in full service, with minimum expenses, and the least inconvenience to the public and the residence. Improper maintenance is usually worse than none at all. No pavement has been constructed that does not need maintenance (Temesgen, 2016).

2.4 Types of Road Maintenance

Roads are an enormous national investment and require maintenance to keep them in a satisfactory condition and ensure safe passage at an appropriate speed and with low road user costs. Late or insufficient maintenance will increase the ultimate repair costs and raise road user costs and inconvenience, and reduce safety. Road maintenance requires a range of organizational and technical skills and the work on roads in use by traffic makes the work potentially hazardous to both the workmen and road users. It is therefore essential that appropriate formal and on the job training is given to each category of personnel involved in road maintenance activities to achieve efficient and safe operations. Road Maintenance is therefore an essential function and should be carried out on a timely basis (ERA, 2013).

There is a diversity of maintenance activities, the class and type of the road, the cross section to be maintained, the defects recognized, and the resources available. However the general methods proposed here for each activity (with some exceptions) are given under the following headings:

Road maintenance works are categorized into three: namely, routine, periodic and emergency maintenance (ERA, 2013).

2.4.1 Routine Maintenance

Routine maintenance operations are those that may be predicted and planned in advance. These operations, which may be preventive or corrective in nature, are conducted on a regularly scheduled basis using standard procedures. Proper scheduling of these operations

is utilized to provide minimum disruptions and hazards to the driving public (Biniyam, 2015).

All routine maintenance activities have to be performed at least once a year. Such activities involve inspections, cleaning of drains, controlling of vegetation and filling of potholes and ruts. Routine maintenance has a lower cost in comparison with any other type of maintenance and new construction projects. Routine maintenance remains as the key activity as it is the least costly activity, which provides the greatest benefits (Sally Burningham and Natalya Stankevich, 2005).

Routine maintenance comprises small-scale works conducted regularly, aims "to ensure the daily pass ability and safety of existing roads in the short-run and to prevent premature deterioration of the roads". Off- carriageway routine maintenance should be done 2 to 3 times per year and the on-carriageway routine maintenance once a year. The frequency of activities varies but is generally once or more a week or month. Typical activities include roadside verge clearing and grass cutting, repairing or replacing signs and other roadside furniture, repainting line-markings, cleaning of silted ditches and culverts, patching, crack sealing and pothole repair (Sally Burningham and Natalya Stankevich, 2005).

Routine maintenance is based on routine (daily) inspection of the condition of the pavement, cut and fill slopes, drainage, bridges and other structures and facilities to monitor any defects and damage. The results of routine inspection will be promptly reported to the operation office for follow-up maintenance works to be undertaken either continually throughout a year or at certain intervals every year. The term "preventive maintenance" refers to repair that addresses causes of deterioration leading to the need for costly rehabilitation work in the future (JICA, 2003).

Routine maintenance activities before proceeding to the assessments of the maintenance work to be done; the next section is a reminder of the activities that are included under routine maintenance (JICA, 2003).

1. **Clearing bush and cutting grass:** bush or grass to be cleared should be given a category of light medium or hard. All debris removed from the road, ditches and verges was cleared away from the road. In areas where houses line the edge of the roads, the material from the drains is taken to a nearby dump site identified by further than 500m from the road site.

2. Clear debris from bridges: As bridges and major culverts come in various shapes and

sizes, the volume of work must be calculated for each case. Volume = height x length x width (m^3) and all debris removed from the road, ditches and verges were cleared away from the road. In areas where houses line the edge of the roads, the material from the drains is taken to a nearby dump site identified by the number further than 500m from the road site.

3. Cleaning culverts including inlets and outlets: The cleaning of culverts includes the clearing of the entrance and exits for a minimum of 10m from the end of the pipes or boxes. The diameter of the pipe culvert and the height and width of a square culvert should a maximum of 80 cm (0.8 m).

4. Cleaning of side and outlet drains: All soil, silt and debris removed from the drains were cleared away from the road. In areas where houses line the edge of the roads, the material from the drains will be taken to a nearby dump site identified by the road supervisor no further than 500m from the road site. Note: This work is extra to grass cutting and bush clearing. If only grass cutting and bush clearing are needed then this should be included in item 1.

5. Repair of erosion on shoulders and slopes: This work includes the removal of spoilt soil and the filling of the eroded areas with good soil, watering and compacting of the new soil to recover the shoulder shape and height and the slope shape with deeper erosion or vehicle damage up to a depth of 15 cm covering a maximum area of $75m^2$.

6. Grubbing of carriageway: For the assessment of the work to be done, the important factor for grubbing is the extent of the grass covering the carriage way.

7. Grass planting: Where the grass is available and ready to plant different task rates apply. Should it be necessary to gather the grass plants first, this is an extra task and needs to be calculated separately based on local conditions.

8. Non-standard activities (Minor repairs to retaining walls and culverts): Pothole filling (gravel road) using material on or next to the road: 15 potholes /width, Maximum size (0.5 m^2).This work includes excavating and cutting the pothole to a square shape, removing all spoilt soil, replacing with good soil and water and compacting in layers.

9. On-carriageway maintenance: it is the works includes comprises of a breadth of road over which there is no obstruction with any physical barriers or separation for any vehicle to transit parallel. The work on-carriageway needs to be planned and implemented.

The towns are recruited for one road link; however, the on-carriageway maintenance should be prepared for the total number of links in the district/sub-district as one contract. Whether the contract is for the district or sub-district was depend on the number of links

and length of road to be put under routine maintenance.

10. Shoulder fills to support the edge of the carriageway: filling should only be over short distances as major repairs to the road surface cannot be included in routine maintenance, but must be done separately with a separate budget. The length of road where ruts need repairing should not exceed 10% of the road length or a maximum of 300m² in each kilometer.

2.4.2 Periodic Maintenance

Periodic maintenance is something that happens less frequently every 4 or 5 years. Carrying out periodic maintenance involves more work and higher costs, and includes such things as re-gravelling, surface overlay, major repairs to bridges and culverts, or improving of longer stretches of bad areas on the road. Operations are occasionally required on a section of road after a period of a number of years. They are normally large scale and require specialist equipment and skilled resources. These operations are costly and require specific identification and planning. Activities can be classified as preventive, resurfacing, overlay, and pavement reconstruction. Resealing and overlay works are generally undertaken in response to measured deterioration in road conditions (Sally Burningham and Natalya Stankevich, 2005).

Periodic maintenance is based on a detailed inspection performed at certain time intervals such as seasonally or yearly depending on the type and kind of facilities. It includes checking and testing the conditions of various structures and facilities. Defects and damage will be reported for repairs or remedies. Maintenance plans covering several years should be developed (JICA, 2003).

2.4.3 Emergency Maintenance

Emergency repairs are all maintenance activities that have to be carried out immediately to save lives or prevent disastrous consequences of damaged infrastructure. Typical examples of such emergencies are structural damages to flyovers due to accidents, collapsed culverts, wash away, landslides that block roads. Maintenance departments need unrestricted access to emergency maintenance budgets that allow them to carry out repairs that mitigate immediate dangers. Some senior management may wish to control access to emergency repairs for works with a more long-term focus (Biniam, 2015).

Emergency maintenance comprises works to restore road and road-related facilities to their normal operating conditions after they are damaged by road accidents or natural causes. It is impossible to foresee the frequency, but such maintenance requires immediate action

(JICA, 2003).

Table 2.6: Typical maintenance activities (JICA, 2003)

Maintenance Type	Activity
Routine including Preventive	Clearing of pavement
	Mowing and maintenance of plants
	Clearing of ditches and culverts
	Repair of traffic signs and road markings
	Shoulder grading
	Pothole patching and crack sealing
	Repair of sealants and expansion joints of bridges
	Repair of cut and fill slopes
Periodic Maintenance	Re-graveling
	Resealing/surface dressing
	Overlay
	Maintenance of traffic signs and road markings
Emergency Maintenance	Removal of debris or obstacles from natural causes
	Repair of damage caused by traffic accidents

2.5 Road Maintenance Process

The approach involves defining activities, planning, allocating resources, overseeing implementation, monitoring and evaluating of works (Temesgen, 2016). It normally contains the following components:

I. Inventory and/or condition survey: This is used as the basic reference for planning and carrying out maintenance and inspections. Inspection of road conditions is the process of taking physical measurements of defects on the road network in the field.

II. Maintenance needs: These are determined by comparing the measurements of road conditions with predetermined maintenance intervention levels that are based upon economic criteria.

III. Costing: Unit costs are applied to the identified maintenance tasks to determine the budget required.

IV. Priority setting: If the budget is insufficient for all of the identified work to be carried out, it is then necessary to determine priorities to decide which work should be undertaken and which should be deferred.

V. Execution of works: The work identified is carried out with the assistance of several

systems of scheduling and cost accounting.

VI. Monitoring: Monitoring serves two purposes. That is, it ensures that work identified has, in fact, been carried out and it also provides data to enable unit cost and intervention levels to be checked and adjusted if necessary.

2.6 Importance of Road Maintenance

Roads are among the most important public assets in many countries. Road improvements bring immediate benefits to road users through improved access to hospitals, schools, and markets; improved comfort, speed, and safety; and lower vehicle operating costs. For these benefits to be sustained, a well-planned program of maintenance must follow road improvements. Without regular maintenance, roads can rapidly fall into disrepair, preventing the realization of the longer-term impacts of road improvements on development, such as increased agricultural production and growth in school enrollment (Sally Burningham and Natalya Stankevich, 2005).

I. Reducing Deterioration: Eventually, the end of pavement design life will be reached and there is a need for pavement reconstruction or upgrading. These are normally relatively expensive and should be postponed for as long as possible carrying out effective and timely maintenance.

II. Lowering VOC: Robinson (2000) explained that the relative proportions of road administration costs and vehicle operating costs in the total lifetime transport cost with road vary depending on the traffic level. The relative proportion of VOCs rises from about 40 percent at 50 vehicles per day to over 90 percent at 6000 vehicles/day. For a good condition road having a traffic level of about 1000 vehicles/day requires 2% of the discounted cost to be spent on maintenance. However, if maintenance funds are reduced, the pavement will start to crack and potholes will gradually appear and with these levels of deterioration, vehicle-operating costs are likely to increase by about 15 percent. If there is complete neglect of maintenance, a paved road will eventually start to disintegrate and annual VOCs will increase by about 50 percent.

III. Keeping the Road Open: Robinson (2000) explained the third reason for carrying out maintenance as to keeping the road open continuously. Since their closure for whatever reason causes potentially serious social and economic consequences.

IV. Safety: Accidents have proved to be an inevitable result of road transport and deaths and injuries are very tangible impacts of the roads on the community. Road maintenance works can often provide an opportunity for improvement of road safety by contributing

engineering factors in the areas of pavement and footway surfaces, carriageway markings and signs, streetlights and road furniture.

V. Environmental Issues: - the conditions of roads affect the environment (World Bank 1994).

The purpose of maintenance is to ensure that the road remains serviceable throughout its design life. Road maintenance is important because it:

- prolongs the life of the road by reducing the rate of deterioration, thereby safeguarding previous investments in construction and rehabilitation;
- lowers the cost of operating vehicles on the road by providing a smooth-running surface;
- Keeps the road open for traffic and contributes to more reliable transport services;
- Sustains social and economic benefits of improved road access.

The first purpose is primarily in the interest of the responsible government authorities. The last three are of more general interest to the inhabitants of the area traversed by the road and to the vehicle operators (Donnges et al., 2007).

2.7 Road Maintenance Practices in Developed Countries

2.7.1 United States of America

Before undertaking any maintenance activities, proper road inventory and condition surveys are undertaken in the USA to select the appropriate treatment type. The Maryland state highway transportation official annual network-level data collection includes ride quality, rutting and friction for all directional miles under the responsibility of MDSHA (100 percent coverage). These data are collected using automatic data collection equipment: an automated roadway analyzer (ARAN) vehicle from Road ware, and a locked–wheel skid tester. The ARAN vehicle collects ride quality, rutting, right-of-way digital video and downward digital video for automated cracking identification. At the project level data collection includes pavement material structure and thickness determination, nondestructive deflection testing, and ride-quality testing. These data are collected using a high-speed profiler, a falling weight deflectometer (FWD), ground-penetrating radar (GPR), drilling/coring rigs and manual visual surveys (using the paver pavement condition index) (Yetnayet, 2017).

DOTs outsource their road maintenance work for various reasons, the most prominent being cost savings. Studies showed that outsourcing road-maintenance projects when using the PBC method achieved cost savings up to 50% and suggested that to achieve cost

savings by using the PBC method, the contract duration should be relatively long (the contract duration of PBC projects varies from 3 to 30years). The studies on DOTs cited herein claimed cost savings by outsourcing; however, while calculating the cost savings, these studies did not consider the quality delivered whether the outsourced projects delivered the same quality, better quality, or poorer quality compared to projects completed by other methods (Shrestha et al., 2017).

Currently, state DOTs are trying to reduce cost and increase quality in project development and execution. The important one of outsourcing using the PBC method was increasing and maintaining the quality of the road asset or the level of service (LOS). To increase the quality of maintenance projects, the quality delivered by the PBC contractor was tied to incentives/disincentives to the contractor. Some studies indicated that road maintenance works performed by a PBC contractor increased the quality of the maintenance works (Shrestha et al., 2017).

Synthesizes the practices of PBC and the traditional contracting method or MBC, focuses on work procedures. In this method, the contractor is paid based on the quantity of each activity completed and the contractor's bid price. On the other hand, in PBC, the owner sets the work performance targets, and the contractor needs to meet these targets as described in the specification. Generally, the contract period of the PBC is longer than MB. Further, the author suggested four advantages of PBC over MBC as the following (Gunter J. Zietlow, 2014):

- it reduces total maintenance costs,
- it improves asset quality and standards,
- it offers transparency to all people concerned with roads, and
- It enhances overall road conditions as well as ensures greater satisfaction by road users.

2.7.2 South Africa

South Africa has the longest total road network in Africa and the 10th longest in the world, similarly the 18th longest paved road network in the world. The total length is approximately 746,978 km, with only 21% paved (153,719 km). However, despite the fact that South Africa is economically foremost on the continent, it has roads in a fair to poor road condition of about 38%. Some of these conditions are due to a lapse in maintenance actives, although it is better when compared with that of other African countries (Mostafa Hassan, 2018).

Road maintenance in South Africa is handled by South African National Road Agency Ltd

(SANRAL); the creation of SANRAL in 1998 was a result of the government commitment towards transforming public sector. SANRAL has jurisdiction over 92% of the national road network, of which 81% are non-toll and the remaining tolled (over 19,000 km). Further, the remaining 8% of the total road network is also tolled and is developed and managed by private bodies (through public-private partnerships). Management by these private bodies is still overseen by SANRAL based on concession contract agreements. The concession contract duration is thirty years, after which the road is handed over to SANRAL (Mostafa Hassan, 2018). SANRAL funds the maintenance of the directly managed toll roads through toll revenue and borrowings from capital markets (Ross, 2018).

2.7.3 China

After completion of a road project, if it is a commercially operated toll road it is operated by the investor, which is also responsible for maintenance of the road. If the road is a government loan repayment toll road, it is operated by provincial or municipal highway bureau; non-toll roads are normally operated by local highway bureaus (Asian Development Bank, 2012).

According to Ministry of Transport (MOT) is responsible for issuing technical standards, specifications, and relevant guidelines for road maintenance at the central government level. The MOT also establishes a five-year road maintenance administration plan to guide road maintenance work in each of the provinces. After the fuel tax reform, the MOF transfers the fuel tax revenues to each province to pay for maintenance activities every year based on the allocation formula (Asian Development Bank 2012).

On the other hand contracting models for rural road maintenance in China, which are four in number is stated below. The contractors can be individuals, companies, road maintenance teams and benefited enterprises (Fan, 2011).

- Individual or family contracting model: In this model, the rural road maintenance task is distributed to the farmers or families alongside the road. The individuals or families sign a contract with the local government road institution and are paid for maintaining a certain length of the road.
- Company contracting model: In this model, some counties, towns or villages assign the entire rural road maintenance work to the professional maintenance companies, which can be selected through bidding or authorized directly by the government transport institutions.
- Road maintenance team contracting model: The road maintenance team contracting

model ensures that the local governmental road institutions contract road maintenance work to local maintenance teams.

- Benefited enterprises contracting model: The benefited enterprises contracting model states that when certain sections of a road are mainly used to serve a particular enterprise, that enterprise can assume the road's maintenance.

2.7.4 New Zealand

Road asset managers in New Zealand currently use the Road Asset Maintenance Management (RAMM) system as a technical management tool having high-quality inventory data covering road network conditions and history of maintenance activities. Road asset managers use RAMM software mainly inventory database storage for road structures, drainage and surfacing plus condition data including skid resistance, rutting, and cracking. It contains the treatment selection algorithm, plus national optimization of maintenance allocation by decade (NOMAD), which stores the 10 years forward works program. The treatment selection algorithm was made to indicate which works should be performed in the coming year. Maintenance management tools like RAMM have written and modified their maintenance specifications (Temesgen, 2016).

According to COMCEC Coordination Office (2016), the following four contract types to procure maintenance and operations are used within the Road Network Management Areas; Performance specified contracts, which are awarded for 10 years to single suppliers who are responsible for providing all services. Most resurfacing work is done through performance specified contracts, Hybrid contracts which are awarded for five years and involve consultants and contractors working in a partnering arrangement to deliver services, Traditional contracts which are awarded for varying terms and involve consultants managing suppliers who deliver physical works on the highway network, similar to traditional road engineering construction contracts. Most pavement strengthening works and bridge repairs are managed through this type of contract, and Alliances, arrangements in which groups of organizations combine in partnership and work together.

2.8 Problems of Road Maintenance

There are many causes for not having effective sustainable road maintenance practices. Those are related to management, technology and finance (Malkanthi et al., 2012).

The biggest technical challenge facing highway engineers today is not the construction of new roads but the maintenance of the existing road network. Pavements must be selected for maintenance when they are still effective and functional; before the need is apparent to

the casual observers in order to avoid the rapid deterioration after a certain limit. The sustainability of transport infrastructure is threatened by inadequate maintenance together with insufficient enforcement of transport regulations. Recurrence of pavement damage and further disruption to traffic soon after completion of repair work is becoming more common nowadays (Naazie et al., (2018).

In Ethiopia, road infrastructure was deteriorating to such an extent that they were hindering rather than facilitating the movement of people and goods. This was the direct consequence of inadequate maintenance funds and failing to provide the road as per its requirement. Specific problems encountered in carrying out both routine and periodic maintenance were: Inadequate funding for works; Capacity limitation due to limited equipment, spare parts and materials; Giving more priority to new construction and Institutional problem of many natures; and shortcoming in maintenance planning/prioritization. Therefore, the resulting outcome was as mentioned before deterioration of a big proportion of the road network in Ethiopia (Biniyam, 2015).

The study on Road Asset Management practices in Addis Ababa City Roads Authority (AACRA) revealed that seventy-three (73%) percent of the respondents explained that there is lack of an organized Road asset management department and ninety-one (91) percent of the respondents said that there is a lack of professional associations, conferences and short courses to get updated in state of the art techniques of asset management. Moreover, financial challenges, overall asset system problems, organizational challenges, professional competency and integration are the major causes of the problems in RAM (Yetnayet, 2017).

In general, why have governments in Sub-Saharan Africa (SSA) been pursuing ineffective and unsustainable road maintenance policies? Although there is no simple answer, there are some common trends. The main problems are of institutional nature and this affects incentives. They include serious human resource constraints, inadequate financing arrangements, and lack of clearly defined responsibilities, inefficient management structures, and weak management systems. These cause road agencies to be inefficient (Heggie I. G., 2004).

2.9 Effects of Poor Road Maintenance on Road Function

Without proper maintenance, the high value of any road network can be rapidly eroded and road users and society can experience significant adverse impacts if a road condition is in a

poor state. Inadequate road maintenance affects not only the present generation but places an undue burden on future generations (World Highways, 2015).

A review of practice reveals that insufficient level of spending or poor management of the road network often has serious consequences for the economic and social life of a country in terms of vehicle operating costs (VOC), travel time costs, accident costs and environmental impact. Despite an increase in the attention paid by global road agencies to the environmental and the road users' satisfaction, the overwhelming evidence from the available literature agree on the lack of similar levels of attention for the two factors in many developing countries. While many sources agree that the road maintenance backlog is caused by either the shortage of expenditures or lack of proper management or both, it appears that managing the available assets particularly in the developing countries is the main issue (Oronje et al., 2014).

Most roads in Africa are poorly managed and badly maintained. The poor state of the road network is reflected in the large backlog of delayed maintenance. During the past 20 years, African countries have spent far too little on routine and periodic maintenance and as a result, nearly a third of the $150 billion invested in roads has been eroded through lack of maintenance. Africa has been living off its road assets. To restore only those roads which are economically justified and to prevent further deterioration will now require annual expenditures over the next ten years of at least $1.5 billion. The balance of the network requiring restoration will either have to receive minimal maintenance or be handed over to lower levels of government (Oronje et al., 2014).

The economic costs of poor road maintenance are borne primarily by road users. In rural areas, where roads often become impassable during the rainy season, poor road maintenance also has a deep effect on agricultural output. When a road is not maintained and is allowed to deteriorate from good to poor condition each dollar saved on road maintenance increases VOCs by $2 to $3. Far from saving money, cutting back on road maintenance increases the costs of road transport and raises the net costs to the economy as a whole. It is estimated that the extra costs of insufficient maintenance in Africa amount to about $1.2 billion per year or 0.85 percent of regional GDP. About 75% of these costs are in the form of scarce foreign exchange. It is no wonder that road user organizations, particularly those in Zambia, Zimbabwe and Tanzania have expressed a willingness to pay for road maintenance provided the money is spent on roads and the work is done efficiently (Gunter J. Zietlow, 2014).

Poorly maintained roads mean longer travel times and reduced access. Longer travel times and reduced access is not just an irritant. In the context of development and poverty alleviation, longer travel times and reduced access take time away from other productive activities and reduce the opportunities for development. In short, these are major barriers to development and poverty alleviation. Reduced, or loss of, access leads not only to economic losses but also to the lower enrolment of children in schools, higher rates of infant, child and maternal mortality and a general disconnect from the process of national development (COMCEC Coordination Office, 2016).

In addition to these, as noted in the failure to respond to the maintenance needs in the right time will result in a high VOC and rampant potholes, leading to a decline in road safety and a deterioration of service levels for those who are using roads to transport people or to deliver goods to markets. Road deterioration will have a severe impact in terms of (Jamaa Salih, Francis Edum-Fotwe, 2016).

- **VOC:** If Road conditions deteriorate, there is an increased cost to road users (e.g. vehicles consume more fuel and may need more frequent maintenance).
- **Travel time costs**: If the road conditions deteriorate, vehicles generally travel at a slower speed but this effect is offset by fewer planned disruptions (due to less maintenance work being carried out if budgets are reduced) resulting in less delay at road works.
- **Accident costs**: As a result of road condition deterioration, and thus lower skid resistance, there will be an increased risk of accidents. Most of these accidents caused by bad road conditions occur because the driver attempts to take the steps to avoid the accident in the first place. Maybe they saw a pothole and tried to avoid it. Some other hazards that can cause accidents include issues with zoning, signage that is perplexing and hard to understand, not enough signage, and sudden driver maneuvers.

2.10 Possible Solutions for Sustainable Road Maintenance

The importance of addressing road maintenance properly is now well understood and is illustrated by the consequence of neglect. It is acknowledged that roads enhance mobility, taking people out of isolation and therefore, poverty will be decreased (Jamaa Salih, Francis Edum-Fotwe, 2016).

A new public-private partnership in financing and managing road maintenance can provide an adequate solution. The two basic principles of such an approach are to put road maintenance on a fee-for-service basis and to transfer road maintenance management from a "government ministry environment" to a "company environment" (Gunter J. Zietlow,

2014).

The key concept required to overcome the problems in road maintenance is commercialization: bring roads into the marketplace, put them on a fee for service basis, and manage them like any other business enterprise. However, since in SSA roads are under a public monopoly and ownership of most roads will remain in government hands for some time to come, commercialization requires complementary reforms in four other important areas. These are referred to as the four basic building blocks. Those focus on: Creating ownership by involving road users in the management of roads to win public support for more road funding, to control potential monopoly power and constrain road spending to what is affordable; Stabilizing road financing by securing an adequate and stable flow of funds; Clarifying responsibility by clearly establishing who is responsible for what; and Strengthening management of roads by providing effective systems and procedures, and strengthening managerial accountability(Heggie I. G., 2004).

The best way to secure an adequate and stable flow of funds is to charge road users a road maintenance tariff in exchange for the services of maintaining roads and not to rely on taxes. In most countries, the financing of road maintenance through taxes has never worked satisfactorily and it would be dangerously misleading to assume that this will change for the better in the future. Road maintenance can be managed as a public service similar to water supply, telephone and electricity services, where the user pays for the services received. To be able to do so, the following conditions must be met: the road user pays in relation to road usage, the one who pays should receive adequate road maintenance services, and somebody not using the road system should not pay. In addition to these criteria the charging system should be easy and inexpensive to administer and avoid any difficulty. The system which best suits the mentioned criteria is an electronic tolling system covering the whole road network. Each vehicle can thus be charged individually according to its usage of any particular road (Gunter J. Zietlow, 2014).

The purpose of road inventory is to know the current status of the road network and its salient features so that it helps to prioritize roads in funding for maintenance and rehabilitation .It also creates a database of roads and road features so that can be used for purposes like research, legal issues etc. Once a road in the road network is inventoried, there is no need to do it repeatedly unless major change occurs on the road network system like new construction of roads. So, an inventory of roads is a first and crucial step to know the current status of the road network system. The major information required to complete

inventory of a road network are; link name/road name, functional class of the road, length of the road ,width of the road, owner of the road, location of the road (Zone, Woreda, Kebele or others) and surface type of the road (ERA, 2010).

2.11 Road Asset Management Plan

The objective of road asset management is generally to optimize the economic benefits by minimizing the sum of maintenance costs and road user costs road asset management looks not only at the maintenance costs for the road entities, but also at the road transport costs for road users, encompassing all the costs related to road transport (total road transport costs). Road asset management can help determine the optimal funding levels that help minimize these total road transport costs for a country, and can demonstrate how available funding can best be allocated to specific roads or road sections, and to specific types of maintenance and repair. In doing so, it does not look at short-term impacts on the road network, but rather at medium or long-term impacts (Asian Development Bank, 2018).

Road asset management is based on an analysis of road data related to inventory, condition, traffic, unit costs, and road deterioration models. The data is entered into a Road Asset Management System (RAMS) that allows the data to be analyzed, and optimal budget levels and allocations to be determined. However, road asset management is more than just the RAMS, and includes the integration of the RAMS into the wider context of structures and procedures within which it operates, complementing the economic optimization criteria of the RAMS with other policy objectives. Proper road management requires separation of these responsibilities, with the road manager responsible for planning, budgeting, and performance monitoring, while the implementing entity (contractor) is responsible for achieving the planned results. Where the same entity is responsible for both planning and monitoring the results, and achieving these results, a conflict of interest arises as the entity is responsible for assessing its own performance (Asian Development Bank, 2018).

The government of Ethiopia in collaboration with the development partners has reached at an agreement to scale up the program to additional cities The urban local government program (ULGDP) gives due attention not only for the provision of infrastructure to the cities, but also for proper management and administration of Asset inventory and updating, condition analysis, and maintenance of infrastructure are key pillars of asset management plan (AMP) in ULGDP. With this regard, city administrations in the region are collecting and updating different infrastructure assets in yearly bases so as to plan, maintain analyze

the progress, and use to g periodic reports. However, infrastructure data are n systematically registered and used in the cities as well as Bureaus for proper planning and communication. Furthermore, the data and information of cities infrastructure used by different stakeholders are inconsistent and lacks clarity. And to address this problem, Shashemene City Municipality intends to undertake asset inventory, registry and Asset Management Plan Preparation for the years 2014-2016(City Administration, 2013).

2.12 Research Gap

There is a vast amount of literature on road condition assessment, maintenance problems and asset management plan in many developing countries. Based on the above surveyed studies, there was no study which focused on condition assessment and maintenance problems of road infrastructure asset management plan mostly focus on the contribution and condition that affect the road components. The literatures on condition assessment and maintenance problem of road infrastructure face internationally are not reviewed. But the condition assessments on road inventory, maintenance, progress and overall presence as a firm have not been studied in the context of Ethiopia. Therefore, condition assessment and maintenance problems of road infrastructure asset management plan in south oromia are about to assessed on this research paper.

The assessments on road functionality, progress, condition, maintenance and overall presence as a firm have not been studied in the context of Ethiopia particularly around Southern Oromia Zone. Therefore, there is a lack of clear condition assessment method and maintenance problem identification concerning road infrastructure based on their deterioration types, condition rating method and problems related to asset management plan. On the other case most of urban local governments don’t have clear frame work for condition assessment and maintenance management guideline.

CHAPTER THREE

RESEARCH MATERIAL AND METHODOLOGY

3.1 Introduction

As road construction and maintenance activities consumes a huge amount the nation's budget so, it must be administered in a systematic manner through proper road condition assessment, maintenance problems and asset management plan (for the case South Oromia UIIDP cities). In this regard, the main objective of this research is to assess the road condition assessment, maintenance problems and asset management plan.

This chapter discusses the line approach of the study. The first aspect deals with the method, population and sample of the study and the second part provides the tools and techniques employed in the research. It also presents the procedure of the study. The whole plan of the study is discussed in detail under this chapter. The succeeding section provides a general description of the research design, as well as a justification of the methodology.

3.2 Study Location

The study was conducted in South Oromia Zone, Oromia regional state, the southern part of the Ethiopia. The Cities are one of the major transport nodes in the southern part of the country connecting urban centers of SNNPS and Oromia regions and route to the main cross country and abroad road and transportation network that extended from Addis Ababa to Moyale and Kenya. This strategic location of the town made the cities to be one of the big market places in the region eventually results to daily entrance of substantial number of business persons, visitors, transitory persons.

According to Oromia urban grading, Shashemene is in the first rank of urban hierarchy and has very important link to regions in Oromia and SNNPRS. However, infrastructure management problems, lack of quality inter-operable and technologically efficient asset handling system and related infrastructure facilities coupled with lack of comprehensive infrastructure plan that explicitly show infrastructure arrangement and Geographic Information System (GIS) use which are critically problems. The aforementioned problems can only be addressed by coining infrastructure management strategies backed by most interoperable, modern and conversant GIS system.

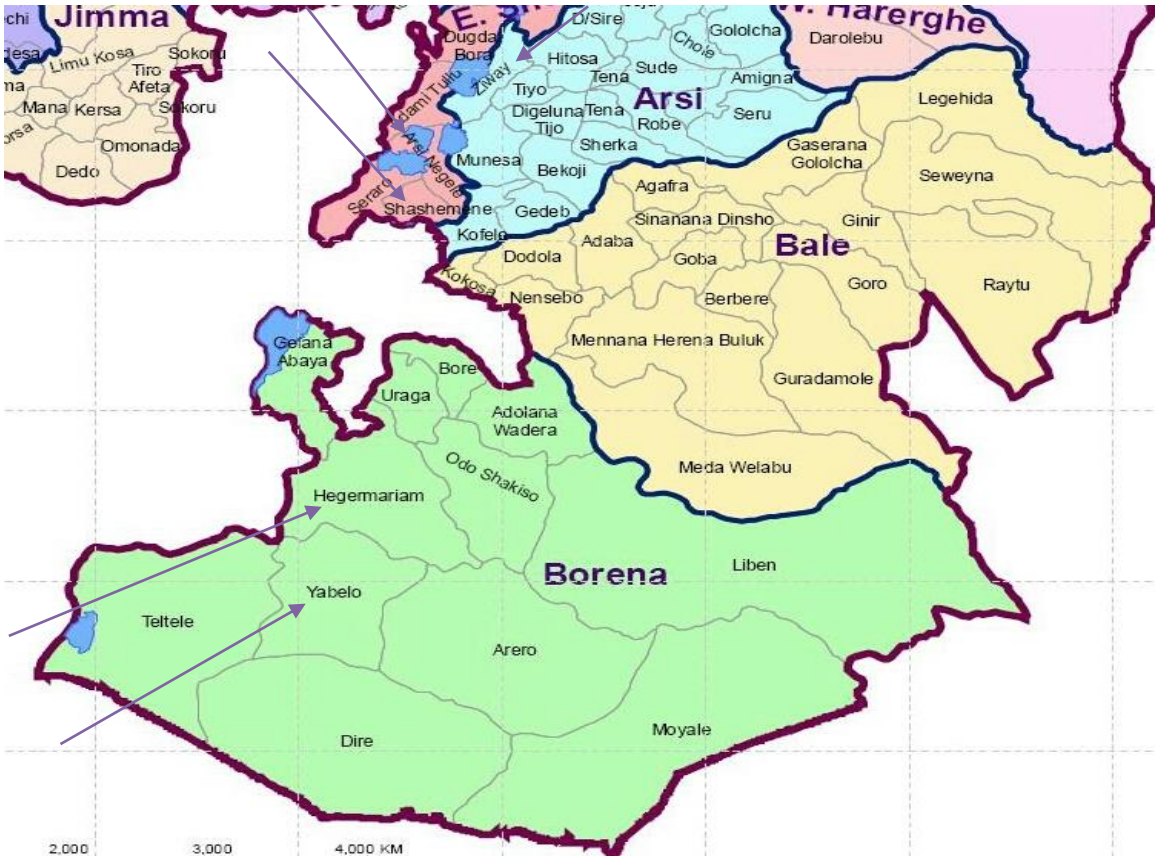

Figure 3.1: Map of the study area (Southern zones of Oromia)

3.3 Research Design

The research started from the literature review to develop the theory of the research study and the study adopted descriptive types of research design which is used to provide the quantitative or numerical description. The study was conducted by distributing the structured questionnaire to project managers from contractors, resident engineers from consultants, counterpart engineers and team leaders from road network and safety management branch directorates under city municipality; those have direct involvement in road maintenance projects and inventory of condition assessment. The questionnaire was addressed in the closed-form of questionnaire and the respondents were asked to indicate the suitable techniques of condition assessment method and magnitude of problems in road maintenance by the frequency of road maintenance on road projects in five-point Likert scale. Upon obtaining the desired data, checking and sorting of data were done. Then, the data were analyzed for extracting the information obtained through the overall research work. These were followed by thorough discussions in order to draw a conclusion and to forward recommendations based on the findings of the study.

Semi-structured interview type was selected because it helps to collect reliable qualitative data through the flexible way by keeping the structured questions.

The researcher was survey and involves fact finding enquiries of infrastructural asset condition assessment method. The major purpose is to describe the current asset management plan method of UIIDP cities in South Oromia regional government. So the study was used both qualitative and quantitative mixed research approaches, and this help the researcher to investigate and answer research questions effectively. A total of 47 questionnaires were distributed to construction professionals working on specific road projects in all places, and 39 questionnaires were returned from distributed questionnaires. Using this research design, this study focused on acquisition of quantitative and qualitative data from different professional people involved in the road construction sector. The overall research process is:-

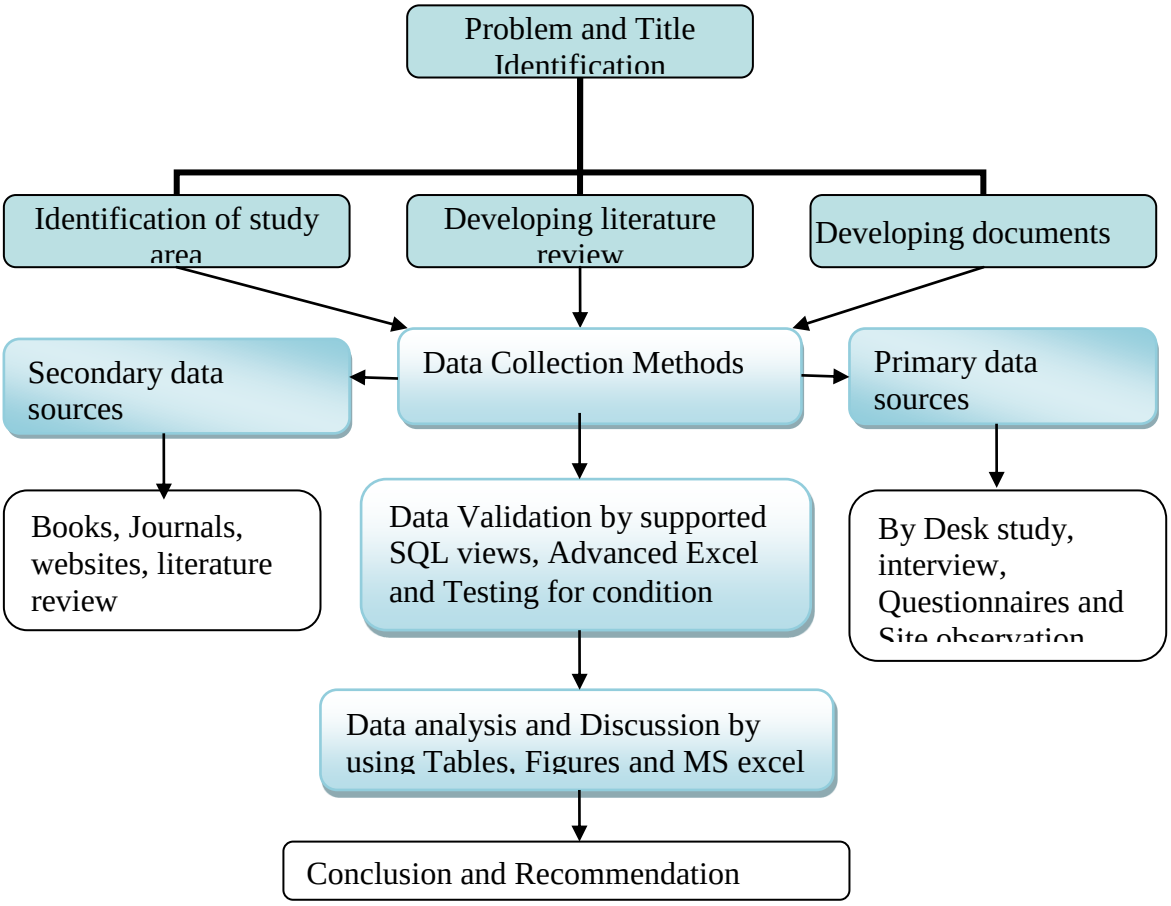

Figure 3.2: Thesis work flow

3.4 Sources of Data

Data required for this study were collected from both primary and secondary data. The primary data were obtained through, site observation, desk study and a questionnaire directed to project managers from contractors, consultants, counterpart engineers and team leaders under city Municipality.

A desk study was chosen as one of the instruments to assess and obtain actual data about

the road assessment and maintenance forecast practice of city municipality from secondary data. The secondary data which involves information from a published document such as academics publications, journals, and government publications, past research papers, archives and internet resources were used to support the primary data. The secondary data were used to get an insight into the problem and used as criteria for developing and analyzing the primary data.

In addition to this, required qualitative data were obtained through a semi-structured interview directed to the experts from the office of road fund in order to strengthen the quantitative data obtained from a questionnaire. On the other hand, the importance of including the road users (basically drivers and passengers) while collecting the primary data in relation to the title of this thesis is undeniable; however, it is believed and considered that almost all the respondents included in the questionnaire and interview are either drive the vehicle (driver) or travel through the road transportation (passengers) and have a well understanding on the terminology and subject matter of this thesis.

Finally the respondents' documents were collected by asking voluntary from contractor, client representatives and consultants. Archival documents were mostly from completed project contract document, weekly reports, monthly reports, correspondence letters, consultancy completion reports and payment certificates were investigated thorough which were very important in identifying the current condition assessment and problems related to maintenance methods on Road construction projects.

3.5 Population of the Study

The sampling frame is the list of population from which the samples were drawn from. The target population consisted of urban segments' roads and town internal asphalt, gravel and cobblestone which are completed and ongoing by different bodies, while the questionnaire respondents were government representatives from road authorities under city administration, but as their response on questionnaire the targeted group were zone administration, zonal construction authorities, the contractors and consultants (resident engineers), driver, Passenger used the road. The technique was applied so as to obtain a representative sample when the population does not constitute a homogeneous group.

Professionals included in this study are those who have direct involvement in road segments work: inventory works, condition assessments and maintenance projects were the selected professionals for the data collection using the questionnaire. Accordingly, 12 questionnaires for the clients, 13 questionnaires for the Consultants and 22 questionnaires

for the contractors were distributed (a total of 47 questionnaires were distributed).

3.6 Sample Size and Sampling Procedure

The target populations consisted of urban segments' roads and town internal asphalt, gravel, red ash and cobblestones which are completed and ongoing by different bodies on the road sector in south part of Oromia city municipality of Southern Oromia roads authority participants. The research focused in the ULGDP/UIIDP participating cities of South Oromia, the cities have categorized into two levels: higher and medium cities. So from 13 UIIDP cities, ten cities (Nagelle Arsi, Dodola, Bokoji, Goba, Ginnir, Adola Woyu, Shakiso, Nagelle, Bule Hora and Yabello) are new to the system UIIDP and 3 cities (Shashamane, Batu and Robe) are old from ULGDP II and UIIDP for the last 9 years.

The sizes of populations were selected by probability sampling method which mostly each member of the population has equal probability of being selected (Showkat and Parveen, 2017). The study was adopting a random sampling method for selecting based on the surface material of road structure as a case and condition behavior.

Based on past experience and availability of data Batu, Nagelle, Yabello and Shashamane are selected as the sample cities. From road categories asset of each ULGDP Paved road, Cobblestone road, Gravel road and Red ash road are taken as population sample of the research.

3.6.1. Sampling Technique

The sampling techniques were used to select representatives of the population and were purposive sampling and snowball sampling. Snowball sampling focuses on asking people who have participated in a survey to nominate other people they believe was willing to take part. This technique is often used when the population is difficult for the researchers to identify (Kitchenham, 2002). Purposive/ judgmental sampling is a useful sampling method consisting of getting information from a sample of the population that one thinks where participants knows most about the subject matter or were knowledgeable and able to deliver the required data. Non probability sampling is also known by different names such as deliberate sampling, purposive sampling and judgment sampling.

The researcher was intentionally select routes of road from each of targeted ULGDPs, and gather reliable and relevant information that suited the purpose of the study. This was including from the road surface type cobblestone road, gravel road, red ash road and asphalt road owned.

3.6.2. Determination of the Sample Size

The target groups in this study were Southern part of oromia region on road condition assessment and maintenance methods of construction projects and their participants that are owners, contractors and consultants. The table 3.1 illustrates the number of respondents:

Table 3.1: Sampling size of respondents in table form

Participants	Target population	Stratified Sample Returned	Percentage
Owners	12	**11**	28.21%
Consultants	13	**10**	25.64%
Contractors	22	**18**	46.15%
Total	**47**	**39**	**100%**

3.7 Data Collection Techniques

Both primary and secondary data were employed to conduct this research. primary data collected through questionnaire, site observation, desk study and field survey to supplement the secondary data for the analysis of the qualitative part of the study, while secondary data gathered through review of working document, books, international journal and reviewing different documents of participants including monthly, fourth quarter and annual performance reports were collected to provide the explanatory analysis of the research questions.

3.7.1. Primary Data Collection Techniques

For this research purpose primary data were collected through standardize questionnaire. Primary data was originated by a researcher for the specific purpose of addressing the problem at hand. The questionnaires paper or inventory template was prepared for total respondents' of road segments which is identified by their route Id, by interviewing AMP focal persons from the cities and questionnaire. The questionnaires to the respondents were administered face to face and via email. Telephone and email address including physical address of the respondents were obtained. Deliveries were carried out and followed up with reminders and personal collection was done by the researcher and the assistant. A few questionnaires were received through email. Primary data collected through questionnaire, desk study, site observation, interviews and field survey to supplement the secondary data for the analysis of the qualitative part of the study.

3.7.2 Secondary Data Collection Techniques

For secondary data, gathering the depth concept from different books, journals and various web sites, internet sources, other unpublished materials and articles related to road asset infrastructure and maintenance valuation material were used. This data was serving as reference and guide the focus of clarify research question. Literature review concerning the concepts of infrastructural asset inventory, condition assessment and maintenance types. Spatial and tabular database management structure from ULG's GIS based IAMP was used as a secondary data.

3.8 Data Collection Tools

The instruments to be used in this study were Desk study, site observation, Questionnaire Design and Interviews.

3.8.1 Desk Study

Desk study was chosen as one of the instruments to assess and obtain actual data about the Asset management plan from relevant studies, reports, documents like asset components implementation, decision making, data collection, data management and project selection and relevant tools during asset management practice in southern Oromia road as used.

Desk study was chosen as one of the tools to find out the answer for the third research question, how the city keeps GIS based road infrastructural asset database information available for easy access in the future? And how is the software applied for road condition assessment purposes? Specific documents studied were manually collected data, Data collection equipment used, Excel sheet stored data, manually evaluated condition data and project selection and decision made on the collected data and currently executed maintenance works, observation on the organization individual management usage and integration of those management systems and inventoried documents in excel sheet.

3.8.2 Questionnaire Design

The questionnaire design was based on a combination of an extensive review of literatures dealing with road condition assessment and maintenance forecast methods in asset management plan. Questions were developed from the information gathered from literature and on best practices of asset management supplemented to achieve the research objectives. The questionnaire form was accompanied by a cover letter. The questionnaire survey mainly contains close-ended questions because close ended questions are often easier and quicker for to record and code the responses obtained from the respondents, and also easier and quicker for the respondents to fill (circle) the responses.

The questionnaire categorized in to four section the first section is the respondents profiles,

section two is about suitable techniques of road asset inventory and condition assessment method, section three of the questionnaire asked about problems of road maintenance and showing the magnitudes of budget from whether the recurrent or capital budget of ULG's and the last section of the questionnaire focused on GIS based road infrastructural asset database structure to keep information available for easy access in the future. The whole section of the questionnaire is depicted on Appendix2.

Limited numbers of open ended questions were also included in the questionnaire because open ended questions allow respondents to include additional information including feelings, attitudes and understanding of the subject and enable them to raise new issues. This allows the researcher to better access the respondents' true feelings on an issue under study and to access extra information from them.

A Total of 47 questionnaires were distributed for 12 owners' representatives, 22 road contractors and 13 consultants. These questionnaires were filled by Road contractors, Consultant engineers, Road Authority Engineers in different companies. 39 (83%) questionnaires were returned from 47 distributed questionnaires as follows: 11 (91.67%) from owners' representatives, 18 (81.81%) from contractors and 10 (76.92%) from consultants or Supervising Engineers as respondents.

Table 3.2: Details of the responsiveness of the questionnaire

Participants	Total population	Sample returned from respondents	Percentage
Clients	12	11	91.67%)
Consultants	13	10	76.92%
Contractors	22	18	81.81%)
Total	47	39	**83%**

3.8.3 Interviews

Information on research questions and objectives was requested from key informants in order to deepen the findings of the desk study and questionnaire. The purpose of the interview was to assess the practices and perceptions of key informants on Condition assessment and maintenance forecast methods of road infrastructure in Asset Management practices. More efforts were done to identify additional problems which were not identified through the questionnaires and the desk studies; and to increase the accuracy and reliability of the challenges obtained through questionnaire. The interview schedule is depicted on Appendix3.

3.9 Data Analysis Methods

Data collected through the desk study were analyzed in relation to the theoretical propositions and the method used to analyze the interviews and questionnaires data was descriptive statistics method was employed for the analysis of data obtained from both the primary and secondary sources. This method of analysis helps to analyze the responses in actual numbers. Simple statistical tools like percentage, tables, charts and frequencies were used in the analysis and presentation of quantitative data. With regard to the data that were gathered through interviews, the researcher was record the interview's voice, was takes notes, codes the obtained data, was described the data and analyzes the data thematically.

The statistical tool used to run the analysis was descriptive statistics and the Relative Important Index (RII) was used to rank the identified variables and used to determine the rank of maintenance and inventory problems, and the condition assessment in road construction projects. Rating scale is one of the most common formats for questioning respondents on their views or opinions of an event or attribute. To provide a degree of importance for each maintenance and inventory problems, an importance index was calculated and in this regard, participants were asked to indicate the level of the problems of road inventory and maintenance methods implementation by rating them on five point scale; 1= Insignificant, 2=Less significant, 3=averagely significant, 4= significant and 5= Very significant in a manner similar to that in Assaf et al. (1995).

Relative Importance of Index (RII) = $\frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5(n_5+n_4+n_3+n_2+n_1)}$ equation 3.2

Where, n1 = number of respondents who answered insignificant,

n2 = number of respondents who answered less significant,

n3 = number of respondents who answered averagely significant,

n4 = number of respondents who answered significant, and

n5= number of respondents who answered Very significant.

The RII values have a range of 0 to 1 (0 not inclusive). In comparing two factors, the factor which scores greater value of RII is more important than the other corresponding factor which scores low value of RII.

The second method of data analysis method is done based on the international asset management standards require the use of a quantitative scale to express, rank, compare, and benchmark the operating condition of infrastructure assets.

There are two approaches that can be utilized to assess the condition of an infrastructure

asset and express the results on a numeric scale under the ACI. The first approach is based on determining the ACI based solely on assessing the physical condition of the asset at the component level which is applied for this study. The second approach combines each asset component's physical condition rating with an asset functional performance rating to improve the results of condition assessment (Pacific Region Infrastructure Facility, 2020).

To calculate the asset condition index (ACI), start by multiplying each component's weight by its physical condition rating. This gives an "actual score" for each component. Next, add together the results for every component to obtain the "total actual score". Then, divide the total actual score by the total maximum score and multiply by 100 to obtain the ACI expressed on a common scale of 1 to 100 for all assets (Salman, 2011).

Asset condition index = (Total actual score/maximum score) x 100.

Component's weight means, in respect of a component of the underlying interest, the value set out under the heading determined by sum up the response of each respondents which rates from 1-5 scale based on the questionaries' distributed of condition assessments.

The physical condition rating (PCR) of an infrastructure asset component represents its current operating condition. It is determined through asset condition assessment. This document employs five ranks to represent PCRs for infrastructure assets' components, from 1 to 5, where 5 represents an asset in excellent physical condition and 1 an asset in very poor condition. During preliminary screening, the component may be assessed based on visual inspection only and, for those components found in less than satisfactory condition, detailed investigations should be performed to confirm if they should be ranked as being in excellent, Good, fair, poor, or very poor condition.

Table 3.3: Asset Component Physical Condition Ratings

Asset Component Condition	Physical Condition Rating	Interpretation
Asset component in brand new condition, with no wear, no damage, no deformation, no defects, no deterioration, no impairment.	5	Excellent
Asset component in "like new" condition, with minor wear and no damage, no defects, no deformation, no deterioration, and no impairment.	4	Good
Asset component shows minor wear, minor deformation, minor damage, minor defects, minor deterioration, minor impairment,		Fair

asset condition can be maintained through normal preventative maintenance.	3	
Asset component with major deformation, degradation, deterioration, damage or defects and serious impairment in condition; requires efficient rehabilitation/refurbishment of degraded	2	Poor
Asset component with major degradation, deterioration, damage or defects and serious impairment in condition, and it is not possible to restore the component condition through economically efficient rehabilitation/refurbishment.	1	Very poor

The presentation of the condition assessment requires a scale to identify the condition of the asset. The scale utilized in the research is 0% to 100%. The excellent condition level is from 100% to 81%. The good condition level is from 80% to 61%. The medium condition level is from 60% to 41%. The poor condition level is 40% to 21%. Finally, the very poor condition is from 20% to 1% (Salman, 2011). The scale is illustrated in figure (3.3)

Figure 3.3: Road condition scale

The third implementation category is Arc Map (GIS). This software enables the user to implement modification on the Geographic Information Systems. This can be used to illustrate the condition and attributes of the road. The attributes can contain a different type of information including size, type, action required and location. It is a common practice locally and internationally to represent the condition assessment of the road is Arc Map. This created an easy to understand the status of the assets in addition to providing different customization options. The conditions obtained are converted to a scale from 1 to 5 instead of 0% to 100%. This step makes the sorting of the data in the program easier.

The final category in the condition assessment implementation is the comparative charts.

In order to study the trend of the results, comparative charts were established for each road and roads conditions. In each chart, there was a comparison between the municipality data, team's experiment using Municipality Method and the newly developed model. This step is important in order to create benchmarks for validation and understanding of the difference between the new model and the municipality data. Finally, the conclusion and recommendations are partially obtained from the comparison.

3.10 Ethical Consideration

Ethical considerations in research are critical. Ethics are the norms or standards for conduct that distinguish between right and wrong. First, ethical standards prevent against the fabrication or falsifying of data and therefore, promote the pursuit of knowledge, considerations such as ensuring quality, safety and integrity, informed consent, confidentiality and anonymity of respondents on this research was expected to contribute and truth that is the primary goal of research. Therefore, researcher is believes and gives attention to the ethical issues. The researcher was conscious to have the required information with informed consent. The discussion with selected targets was on voluntary participation. The discussion was concluded with respect, confidentiality and privacy. The interviewed and opened questions were designed in order that it did not harm anyone.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSIONS

4.1 Introduction

This chapter discusses the interpretation and presentation of the data collected by means of questionnaires, Desk study and interviews. The study aimed to assess the condition and maintenance problems of road infrastructure asset management plan (case of South Oromia UIIDP cities). At this stage the data were examined and described in relation to the objectives of the study. Frequency distribution, tables and charts were used to organize data, to give meaning to the response rates and the statistical tool used to run the analysis was descriptive statistics and the Relative Important Index (RII) in the frequency tables. The data was then presented through figure and analyzed by the programme MS-excel. Accordingly, interpretation and discussions would be presented on the basis of the findings and limitations observed. The complete survey questions are provided in Appendix2 and 3.

Before getting to the analysis and discussion parts from the desk study which dealt with asset management plan of road infrastructure, it is important to present the finding from the responded questionnaires which dealt with the road condition assessment and maintenance problems of road infrastructure practices of city municipality in south Oromia.

4.2 Basic Information of the Respondents from Questionaries'

4.2.1 Distribution and Response Rate

Accordingly, a questionnaire was developed and distributed to the main parties directly involved in the ongoing and completed road projects to the client, consultants and contractors the respondents from the three parties are:

A total of 47 questionnaires were sent to the three groups of respondents in condition assessment and maintenance forecast method of road infrastructure asset management plan. Out of 47 questionnaires, 39 questionnaires were collected which comprises 11 from a client (City Municipality), 10 from consultants and 18 from contractors. This gives a response rate of 83% as shown in the table below the breakdown of responses from the various sample groups.

An overall response rate of 83% was achieved. This is significant for the purpose of validating the research results. The respondents were generally slow in responding to the questionnaires, but all were compiled within a reasonable time space. The percentage returned from the consultants' and contractors' side were a little bit smaller than that of the client's side, this is due to some of the respondents from consultants and contractors were

living in the project area with limited internet access to respond on the time. Table 4.1 shows the summary of overall survey response levels.

Table 4.1: Summary of overall survey response level

Participants	Questionnaire Distributed	Questionnaire Returned	Percentage Returned (%)
Clients	12	11	91.67%)
Consultants	13	10	76.92%
Contractors	22	18	81.81%)
Total	47	39	83%

4.2.2 General Characteristics of Respondents

The characteristic of respondents observed in this study includes, organization type, work position, age, level of educational, working experience of the respondent. The review of these characteristics might give some insights as to why the answers of the respondents vary. Sample sizes of 39 respondents were taken and the following are their characteristics. The responses from the respondents are summarized in table 4.2.

Table 4.2: Respondents Profile

1	Position in the Firm	Contractor	18	46.15
		Client	11	28.20
		Consultant	10	25.64
2	Age of respondent	20-29 years	3	7.69
		30-39years	9	23.08
		40-49 years	13	33.33
		Above 50 years	14	35.9
3	Year of experience	0-5 years	2	5.13
		5-10 years	8	20.51
		10-15years	12	30.77
		Above 15 years	17	43.59
4	Level of education	Diploma	6	15.38
		Bachelor's Degree	18	46.15
		Masters	15	38.47
		PhD	0	0.00

From the study results as shown in table 4.2 respondents profile on number one (1) as indicated above, the respondents were requested to indicate the position of worked in the firm. From the research findings, it was noted that 46.15% worked as contractors, 28.20% worked as client firm, 25.64% % worked as consultants with the city municipalities. This implies that all respondents worked with various organizations which are engaged in road construction playing various roles which place in a position of being capable of providing very reliable information in this research study.

The respondents were asked to state their age bracket as indicated in the above table number (2) shows the study results, it was noted that 7.69% of respondents were aged between 20-29 years, 23.08% were aged between 30 to 39 years, and 33.33% were aged between 40 to 49 years, whereas 35.9% were aged over 50 years. This indicates that respondents were fairly spread in relation to age.

As determined in above table column number three (3) the respondents were requested to indicate their experience in years that they were involved in construction industry; thus from the study it was noted that 5.13% were involved in construction projects for less than 5 years, 20.51% were involved in road construction projects for a period of 5 to 10 years, 30.77% have been involved in construction projects for a period of 10-15years, whereas 43.59% were involved in construction projects for more than 15 years. This result implies that most respondents were involved in road construction projects for a significant time length which enable them to give reliable information to this study.

From the research findings as indicated on column number four (4) in the table above, the study noted that 46.15% held bachelor's degree, 38.47% of the respondents indicated to hold master's degree, 15.38% of the respondents indicated to hold diploma certificate, while 0% held PhD. This result shows that respondents were educated thus able to respond to research questions easily. It also indicates that the road construction industry is run by very well educated professionals.

4.3 The Condition Assessment of Road Components in Selected cities

Assessing the condition of assets may require benchmarking, i.e., the development of quality/standards profiles against which the assets can be measured. With above ground assets this will generally take the form of visual inspection, although in some cases it may also involve mechanical testing. A road for example needs to have some definition of the types of deterioration that occurs and a quantitative description of what constitutes the different levels of deterioration.

4.3.1 Condition of Road network in Shashemene town

Table 4. 3: Road deterioration area and percentage in Shashemene

Components of road	Sum of Deterioration Area	Sum of Area (km^2)	Deterioration %
Asphalt	444.31	117,597.41	0.4%
Cobble Stone	7,048.56	708,985.62	1.26%
Earth Pressed	5,090.28	21,445.11	23.7%
Earthen	148,742.78	733,458.83	20.3%
Gravel	1,173.11	3,966.71	29.6%
Large Block Stone	34,786.76	274,344.70	12.7%
Red Ash	289,727.42	2,394,882.21	12.1%
Grand Total	**487,013.21**	**4,254,680.61**	**100%**

Condition Assessment had been done using the revised asset management operational manual of ministry of urban development and housing five level condition indicators and deterioration type of each segment and area were captured. The condition assessment presented in this document is only for the city owned assets. Accordingly, the inventory result revealed that from the total Asphalt, Cobble, Gravel, Red Ash, Large Block Stone, Earth Pressed, and Earthen roads; about 0.4%, 1.26%, 23.70%, 20.3%, 29.6%, 12.70% and 12.10% of their surface area has been deteriorated respectively.

Table 4.4: Road feature class by condition in Shashemene town

Feature Class (Road Surface Mat.)	Very Good (Km)	Good (Km)	Moderate (Km)	Poor (Km)	Very Poor (Km)	Total in Km
Asphalt	14.49	0.18	1.75	0.38	0.00	16.80
Cobble Stone	70.24	26.84	3.44	0.56	0.20	101.28
Earth Pressed	0.09	0.67	1.63	0.19	0.48	3.06
Earthen road	32.57	13.43	28.63	13.65	16.51	104.79
Gravel	0.00	0.07	0.27	0.04	0.19	0.57
Large Stone	17.13	5.92	7.08	6.79	2.26	39.18
Red Ash	175.70	35.07	67.48	37.70	26.17	342.12
Total L (Km)	**310.22**	**82.18**	**110.28**	**59.31**	**45.82**	**607.81**
Percentage	**51.18%**	**13.5%**	**18.1%**	**9.8%**	**7.5%**	**100.0%**

The infrastructure asset inventory result of Shashemene city road further revealed that from the total Shashemene City Asphalt Road 16.80-kilometer length, about 14.49 kilometer is

in very good condition while from the total of 101.28km cobble stone road about 70.24 kilometer is in very good condition. From the total of 104.79kilometer of earthen road 32.57km is in very good condition while 16.51km is in very poor condition. From the total 342.12 kilometers of Red ash; 175.70kilometer is very good condition and 36.65km, 68.75 km, 37.80km and 26.38km are found in good, moderate, poor and very poor conditions respectively. From the total 39.18 kilometers of large block stone 17.13 kilometers is found in very good condition while 5.92km, 7.08km, 6.79km and 2.26km are fond in good, moderate, poor and very poor conditions respectively.

Regardless of surface type, from the total 607.81km city owned road asset 310.22km (51.18%) are found to be in very good condition, 82.18 km (13.5%) and 110.28km (18.1%) are found in good and moderate states respectively. While the remaining 59.31km (9.8%) are in poor condition and 45.82 km (7.5%) are in very poor condition. The details of road surface condition assessment in shashemene town are referred from the table above.

4.3.2 Condition of Road network in Batu town

Table 4.5: Road feature class by deterioration area and percentage in Batu city

S/No	Road Surface Material	Deterioration Area (m^2)	Surface Area **(m^2)**	Deterioration Percentage
1	Cobble Stone	23,169.66	500,387	32.89%
2	Gravel	48,918.64	392,077	25.77%
3	Red Ash	5,391.73	19,143.03	1.26%
4	Earthen	133,855.01	609,569.45	40.07%
	Total	**211,335.04**	**1,521,176.85**	**100.00%**

Condition Assessment had been done using the revised asset management operational manual of ministry of urban development and housing five level condition indicators and deterioration type of each segment and area were captured. The condition assessment presented in this document is only for the city owned assets. Accordingly, the inventory result revealed that from the total Cobble stone, Gravel, Red Ash and Earthen roads; about 32.89%, 25.77%, 1.26% and 40.07%of their surface area has been deteriorated respectively.

Table 4.6: Road feature class by condition indicators in Batu town

S/No	Feature Class (Road Surface Mat.)	Total (Km)	Condition Indicators				
			Very Good (Km)	Good (Km)	Fair (Km)	Poor (Km)	Very Poor (Km)
1	Cobble Stone	38.02	14.21	18.05	3.76	1.50	0.49
2	Gravel	32.03	1.39	8.12	13.23	7.91	1.39
3	Red Ash	2.00	0	0.01	0.10	1.89	0
4	Earthen	61.25	-	7.23	29.08	17.44	7.51
Total		**216.83**	**133.31**	**15.61**	**33.42**	**46.16**	**28.74**

The infrastructure asset inventory result of Batu city road further revealed that from the total city cobble stone road 38.02 kilometer length, about 14.21kilometer is in very good condition while about 18.05 kilometer and 3.76kilometer is in good and fair condition respectively. From the total of 61.25 kilometer of earthen road 7.23km is in good condition while 29.08km and 17.44km are in fair and poor condition respectively. From the total 32.03 kilometers of Gravel; 1.39km and 8.12km is very good and good condition while 13.23km, 7.91km and1.39km, are found in moderate, poor and very poor conditions respectively. From the total 2.00kilometers of Red Ash, 0.01km, 0.10 km 1.89kilometers are found in good, moderate and poor conditions respectively.

4.3.3 Condition of Road network in Negelle town

Condition assessment had been done using the revised asset management operational manual of Ministry of Urban Development and Housing five level condition indicators and deterioration type of each segment and area were captured. The condition assessment presented in this document is only for the city owned assets.

Table 4.7: Road deterioration area and percentage in Negelle town

Components of road	Deterioration Area (m^2)	Sum of Area (m^2)	Deterioration %
Asphalt	215.00	76,014.3	3.54%
Cobble Stone	30160.9	87,777.73	2.91%
Earth Pressed	534,890.50	79,876.32	25.80%
Earth Natural	148,742.78	733,458.83	20.3%
Gravel road	201,941	335,666.63	35.05%
Large Block Stone	34,786.76	274,344.70	12.7%
Grand Total	**950,736.94**	**1,587,138.51**	**100%**

Condition assessment had been done using the revised asset management operational manual of ministry of urban development and housing five level condition indicators and deterioration type of each segment and area were captured. The condition assessment presented in this document is only for the city owned assets. Accordingly, the inventory result revealed that from the total Asphalt, Cobble Stone, Earth Pressed, Earth Natural, Gravel road and Large Block Stone; about 3.54%, 2.91%, 25.80%, 20.3%, 35.05% and 12.7% of their surface area has been deteriorated respectively.

Table 4.8: Conditions of all roads by surface finish material in Negelle town

Road Asset	Total length in km Converted to 7m width	Very Good km	Good in Km	Fair in Km	Poor in Km	Very Poor in Km
Asphalt Road	10.86	8.53	2.27	0.02	0.041	0.00
Cobble stone	12.54	7.88	3.28	0.55	0.69	0.12
Gravel	47.95	7.43	3.89	5.36	2.51	28.76
Large Block	0.23	0.23	0.00	0.00	0.00	0.00
Earth Pressed	11.41	0.00	1.57	0.00	6.30	3.54
Earth Natural	112.95	3.59	21.77	2.86	14.67	70.06
Total (Km)	**195.95**	**27.68**	**32.78**	**8.79**	**24.22**	**102.48**
Percentage	**100%**	**15%**	**17%**	**4%**	**12%**	**52%**

The infrastructure asset inventory result of Negelle city road further revealed that from the total Negelle city Asphalt road 10.86 kilometer length, about 8.53 kilometer is in very good condition while 2.27km, 0.02 0km and 0.041km are found in good, fair and poor condition respectively. From the total of 12.54 kilometer of cobble stone 7.88 km is in very good condition while 3.28 km, 0.55 km, 0.69 km and 0.12 km are found in good, fair, poor and very poor condition respectively. From the total 112.95 kilometers of earth natural; 3.59 kilometer is very good condition and 21.77km, 2.86km, 14.67km and 70.06km are found in good, moderate, poor and very poor conditions respectively. From the total 47.95 kilometers of gravel road 7.43 kilometers is found in very good condition while 3.89km, 5.36km, 2.51km and 28.76km are fond in good, moderate, poor and very poor conditions respectively. Finally from the total 11.41kilometers of earth pressed; 1.57 kilometers is found in good condition while 6.30km and 3.54km found in poor and very poor condition respectively.

Regardless of surface type, from the total 195.95 km city owned road asset 27.68km (15%) are found to be in very good condition, 32.78km (17%) and 8.79km (4%) are found in good and moderate states respectively. While the remaining 24.22km (12%) and 102.48km (52%) are found in poor and very poor condition respectively. The details of road surface condition assessment in Negelle town are referred from the table above.

4.3.4 Condition of Road network in Yabello town

The condition of the asset coverage of deterioration and severity of damage are to be assessed to judge the road quality based on the aforementioned criteria. The standard developed to assess the road quality along section of route (Road line) is described below:

Limited deterioration, where the deteriorated road covers less than 30% of the road surface and deterioration indicators are generally light. This can be repaired with normal maintenance procedure.

Moderate deterioration is where the deteriorated road covers between 30% and 70% of the road surface and deterioration indicators are generally moderate and this requires major maintenance or repair while severe deterioration is where the road deterioration covers in excess of 70%, with deterioration being either moderate or extreme. This requires full rehabilitation. Accordingly, regarding maintenance schedule, the roads that fall to moderate condition urgently require maintenance while the roads classified as extreme would probably require rehabilitation.

Table 4.9: Road asset category condition assessment in Negelle town

Road Feature Class	Condition Result					
	Very Good (km)	Good (km)	Moderate (km)	Poor (km)	Very Poor (km)	Total (KM)
Cobble	0.475	4.036	0.305	0.239	0	**5.046**
Gravel	0	0	2.654	2.48	0	**5.134**
Earthen	0	7.149	43.94	87.38	8.27	**146.7**
Total	**0.475**	**11.11**	**46.90**	**90.10**	**8.27**	**156.9**

The infrastructure asset inventory result of Yaballo city road further revealed that stated by equivalent 7m length from the total Yaballo city gravel road 5.134 kilometer length, about 2.654 kilometer is in moderate condition while from the total of 5.045 km cobble stone road about 4.036 kilometer is in good condition. On the other hand, the city has a total of

146.74 kilometer of earthen road. From the quantity which is 87.38 km is found under poor condition. While from all surface of road the rest found under different condition level as presented in the above. The details of road surface condition assessment are referred from the table above.

4.3.5 The Condition Assessment of Road Components by Using Asset Condition Index

The condition and operating performance of all infrastructure assets gradually degrade. The reasons for this degradation include:

I. Gradual wear and tear, corrosion or erosion, deformation, or other physical or chemical changes in an asset's components;
II. Damaged or defective parts within components;
III. increase in frictional forces due to drying of lubricants, elevated operating temperature due to low levels of coolants, or increase in vibrations (in the case of assets with moving parts); and
IV. Lack of preventative maintenance resulting in premature asset impairment

In addition to gradual degradation, infrastructure assets can also suffer damage or sudden failure caused by accidents or natural disasters. The degradation in physical condition of an asset's components directly impacts its ability to deliver its intended operating performance safely and reliably.

To calculate the ACI, start by multiplying each component's weight by its physical condition rating. This gives an "actual score" for each component. Next, add together the results for every component to obtain the "total actual score". Now, divide the total actual score by the total maximum score and multiply by 100 to obtain the ACI (expressed on a common scale of 1 to 100 for all assets).

Table 4.10: Earth work road components typical condition assessment

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	15	2	75	30
Consultant	13	2	65	26
Contractor	29	4	145	116
Total Score	57		**285**	**172**
Asset condition index = (actual score/maximum score) x 100				**60.35**

As shown on the table 4.10, physical condition of earth formation in both sealed and unsealed roads that assumed to not degrade, with no investment requirements for renewal

or replacement because the medium or fair condition level is 60.35 % that ranges from 60% to 41% almost all near to good condition level. The curbs, footpaths, and drainage system are replaced as a whole component when they reach the end of their lives and they do not have short-life components. Asset component shows minor wear, minor deformation, minor damage, minor defects, minor deterioration, minor impairment, asset condition can be maintained through normal preventative maintenance. Therefore, from the result of condition rating 3 or value of ACI=60.35% the component require repair, usually by a specialist and has been subjected to abnormal use or abuse, and its poor state of repair is beginning to affect surrounding elements and asset condition can be maintained through normal preventative maintenance in which backlog maintenance work exists.

Table 4.11: Gravel road assessed on component condition rating

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	19	3	95	57
Consultant	14	2	70	28
Contractor	25	4	125	100
Total Score	58		**290**	**185**
Asset condition index = (actual score/maximum score) x 100				**63.79**

As seen from table 4.11 above, the action required is the condition based maintenance where the gravel layer exhibits superficial wear and tear, minor defects, and minor signs of deterioration to surface finishes and requires maintenance or servicing.it can be reinstated with routine scheduled or unscheduled maintenance since the condition assessment ratings ranges between 61% and 80% which is in good condition level assessment values with ACI=63.79%. For unsealed roads, planned inspections and minor maintenance is performed once every 5 years to identify major impairments and identify need for regarding of the existing base.

Table 4.12: Asphalt road assessed on component condition rating

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	14	2	70	28
Consultant	11	4	55	44
Contractor	22	5	110	110
Total Score	47		**235**	**182**
Asset condition index = (actual score/maximum score) x 100				**77.45**

As shown on the table 4.12, the maintenance action required is the condition based maintenance where the gravel layer exhibits superficial wear and tear, minor defects, and minor signs of deterioration to surface finishes and requires maintenance or servicing. It can be reinstated with routine scheduled or unscheduled maintenance since the condition assessment ratings ranges between 61% and 80% which is in good condition level assessment values with ACI=77.45%. Here the reason behind asphalt road safely provides a smooth, sealed surface to facilitate traffic flow at required speeds is preventing ponding of road surfaces, by draining water into gutters along the curbside, and prevents degradation of the base. According to road condition indicators the asphalt condition is good; it can be repaired with normal maintenance procedure. The intervention includes minor repair and maintenance of a road using labour to keep the road shoulders, pavement, slopes, drainage and all other structures within the right of way as nearly as possible to their as constructed conditions.

Table 4.13: Cobblestones road assessed on component condition rating

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	19	4	95	76
Consultant	15	3	75	45
Contractor	27	5	135	135
Total Score	61		**305**	**256**
Asset condition index = (actual score/maximum score) x 100				**83.93**

As shown on the table 4.13 above, the action required is the planned preventive maintenance where the component is either new or has recently been maintained, does not exhibit any signs of deterioration, since the condition assessment ratings ranges between 61% and 80% which is in excellent condition level assessment values with ACI=83.93%.

The result obtained from cobblestone condition assessment requires a scale to identify the condition of the asset as excellent is due to construction methods of cobblestones that should be compacted and tamped with a mechanical plate compactor or another technique accepted by the board or its agent. Subsequently an adequate area of roadway has been laid and additional joint filler of the sand or cement blend should be uniformly distributed as required to seal all of the voids to prevent degradation modes.

Table 4.14: Curb and gutter, drainage sumps and footpath road condition rating

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	19	4	95	76
Consultant	15	3	75	45
Contractor	27	4	135	108
Total Score	61		**305**	**229**
Asset condition index = (actual score/maximum score) x 100				**75.08**

As shown on the table above, the action required is the condition based maintenance or minor maintenance where the curb and gutter, drainage sumps and footpath components exhibits superficial wear and tear, minor defects, and minor signs of deterioration to surface finishes and requires maintenance or servicing.it can be reinstated with routine scheduled or unscheduled maintenance since the condition assessment ratings ranges between 61% and 80% which is in good condition level assessment values with ACI=75.08% which substantially free of defects and requiring only routine maintenance.

Absent concrete curbs, the pavement erodes at the edges and degrades quickly, compromising the width of travel lanes. The road surface layer also has the road markings, which help drivers, stay within lanes, reducing risk of collision. For safe driving, lane markings should be visible. Concrete curbs also degrade in strength with time, but concrete degrades more slowly than asphalt. Once the curb has been damaged, it exposes the asphalt surface to water seepage from the edges, and road edges begin to crumble and break up. Therefore, to protect road pavement, it is important to repair the concrete curbs promptly.

Concrete footpaths degrade due to soil erosion if the soil below the footpath is washed away during a rainstorm. Grass and weed roots can start growing through the footpath, causing cracking of the concrete footpath. The condition assessment of the base course, curbs, gutters and drainage sumps, and footpaths is assessed through visual inspection and severity and number of defects in curb and gutter per unit length in a road section is determined.

Table 4.15: Concrete and steel bridge assessed on component condition rating

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	13	4	65	52
Consultant	11	4	55	44
Contractor	18	5	90	90
Total Score	42		**210**	**186**
Asset condition index = (actual score/maximum score) x 100				**88.57**

As shown on the table 4.15 above, the action required is the Planned Preventive Maintenance where the component is either new or has recently been maintained, does not exhibit any signs of deterioration , since the condition assessment ratings ranges above 80% which is in excellent condition level assessment values with ACI=88.57%.

Based on this result the planned condition assessment performed once every 5 years comprehensive condition assessment of all roads and bridges to determine physical condition of the roads assess need for resealing, repaving or other repairs and their timing. As seen from the above result the recommended type of bridge used is concrete bridges through the cities because it can be formed into any shape to carry axial and bending loads. Since bending results in a combination of compressive and tensile stresses, concrete bending members are typically reinforced with either reinforcing steel bars or with pre-stressing steel in order to carry the tensile stresses in the member and secondly used bridge material is steel bridge, due to its high strength and ease of manufacturing, is popular material for bridge construction. Rolled steel shapes commonly used on bridges include bars and plates, angle irons, channels, and beams to prevent the degradation mode of structures.

Table 4.16: Concrete and steel culvert assessed on component condition rating

Respondents	Weight	Condition ratings	Maximum score	Actual Score
Client	18	3	90	54
Consultant	15	2	75	30
Contractor	23	4	115	92
Total Score	56		**280**	**176**
Asset condition index = (actual score/maximum score) x 100				**62.86**

As shown on the table 4.16, the action required is the condition based maintenance where

the gravel layer exhibits superficial wear and tear, minor defects, and minor signs of deterioration to surface finishes and requires maintenance or servicing. It can be reinstated with routine scheduled or unscheduled maintenance since the condition assessment ratings ranges between 61% and 80% which is in good condition level assessment values with ACI=62.86%.

The culverts can vary broadly, based on the factor of safety employed in their design and the protective treatments used to delay the degradation of components and from the result observed, the maintenance is done continually on the roads to reduce the degradation of the culvert. The main focus is to minimize erosion on the carriageway and maintain the side drains and cross-drainage structures. The intervention includes minor repair and maintenance of a road using labour to keep the road shoulders, pavement, slopes, drainage and all other structures within the right of way as nearly as possible to as constructed conditions.

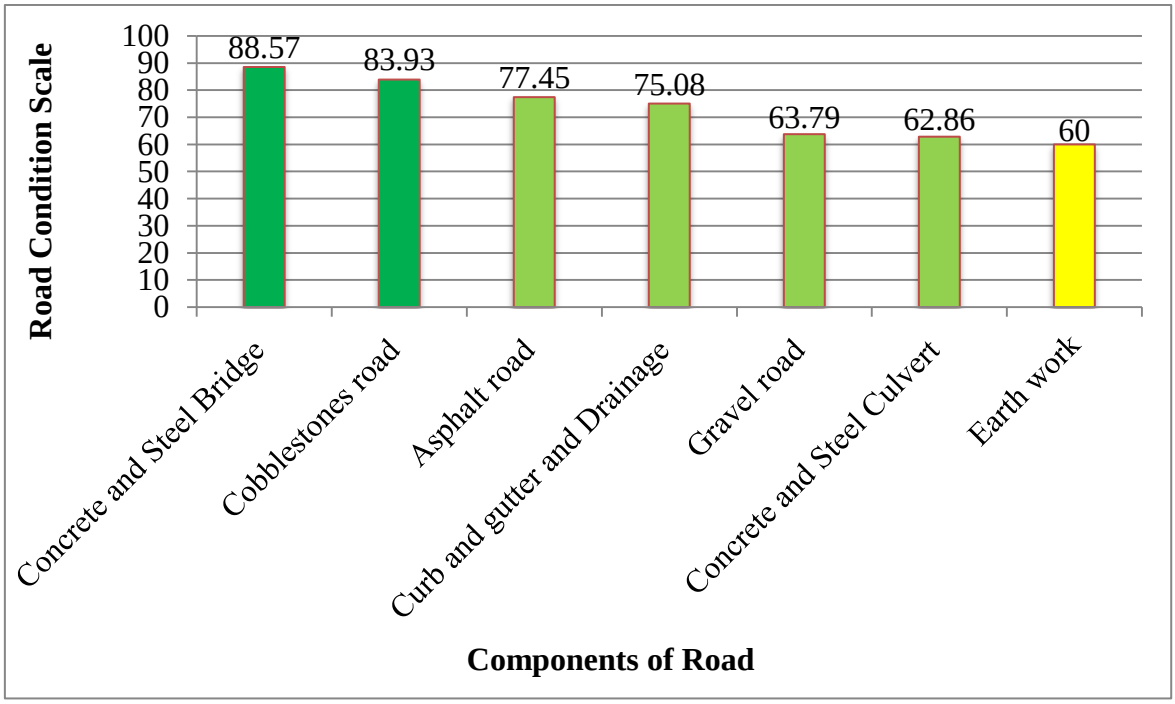

Figure 4.1: Road condition scale

4.4 Existing Problems of Road Maintenance in Southern Oromia

Identification of the existing problems of road maintenance was exhaustively done through questionnaires and informal discussion made with municipalities officials and professionals in the sector. Accordingly, a total of fifty eight (58) problems were identified under four categories, namely clients-related problems, consultants-related problems, contractors-related problems and other problems. Summary of the numbers of problems

identified under each category is presented in Table below.

Table 4.17: Number of identified problems on road maintenance

Problems Categories	No of identified problems	Percentage (%)
Client related problems	16	27.59
Consultants related problems	15	25.86
Contractors related problems	18	31.03
Other problems	9	15.52
Total	**58**	**100**

In the structured part of the questionnaire, the respondents were asked to rate the magnitude/extent of the variables drawn from the literature review and informal discussion made with municipality officials and professionals in the sector. The responses were analyzed using the Microsoft Excel software package.

A ranking system using the Relative Importance Index (RII) method was calculated to find the most significant problems for each category. As the same questionnaire was designed for all the parties, analyzing the combined view is important in addition to analyzing each respondent's point of view. The result of combined view was calculated by combining all the respondents' response in together and using the same formula presented in equation 3.2.From the results presented in the following sections, one can observe that the perspective of each party and combined view towards each category of the problems in road maintenance. Even though the discussions for each point of view have been presented, the result of combined view was used to meet one of the objectives of this study (identifying existing problems of road maintenance and showing the magnitudes of budget from whether the recurrent or capital budget of ULG's) by considering that it can present the overall views of those who are involving in the road maintenance.

4.4.1 Client-Related Problems on Road Maintenance

The results of this part of the study provide an indication of the participants and combined relative importance index (RII) and rank of client-related problems in road maintenance There are sixteen (16) client related problems in road maintenance that were identified for the informal discussions with professionals in the sector and the major problems are discussed under each respondent's point of view and finally in combined view.

Table 4.18 shows responses by RII of the clients, consultants, and contractors by combined on client related problems in road maintenance and were ranked accordingly.

Table 4.18: Participants RII and rank of clients related problems

Code	Clients-related Problems	Clients		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
C-1	Change of plan and scope of the project	0.53	11	0.58	9	0.56	13	0.56	13
C-2	Repeated change order and variation order	0.58	9	0.66	5	0.63	11	0.62	11
C-3	Human resource constraints	0.62	8	0.72	2	0.60	12	0.65	9
C-4	High turnover of senior staff (Leaving of senior staff)	0.45	12	0.64	6	0.73	7	0.61	12
C-5	Lack of qualified client staff	0.55	10	0.58	9	0.41	14	0.51	15
C-6	Lack of capacity-road training for client staff, contractors and consultants in maintenance.	0.64	7	0.62	7	0.69	9	0.65	9
C-7	Not advocating Public Private Partnership (PPP) in road maintenance	0.75	4	0.68	4	0.83	1	0.75	2
C-8	Not managing the roads as part of the market economy	0.67	6	0.70	3	0.78	5	0.72	5
C-9	Insufficient road condition survey with lack of appropriate project prioritization mechanism	0.80	1	0.66	5	0.77	6	0.74	3
C-10	Difficult bureaucracy in client organization	0.71	5	0.72	2	0.68	10	0.70	7
C-11	Lack of effective budget (allocated budget is not consumed effectively)	0.76	3	0.74	1	0.80	3	0.77	1
C-12	Slow decision-making process	0.64	7	0.60	8	0.73	7	0.66	8
C-13	Procurement delay	0.78	2	0.56	10	0.81	2	0.71	6
C-14	Poor organization	0.58	9	0.52	12	0.79	4	0.63	10

	structures								
C-15	Lack of communication and coordination by owner	0.53	11	0.54	11	0.56	13	0.54	14
C-16	Not hiring supervision consultants for all maintenance projects	0.80	1	0.70	3	0.70	8	0.73	4

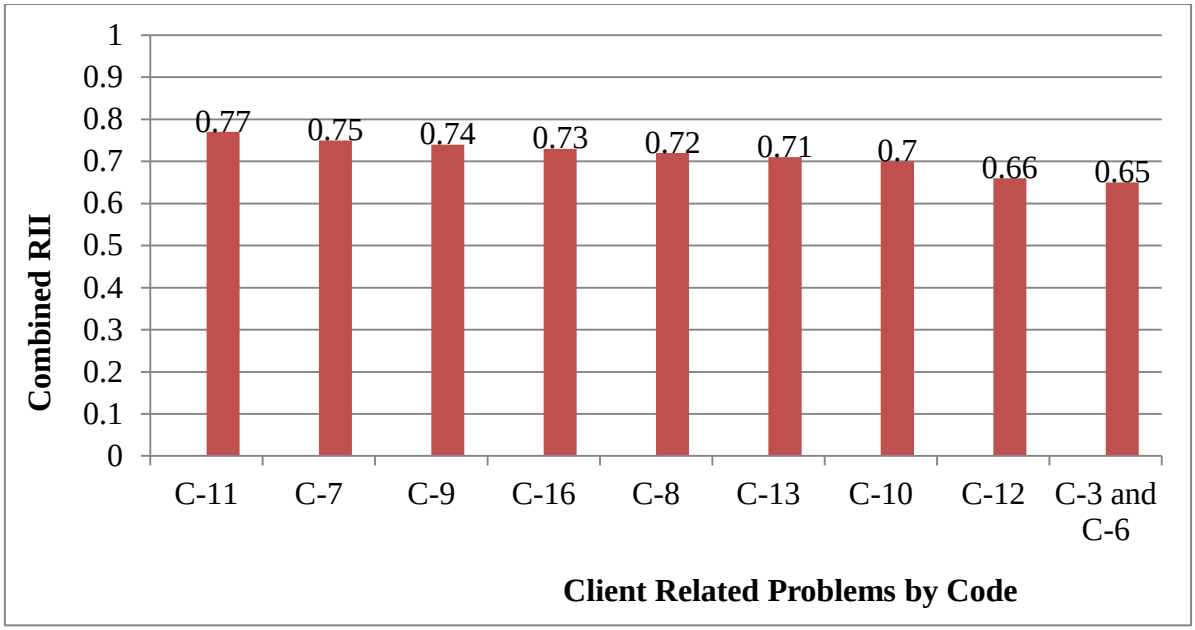

Figure 4.2: Combined RII and rank of the top 10 client related problems

4.4.1.1 Client's Point of View

As shown in table 4.18 above, the respondents from the clients-side ranked insufficient road condition survey with lack of appropriate project prioritization mechanism and not hiring supervision consultants for all maintenance projects with (RII=0.80) as the most significant client-related problem in road maintenance; and procurement delay with (RII=0.78) is ranked as the second significant clients-related problem in road maintenance. Fortunately, the respondents from the consultants' and contractors' sides had ranked the same for the aforementioned problems.

Following these, lack of effective budget (allocated budget is not consumed effectively), not advocating Public Private Partnership (PPP) in road maintenance, difficult bureaucracy in client organization and not managing the roads as part of the market economy are the third ,fourth, fifth and sixth significant clients-related problems in road maintenance with the value of RII (=0.76, 0.75,0.71 and 0.67) respectively.

According to the respondents of this category, high turnover of senior staff (leaving of senior staff) (RII=0.45) is ranked as the least existing clients-related problem in road maintenance.

4.4.1.2 Combined Results on the Problems of Road maintenance (Client-Related)

As shown in Table 4.18 above, the combined RII and Rank for each clients-related problem were analyzed by taking the responses of the overall respondents from the three parties. Accordingly, out of sixteen identified client-related problems in road maintenance, the top ten (10) ranked problems with the RII value of greater than 0.65 are discussed below and shown in Figure 4.2. Even though all the problems have the RII value of greater than 0.51, only the top ten problems are selected for discussions in order to focus on the most significant problems.

The result reveals that the problems of category have the highest degree of significance. Based on the result of client-related problems, lack of effective budget (allocated budget is not consumed effectively)and not advocating Public Private Partnership (PPP) in road maintenance have the RII value of 0.77 and 0.75, which shows the problems have a very high degree of significance in road maintenance respectively.

Whereas, the problems such as Insufficient road condition survey with lack of appropriate project prioritization mechanism, not hiring supervision consultants for all maintenance projects ,not managing the roads as part of the market economy (roads are managed like a social service), Procurement delay, difficult bureaucracy in client organization, slow decision-making process, lack of capacity-road training for client staff, contractors and consultants in maintenance and human resource constraints have the RII value of between 0.64 and 0.75, which shows that the problems have a high degree of significance in road maintenance.

All of the problems were selected as significant and very significant by most of the respondents and the most significant client-related problems in road maintenance; hence, municipalities' shall consider all the existing problems while undertaking any road maintenance in order to alleviate the mentioned problems and minimize their capital budget.

4.4.2 Consultant-Related Problems on Road Maintenance

The results of this part of the study provide an indication of the participants and combined relative importance index (RII) and rank of consultant-related problems in road maintenance.

There are fifteen (15) identified consultant-related problems in road maintenance taken from literature review and informal discussions with professionals in the sector are discussed below. Table below shows responses by RII of the clients, consultants, and contractors with combined RII on consultant-related problems in road maintenance. These problems were ranked accordingly.

Table 4.19: Participants RII and rank of consultants-related problems

Code	Consultants-related Problems	Clients		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
D-1	No specialized consultants on the road maintenance	0.55	9	0.62	6	0.51	11	0.56	12
D-2	Inadequate maintenance experiences of consultant staff	0.51	12	0.58	8	0.50	12	0.53	14
D-3	High turnover of consultant staff	0.62	7	0.56	9	0.53	9	0.57	11
D-4	Staff unavailability on the site	0.54	10	0.54	10	0.65	4	0.58	10
D-5	Poorly qualified engineers and staff assigned to the project	0.62	7	0.60	7	0.57	8	0.60	8
D-6	Shortage of technically qualified personnel/staff	0.64	6	0.62	6	0.60	7	0.62	7
D-7	Poor communication and coordination of the consultant with other parties	0.67	4	0.64	5	0.68	3	0.66	5
D-8	Poor monitoring and controlling	0.65	5	0.66	4	0.71	2	0.68	3
D-9	Poor maintenance contract management and project administration	0.73	2	0.72	2	0.57	8	0.67	4
D-10	Quality assurance or control problems	0.71	3	0.70	3	0.71	2	0.71	2
D-11	Insufficient data collection and condition survey before road maintenance	0.76	1	0.74	1	0.73	1	0.74	1
D-12	Shortage of technically	0.64	6	0.56	9	0.52	10	0.57	11

	qualified personnel/staff								
D-13	Poor inspection and testing	0.57	8	0.52	11	0.68	3	0.59	9
D-14	Lack of interest by consultants to conduct laboratory and field tests	0.67	4	0.64	5	0.64	5	0.64	6
D-15	Late approval of test	0.53	11	0.50	12	0.62	6	0.55	13

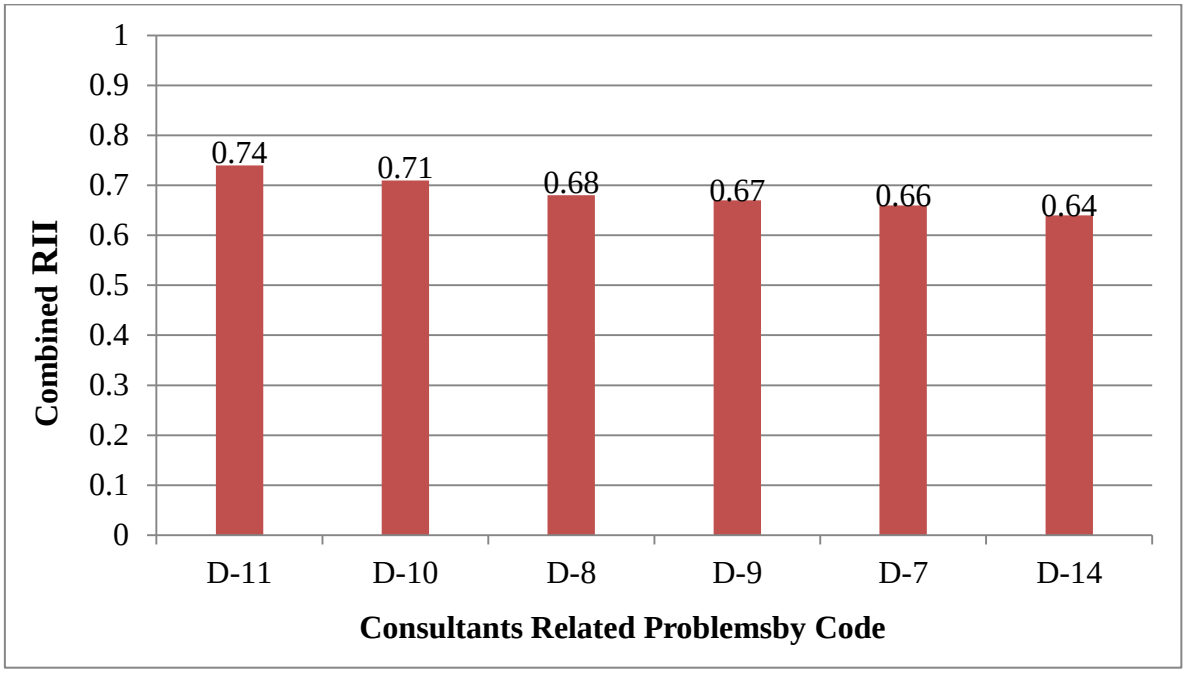

Figure 4.3: Combined RII and rank of the top 6 consultants related problems

4.4.2.1 Consultants' Point of View

In the contrary to respondents from the contractor side, the consultants' respondents have ranked Insufficient data collection and condition survey before road maintenance (RII=0.74) and client ranked as the most significant consultant-related problem in road maintenance with RII of 0.76. Poor maintenance contract management and project administration are ranked as the second significant consultant-related problem in road maintenance with the same value of RII=0.72.

Following these, poor monitoring and controlling and poor communication and coordination of the consultant with other are the third and fourth significant consultant related problems in road maintenance with the value of RII =0.66 and 0.64 respectively.

According to the respondents of this category, poor inspection and testing and late approval of test are ranked as the least significant consultant-related problems in road maintenance with the value of RII = 0.52 and 0.50. From this result, it can be concluded

that the consultants' perspective towards the consultant-related problems as government is paying for the consultants by considering the residence of all their staff on the project site, the consultants are responsible for any consequences due to this problem; even, the consultants are liable as per professional ethics. Fearing this, the consultants are being protective of themselves from revealing or accepting their significant problems.

4.4.2.2 Combined RII on the Problems of Road maintenance (Consultant-Related)

As shown in Table 4.19, the combined RII and rank for each consultant-related problem were analyzed by taking the responses of the overall respondents from the three parties. Accordingly, out of fifteen (15) identified consultant-related problems in road maintenance, the top six ranked problems with RII value greater than 0.64 are discussed below and shown in Figure 4.3. Even though all the identified problems have the RII value of greater than 0.53, only the top six problems are selected for discussions in order to focus on the most significant problems.

As shown in Figure 4.3 above, the problems of this category have a high degree of significance. Based on the result of consultant-related problems, all of the top six consultant-related problems were insufficient data collection and condition survey before road maintenance, quality assurance/control problems, poor monitoring and controlling, poor maintenance contract management and project administration, poor communication and coordination of the consultant with other and lack of interest by consultants to conduct laboratory and field tests have the RII value of 0.74, 0.71,0.68, 0.67, 0.66 and 0.64 which shows that the problems have a high degree of significance in road maintenance. All of these problems were selected as significant by most of the respondents and therefore, they are the most significant consultant-related problems in road maintenance; hence, all the consultants shall consider them while undertaking any road maintenance in order to alleviate the mentioned problems and minimize the capital budget of road maintenance.

4.4.3 Contractor-Related Problems on Road Maintenance

The result of this study provides an indication of the participants and combined relative importance index (RII) and rank of contractor-related problems in road maintenance.

There are eighteen (18) contractor-related problems in road maintenance that were identified from the questionnaires and informal discussions with professionals in the sector and the major problems are discussed below.

Table below shows responses by RII of the clients, consultants, and contractors with combined on contractor-related problems in road maintenance and problems were ranked

accordingly.

Table 4.20: Participants RII and rank of contractors-related problems

Code	Contractors-related Problems	Clients		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
E-1	No specialized contractors on road maintenance	0.62	10	0.58	8	0.60	10	0.60	10
E-2	Inadequate maintenance experience of contractors	0.55	14	0.60	7	0.53	7	0.56	12
E-3	No Knowledge of maintenance specification	0.64	8	0.62	6	0.58	11	0.61	9
E-4	High turnover of contractor's staff	0.67	5	0.64	5	0.73	1	0.68	3
E-5	Not enough experience of contractor's staff	0.62	10	0.66	4	0.61	9	0.63	7
E-6	Poor communication and coordination of the contractor with other parties	0.72	3	0.70	2	0.69	4	0.70	2
E-7	Corruption	0.58	12	0.56	9	0.53	14	0.55	13
E-8	Poor maintenance contract management and project administration	0.66	6	0.66	4	0.62	8	0.65	5
E-9	Poor site management	0.53	15	0.72	1	0.51	15	0.59	11
E-10	Inefficient work methods	0.57	13	0.68	3	0.68	5	0.64	6
E-11	Poor labor supply and productivity	0.73	2	0.72	1	0.72	2	0.72	1
E-12	Not managing resources efficiently and effectively	0.74	1	0.56	9	0.61	9	0.64	6
E-13	Poor demand and supply chain	0.61	11	0.62	6	0.71	3	0.65	5
E-14	Insolvencies and bankruptcies or cash flow problem	0.63	9	0.60	7	0.65	6	0.62	8
E-15	Shortage of equipment	0.65	7	0.52	11	0.73	1	0.63	7
E-16	Equipment allocation/management	0.53	15	0.54	10	0.57	12	0.54	14

	problems								
E-17	Incompatibility with new technology	0.71	4	0.64	5	0.62	8	0.66	4
E-18	Lack of acquiring new and recent technology equipment	0.63	9	0.60	7	0.56	13	0.60	10

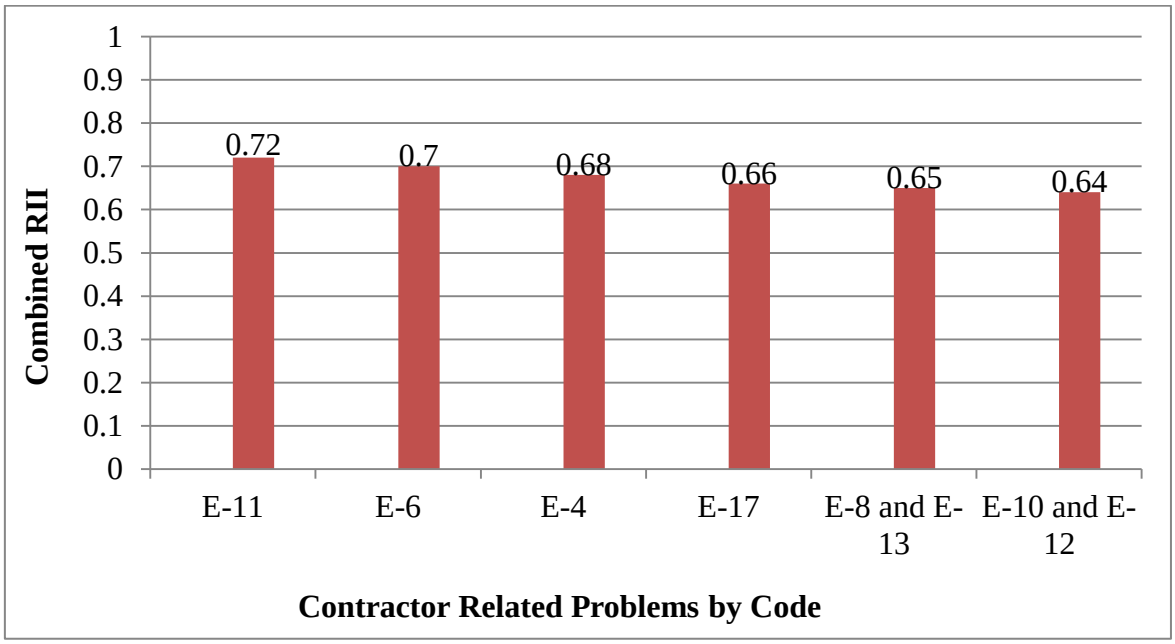

Figure 4.4: Combined RII and rank of the top 8 contractors related problems

4.4.3.1 Contractors' Point of View

The contractors' respondents have ranked shortage of equipment and high turnover of contractor's staff (leaving of contractor's staff) as the most significant with the value of RII=0.73. In contrary to the respondents from the client and consultant side, the contractors' respondents have ranked poor labor supply and productivity problem as the second significant contractor-related problem in road maintenance with the value of RII=0.72.

Following these, poor demand and supply chain and poor communication and coordination of the contractor with other parties are the third and fourth significant contractor-related problems in road maintenance with the value of RII=0.71 and RII=0.69 respectively. Insolvencies and bankruptcies or cash flow problem are fifth significant contractor-related problems in road maintenance with the value of RII=0.65. According to the respondents of this category, corruption and poor site management ranked as the least significant contractor-related problem in road maintenance with the value of RII=0.53 and 0.51 respectively.

From the result shown in Table 4.20 above, it can be concluded that the contractors' perspective towards some of the contractor-related problems is somehow protecting themselves from revealing or accepting some of the significant problems. For instance, some of the most significant contractor-related problems such as incompatibility with new technology and lack of acquiring new and recent technology equipment are ranked in the top four and fife by both client and consultants with the RII value of greater than 0.63. However, these problems are ranked as eighth and thirteenth (13^{th}) by the contractors with the RII value of 0.62 & 0.56 respectively, which are so far as compared to others. In fact, these problems are innovation problems of the contractors as they are technology rated. In current trends, there might be no mandate to solve these problems; however, it is vital for the contractors in the modernization of their organization by using the recent technology in all aspects to be an effective and competent company.

4.4.3.2 Combined RII on the Problems of Road maintenance (Contractor-Related)

As shown in Table 4.20, the combined RII and Rank for each contractor-related problem were analyzed by taking the responses of the overall respondents from the three parties. Accordingly, out of eighteen (18) identified contractor-related problems in road maintenance, the top eight (8) ranked problems with RII value greater than 0.64 are discussed below and shown in Figure 4.4. Even though all the problems have the RII value of greater than 0.54, only the top eight ranked problems are selected for discussions in order to focus on the most existing significant problems.

As shown in Figure 4.4 above, the problems of this category have the highest degree of significance. Based on the result of contractor-related problems, poor labor supply and productivity problems and poor communication and coordination of the contractor with other parties have the RII value of between 0.72 and 0.70 respectively, which shows that these two problems have a very high degree of significance in road maintenance.

Whereas, the problems such as high turnover of contractor's staff (leaving of contractor's staff), incompatibility with new technology, poor demand and supply chain, poor maintenance contract management and project administration, inefficient work methods and not managing resources efficiently and effectively have the RII value of between 0.63 and 0.70, which shows that the problems have a high degree of significance in road maintenance.

All of these problems were selected as significant and very significant by most of the respondents and therefore, they are the most significant contractor-related problems in road

maintenance; hence, all the contractors shall consider them while undertaking any road maintenance in order to alleviate the mentioned problems and minimize the capital budget of maintenance.

4.4.4 Other Problems

The results of this part of the study provide an indication of the participants and combined relative importance index (RII) and rank of other problems in road maintenance. This category of problems in road maintenance is the problems that occurred due to external stakeholders (other than the three parties), those who haven't direct involvement on road maintenance projects; however, their influence to have proper road maintenance is not insignificant.

There are nine (9) other problems in road maintenance that were identified by the questionnaires and informal discussion with professionals in the sector is done. Table below shows responses by RII of the clients, consultants, and contractors with combined on other problems in road maintenance and the problems were ranked accordingly.

Table 4.21: Participants RII and rank of other problems

Code	Other Problems	Clients		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
Oth-1	Road maintenance is politically unattractive	0.53	9	0.54	7	0.60	7	0.56	8
Oth-2	People in power have little/no understanding of the importance of road maintenance	0.61	8	0.56	6	0.56	8	0.58	7
Oth-3	Inadequate financing arrangements/ insufficient budget for road maintenance.	0.62	7	0.64	5	0.62	6	0.63	6
Oth-4	The financial source for road maintenance is limited (only road fund)	0.64	5	0.66	4	0.65	4	0.65	4
Oth-5	Road users are not directly paying for	0.67	3	0.70	2	0.63	5	0.67	3

	roads								
Oth-6	Lack of interest by professionals to participate in road maintenance works	0.63	6	0.68	3	0.62	6	0.64	5
Oth-7	Road Maintenance has not been looked upon by universities	0.69	2	0.70	2	0.68	3	0.69	2
Oth-8	Donors are not interested to fund road maintenance	0.65	4	0.66	4	0.71	2	0.67	3
Oth-9	Foreign contractors are not interested to participate in road maintenance	0.71	1	0.72	1	0.73	1	0.72	1

4.4.4.1 Client's Point of View

As shown in Table above, the respondents from the client-side ranked foreign contractors are not interested to participate in road maintenance with the value of RII=0.71 and road maintenance has not been looked upon by universities as an intellectual subject with the value of RII=0.69 are considered as the most significant other problems in road maintenance.

Following these, road users are not directly paying for roads, donors are not interested to fund road maintenance and the financial source for road maintenance is limited (only road fund)are the third, fourth and fifth significant other problems in road maintenance with the value of RII=0.67, RII=0.65 and RII=0.64 respectively.

According to the respondents of this category, road maintenance is politically unattractive is ranked as the least significant other problem in road maintenance with the same value of RII = 0.53.

4.4.4.2 Consultants' Point of View

The consultants' respondents have ranked road maintenance is foreign contractors are not interested to participate in road maintenance, road maintenance has not been looked upon by universities as an intellectual subject and road users are not directly paying for roads as

the most significant other problems in road maintenance with the value of RII=0.72 and RII=0.70 respectively.

Following these, lack of interest by professionals to participate in road maintenance works and the financial source for road maintenance is limited (only road fund) and donors are not interested to fund road maintenance are the third and fourth significant other problems in road maintenance with the RII value =0.68 and with the same value of RII=0.66. Inadequate financing arrangements/ insufficient budget for road maintenance and people in power have little/no understanding of the importance of road maintenance are the fifth and sixth significant other problems in road maintenance with the value of RII=0.64 and 0.56 respectively. According to the respondents of this category, road maintenance is politically unattractive is ranked as the least significant other problem in road maintenance with the value of RII = 0.54.

4.4.4.3 Contractors' Point of View

The contractors' respondents have ranked foreign contractors are not interested to participate in road maintenance and donors are not interested to fund road maintenance as the most significant other problem in road maintenance with the value of RII=0.73 and 0.71 respectively. In the contrary, road maintenance has not been looked upon by universities as an intellectual subject is ranked as the third significant other problem in road maintenance with the value of RII=0.68.

Following these, the financial source for road maintenance is limited (only road fund), road users are not directly paying for roads, lack of interest by professionals to participate in road maintenance works and inadequate financing arrangements/ insufficient budget for road maintenance are the fourth, fifth and sixth significant other problems in road maintenance with the value of RII=0.65, 0.63, and 0.62 respectively.

According to the respondents of this category, people in power have little/no understanding of the importance of road maintenance is ranked as the least significant other problem in road maintenance with the value of RII=0.514.

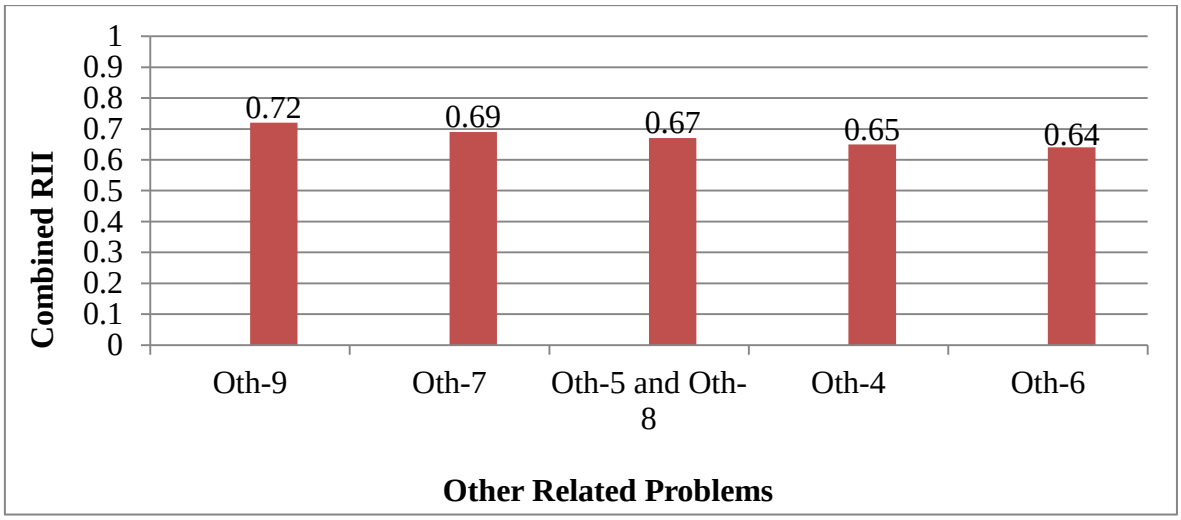

Figure 4.5: Combined RII and rank of the top 6 other problems

4.4.4.4 View of the Combined Result of Other Problems

As shown in table 4.21 above, the combined RII and Rank for each problem were analyzed by taking the responses of the overall respondents from the three parties. Accordingly, out of nine (9) identified other problems in road maintenance, the top six (6) problems with RII value greater than 0.64 are discussed and shown in figure above. Even though all the problems have the combined RII value of greater than 0.56, only the top six ranked problems are selected for discussions in order to focus on the most existing problems.

As shown in figure 4.5 above, based on the result of other problems, foreign contractors are not interested to participate in road maintenance and road maintenance has not been looked upon by universities as an intellectual subject have the RII value of 0.72 and 0.69, which shows that these two problems have a very high degree of significance in road maintenance.

Whereas the problems such as road users are not directly paying for roads, donors are not interested to fund road maintenance, the financial source for road maintenance is limited (only road fund), lack of interest by professionals to participate in road maintenance works have the RII value of between 0.63 and 0.69, which shows that the problems have a high degree of significance in road maintenance.

All of these problems were selected as significant and very significant by most of the respondents and therefore, they are the most significant other problems in road maintenance; hence, all the concerned bodies shall consider them in order to alleviate the mentioned problems and minimize the capital budget of road maintenance in city administrations.

4.5 Desk Study in South Oromia City Municipalities on Road Segments

Desk study was chosen as one of the instruments to assess and obtain actual data about the practices of road infrastructure asset management plan from relevant studies, data's and documents.

A desk study was conducted to assess the asset management plan of road infrastructure in South Oromia towns. During the desk study, the description of the road network, road condition of region, organizations of maintenance and road inventory have been studied. The data or information presented in this section has been gathered from the municipalities official website, archive (various reports, contract documents and other relevant documents), interviews with Engineers working in the RAM department of municipality.

4.5.1 Establishing of GIS Project to Implement AMP successfully in Shashemene City

Establishing a GIS operating environment is an important step that should be carried out for a city for the first time or an existing once to implement Asset Management Plan successfully. Shashemene city has outsourced a consultancy service of GIS based Infrastructure Asset Inventory and Management Plan with an open bid. Accordingly; Compass AEPED Consultancy Private limited company won the consulting service. The consulting firm has conducted detailed inventory of its assets using Geographic Information System (GIS) as platform. Consequently, the consulting firm created the GIS project in ArcGIS 10.7 software by establishing full geo-database of its assets.

4.5.2. The Relationship Between Spatial and Attribute Data

Data is stored in tables known as databases, and a blank table that provides a pre-defined list of columns that define the data to be collected is known as a template. The relationship for defining spatial data versus attribute data depends up on the technology that we apply for preparing Asset Management Plan. Geographic Information System (GIS) provides better platform for storing attribute data while the spatial data displayed as graphics in the display in the drawing window of specific GIS software. Geographic Information System is working in Relational Database Management System with various sequential query languages.

In short spatial data in Infrastructure Asset Inventory and Management Plan is the road center line, drainage line, pedestrian walkway and road median which are represented in polyline in feature geometry in GIS while the attribute data is the route id, node id, width of the road, surface material, deterioration type, condition assessment and year of construction that will be collected from the field survey in a city.

4.5.3 The Geo-Database Structure in Shashemene City

ArcGIS geo-database is a collection of geographic datasets of various types held in a common file system folder, or a multiuser relational DBMS (such as Oracle, Microsoft SQL Server, PostgreSQL, Informix, or IBM DB2). Geo-databases come in many sizes, have varying numbers of users and can scale from small; single-user databases built on files up to larger workgroup, department, and enterprise geo-databases accessed by many users (ESRI, 2015).There are three types of geo-database in ArcGIS. Namely

I. Personal Geo-database
II. File Geo-database
III. Arc-SDE Geo-database

The Shashemene AMP geo-database is designed in File Geo-database which has a Terabyte memory which allows various raster and vector data to be stored.

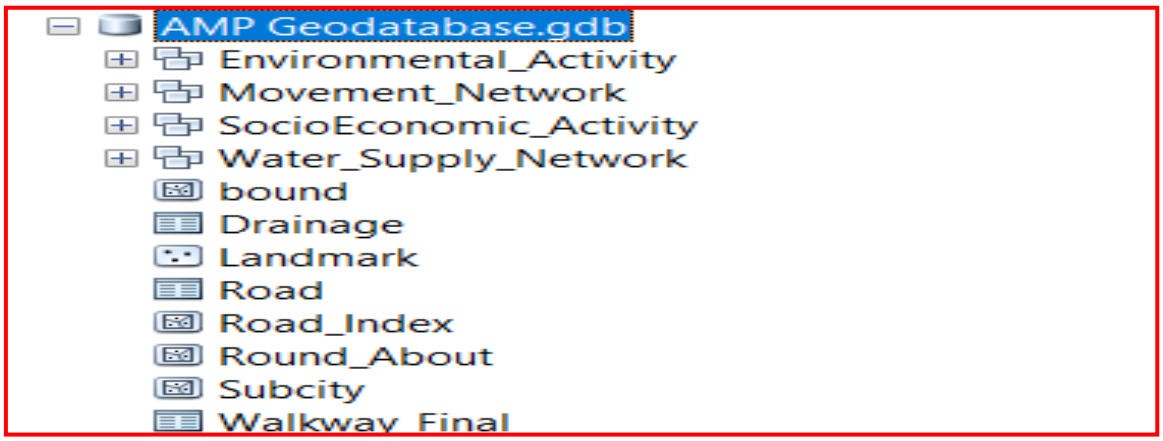

Figure 4.6: Shashemene AMP geo-database designed in ArcGIS 10.4.1 Software

The Shashemene AMP File Geo-database is structured in feature dataset, raster dataset, and feature class, and geo-database table. This helps the user to have a quick view of the data in Arc Catalog of ArcGIS and allow automatic calculation of length and area while you work in ArcGIS Geo-database. Moreover, the geo-database is structured using attribute domain and subtype. The logic behind organizing data in attribute domain is to set the permissible value of a field type or to constrain the value allowed for any particular attribute for a table, feature class or sub-type.

The attribute domain is sharing of the same attribute by different feature class. For instance, the general condition assessment of all asset categories is modeled (coded) as:1(Very Good), 2(Good), 3(Moderate),4(Poor) and 5(Severe) that is shared from the geo-database by all feature class of road, walkways, drainage, land sliding retaining and flood

controlling wall to describe the condition of the given infrastructure asset. So, the attribute domain enforces data integrity by maintaining common values to share same information that can be performed by different persons and different attributes of different feature class to share the same attribute so as to realize consistency, validity and integrity of data.

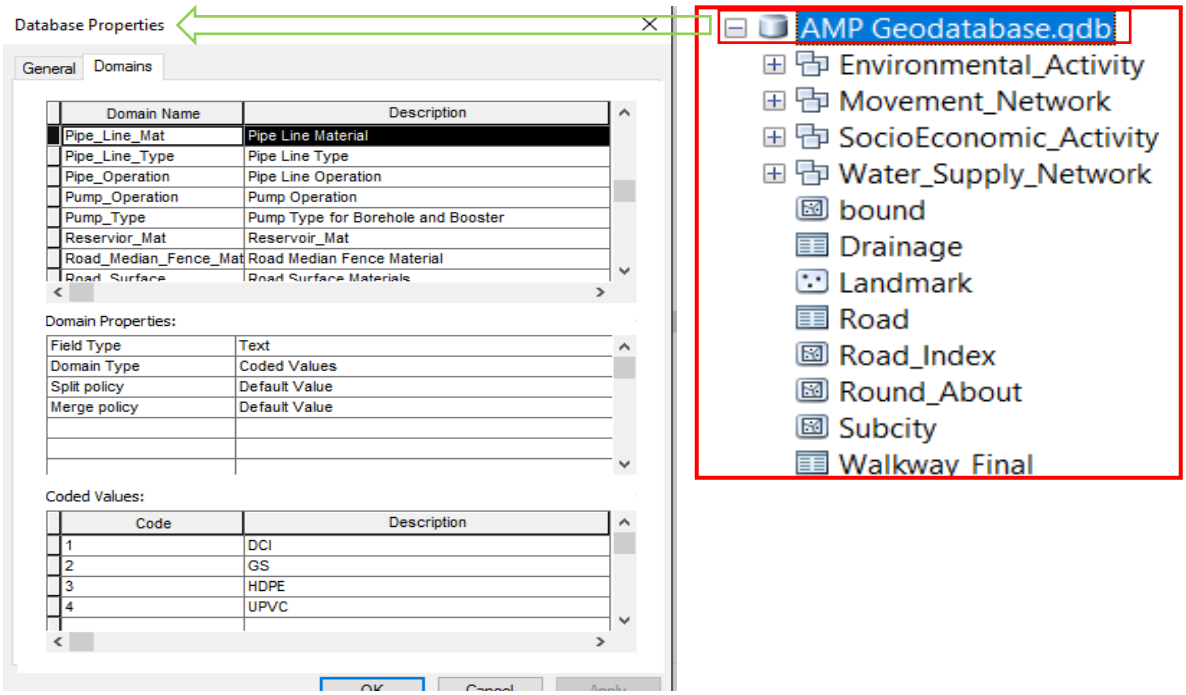

Figure 4.7: Attribute domain and subtype for Shashemene AMP geo-database

The AMP computer directory management system of Shashemene City has been prepared maintenance requirements and maintenance planning. These have been arranged in an integrated form (Folders, Geo-database, Feature Dataset, Feature Classes, and tables for viewing, manipulating, updating and analyzing spatial data. Besides, the directory also contains Microsoft Word format report, and ortho photo of the City.

The other important technology selection for this project is choice of the appropriate software. Arc Info ArcGIS 10.7 has been selected by the World Bank for Infrastructure Asset Inventory and Management Plan as ideal software for the preparation of Shashemene AMP. This software is the product of Environmental Systems Research Institute (ESRI, 2015 Redlands California USA) which is the most powerful GIS software for entertaining large database which are compatible in any database soft wares like SQL Server or Oracle and programming languages like C#, VB.Net, Python, and Java. Desktop ArcGIS 10.7 has a number of extensions for instance Linear Referencing, Spatial Analyst, Network Analyst, 3D Analyst, from the available extensions, Linear Referencing, Network Analyst and Spatial Analysis were chosen to perform the Asset Management Plan study of the city.

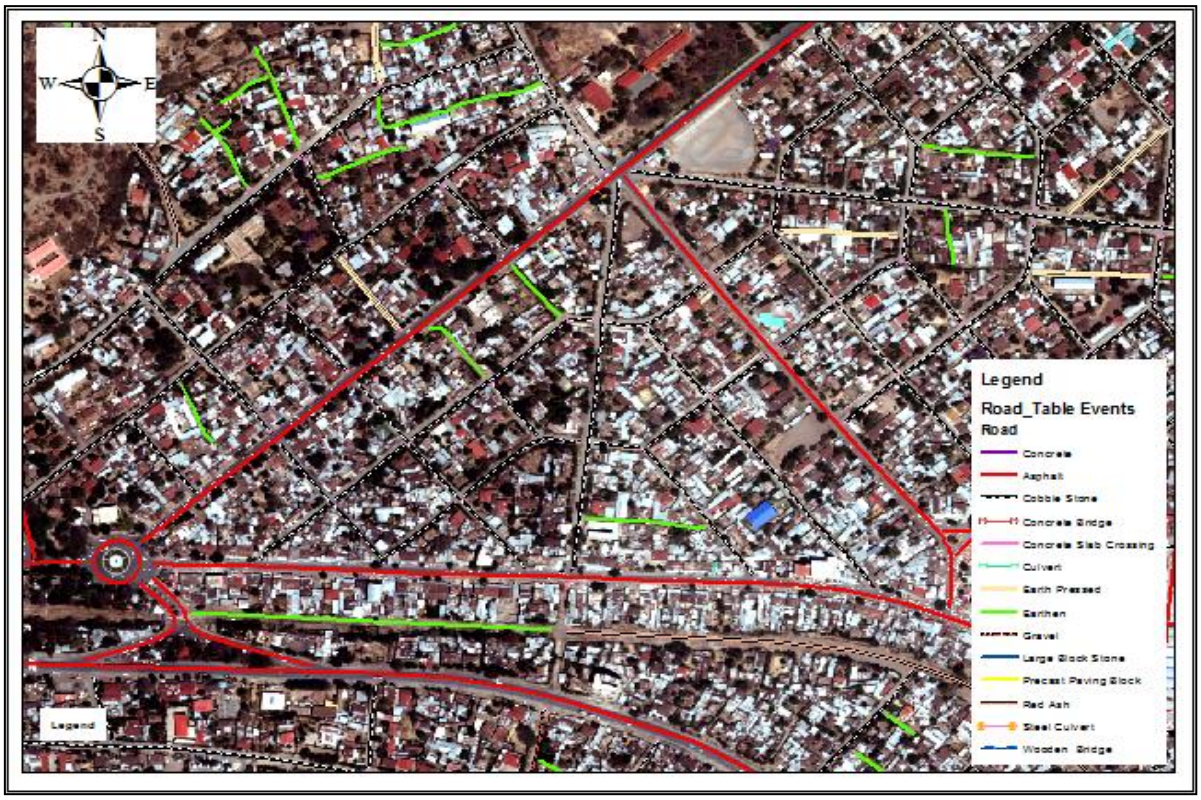

Figure 4.8: Event feature map of road asset done by the consulting firm in Shashemene

4.5.4 Establishing of GIS Project to Implement AMP successfully in Batu City

Asset Management is built on accurate data collection and the effective use of data to generate information that is underpin a decision-making process regarding the management of the city's physical assets. The new AMP manual is constructed on the basis that all data collected are stored in databases that are linked, interactively, with a Geographical Information System (GIS). This in turn means that the GIS provide the wider management framework for the Asset Management Plan (AMP).

When establishing a GIS project for the asset management plan in Arc GIS desktop, the project first needs to be established in the geo-database environment by creating a new folder in arc catalogue. Working in a geo-database environment, it is possible to enforce the legal value of a field type in order to enforce data integrity; control the validity of data entry; share common attributes; and provide range or coded domains for an attribute field. The basic component of the geo-database is the feature class. This is a homogeneous collection of common features each having the same spatial representation such as points, lines or polygons and a common set of attribute column.

4.5.5 The Database Structure for the Asset Management Plan in Batu City

The final step in building an integrated data structure for asset management is translating the given data collection activities into structured datasets capable of providing

information within the context of a GIS-based asset management system.

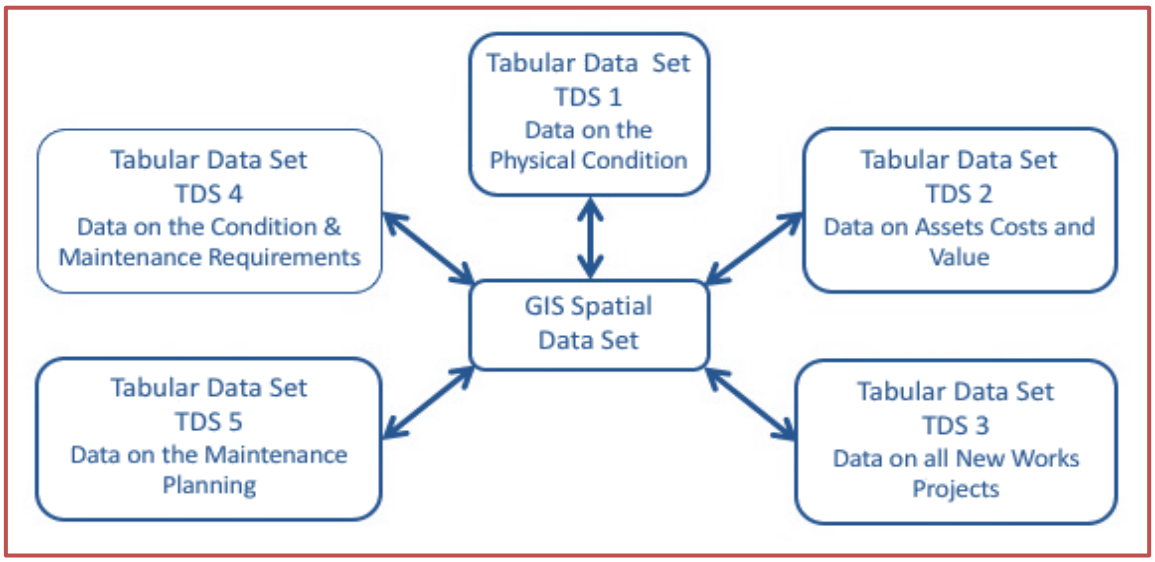

Figure 4.9: Relational diagram of the attribute databases used for the AMP

Table 4.22: list of feature classes in the city's AMP, allocated to 3 GIS feature type

Point Feature	**Line Feature**	**Polygon Feature**
Road furniture	Asphalt road	Paved area
Manhole	Cobblestone road	Roundabout
Pump	Gravel/ red ash road	Reservoir
Valve	Compacted earth road	Retention and detention ponds
Access box	Cycle path	Landfill site
Water meter	Footpath	Administrative boundary
Hydrant	Bridge	External site boundary
Customer connection	Culvert	Internal boundary
Communal standpipe	Retaining wall	Building and facility
Public and communal toilet	Drainage channel	
Bucket collection point	Pipe drainage	
Weigh bridge	Water pipeline network	
Solid waste container	River channel centre lin	

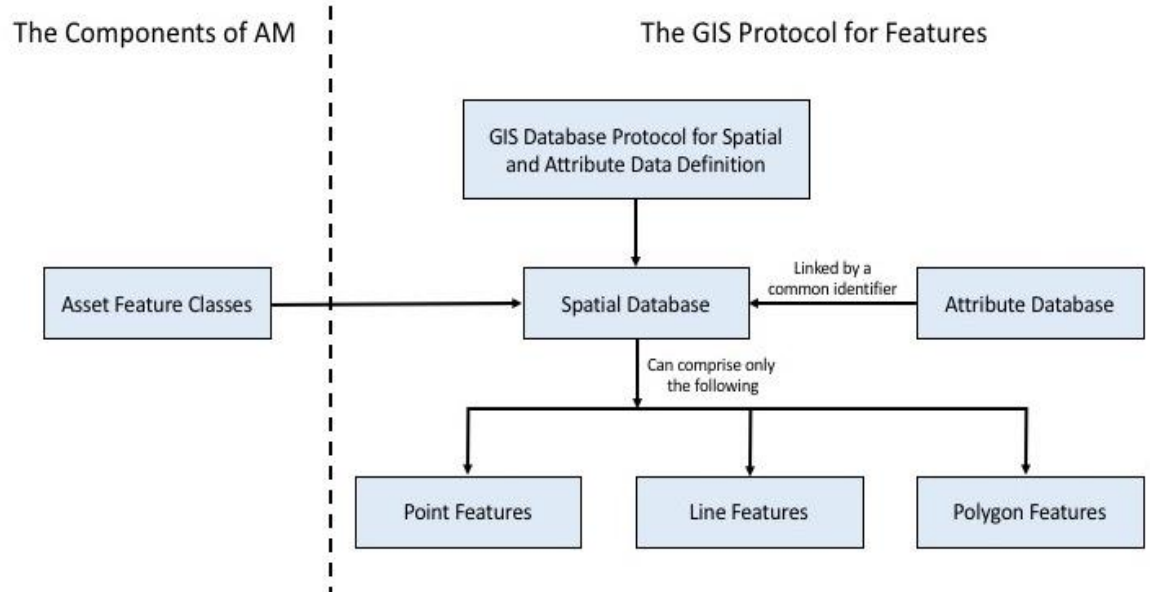

Figure 4.10: The Linkage between the feature classes and the GIS protocol

4.5.6 Establishing of GIS Operating Environment for the AMP of Yabello City

The spatial operating environment, which the consulting firm used for establishing the GIS assignment, is GIS and Specifically Dynamic Segmentation tool from Linear Referencing extension of Arc-GIS 10.5 software. This tool has many advantages which are due to versatility for data entry, management, updating, and analysis; and besides for water assets; the company used Network Analyst extension of Arc-GIS 10.5.

Linear Referencing (LR): is the method of storing geographic locations by using relative positions along a measured linear feature. Distance measures are used to locate events along the line. In most data models, linear features split at intersections where they connect with two or more line features and frequently also split where key attribute values change, such as a change in the road name.

Dynamic segmentation is the process of computing the map locations of events stored and managed in an event table using a linear referencing measurement system and displaying them on a map. The term dynamic segmentation is derived from the concept of line features need not be split (in other words, "segmented") each time an attribute value changes; then "dynamically" locate the segment. . In ArcGIS, the term route refers to any linear feature, such as a city street, highway, river, or pipe that has a unique identifier and a common measurement system along each linear feature. There are two primary data types that are used to implement linear referencing in ArcGIS: Route feature classes and Event tables.

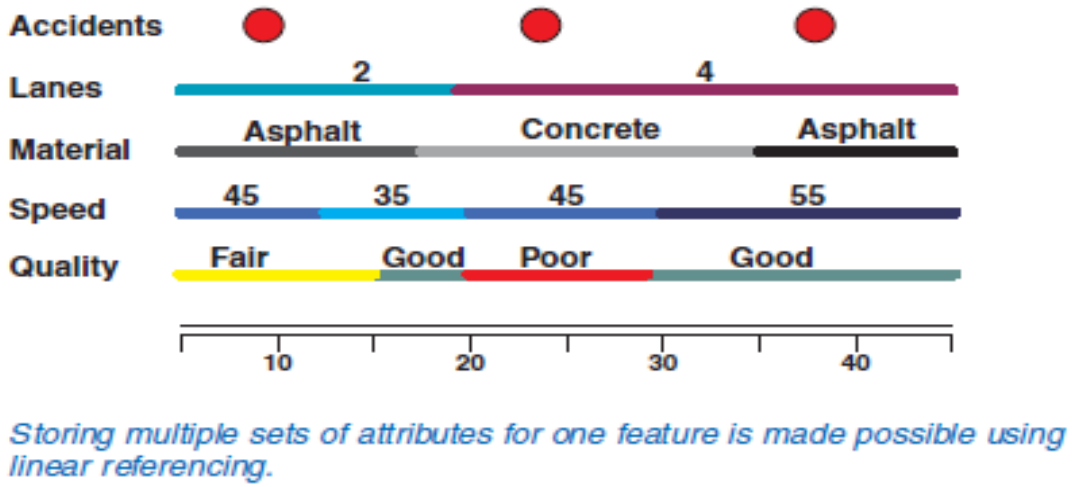

Figure 4.11: Storing multiple sets of attributes for a feature performed using LR

Using dynamic segmentation, events from event tables are located on line features in a route feature class.

Figure 4.12: Event feature map of table of road asset in Yabello city

4.5.6.1 The Yabello City Institutional Framework

The Asset Management Plan is prepared by a task team approved by city mayor, which is composed of experts from different sector. The official designation name of the AMP

group in the City is ‘‘The Yabello AMP Group’’. The AMP unit is situated in the separate office of the City which is known as ‘’ City UIIDP Technical Team Office’’.

The city administration has a UIIDP Coordinator which is under the City`s Manager Office and has eight major focal namely: Monitoring and Evaluation Expert, Procurement Expert, Public Finance Expert, Infrastructure Development Main Business Process, Capital Investment plan, Revenue Enhancement Plan, Infrastructures Asset Management Plan and Environmental and Social Safeguard Expert.

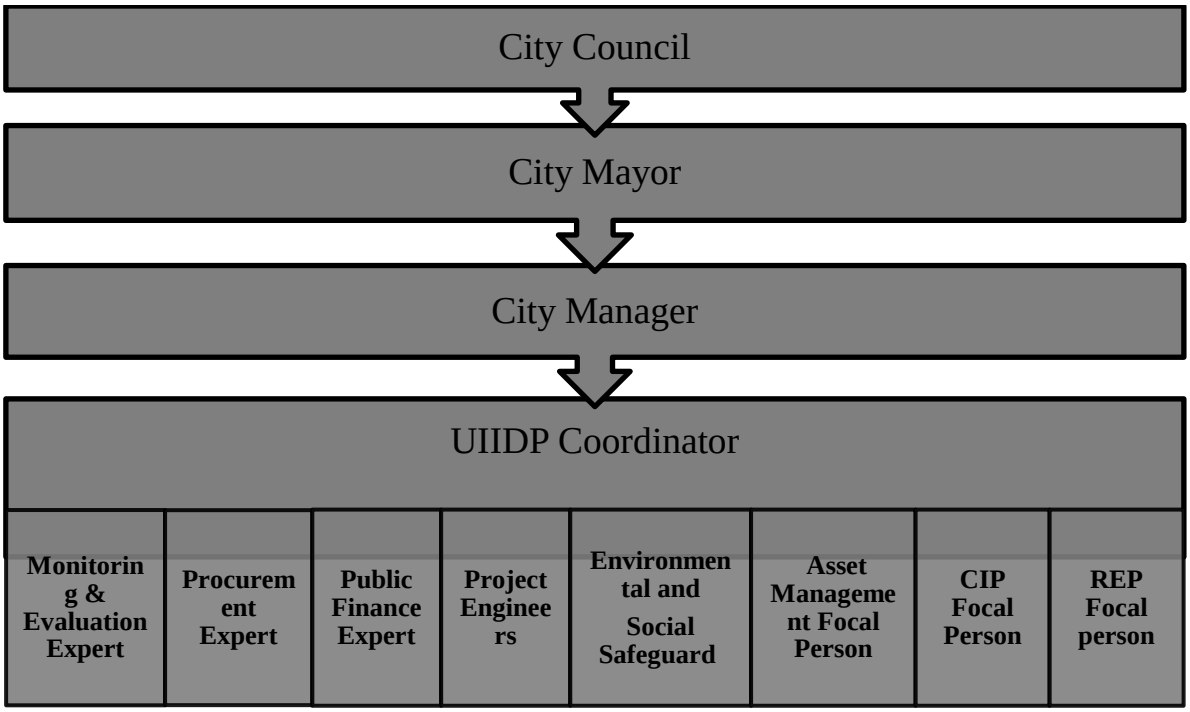

Figure 4.13: Organizational structure of the Yabello city

4.5.7 Establishing GIS Project to Implement Asset Management Plan in Negelle City

Establishing a GIS operating environment is an important step that should be carried out for a city for the first time or an existing once to implement Asset Management Plan successfully. Negelle city has outsourced a consultancy service of GIS based Infrastructure Asset Inventory and Management Plan with an open bid. Accordingly; Brave Consultants Private limited company won the consulting service. The consulting firm has conducted detailed inventory of Cities assets using Geographic Information System (GIS) as platform. Consequently, the consulting firm created the GIS project in ArcGIS 10.7 software and Microsoft SQL 2016 Software by establishing full interconnected geo-database System of the assets. ArcGIS 10.7.0 is the newly released GIS software from the ESRI suite of products which is full inclusive of all the functionalities of ArcGIS 9.x versions. It is seamlessly integrated in all platforms in ArcGIS for Server, ArcGIS for desktop and

ArcGIS for mobile with a support package from ESRI insurance company and Partners in the region. Thus, ArcGIS 10.7.0 is the recommended version for Asset Management Plan of Negelle.

4.5.7.1 GIS Protocol Used for the Asset Management Plan in Negelle City

Only a GIS is capable of meeting the requirements of spatial database and the attribute databases. Even with the condition assessment it is necessary to go further and specify a preference for particular GIS software, because each manufacturer was construct an internal relationship for the spatial data template in a different way. So, the software chosen as the platform for the GIS is ArcGIS, produced by the company ESRI. Within ESRI there is what can best be termed a protocol for spatial data, which is illustrated in figure below. This section deals with the top half of this diagram, which looks at the relationship between the spatial database and the attribute databases.

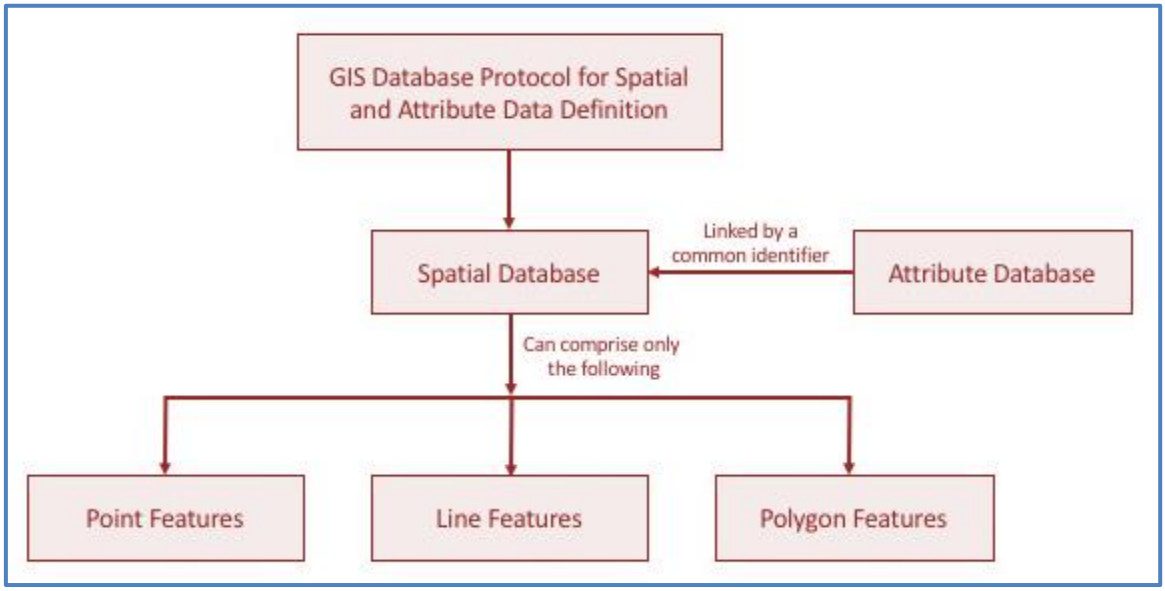

Figure 4.14: The GIS protocol of spatial data definition

4.5.7.2 Ensure the Image is Geo-Referenced and Link to the GIS of Negelle City

The city has already a base map in place. Using the base map, the Ortho Photo captured and geo-referencing was done by already established Ground Control Points and the alignment process built into the Arc-GIS software to match points on the image to the points on the ground that enabled ease of the map geo-referencing the digitized map.

The municipality of Negele should provide the AMP focal person with the computer hardware and software, together with an operational budget, that is enable the team to carry out their task. This includes:- A computer with a specification that is sufficiently powerful (in RAM, clock speed and storage capacity) for the task of running the GIS software, A computer monitors with a minimum screen size of 32 inches, A second computer for the

team, An external hard drive with a minimum storage capacity of 2TB, A printer, A copy of the latest version of Arc Info software, relational database software compatible with the GIS software and Supporting software such as documentation, spreadsheets.

Figure 4.15: Geo-referenced digitized road network of Negelle City

4.5.7.3 The Negelle City Institutional Framework

Currently Negelle city is one of the reform towns in the region and it has a city administration consisting of three kebeles. The critical importance of the asset management plan to the capital investment program, city administration has made a lot to build the implementation capacity of Infrastructure Service Delivery and Management Work Process departments with materials and manpower. In addition to this, the city has established a department called UIIDP coordination office which is equipped with Materials and technical staff, which is also responsible for building, road and maintaining the Asset Management Plan for infrastructure. The implementation strategy begins with the establishment of a sustainable institutional and organizational structure for the AMP within the city administration, which incorporates clearly defined roles and relationships for all parties involved with or contributing towards the AMP.

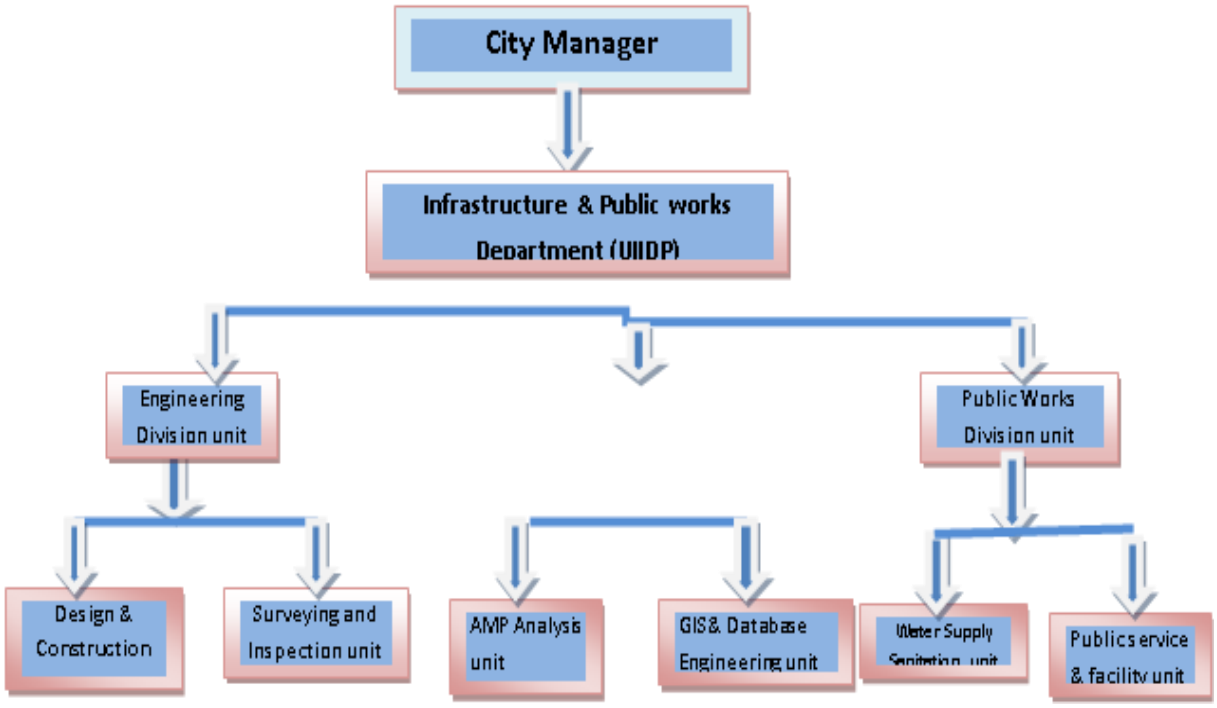

Figure 4.16: Organizational structure of the Negelle city

4.5.8 The Movement of Road Network in South Oromia Cities

4.5.8.1 Inventory of Road Networks in Shashemene City

Table 4.23: The extent of the shashemene city road network coverage

Service component	Unit of measurement	Quantity (to be provided)
Areas within the city boundary	Km^2	129.17
Total length of road (all surface types)	km	538.50
Equivalent (7m width) length of road	km	652.44
Total area within the road reserve	Km^2	7.96
Percentage of the city area occupied by the road reserve	%	6.16

According to the above table the infrastructure asset inventory result; there was a total length of about 652.44 Kilometers of road in Shashemene city urban boundary. This number includes the road network owned by the Ethiopian and Oromia Road Authority. The total area according the structure plan boundary of the city had an area of 129.17 kilometer square; of which the total area reserved for road network from the structural plan was 7.96 kilometer square with a total percentage of 6.16.

Table 4.24: The road asset category in Shashemene city

Feature Class (Road Surface Mat.)	Primary Road in km	Secondary Road in km	Collectors and Local Road in km	Total in km	Coverage %
Asphalt	42.87	12.25	6.12	**61.25**	**9.4%**
Cobble Stone	70.90	20.26	10.13	**101.28**	**15.5%**
Gravel	2.14	0.61	0.31	**3.06**	**0.5%**
Red Ash	73.40	20.97	10.49	**104.86**	**16.1%**
Large Block Stone	0.40	0.11	0.06	**0.57**	**0.1%**
Earth Pressed	27.43	7.84	3.92	**39.19**	**6.0%**
Earthen	239.61	68.46	34.23	**342.30**	**52.5%**
Total	**119.37**	**66.21**	**932.50**	**652.50**	**100.00%**

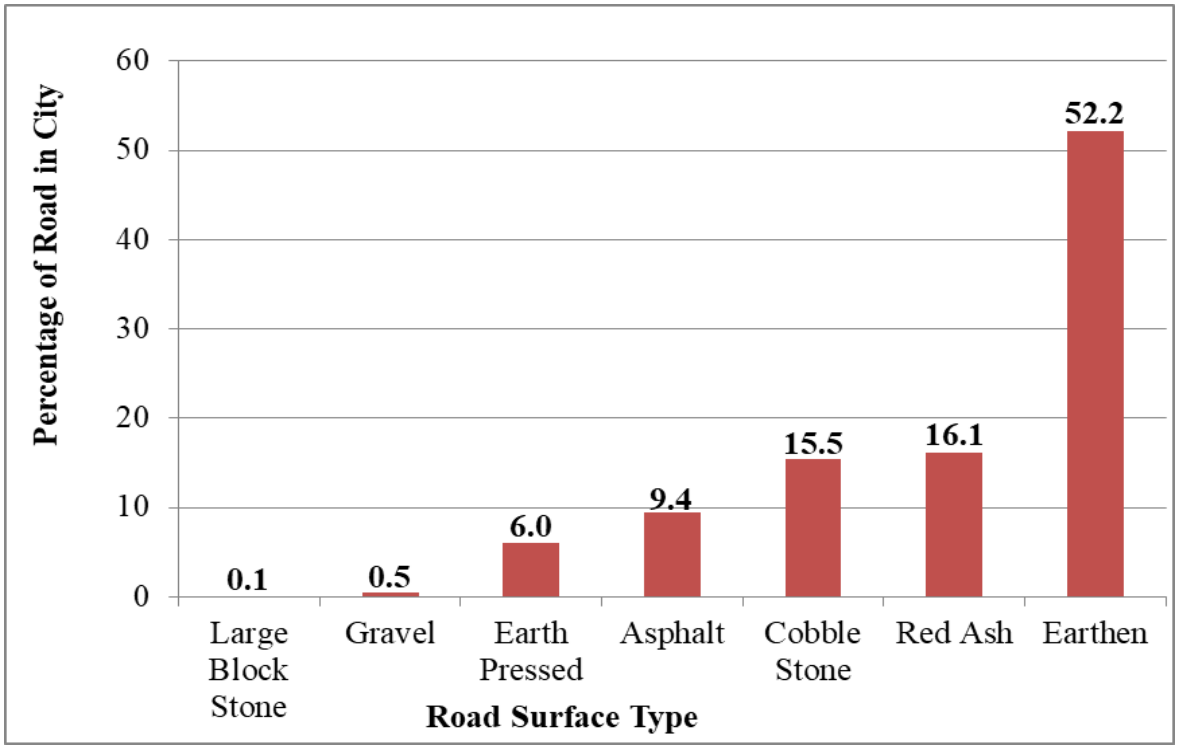

Figure 4.17: The percentage of road surface material coverage in Shashemene city

As indicated in the above figure the Infrastructure Asset Inventory of Shashemene City including ERA owned assets are further revealed that earthen road has the maximum coverage which accounted 342.296 kilometers (52.46%) followed by Red Ash Road which has a total length of 104.856 (16.07%) kilometers and while Cobble Stone roads and Asphalt (including ERA owned) has a total length of 101.284 Kilometers (15.52%) and 61.25 kilometers (9.4%) respectively.

4.5.8.2 Inventory of Pedestrian Walkways in Shashemene

Table 4.25: Inventory of pedestrian walkways in Shashemene city

Pedestrian Walkway Surface	PAS (Km)	SAS (Km)	CS (Km)	LS (Km)	Total	Coverage %
Asphalt	0.000	0.000	0.000	0.000	0.000	0.0%
Cobble Stone	5.260	0.096	5.924	25.854	37.133	74.3%
Terrazzo / Clay Tile	2.808	1.781	0.000	0.000	4.589	9.2%
Gravel	0.000	0.000	0.000	0.024	0.024	0.0%
Precast Paving Block	0.000	0.000	0.000	0.022	0.022	0.0%
Red Ash	8.212	0.000	0.000	0.015	8.227	16.5%
Total	**16.280**	**1.876**	**5.924**	**25.915**	**49.99**	**100.0%**

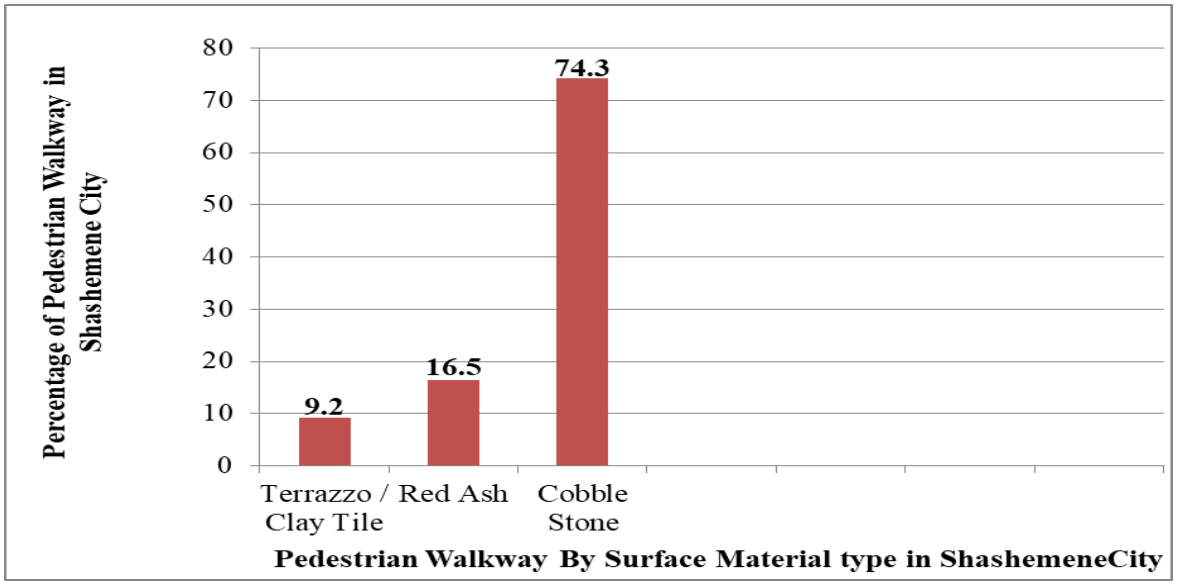

Figure 4.18: Inventory and percentage of pedestrian walkway by surface material type

Pedestrian Walkways has also been inventoried for the city of Shashemene. All pedestrian walkways have been changed in to 2.5 meter equivalent width to change in to kilometer length. The inventory result reveals that about 49.99 kilometer of the total pedestrian is surfaced with cobble stone followed by Red Ash and Terrazzo/Clay tiles which have a total length of 37.13(74.3%), 8.23(16.5%) and 4.59(9.2%) kilometer respectively. Besides, the result also revealed that from the total cobble stone; about 5.26 kilometer resides in primary road followed by Red Ash material of 8.21 kilometers on the same road hierarchy. The details Pedestrian surface types categorized based on road hierarchy are clearly depicted in the table above.

4.5.8.3 Inventory of Road Structures in shashemene City

Table 4.26: Road structure by road hierarchy in Shashemene city

Type	Primary Road in No.	Secondary Road in No.	Collectors Road in No.	Local Road in No.	Total Length	Coverage (%)
Bridge	13	4	3	19	39	16.18%
Concrete Culvert	60	15	37	86	199	82.16%
Steel Bridge				3	3	1.24%
Wooden Culvert				1	1	0.41%
Total	**73**	**19**	**40**	**109**	**241**	**100.00%**

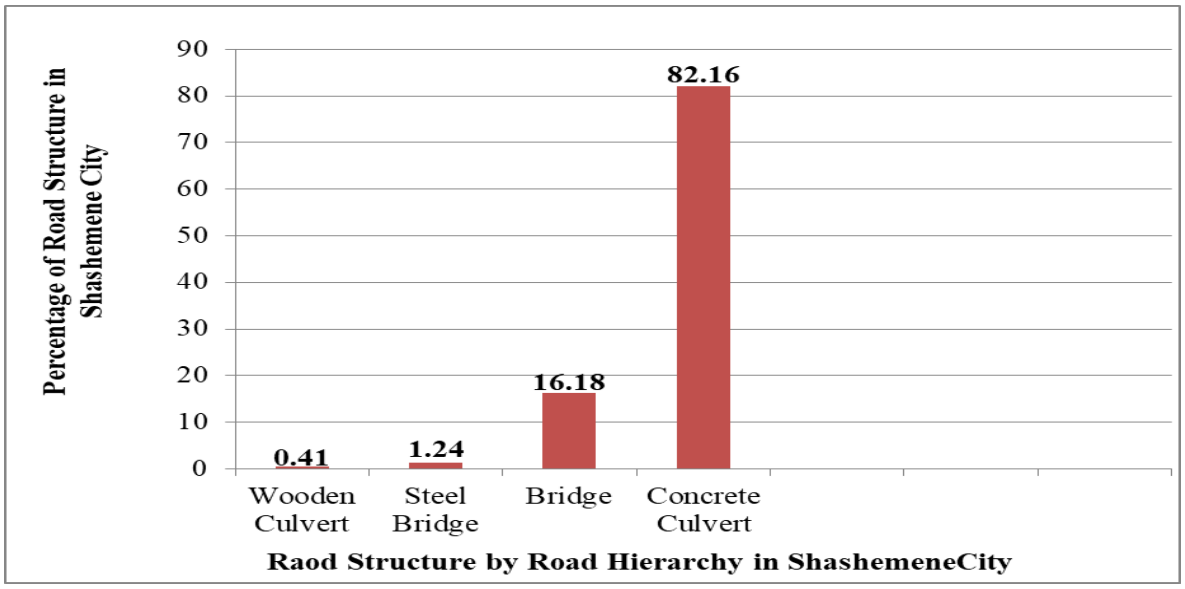

Figure 4.19: Inventory and percentage of road structures in Shashemene city

Road Structures include Bridge and Culvert is inventoried in this infrastructure asset inventory and management plan project. A total of 241 road structures including ERA owned are found within the city boundary. The city administration has a total of 42 bridges and 199 Culverts. The percentage of this road structures with respects to road hierarchy is summarized in the above figure.

4.5.8.4 Inventory of Road Median in Shashemene City

In the category of movement network about 6.465 km length of road median are inventoried with in the city boundary. In the inventory of road median, the number and type of the trees found within the median are also inventoried.

4.5.9 Inventory of Road Networks in Batu City

Table 4.27: The extent of the Batu city road network coverage

Service component	Unit of measurement	Quantity (to be provided)
Land areas within the city boundary	Km^2	20.58
Equivalent (7m width) length of road	Km	229.81
Total area within the road reserve	Km^2	1.61
Percentage of the city area occupied by the road reserve	%	7.82%

According to the infrastructure asset inventory result; there was a total length of about 229.81kilometers of road in Batu city urban boundary. This number includes the road network owned by the Ethiopian and Oromia Road Authority. The total area according the structure plan boundary of the city had an area of 20.58 kilometer square; of which the total area reserved for road network from the structural plan was 1.61 kilometer square with a total percentage of 7.82% as indicated in the above table.

Table 4.28: The Road asset category in Batu city

Road types of Surface	Primary Road (km)	Secondary Road (km)	Collectors and Local Road (km)	Total length(km)	Total Length (km)converted to 7m width	Coverage %
Asphalt	9.05	0	0	9.05	13.39	5.82%
Cobble Stone	3.21	15.58	19.23	38.02	71.48	31.05%
Gravel	2.61	5.87	23.54	32.03	55.12	23.94%
Red Ash	-	0.22	1.79	2.00	2.73	1.19%
Earthen	2.38	2.41	56.46	61.25	87.08	37.83%
Total	**17.26**	**24.07**	**101.02**	**142.36**	**229.81**	**100%**

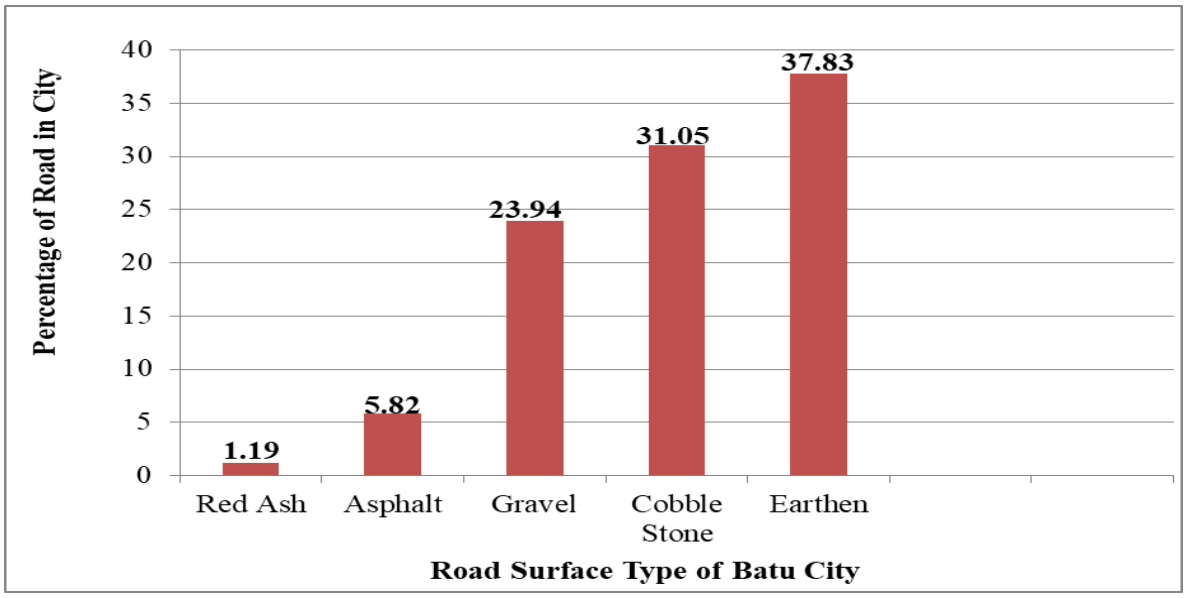

Figure 4.20: The Percentage of road surface material coverage in Batu city

As indicated in the above figure the infrastructure asset inventory of Batu City owned assets are further revealed that earthen road has the maximum coverage which accounted 87.08 kilometers (37.83%) followed by cobble stone road and gravel road which has a total length of 71.48 kilometers (31.05%) and 55.12 kilometers (23.94%), and while Asphalt (including ERA owned) and Red ash roads has a total length of 13.39 kilometer (5.82%) and 2.73 kilometers (1.19%) respectively.

4.5.9.1 Inventory of Pedestrian Walkways in Batu City

Table 4.29: Inventory of pedestrian walkways of Batu city

Pedestrian Walkway Material	Primary Road (km)	Secondary Road(km)	Local Road and Collector Street	Actual total length /km	Total Length equivalent to 3m width in km	Coverage %
Terrazzo with Cobble	1.86	0	0	1.86	3.10	10%
Cobble Stone	1.55	2.78	6.14	10.47	7.14	24%
Earthen	0.73	6.30	8.25	15.28	19.93	66%
Total	**4.14**	**9.09**	**14.38**	**27.61**	**30.17**	**100%**

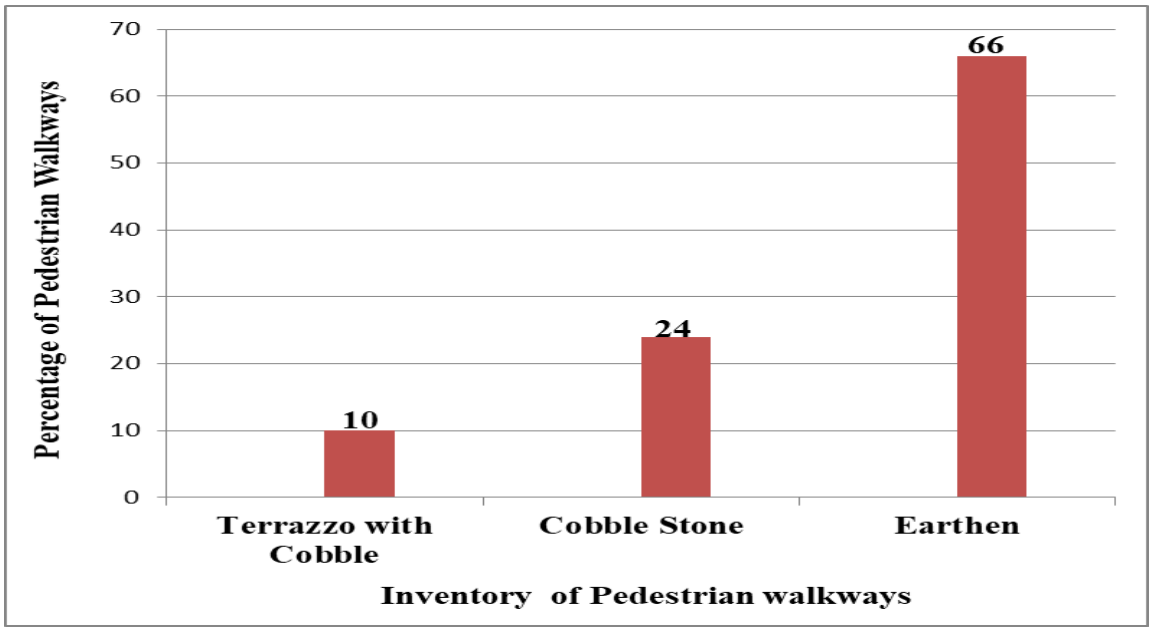

Figure 4.21: Inventory of pedestrian walkway by surface material type in Batu city

Pedestrian Walkways has also been inventoried for the city of Batu. All pedestrian walkways have been changed in to 3 meter equivalent width to change in to kilometer length. The inventory result reveals that about 30.17 kilometers of the total pedestrian is surfaced with Terrazzo with Cobble followed by Cobble Stone and earthen road which have a total length of 19.93(66%), 7.14(24%) and 3.10(10%) kilometers respectively.

4.5.9.2 Inventory of Road Structures in Batu City

Table 4.30: Inventory of road structure by road hierarchy

Road Structure	Unit	Culvert on Primary road in No	Culvert on Secondary road in No	Culvert on Collectors and Local Road in No	Percentage
Culvert	No	31	30	64	**1.25**
	M^2	638.60	879.70	1466.92	**29.85**

Road Structure Culvert is inventoried in this infrastructure asset inventory and management plan project. A total of 125 road structures owned are found within the city boundary. The city administration has a total of 125 Culverts. The percentage of this road structures with respects to road hierarchy is summarized in the above table.

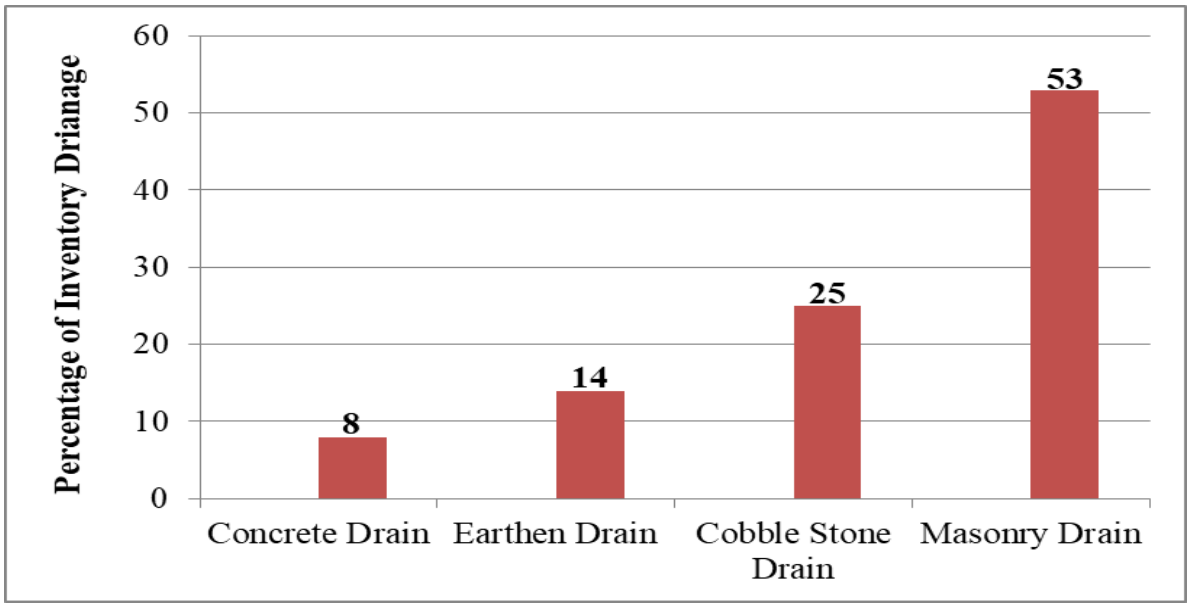

Figure 4.22: Percentage of drainage category by type of material in Batu city

The asset inventory result revealed that there is a total 44.6 kilometers of drainage line with an equivalent width of 1.5 meters in Batu City; of which about 23.50 Km of the drainage line is masonry drain; followed by cobble stone drain and earthen drain with a total length of 11.42 and 6.26 kilometers respectively. On the other hand; Concrete Line drain has a total length of 3.49 kilometers. In addition, along the drainage lines 15,310 ditch cover is inventoried and incorporated in the drainage data set. The full details of drainage network of the city categorized by their type and road hierarchy is fully illustrated in table above.

4.5.10 Inventory of Road Infrastructure Assets in Yabello City

Infrastructure Asset Inventory of Yabello has been compiled after a comprehensive inventory of all assets, carried out initially by building a set of vector layers in the GIS, using an Ortho-rectified aerial photograph of the city as the backdrop image and conducting detail inventory of infrastructure assets by surveying crew on the ground.

4.5.10.1 Inventory of Road Networks in Yabello City

According to the infrastructure asset inventory result; there was a total length of about 156.92 Kilometers of road in Yaballo city urban boundary. This number includes the road network owned by the Ethiopian and Oromia Road Authority. The total area according the structure plan boundary of the city had an area of 22.449 kilometer square; of which the total area reserved for road network from the structural plan was 1.098 kilometer square with a total percentage of 4.89.

Table 4.31: The extent of the city`s road network

Service component	Unit of measurement	Quantity (to be provided)
Land areas within the city boundary	Km^2	22.449
Equivalent (7m width) length of road	km	156.92
Total area within the road reserve	Km^2	1.098
Percentage of the city area occupied by the road reserve	%	4.89

Table 4.32: Road asset category of Yaballo city

Road type	Total length (Km)	Total Eqiv. 7m Length (Km)	Total number of Roads	Secondary Road (Km)	Collectors and Local Road (Km)	Percentage
Cobble Stone	3.724	5.046	31	0	5.046	**3.22**
Gravel road	2.796	5.134	9	5.109	0.025	**3.27**
Earthen	92.94	146.74	486	15.42	131.32	**93.51**
Total	**99.46**	**156.92**	**526**	**20.529**	**136.39**	**100**

The infrastructure asset inventory of Yaballo City owned assets are further revealed that earthen road has the maximum coverage which accounted 146.74 kilometers (93.51%) followed by cobble stone road which has a total length of 5.046 (3.22%) kilometers, gravel covers the total length 5.134 kilometers (3.27%) as shown in the above table.

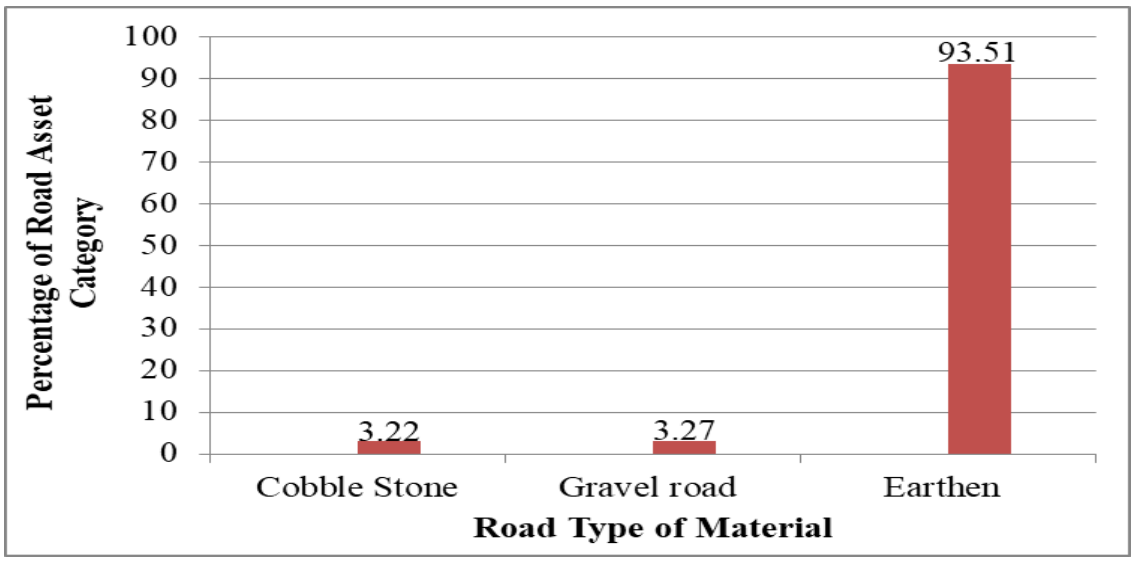

Figure 4.23: The percentage of road surface material coverage in Yabello city

4.5.10.2 Inventory of Road Structures in Yabello City

Road structures that include bridge and culvert are inventoried in Yaballo City infrastructure asset inventory and management plan project. The road crossing (Slab) structures which are found at the junction of roads and which has a short span with no defined structural components are also inventoried. The city administration has a total of road structures of which 19 are bridge structure, 30 are culverts .The locations of this road structures with respects to road hierarchy and the total inventory owned by the city administration is summarized in the table below.

Table 4.33: Inventory of road structure in Yabello city

Type	On Primary road in No.	On Secondary road in No.	On Collectors and Local Road in No.	Total in No.
Culvert	1	5	24	30
Bridge	5	2	12	19

4.5.10.3 Financial Forecast Consideration in Yabello City

The financial forecast for capital investment plan indicates that the fund for the proposed new work projects can be obtained from the city own revenue, regional grant, road fund and IDA matching fund. The forecasted own sources, regional, and external pledged financial sources would ensure that the proposed projects would be financed with minimum budget risks in the project period.

4.5.11 Inventory of Movement Network in Negelle City

4.5.11.1 The Extent of the City`s Road Network

According to the infrastructure asset inventory result; there was a total length of about 147.26 Kilometers of road in Negelle city urban boundary of which 141.19 kilometers belongs to the city administration and 6.07 kilometers belongs to the Ethiopian Road Authority. The total area according the structure plan boundary of the city had an area of 43.05-kilometer square; of which the total area reserved for road network from the structural plan was 1.44-kilometer square, which constitutes 3.4 % of the total area of the land.

Table 4.34: The extent of the Negelle city road network

Service component	Unit of measurement	Quantity (to be provided)
Land areas within the city boundary	km^2	43.05
Total length of road (all surface types)	km	147.203
Equivalent (7m width) length of road	km	206.354
Total area within the road reserve	km^2	1.44
Percentage of the city area occupied by the road reserve	%	3.4

The below table summarizes the road assets by type of surface finish material as well as standard width of roads, equivalent to 7-meter width. In terms of construction material, close observation and desk study at table below revealed that from the total length of all roads earthen natural road covers 112.95 Km (53.21%) followed gravel road with a total length of 47.95km, (24%) and the remaining 35.04Km (22.79%) of road Surface is paved with asphalt, cobble stone, large block, and earth pressed with the length of 10.86km (6.07%); 12.54 km(9.29%), 0.23km(0.45%) and 11.41km(6.98%) respectively.

Table 4.35: Negelle city road inventory by surface type and equivalent length

Road material type	Actual length/km	Acttual Area/km^2	Length of Road in km converted to 7m width	Coverage %
Asphalt Road	6.79	76.02	10.86	6.07%
Cobble stone	9.29	87.78	12.54	9.29%
Gravel	30.09	335.65	47.95	24%
Large Block	0.45	1.61	0.23	0.45%
Earth Pressed	6.98	79.87	11.41	6.98%
Earth Natural	87.52	790.65	112.95	53.21%
Total	**141.13**	**1,371.58**	**195.95**	**100%**

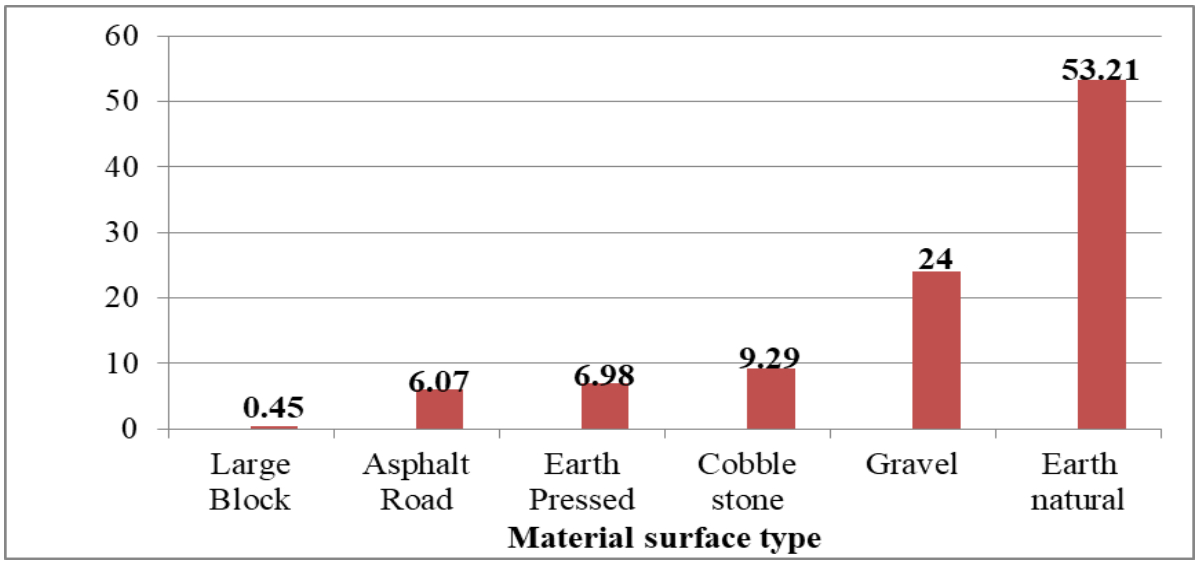

Figure 4.24: Percentage of road coverage by surface material in Negelle city

4.5.11.2 Inventory of Road Structures in Negelle Borena

Road Structures that include Bridge and Culvert are inventoried in the city infrastructure asset inventory and management plan project during site observation and desk study. According to the data obtained during the site observation; there were 8 bridges in the city. Totally 23 under road cross culverts are registered with the total length of 286 meter; Out of this length 22 % of culverts are constructed with concrete pipe culvert, and the largest portion 78 % of culverts are constructed with concrete box culvert.

Table 4.36: Inventory of road structures in Negelle city

Culvert type	Number	Length	Area/m^2
Box Culvert	18	229	818.44
Pipe Culvert	5	57	221.8
Total	**23**	**286**	**1040**
Bridge type	Number	Length	Area/m2
Steel Bridge	1	50	125
Concrete Bridge	7	100	942.05
Total	**8**	**150**	**1067.05**

4.5.11.3 Inventory of Pedestrian Walkway in Negelle City

Table 4.37: Coverage of pedestrian walkway by surface material

Material type	Actual length/km	Acttual Area/m^2	Length of Pedestrian walkways in km converted to 3m width	Coverage %
Terrazo Tile	4.02	4,023.14	1.34	**19.76%**
Concrete	2.10	4,091.48	1.36	**20.1%**
Cobble Stone	3.74	3,641.21	1.21	**17.84%**
Earthen	6.77	8,584.88	2.86	**42.2%**
Total	**16.63**	**20,340.71**	**6.78**	**100%**

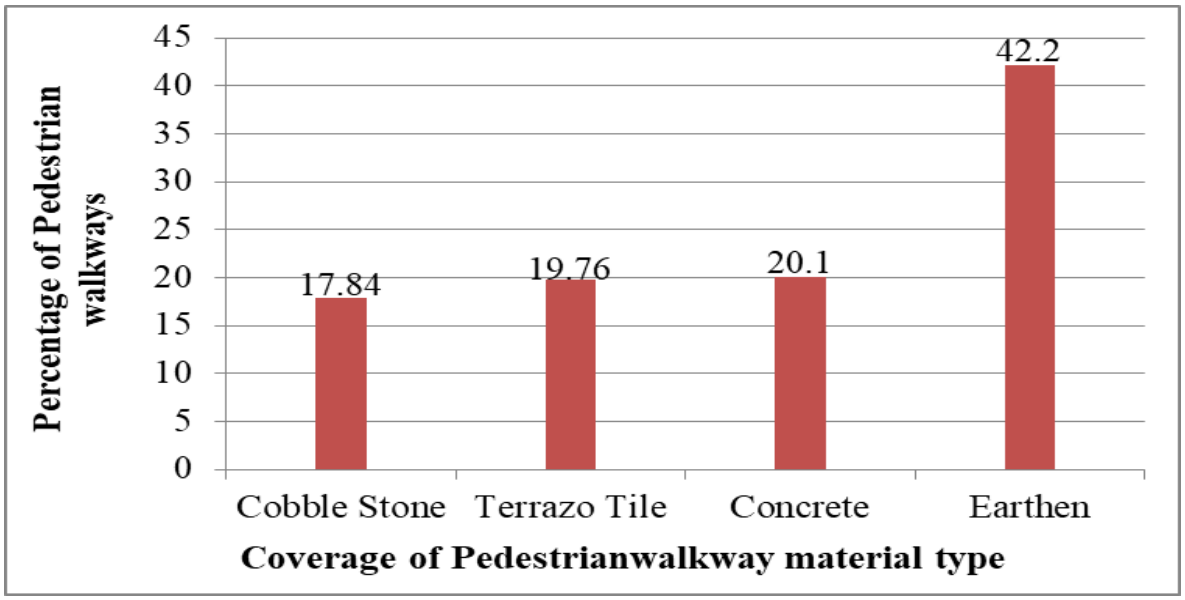

Figure 4.25: Pedestrian walkway by surface type and length in percentage

The municipal Pedestrian walkway network consists of, Concrete, Terrazzo Tile, Earthen and cobble stone pedestrian walkway surfaces. The Pedestrian walkway network is a total of 6.78 kilometers in length, with a standard width of 3 meters.

The above figure summarizes the pedestrian walkway network by type of surface finish material as well as standard width of roads, equivalent to 3-meter width. In terms of construction material, close observation at table above revealed that from the total length of all roads earthen natural road covers 2.86Km (42.2%) followed concrete road with a total length of 1.36 (20.1%) and the remaining 2.55Km (37.6%) of road Surface is with terrazzo tile, cobble stone with the length of 1.34 km (19.76%); 1.21km (17.84%) respectively.

The municipals' Drainage Network consists of, concrete, Masonry, Concrete Pipe, and

Earthen drainage lines. The length of drainage network is 32.25 kilometers in length, and 14.53 Km with a standard width of 1.5 meters and 16.25(54.92%) Km of the drainage line is open masonry drainage; followed by closed masonry drainage and open earthen drainage with a total length of 11.72 (33.31%) and 2.01(6.68%) kilometers respectively. On the other hand; cobble stone drain and curb stone drain line drainage has a total length of 2.27 kilometers.

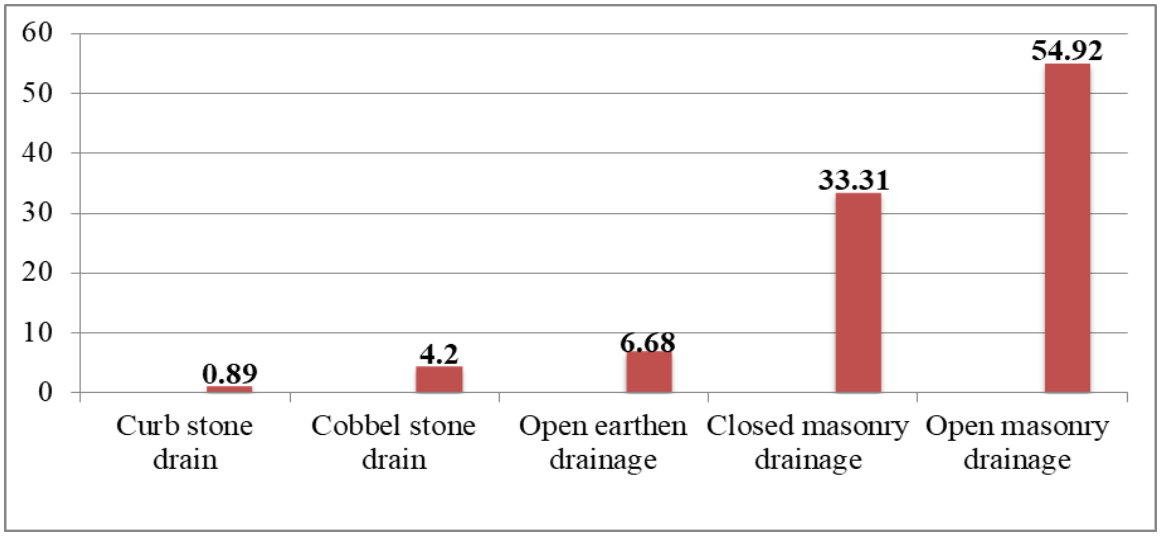

Figure 4.26: Percentage of drainage network inventory by material type in Negelle city

4.5.12 Summary of Financial Forecast Consideration for all Road District

The financial forecast for capital investment plan indicates that the fund for the proposed new work projects can be obtained from the city own revenue, regional contribution (30 %) of (ULGDP II + UIIDP), road fund and IDA Performance Grant (ULGDP II + UIIDP)matching fund. The forecasted own sources, regional, and external pledged financial sources would ensure that the proposed projects would be financed with minimum budget risks in the project period.

4.6 Interview with the Experts from Office of Asset Management Plan (AMP)

The main research methodology for this study is through a structured questionnaire, which targeted the population from the three main contracting parties having direct involvement in road maintenance projects of city administrations. Hence, it is crucial to obtain the perceptions on the finding of the study. Thus, the interview was focused on the engineering department of the office, namely the planning and technical Directorate. Seven interviewees having different positions under the aforementioned directorate were interviewed and their socio-demography is shown in Table below.

Table 4.38: Socio-demography of interviewees

Position	No of interviewee	Educational Status	Field of specialization	Years of experience in road sector
UIIDP Coordinator	1	BSc	Civil Engineer	10 to 15 years
Design and contract administration	1	BSc	Civil Engineer	Above 15 years
Surveyors	1	Diploma	Surveying	5 to 10 years
Senior Engineer	1	BSc	Civil Engineer	Around 12 years
RAMP data base directorate director	1	BSc	Computer SC.	5 to 10 years

The aforementioned interviewees have been interviewed the following seven questions based on the finding of the desk study collected from the documents, stored file, questionnaires, paper format and the responses are also presented under each question.

4.6.1 The Data Management mechanism followed by Sector

According to interview made with road asset management data base directorate director, the data management in road sector since 2006 to 2008 is done as follows: - data collected in paper format converted into Excel sheet and stored. The same answer is given by the UIIDP coordinator who made an interview with the researcher. However, as the UIIDP coordinator response the ten steps of Asset Management Plan operational manual prepared by the Ministry of Urban Development and Housing published in June, 2016.

The Asset Management Plan of City is designed and managed using ArcGIS 10.7 software after a comprehensive geo-database. This comprehensive geo-database is named “City AMP Geo-database” which is organized in Feature Dataset, Feature Class and Geo database table. The data management of AMP has been prepared after conducting detailed inventory of the City`s Assets using high resolution Ortho-photo as a base map.

4.6.2 Data Integration of Road Asset Management System

According to the Road Asset Management Directorate Director, the organization has neither applied asset management integration software nor individual management systems until the period of the interview. But according to the interview with the team leaders the organization is developing a model called Kyoto Model with Japanese government cooperation called (Jica). There is also planning to integrate those models developed by Jica which are in separate asset management data bases. Now days the city administration

use ArcGIS 10.7 and Arc-GIS 10.5 software related functionalities alternatively to be incorporated in the databases as external software that enhances the analytical and reporting capabilities of the system.

4.6.3 Data used to Prioritize Projects

The next question forwarded to the interviewees was to rate the importance of identified roadway assets for selection in respect of location, Attributes/characteristics, structural condition, functional condition, initial agency costs, life-cycle costs, usage and customer or user feedback. The UIIDP coordinator pointed out that the project selection between two projects is made mostly based on location, structural condition, budget and functional condition. Whereas the Asset Management Directorate Director informed that the most important factors are location, structural and functional condition. A project which has economic, political and social impact was given priority. For example if the road from bus station to city administration has 5 potholes where as the road from bus station to other place late say to abosto has 10 potholes, the priority is given to the former rather than to the latter because of its political use. Similarly, the roads around market area get priority because of economical influence. Generally location is ranked first because political and economic importance. The results confirm to common sense, personal judgments and also show that the responding officials had predominantly the same perception of the data that would prioritize project selection between different assets.

4.6.4 Decision made to go for Rehabilitation or Maintenance Finance

According to UIIDP coordinator and the Data base Directorate Director there is no explicit way of analyzing alternatives and get a decision based on scientific way of analysis like life cycle cost. As discussed, and presented by senior engineer assets that need rehabilitation and or replacement are identified from the condition assessments. In parallel the financial requirement for rehabilitation is forecasted. The total forecasted funding needs to restore and replace severely deteriorated assets is estimated and all rehabilitation projects by activity area is identified based on project activities.

Ensuring promoting equity to the local community, strengthen and promoting the urban local socioeconomic development, environmental consideration and attracting investments has been some of the major evaluating criteria of rehabilitation or new works. The appraised new works project proposals are then again ranked by priority based on the funding capacity of the municipality. The financial forecast for capital investment plan indicates that the fund for the proposed new work projects can be obtained from the city

own revenue, regional grant, road fund and IDA matching fund. The forecasted own sources, regional, and external pledged financial sources would ensure that the proposed projects would be financed with minimum budget risks in the project period.

The role of maintenance to ensure proper functioning of the urban economy and social system cannot be over emphasized. Maintenance has very important bearing on both the physical and economic lives and performance of infrastructure and urban facilities. According to the revised AMP manual, a maximum maintenance budget of 20% of the 10% of CIP budget would be allocated to routine and periodic maintenance and the rest 80% would be allocated to the maintenance backlog. Irrespective of this, the maintenance budget can cover all the maintenance backlogs of the city with in the three year if proper implementation can be applied.

4.6.5 Economic Evaluation Analysis Method to Evaluate Road Maintenance

According to UIIDP coordinator along with development efforts to increase investments in infrastructure and vital urban elements; the cities expected to strive to establish a sustained short to long-term programs of investment in maintenance. There are many ways and techniques to value the municipal assets. As per the AMP manual and international practices the valuation of infrastructure assets employed is based on the calculation of the current replacement cost (CRC) and Depreciated Replacement Cost (DRC).

Valuation analysis plays an important role in enabling reporting of the physical condition of the city assets in monetary terms. The valuation of the city assets is based on the calculation of DRC (Depreciated Replacement Cost). Furthermore, applying depreciated replacement cost (DRC) to estimate current value of the city assets is a common international practice and recommended by the revised AMP manual.

DRC is based on current replacement cost of assets less an allowance for deterioration of condition to date, and based on the fraction of remaining useful life over expected useful life. So DRC is thus simply computed as the ratio of the remaining useful life to the expected useful life as a percentage of current replacement cost.

4.6.6 Reports on Road Maintenance Activities

All of the interviewees have agreed and revealed the following reasons: The evidence shows that adoption of sound asset management principles as the basis for technical and management decisions improve road network performance. The report does not provide detailed guidance but describes the importance of taking a long term view of road maintenance focusing on:

- Establishing appropriate levels of service for different parts of the road based on the social, environmental and economic need.
- Understanding the extent and nature of the road and the demands on its use by operating appropriate management systems;
- Understanding all direct and indirect costs of network operation and maintenance is needed; with appropriate use of prediction models required
- Audit and reporting of maintenance and management operations, to generate a cycle of continuous improvement
- Effective maintenance programming using robust and formal design and decision making processes, based on regular monitoring and reporting.

4.6.7 Annual Visual Condition Assessment Surveys

Road condition surveys must be undertaken annually with the method recommended for adoption being based on the conventional visual inspection described in the technical methods of road categories. According to the method defects observed on 5 km road segments are rated on a scale of 1 to 5 according to their degree and extent, with degree representing severity of the defect, and extent estimating the quantity or magnitude of the defect. The defects that are assessed include gravel loss, usable road width, erosion of the carriageway, and erosion of the side drains, potholes, corrugations, rutting and impassability.

All of the interviewees have agreed and revealed the following reasons for the question of Does your organization carry out annual visual condition assessment surveys for carriageways, shoulders of gravel, earth roads and cobblestone?

Yes ( ) No ( ) I don't know ( )

- All roads shall be subjected to routine maintenance on an annual basis
- A factor of 1.5 shall be applied to cater for spot improvements and emergency works
- Only roads that are in fair condition shall be candidates for periodic maintenance
- The agency will undertake periodic maintenance on 100% of the roads indicating Fair condition
- The agency shall, on a yearly basis, rehabilitate 50% of the roads in poor condition
- The agency shall, on a yearly basis, reconstruct 50% of roads in very Poor condition on a yearly basis, funds shall be sought to upgrade 20% of the earth roads

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study points out the general approach of condition assessment and maintenance forecast method of road infrastructure asset management plan. The study is not limited to determine the physical condition rating of road components by using asset condition index (ACI); it extends to identify existing problems of road maintenance. Besides, the study is focused on the assessment of the establishment of GIS based infrastructure asset inventory database structure to implement asset management plan successfully.

Accordingly, the physical condition rating of road components by using asset condition index (ACI) , several maintenance problems under four categories (namely client-related problems, consultant-related problems, contractor-related problems and other problems) and assessment of the establishment of GIS based infrastructure asset are identified based on the questionnaires, review of literature and the discussions made with the professionals in the sector. Thus, the following conclusions have been made based on the study of this research.

1) The conclusions made on the physical condition rating of road components by using asset condition index (ACI)

- According to road condition indicators, the concrete and steel bridge condition is excellent with the value of ACI=88.57%; which repaired with normal maintenance procedure and the component is either new or has recently been maintained, does not exhibit any signs of deterioration.
- Cobblestones road condition is good with the value of ACI=83.93%; which repaired with normal maintenance procedure and this result reflects general surface and voids between each cobbles are washed out due to rains.
- According to road condition indicators, the asphalt road condition is good; which repaired with normal maintenance procedure.
- The condition assessment of earth work or formation is 60% which is categorized in moderate scale. Accordingly, the inventory result revealed that from the total earth work about 40% of the surface area has been deteriorated and small areas of coverage can be repaired with hand held compactors.

2) The conclusions made on the several maintenance problems based on the four categories (namely client-related problems, consultant-related problems, contractor-related problems and other problems).

- Sixteen (16) client-related problems on road maintenance are identified and the top ten (10) ranked problems are acknowledged as the most significant problems in road maintenance and need due attention from the client (municipalities). Among these problems, the top three problems such as lack of effective budget (allocated budget is not consumed effectively), not advocating Public Private Partnership (PPP) in road maintenance and insufficient road condition survey with lack of appropriate project prioritization mechanism and critical attention to enhance sustainable and effective road maintenance in the region.
- Fifteen (15) consultant-related problems on road maintenance are identified and the top six (6) ranked problems are acknowledged as the most significant problems in road maintenance and need due attention from the consultants. Among these problems, the top three problems such as insufficient data collection and condition survey before road maintenance, quality assurance/control problems and poor monitoring and controlling and critical attention to enhance sustainable and effective road maintenance.
- Eighteen (18) contractor-related problems on road maintenance are identified and the top eight (8) ranked problems are acknowledged as the most significant problems in road maintenance and need due attention from the contractors. Among these problems, the top three problems such as Poor labour supply and productivity, poor communication and coordination of the contractor with other parties and high turnover of contractor's staff should require critical attention to enhance sustainable and effective road maintenance.
- Nine (9) other problems on road maintenance are identified and the top six (6) ranked problems are acknowledged as the most significant problems in road maintenance and need due attention from the concerned bodies. Among these problems, the top three problems such as foreign contractors are not interested to participate in road maintenance, road maintenance has not been looked upon by universities as an intellectual subject and road users are not directly paying for roads required critical attention to enhance sustainable and effective road maintenance in Ethiopia.
- The least ranked problems under each category have a low degree of significance on road maintenance as compared to the top-ranked problems, so there is no need of focus on them from the concerned bodies as significance problem.

3) The financial forecast for capital investment plan in all municipalities indicate that the fund for the proposed new work projects can be obtained from the city own revenue, regional grant, road fund and IDA matching fund. The forecasted own sources, regional, and external pledged financial sources would ensure that the proposed projects would be

financed with minimum budget risks in the project period.

4) The Asset Management Plan of Cities designed and managed using ArcGIS 10.7 and Arc-GIS 10.5 software related functionalities alternatively to be incorporated in the databases as external software that enhances the analytical and reporting capabilities of the system after a comprehensive geo-database.

5.2 Recommendations

Based on the finding of the study, the following general recommendations are forwarded to the main stakeholders or parties to minimize the problems and to have proper road maintenance in the municipalities.

- The client (Municipality) is recommended to give all due attention towards the most significant existing client-related problems in road maintenance while undertaking any road maintenance in order to alleviate the problems and implement an effective strategy to minimize the capital budget of road maintenance on road function. The client is also recommended to support, aware, guide and enforce other stakeholders to give all due attention to their problems.
- The consultants are recommended to give all due attention towards the most significant existing consultant-related problems in road maintenance while undertaking any road maintenance in order to alleviate the problems and minimize the budget of road maintenance.
- The contractors are recommended to give all due attention towards the most significant (acknowledged) contractor-related problems in road maintenance while undertaking any road maintenance in order to alleviate the problems and to minimize the degradation of road components.
- Data collection methods should be done based on international experience, individual management systems data need and standard automated equipment's need to be used to analyze the severity of the deterioration.
- Higher educational institutions need to be established in Ethiopia regarding Asset Management Plan and accordingly courses should be offered at undergraduate and graduate levels; to produce competent and qualified professionals in area.

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APPENDICES

Appendix 1: Letter of Transmittal

Adama Science and Technology University

School Of Civil Engineering and Architecture

Department Of Civil Engineering

To Whom It May Concern

Dear Respondents,

Re: Seifu Tadesse

This is to confirm that the above named is a student at the university of Adama Science and Technology; school of Civil Engineering And Architecture, Department of Civil Engineering (Specialization in Construction Engineering and Management) pursuing of course leading to the award of master of Engineering in Construction Engineering and Management. The purpose of this letter is to request you to kindly participate in this research by filling the attached questionnaire's as accurately as you can. I seek your understanding and assistance in this study.

You are kindly requested to contribute to this research work by completing this questionnaire and providing reliable information for the quality of the research work. The identity of the respondent and that of the company you represent shall remain confidential and all data found from the survey will only be used for an academic purpose. I would like to extend my gratitude for taking your precious time to respond to this questionnaire. If you have any inquiry, please contact me through the following addresses.

Seifu Tadesse

Mobile: **-251+913251585**

Email**: seifu59@gmail.com**

Yours Sincerely!

APPENDIX 2: Research Questionnaire

SECTION I: Respondents' Profile: (Please tick the appropriate box (√).

1) Which of the following best describes your position in the organization/company?

Client ( ) Consultant ( ) Contractor ( ) if others specify_____

2) State the number of years of experience of your company has in road maintenance projects (for consultants & contractors).

0-5 ( ) 5-10 ( ) 10-15 ( ) more than 15 ( )

3) Which one best describes your age bracket?

20 – 29 years ( ) 30 – 39 years ( ) 40– 49years ( ) Over 50 years ( )

4) Please indicate the level of your education?

Diploma ( ) Bachelor's degree ( ) Masters ( ) PHD ( )

Others (Please specify)……

SECTION II: To determine the condition assessment of road components by using asset condition index (ACI).

Element: Road inventory and Physical Condition Assessment Method

5) From your experience, please express your opinion on the identification and description of degradation symptoms to determine the physical condition assessment of road components including inventory, condition data and availability of data to the researcher based on the associated numbers given below. (Please tick the appropriate box (√).

1= Very Low 2= Low 3= Moderate 4= High 5= Very High

Road Components	**Degradation Symptoms to Consider When Selecting Condition Rating**	1	2	3	4	5
Earth work or Formation	Severity of soil erosion or cracks or earth sinking and extent of earthwork required to restore the road formation.					
Red ash or Gravel layers	Loss of strength and disintegration of aggregate under load, with exposure to moisture, deep potholes into sub-base layers.					
Asphalt road	Cracks and damaged by heavy rain, flood that require frequent repairing or flushing and bleeding, development of cracks, formation of potholes,					
Cobblestones	Absences of drainage structures, lack of highly compaction, lack of accurately fill fine aggregate and					

	suddenly high loads vehicle applied on cobblestone road.					
Curb and gutter	Severity of structural cracks and number of defects in curb and gutter per unit length in a road section.					
Drainage Sumps	Structural cracks or blocked drains, corrosion of steel					
Footpath	Severity of structural cracks, Surface area affected by spalling, extent of rebar corrosion, extent of deformation.					
Concrete Bridge	Blisters, cracking, crazing, curling, delamination, efflorescence, low spots, pop outs					
Asphalt Bridge	Potholes, surface and base layer deformation.					
Concrete Culvert	Structural cracks, depth and surface area affected by spalling, extent of rebar corrosion, extent of deformation.					
Steel Culvert	Severity of corrosion, reduction in cross-section area due to corrosion, degree of deflection from vertical.					

6) Condition Assessment had been done using the revised Asset Management Operational manual of Ministry of Urban Development and Housing (MUDH) five level condition indicators and deterioration type of each segment and area were captured. Therefore please give the area of condition assessment captured for your city municipality.

Feature Class (Road Surface Mat.)	Road Feature Class by Condition				
	Very Good (Km)	Good (Km)	Moderate (Km)	Poor (Km)	Very Poor (Km)
Asphalt					
Cobble Stone					
Earth Pressed					
Earthen					
Gravel					
Large Block Stone					
Red Ash					

SECTION III: Identified Problems of Road Maintenance.

7) To what extend do you rate the following identified problems in road maintenance magnitudes. From your experience, please express your opinion on rate of occurrences on road construction projects based on the representative numbers listed below. (Please tick the appropriate box (√).

(1) = Insignificant (2) =Less Significant (3) =Averagely Significant

(4) = Significant (5) =Very Significant

No	1) Client-related Problems	1	2	3	4	5
1	Change of plan and scope of the project					
2	Repeated change order and variation order					
3	Human resource constraints					
4	High turnover of senior staff (Leaving of senior staff)					
5	Lack of qualified client staff					
6	Lack of capacity-road training for client staff, contractors and consultants those involved in maintenance.					
7	Not advocating Public Private Partnership (PPP) in road maintenance					
8	Not managing the roads as part of the market economy (Roads are managed like a social service)					
9	Insufficient road condition survey with lack of appropriate project prioritization mechanism					
10	Difficult bureaucracy in client organization					
11	Lack of effective budget consumption (allocated budget is not consumed effectively)					
12	Slow decision-making process					
13	Procurement delay					
14	Poor organization structures					
15	Lack of communication and coordination by owner it self					
16	Not hiring supervision consultants for all maintenance projects					

No	2) Consultants-related Problems	1	2	3	4	5
1	No specialized consultants on the road maintenance					
2	Inadequate maintenance experiences of consultant staff					

3	High turnover of consultant staff (Leaving of consultant staff)					
4	Staff unavailability on the site					
5	Poorly qualified engineers and staff assigned to the project					
6	Shortage of technically qualified personnel/staff					
7	Poor communication and coordination of the consultant with other parties					
8	Poor monitoring and controlling					
9	Poor maintenance contract management and project administration					
10	Quality assurance/control problems					
11	Insufficient data collection and condition survey before road maintenance					
12	Shortage of technically qualified personnel/staff					
13	Poor inspection and testing					
14	Lack of interest by consultants to conduct laboratory and field tests					
15	Late approval of test					

No	**3) Contractors-related Problems**	**1**	**2**	**3**	**4**	**5**
1	No specialized contractors on road maintenance					
2	Inadequate maintenance experience of contractors					
3	No Knowledge of maintenance specification					
4	High turnover of contractor's staff					
5	Not enough experience of contractor's staff					
6	Poor communication and coordination of the contractor with other parties					
7	Corruption					
8	Poor maintenance contract management and project administration					
9	Poor site management					
10	Inefficient work methods					
11	Poor labor supply and productivity					
12	Not managing resources efficiently and effectively					
13	Poor demand and supply chain					
14	Insolvencies and bankruptcies or cash flow problem					
15	Shortage of equipment					

16	Equipment allocation/management problems					
17	Incompatibility with new technology					
18	Lack of acquiring new and recent technology equipment					

No	Other Problems	1	2	3	4	5
1	Road maintenance is politically unattractive					
2	People in power have little/no understanding of the importance of road maintenance					
3	Inadequate financing arrangements/ insufficient budget for road maintenance.					
4	The financial source for road maintenance is limited (only road fund)					
5	Road users are not directly paying for roads					
6	Lack of interest by professionals to participate in road maintenance works					
7	Road Maintenance has not been looked upon by universities as an intellectual subject					
8	Donors are not interested to fund road maintenance					
9	Foreign contractors are not interested to participate in road maintenance					

APPENDIX 3 - INTERVIEW SCHEDULE

SECTION III: Interview Section on road infrastructural asset database structure and available information for easy access in the future.

PREFACE

I wish to thank you for your participation in this research. The interview you are about to answer the questions is regarding to a research for a degree of **Master of Science in Construction Engineering and Management**. This research is being done to assess Condition Assessment and Maintenance Forecast Method of Road Infrastructure Asset Management Plan the case of Southern Oromia.

Orientation and Introduction for Participants in Relation to Interview Questions:

1. First of all, I would like say thank you for your valuable time and cooperation to answer the following interview questions.

2. Please note that your response is anonymous and is treated in absolute confidentiality.

3. The interview comprises some questions and may take approximately 30 to 40 minutes to complete.

4. Should your company or organization wish to receive a copy of the final research report, you are welcome to contact **Mr. Seifu Tadesse; phone +251 913251585; Email:seifu59@gmail.com.**

❖ Organization and Respondent's position

UIIDP Coordinator ( ) Senior Engineer ( )

Design and contract administration ( ) RAMP Data Base Directorate Director ( )

Surveyors ( ) if other please specify ……

1) Once the data have been acquired by one or more methods and technologies they are stored in various formats and storage media. Data formats include: paper format, electronic databases, and geo-referenced database systems (such as Geographic Information Systems, GIS). The storage media employed can be paper forms (still in use in many agencies), hard disks, magnetic tapes, CDs, DVDs and combinations of thereafter.

What is the mechanism you follow to manage the data collected in your organization?

……

……

2) Data integration alternatives include two main approaches: a fused database and many interoperable databases. In the first case the integration strategy leads to the creation of one database that contains all integrated data; in the second case existing or newly created databases are linked together and the integration of the data is achieved with the use of queries that provide a view of the linked data. Or GIS software and related functionalities can alternatively be incorporated in the databases as external software that enhances the analytical and reporting capabilities of the system.

What data integration system you use in your organization?

……

……

3) What data are used to prioritize and select between two projects for example between two pavement projects and how much important is it?

Road way asset data	Level of importance						
	Very low	low	Medium	High	Very High	Not important	I don't now
Location							

Attributes/characteristics (i.e., materials, service life, geometry, etc.)							
Structural condition (i.e., how adequate it is for its purpose)							
Functional condition (i.e., how well it can serve the public)							
Initial agency cost (construction/provision)							
Life-cycle costs (including M&R and user costs)							
Usage (i.e., how many users utilize it on a specific time basis, e.g., a day)							
Customer/user feedback and/or complaints							

4) How decisions are made in your organization to finance a project maintenance or rehabilitation need? …….....

……..

5) Which economic evaluation analysis method you use in your organization to evaluate the road maintenance economic viability?

……

……

……

6) Does your organization prepare day to day reports on road maintenance activities?

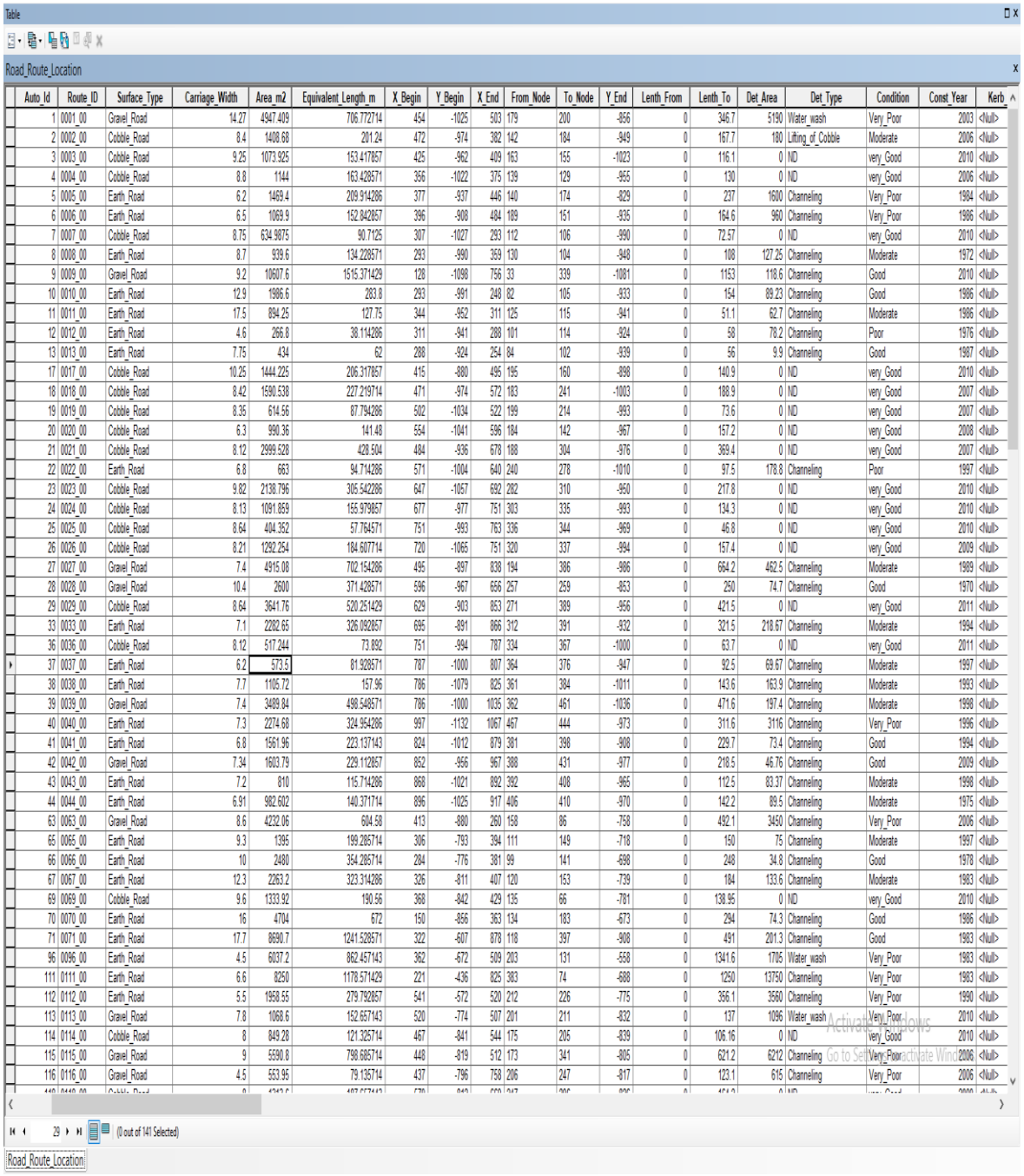
Yes ( ) No ( ) I don't know ( ) if others please tell me……..

7) Does your organization carry out annual visual condition assessment surveys for carriageways, shoulders of gravel, earth roads and cobblestone?

Yes ( ) No ( ) I don't know ( ) if others please tell me……..

……..

Annex from Road District



Table

Road_Route_Location

Auto_Id	Route_ID	Surface_Type	Carriage_Width	Area_m2	Equivalent_Length_m	X_Begin	Y_Begin	X_End	From_Node	To_Node	Y_End	Lenth_From	Lenth_To	Det_Area	Det_Type	Condition	Const_Year	Kerb
1	0001_00	Gravel_Road	14.27	4947.409	706.772714	454	-1025	503	179	200	-856	0	346.7	5190	Water_wash	Very_Poor	2003	<Null>
2	0002_00	Cobble_Road	8.4	1408.68	201.24	472	-974	382	142	184	-949	0	167.7	180	Lifting_of_Cobble	Moderate	2006	<Null>
3	0003_00	Cobble_Road	9.25	1073.925	153.417857	425	-962	409	163	155	-1023	0	116.1	0	ND	very_Good	2010	<Null>
4	0004_00	Cobble_Road	8.8	1144	163.428571	356	-1022	375	139	129	-955	0	130	0	ND	very_Good	2006	<Null>
5	0005_00	Earth_Road	6.2	1469.4	209.914286	377	-937	446	140	174	-829	0	237	1600	Channeling	Very_Poor	1984	<Null>
6	0006_00	Earth_Road	6.5	1069.9	152.842857	396	-908	484	189	151	-935	0	164.6	960	Channeling	Very_Poor	1986	<Null>
7	0007_00	Cobble_Road	8.75	634.9875	90.7125	307	-1027	293	112	106	-990	0	72.57	0	ND	very_Good	2010	<Null>
8	0008_00	Earth_Road	8.7	939.6	134.228571	293	-990	359	130	104	-948	0	108	127.25	Channeling	Moderate	1972	<Null>
9	0009_00	Gravel_Road	9.2	10607.6	1515.371429	128	-1098	756	33	339	-1081	0	1153	118.6	Channeling	Good	2010	<Null>
10	0010_00	Earth_Road	12.9	1986.6	283.8	293	-991	248	82	105	-933	0	154	89.23	Channeling	Good	1986	<Null>
11	0011_00	Earth_Road	17.5	894.25	127.75	344	-952	311	125	115	-941	0	51.1	62.7	Channeling	Moderate	1986	<Null>
12	0012_00	Earth_Road	4.6	266.8	38.114286	311	-941	288	101	114	-924	0	58	78.2	Channeling	Poor	1976	<Null>
13	0013_00	Earth_Road	7.75	434	62	288	-924	254	84	102	-939	0	56	9.9	Channeling	Good	1987	<Null>
17	0017_00	Cobble_Road	10.25	1444.225	206.317857	415	-880	495	195	160	-898	0	140.9	0	ND	very_Good	2010	<Null>
18	0018_00	Cobble_Road	8.42	1590.538	227.219714	471	-974	572	183	241	-1003	0	188.9	0	ND	very_Good	2007	<Null>
19	0019_00	Cobble_Road	8.35	614.56	87.794286	502	-1034	522	199	214	-993	0	73.6	0	ND	very_Good	2007	<Null>
20	0020_00	Cobble_Road	6.3	990.36	141.48	554	-1041	596	184	142	-967	0	157.2	0	ND	very_Good	2008	<Null>
21	0021_00	Cobble_Road	8.12	2999.528	428.504	484	-936	678	188	304	-976	0	369.4	0	ND	very_Good	2007	<Null>
22	0022_00	Earth_Road	6.8	663	94.714286	571	-1004	640	240	278	-1010	0	97.5	178.8	Channeling	Poor	1997	<Null>
23	0023_00	Cobble_Road	9.82	2138.796	305.542286	647	-1057	692	282	310	-950	0	217.8	0	ND	very_Good	2010	<Null>
24	0024_00	Cobble_Road	8.13	1091.859	155.979857	677	-977	751	303	335	-993	0	134.3	0	ND	very_Good	2010	<Null>
25	0025_00	Cobble_Road	8.64	404.352	57.764571	751	-993	763	336	344	-969	0	46.8	0	ND	very_Good	2010	<Null>
26	0026_00	Cobble_Road	8.21	1292.254	184.607714	720	-1065	751	320	337	-994	0	157.4	0	ND	very_Good	2009	<Null>
27	0027_00	Gravel_Road	7.4	4915.08	702.154286	495	-897	838	194	386	-986	0	664.2	462.5	Channeling	Moderate	1989	<Null>
28	0028_00	Gravel_Road	10.4	2600	371.428571	596	-967	656	257	259	-853	0	250	74.7	Channeling	Good	1970	<Null>
29	0029_00	Cobble_Road	8.64	3641.76	520.251429	629	-903	863	271	389	-956	0	421.5	0	ND	very_Good	2011	<Null>
33	0033_00	Earth_Road	7.1	2282.65	326.092857	695	-891	866	312	391	-932	0	321.5	218.67	Channeling	Moderate	1994	<Null>
36	0036_00	Cobble_Road	8.12	517.244	73.892	751	-994	787	334	367	-1000	0	63.7	0	ND	very_Good	2011	<Null>
37	0037_00	Earth_Road	6.2	573.5	81.928571	787	-1000	807	364	376	-947	0	92.5	69.67	Channeling	Moderate	1997	<Null>
38	0038_00	Earth_Road	7.7	1105.72	157.96	786	-1079	825	361	384	-1011	0	143.6	163.9	Channeling	Moderate	1993	<Null>
39	0039_00	Gravel_Road	7.4	3489.84	498.548571	786	-1000	1035	362	461	-1036	0	471.6	197.4	Channeling	Moderate	1998	<Null>
40	0040_00	Earth_Road	7.3	2274.68	324.954286	997	-1132	1067	467	444	-973	0	311.6	3116	Channeling	Very_Poor	1996	<Null>
41	0041_00	Earth_Road	6.8	1561.96	223.137143	824	-1012	879	381	398	-908	0	229.7	73.4	Channeling	Good	1994	<Null>
42	0042_00	Gravel_Road	7.34	1603.79	229.112857	852	-956	967	388	431	-977	0	218.5	46.76	Channeling	Good	2009	<Null>
43	0043_00	Earth_Road	7.2	810	115.714286	868	-1021	892	392	408	-965	0	112.5	83.37	Channeling	Moderate	1998	<Null>
44	0044_00	Earth_Road	6.91	982.602	140.371714	896	-1025	917	406	410	-970	0	142.2	89.5	Channeling	Moderate	1975	<Null>
63	0063_00	Gravel_Road	8.6	4232.06	604.58	413	-880	260	158	86	-758	0	492.1	3450	Channeling	Very_Poor	2006	<Null>
65	0065_00	Earth_Road	9.3	1395	199.285714	306	-793	394	111	149	-718	0	150	75	Channeling	Moderate	1997	<Null>
66	0066_00	Earth_Road	10	2480	354.285714	284	-776	381	99	141	-698	0	248	34.8	Channeling	Good	1978	<Null>
67	0067_00	Earth_Road	12.3	2263.2	323.314286	326	-811	407	120	153	-739	0	184	133.6	Channeling	Moderate	1983	<Null>
69	0069_00	Cobble_Road	9.6	1333.92	190.56	368	-842	429	135	66	-781	0	138.95	0	ND	very_Good	2010	<Null>
70	0070_00	Earth_Road	16	4704	672	150	-856	363	134	183	-673	0	294	74.3	Channeling	Good	1986	<Null>
71	0071_00	Earth_Road	17.7	8690.7	1241.528571	322	-607	878	118	397	-908	0	491	201.3	Channeling	Good	1983	<Null>
96	0096_00	Earth_Road	4.5	6037.2	862.457143	362	-672	509	203	131	-558	0	1341.6	1705	Water_wash	Very_Poor	1983	<Null>
111	0111_00	Earth_Road	6.6	8250	1178.571429	221	-436	825	383	74	-688	0	1250	13750	Channeling	Very_Poor	1983	<Null>
112	0112_00	Earth_Road	5.5	1958.55	279.792857	541	-572	520	212	226	-775	0	356.1	3560	Channeling	Very_Poor	1990	<Null>
113	0113_00	Gravel_Road	7.8	1068.6	152.657143	520	-774	507	201	211	-832	0	137	1096	Water_wash	Very_Poor	2010	<Null>
114	0114_00	Cobble_Road	8	849.28	121.325714	467	-841	544	175	205	-839	0	106.16	0	ND	very_Good	2010	<Null>
115	0115_00	Gravel_Road	9	5590.8	798.685714	448	-819	512	173	341	-805	0	621.2	6212	Channeling	Very_Poor	2006	<Null>
116	0116_00	Gravel_Road	4.5	553.95	79.135714	437	-796	758	206	247	-817	0	123.1	615	Channeling	Very_Poor	2006	<Null>

29 (0 out of 141 Selected)

Road_Route_Location

Figure 1: ArcGIS. Attribute database for data management systems

Table 1: Current Replacement Cost and Residual value of the Movement Network Asset in Yabello

Feature Class	Current Replacement Cost (Br)	Depreciated Replacement Cost	Asset Deficit (Br)	Maintenance Deficit (Br)
Road surface				
Cobble Stone	26,492,802.60	21,230,075.22	5,340,404.08	77,676.70
Gravel	19,227,022.28	7,468,446.78	12,500,745.80	1,890,521.75
Earthen	380,058,464.80	52,528,138.51	355,912,499.97	47,411,920.18
Total	**425,778,289.68**	**81,226,660.51**	**373,753,649.84**	**49,380,118.62**
Road structure				
Bridge	20,948,113.92	13,105,701.14	7,970,612.68	141,649.90
Culvert	13,847,767.04	5,030,718.35	8,917,244.59	221,000.70
Total	**34,795,880.96**	**18,136,419.49**	**16,887,857.27**	**362,650.60**
Street Lights				
Sodium Lamp	234,000	105,300	105,300	128,700
Total	**234,000**	**105,300**	**105,300**	**128,700**

Table 2: The financial plan by possible sources for the proposed project works in Yabello City

S/N	**Sources of Funding**	2014 EFY
1	**IDA Performance Grant (1.1+1.2)**	**24,194,150.92**
1.1	ULGDP II	-
1.2	UIIDP	24,194,150.92
2	**Regional Contribution (30 %) (2.1+2.2)**	**6,442,755.42**
2.1	ULGDP II	-
2.2	UIIDP	6,442,755.42
3	**City Contribution (20%) (3.1+3.2)**	**5,080,771.70**
3.1	ULGDP II	-
3.2	UIIDP	5,080,771.70
4	**Subtotal: ULGDP II/UIIDP (4.1+4.2)**	**35,717,678.04**
4.1	Subtotal: ULGDP II (1.1+2.1+3.1)	-
4.2	Subtotal: UIIDP(1.2+2.2+3.2)	35,717,678.04
5	Unutilized 20…… ULGDP II Budget (ULGDP II)	-

6	**Total ULGDP II/ UIIDP(6.1+6.2)**	**35,717,678.04**
6.1	Total ULGDP II(4.1+5)	-
6.2	Total UIIDP II (4.2)	35,717,678.04
7	Additional Regional Fund for CIP	-
11	State fund from surplus	6,500,000.00
12	**Total Additional City & Regional Fund (7-11)**	**6,500,000.00**
13	Other donor fund except ULGDP II/ UIIDP	1,157,677.58
14	Total fund available for the CIP (6+12+13)	**43,375,355.62**

Table 3: Rehabilitation Summary of Movement Network Assets in Shashemene City

Strategic Activity Area	Rehabilitation/ Replacement Forecast (Birr)
I. The Movement Network Assets	
Road	
Asphalt	-
Cobble Stone	554,207.43
Gravel	912,214.29
Red Ash	25,241,791.67
Large Block Stone	192,088.36
Earth Pressed	1,554,354.91
Sub Total	**28,454,656.66**
Footpath	
Cobble Stone	58,523.69
Precast Paving Block	-
Red Ash	2,842,777.27
Sub Total	**2,901,300.96**
Road Structures	
Concrete Culvert	-
Sub Total	**-**
Movement Network Total	**31,355,957.62**

Table 4: Maintenance Summary by Asset Category of Shashemene City

Social & Economic Strategic Area Assets	Routine and Periodic Maintenance(Br)	Eliminating Maintenance Deficit (Birr)	Total Maintenance Need (Birr)	% for eliminating
The Movement Networks	11,179,354.18	28,045,743.78	39,225,097.96	57%
Water Supply Network Assets	1,256,204.24	1,256,204.24	2,512,408.48	4%
Environmental Activity Area	314,406.92	15,664,155.13	15,978,562.05	23%
Social, Economic and Supporting Activity Area	4,792,995.98	6,739,525.51	11,532,521.49	17%
Total	**17,542,961.33**	**51,705,628.66**	**69,248,589.99**	**100%**

Table 5: Estimated Current Value of the Movement Network in Shashemene

Feature Class	Current Replacement Cost (Br)	Depreciated Replacement Cost (Br)	Maintenance Deficit (Br)	Current Value (Br)	Asset Deficit (Br)
Asphalt	260,394,256.8	142,410,901.4	1,994,347.83	140,226,001.1	120,168,255.81
Cobble Stone	339,300,263.2	244,445,640.4	1,134,646.89	243,311,013.5	95,989,249.72
Gravel	6,893,070.82	4,141,060.19	556,065.00	3,746,615.59	3,146,455.23
Red Ash	204,320,675.4	122,647,344.9	10,056,155.5	113,176,299.2	91,144,376.27
Large Block stone	850,009.95	608,635.79	90,112.78	525,075.72	324,934.24
Earth Pressed	33,313,285.39	18,552,534.05	2,385,969.65	16,310,965.68	17,002,319.71
Total	**845,071,561.7**	**532,806,116.8**	**16,217,297.67**	**517,295,970.7**	**327,775,590.97**
Road Structure	228,250,416.6	128,481,200.0	2,093,657.31	126,760,869.3	101,489,547.39
Walkway	60,640,819.28	39,036,652.35	327,659.41	38,708,992.94	21,931,826.34
Street Light	135,745,750.0	90,444,725.00	9,349,550.00	90,444,725.00	45,301,025.00
Traffic Light	6,600,000.00	4,050,000.00	5,797.50	4,050,000.00	2,550,000.00
Traffic Sign Post	77,300.00	53,685.00	33,000.00	53,685.00	23,615.00
Road Median	974,919.92	974,919.92	18,781.89	974,919.92	712,350.24
Total	**1,277,360,767.**	**795,847,299.0**	**28,045,743.78**	**778,289,162.8**	**499,783,954.93**

Table 5.6: Information on Road and Surface Asset

	Profile		**Full name**		**sub city**	**Kebele code**	**Local name**			**Comments**				**Date**		**Index No**	**Signature**
	Supervisor																
	Enumerator																
01	**02**		**03**		**04**	**05**	**06**	**07**	**08**	**10**				**11**		**12**	
Route Id	**Node Code**		**Length in Mt**		**Road/Bridge Material** *1= Asphalt Road 2= Cobble Stone 3= Gravel Road 4= Red Ash Road 5= Large Block Stone 6=Earthen 7= Concrete Bridge 8= Steel Bridge 9= Culvert 10= Wooden Bridge 11=Steel Culvert 12 = Earth Pressed 13 = Wooden culvert 14 = Concrete Slab Crossing 15 = Precast Paving Block*	**Type of Deterioration** *1= Peeling Minor 2=Peeling Major 3=Crack 4= Pothole 5=Channeling (Gravel, Earthen and Red Ash) 6=Cobble Edge Failure 7=Lifting of Cobble Stone 8=Depression 9=Wash Away (Gravel, Red Ash &, Earth)* 10 = Slab failure 11 = Abutment Failure *12=Siltation 13=Non-compaction 14=No Deterioration*	**Deter. Area in m^2, & length in m** Potholes=min 2*2m Peeling=min1*1m Wash Away=length*width Channeling=Length*Width Crack=crack length*0.6 Lifting=lifting Area Edge failure = Length in (m) Depression=Depression Area ND=No *Deterioration*	**Condition** *1=V. Good 2=Good 3=Moderate 4=Poor 5=Very Poor*	**Carriage Way;** *Avg.Width (M)*	**Carriage Way Kerbing by Material** *1 = Concrete 2=Cobble stone 3= Curb Stone 4 = Masonry 5 =None*				**Construction Year And/or Maintenance Year**		Owner. 1. ---------- CityAdmin. 2.ERA 3. ORA	**Remark**
	From	To	From	To						**Left**		**Right**					
										Mat	*Width (cm)*	*Mat*	*Width (cm)*	Construction Year	Maintenance Year		
0236_00	N0573	N0593	0		3												